EE650: "Advanced Topics in Computer Networks"

This term's topic: "Useful Mathematical Tools for Analyzing Wired and Wireless Networks"

Course Description

Over the last 10 years the Internet has grown from a small scale research network to an immense world wide infrastructure. Analyzing the performance of such a large scale system is a challenging task that requires either extensive/costly experiments, or carefully chosen mathematical tools. At the same time, it has become apparent that wireless networks are going to play an increasingly important role in the world of communications. It is envisioned that in the near future the global network will consist of an Internet-like core and a number of wireless edge-networks like sensor, mobile ad-hoc, delay tolerant, and mesh networks. The goal of this course is to expose graduate students to the mathematical tools that have been successfully used in the last 5-10 years to model and analyze wired networks like the Internet and wireless networks like sensor and ad-hoc ones.

The course will briefly revise basic probability and queueing principles through some examples. It will then present some or all of the following (time permitting): (i) the use of Lyapunov functions in proving various stability and throughput results for network switches, (ii) some combinatorics used to analyze scheduling mechanisms in switches, (iii) fluid models used in modelling long-lived TCP flows, (iv) random walks on graphs and other random processes used to model mobility in wireless networks and, (v) probabilistic and combinatorial techniques used to analyze contention and routing performance in wireless networks, (vi) basic information theory concepts used to study the capacity of ad-hoc networks, (vi) basic elements of game theory used to devise network pricing schemes, and (vii) the notions of heavy-tailed distributions, self-similarity, and long range dependence that play an important role in the analysis of web and network traces.

For each topic, we will first introduce the corresponding research problem/area (e.g. switching), then we will present the corresponding mathematical tools/analysis (e.g. Lyapunov functions), and finally we will go through recent publications (from networking venues, e.g. IEEE INFOCOM, ACM SIGCOMM, ACM SIGMETRICS, IEEE/ACM Transactions in Networking, ACM MOBIHOC, IEEE SECON, ACM MOBICOM) that have successfully applied these tools/analysis.

Instructor

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(more info on the next page)

Lecture

Time: T-Th 11:00-12:20pm
Place: VKC 210

Project

The course involves a project. A project is something original and related to a topic of the class. Think of the finished work as being good enough for a conference submission. You can work in teams of at most 2 people per project. (More information on the project will be given during the first week of classes.)

Presentations

The course involves a couple of presentations. The first is the presentation of you project. The second is a presentation of one or (preferably) a number of research papers that have used an analytic tool to study networks. (Either the tool, or its application should not be part of the course lectures. More info about this presentation, called research presentation, will be given during the first week of classes.)

Grading (tentative)

40% Project report
15% Project presentation (20 minutes, in class, conference presentation quality)
20% Midterm
15% A few homeworks (probably 3 sets of research-style problems)
10% Research presentation (20 minutes, in class)
There will be no final

Schedule (tentative)

- Basic probability and queueing (examples of usage in switching and active queue management, after a brief introduction to these research topics)
- Lyapunov Functions and fluid analysis used in stability of switches
- Combinatorics (bipartite matchings and stable marriages) used in switching algorithms
- Fluid models used in TCP modeling (after a brief review of TCP)
- Random walks on graphs used to model mobility in wireless networks and analyze performance
- Probabilistic and combinatorial analysis of contention and routing in wireless networks
- Basic information theory concepts used to study the capacity of ad hoc networks
- Probabilistic and statistical analysis of Internet traces (applicability of Poisson hypothesis, self-similarity, correlation, heavy-tailed sizes and implications in performance)
-Basic elements of game theory used in pricing

Prerequisites

- One of CS551, EE555, or EE550 is normally required, but exceptions are made subject to instructor's approval.