Syllabus for Stochastic Network Optimization Theory

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Course Overview: This course will give an in-depth introduction to the recently developed Lyapunov optimization theory for stochastic networks. It aims at introducing to the students various concepts of queue stability, general models for stochastic queueing networks, the minimum-drift algorithm design principle, and the Lyapunov drift analysis technique. It will also present applications of the theory to both networking and operations research problems, and encourage the students to apply the theory to their own problems of interest.

Intended Audience: Graduate students in areas of networking, communication, control and operations research.

Prerequisites: Recommended preparation: Students should have taken graduate level courses on networking and engineering probability or random processes.


Supplementary reading:
2) D. P. Bertsekas, A. Nedic, and A. E. Ozdaglar, *Convex Analysis and Optimization*
3) S. Boyd and L. Vandenberghe, *Convex Optimization*
4) D. Bertsekas and R. Gallager, *Data Network*
5) Articles on the Stochastic Network Optimization Homepage: [http://ee.usc.edu/stochastic-nets/](http://ee.usc.edu/stochastic-nets/)

Grading: The course grade consists of the following three components:

1) *Homework* – 20%
2) *Mid-term* – 30%
3) *Course Project* – 50%

The course will emphasize on applying the technique to solving research/real world problems. Hence there is no final exam.

Homework: The homework assignments will consist mostly of analytical problems. A few simulation problems may also be assigned. In one or two homework assignments, the students will be asked to design their own problems and provide solutions.

Course Project: An ideal course project will be a project done by a team of one or two students. The students can decide on their own project problems, but should discuss with the instructor to finalize the problem. The students are encouraged to apply any technique to solve their problems. The project

\[\text{This course will be similar to the course EE649 taught by Professor Michael J. Neely at the University of Southern California. However, this course has a stronger emphasis on relating the Lyapunov technique to the the flow-based optimization techniques.}\]
assignment will involve submitting a project proposal of 1 – 2 pages, and a final project report of 5 – 10 pages. A final project presentation will be performed the end of the semester.

A set of potential project topics include: network pricing, cloud computing, cooperative communications, CSMA protocol design, manufacturing network scheduling, transportation network, etc.

**Course Schedule:** (16 weeks in total)

Below is the tentative schedule of the course

1) Introductions to Queues, Definitions of Stability, Intro to Lyapunov Analysis
2) Single Queue System Analysis, A 2-Queue Control Problem, Multihop Network Scheduling
3) Multihop Network Scheduling, Caratheodory’s Theorem, Virtual Queues
4) Scheduling for Utility Maximization-I
5) Scheduling for Utility Maximization-II
6) Optimizing Functions of Time Averages, Multi-Timescale Control
7) Optimization for Wired Network, NUM and Dual Decomposition
8) Midterm
9) The Optimization Approach and the Lyapunov Technique, Delay Reduction Techniques
10) No Class
11) Lyapunov Analysis for Processing Networks, Algorithm Design for Renewal Systems and Linear Fractional Programming
12) Max-Weight CSMA, Markov Approximation and its Applications, Mixing Time
13) Alternative Lyapunov Functions and Network Control, Systems with Markovian Dynamics
14) Special Topics: Scheduling for Content Distribution Network/Cloud Computing/MapReduce
15) Special Topics: Delay-based Lyapunov Control
16) **Project Presentations**