EE 649 — Course Syllabus
Stochastic Network Optimization

I. COURSE INFORMATION

Instructor:
Michael J. Neely (EEB 520, mjneely@usc.edu, 213-740-3505)
Office Hours (EEB 520): Tu/Thu. (time TBA)

Class Location and Time:
Tu/Thu, TBA

Brief Course Description:
Network layer capacity; optimal control of wireless and ad-hoc mobile networks; opportunistic resource allocation, routing, and flow control; backpressure; minimum energy networking; general utilities and constraints; queue stability; Lyapunov optimization; energy-delay and utility-delay tradeoffs; peer-to-peer networks; stock market trading

Prerequisites:
Prerequisites are EE 464 or EE 465.

Textbook:
M. J. Neely. Stochastic Network Optimization with Application to Communication and Queueing Systems. Morgan & Claypool, 2010. A PDF download is available from the below link from a USC computer, or from any other institution that subscribes to the "Synthesis Lecture" series:
http://www.morganclaypool.com/doi/abs/10.2200/S00271ED1V01Y201006CNT007
The link also provides an order form for a printed and bound version of the book. This link is also available on the instructor webpage.

Web Resources
• Instructor Webpage: http://www-rcf.usc.edu/~mjneely/
• Stochastic Network Optimization Homepage: http://ee.usc.edu/stochastic-nets/

Supplemental Reading
Additional reading in the form of instructor handouts and a list of journal articles will be provided. A current list of papers in the area can be found on the Stochastic Network Optimization Homepage (listed above). For students interested in background reading on queueing theory, Markov chains, and convexity, the following texts are recommended (but not required):
1) Chapter 3 of Data Networks by D. Bertsekas and R. Gallager (Queueing Theory and Little’s Theorem)
2) Discrete Stochastic Processes by R. Gallager (Renewal Theory and Markov Chains)
3) Introduction to Probability Models by Sheldon Ross (8th edition) (Introduction to Markov chains and Discrete Probability)
4) Convex Analysis and Optimization by D. P. Bertsekas, A. Nedic, and A. E. Ozdaglar (Closed/Open Sets, Convexity, Duality, Subgradients)
5) Nonlinear Programming by D. P. Bertsekas (Linear and Convex Programming, Subgradient Algorithms)

Grading:
There will be 2-4 problem sets given during the semester, two midterms, and a course project. There may also be a few 10 minute questions given in class, worth a small amount of extra credit points. There is no final exam. These will be weighted in an overall score as follows: Homework: 20%, Midterm 1: 20%, Midterm 2: 20%, Project: 40%. The following minimum letter grades are guaranteed to students scoring within the specified intervals: 80-100 A, 70-80 A-, 60-70 B+, 50-60 B. The above thresholds may be adjusted at the end of the semester at the discretion of the instructor. Any such adjustments will be in favor of a higher letter grade.

Midterm Exam Dates:
TBA
II. COURSE SUMMARY AND OTHER DETAILS

This text presents a modern theory of analysis, control, and optimization for dynamic networks. Mathematical techniques of Lyapunov drift and Lyapunov optimization are developed and shown to enable constrained optimization of time averages in general stochastic systems. The focus is on communication and queueing systems, including wireless networks with time-varying channels, mobility, and randomly arriving traffic. A simple drift-plus-penalty framework is used to optimize time averages such as throughput, throughput-utility, power, and distortion. Explicit performance-delay tradeoffs are provided to illustrate the cost of approaching optimality. This theory is also applicable to problems in operations research and economics, where energy-efficient and profit-maximizing decisions must be made without knowing the future.

Homeworks will involve analytical problem sets. Some homeworks will also involve computer simulation of simple network algorithms, and will have “design your own problem” questions, where students develop their own problem and solution. The resulting problems and solutions will be printed and given to all other students. Students may also be scheduled to present their work during class.

Course Project:

Students will be encouraged to apply the theory developed in class to study their own problem formulation. Potential topics are peer-to-peer networks, networking with errors, networking with advanced PHY or coding, stock market trading, pricing, inventory control, MANET control, data compression, wireless video, etc. Students are encouraged to incorporate both analysis and simulation into their projects.

Students can work either individually or with one other teammate. A final project report (5-10 pages) and a final presentation will be required of each team. Projects are due and will be presented during the final week of the course.

Statement for Students with Disabilities:

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.-5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Statement on Academic Integrity:

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect ones own academic work from misuse by others as well as to avoid using anothers work as ones own. All students are expected to understand and abide by these principles. Scampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: http://www.usc.edu/dept/publications/SCAMPUS/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/.

III. TENTATIVE COURSE OUTLINE

This is a rough list of lecture topics for each date. We may deviate from this schedule as needed.

- Sample Path Properties, Rates and Rate Stability
- Network Capacity, Randomized Scheduling for Stability
- Linear Programs, Discrete Time Queues
- Lyapunov Drift, Lyapunov Optimization
- Applications to Energy Optimization, Virtual Queues
- Multi-Hop Routing, Backpressure
- Robustness, Imperfect Scheduling, Distributed Implementations
- Network Utility Maximization
- Convex Programming
- Alternative Lyapunov Functions, Queue Grouping, Complexity and Delay
- Universal Scheduling, Applications to Stock Market Trading
- Pricing, Peer-to-Peer Networking
- Optimization for Renewal Systems
- Special Topics