Course Overview

CS 598: Advanced Internetworking
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Who am I?

• Matthew Caesar
• Assistant Professor in CS Dept.
  – Ph.D. from UC Berkeley in 2007
  – Thesis: Internet Routing, Reliability
• How to reach me:
  – caesar at cs.illinois.edu (please include “CS598: Urgent” in subject line)
  – Office hours: TBA, and by appointment
Goals of this course

• Learn how the Internet works
  – Protocols/systems, and how they interact
  – Reasoning behind its design decisions

• Learn how to do networking/systems research
  – How to use research tools and platforms
  – Perform conference-quality research project
  – Appreciate what is good research (problem selection, methodology, presentation)
What this course is about

- How to build, operate, and manage large-scale networks
- Underlying principles and mechanisms
- Router architecture
- Lookup/forwarding algorithms
- Network measurement
- Web/Internet services
- IP QoS; Internet security
- Network virtualization
- Network support for cloud computing
- Programming networked services
- Advanced concepts in IP routing
- DNS services
- IP troubleshooting
What this course is *not* about

- An introduction to networking
  - We will not cover TCP basics, socket programming, etc.

- An introduction to programming
  - Knowledge of either scripting (e.g. Perl) or programming languages (e.g. C++/Java) will help
Why study the Internet?

• Largest network ever deployed
  – Learn about design over a variety of design points and environments
  – Study system behavior on extremely-large scales

• Synergy with wide array of research areas
  – Databases, security, AI, algorithms/theory, computer architecture, HCI, OS, programming languages, social computing...
Internet faces problems

- Protocol bugs, misconfiguration, DoS attacks, spam, persistent instability
  - Harms security, dependability, correctness

- Traditional approach: incremental hacks and workarounds

- Incremental approach isn’t working
Why bother doing Internet research?

• What if we could redesign the Internet from scratch?
  – But that’s not possible, right?

• “Clean-slate” approach allows us to explore conceptual underpinnings

• Can later try to retrofit solutions onto the Internet
### Grading

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Project</td>
<td>50%</td>
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<tr>
<td>Class participation, paper</td>
<td>10%</td>
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<tr>
<td>presentations</td>
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<td>Paper reviews</td>
<td>10%</td>
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<tr>
<td>Homework assignments</td>
<td>20%</td>
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- This is a graduate-level course – grade is less important than what you learn.
Homework expectations

• Goal: hands-on experience in network administration, research tools, etc.

• Three mini-assignments:
  – Build your own (small) ISP
  – Measure the Internet
  – Emulation vs. Simulation tools

• Requires account on Emulab – sign up early!
Course structure: readings

• *Read the required papers before class*

• Write a short 2 paragraph review:
  – Goal: synthesize main ideas/concepts
  – *Critique* the paper, do not summarize
  – Also list questions you had about the paper, and ask them in class discussion
Lecture

• My plan: ~55 mins lecture, ~25 mins discussion
  – I’ll lead some lectures
  – Sign up for papers you’d like to present

• Presentations cover main points of paper
  – Presentations should critique, question design choices, pose alternatives, etc.
**Project expectations**

• Aim high!
  – A good project could become the basis for
    • Publication: CoNEXT, CCS, etc. deadlines coming up.
    • Ph.D. thesis
  – Focus on *impact*

• Your project need not be SIGCOMM-quality but should be conference-worthy with a little more effort

• I am here to help you
• New project ideas posted in a few weeks
Research project: steps

• Choose one of my project ideas or you can come up with your own
• Pick your project, partner, and submit a one-page proposal describing
  – The problem you are solving
  – Your plan of attack with milestones and dates
• Have a one-on-one meeting with me to discuss your project topic
• Give 2 short (5-10 minute) presentations on your progress
• Poster session
• Submit project papers at end of course
Send me the following information

• Tonight, please send me (caesar at cs.uiuc.edu) an email with the following information:
  1. Subject: “CS 598 Registration”
  2. Your research interests/area (e.g., databases, dist’d systems)
  3. Whether you will need help coming up with a project topic
  4. If you have a project in mind, tell me what the topic is
Rest of today:

• Course topic highlights

• More depth/advanced stuff later
What is the Internet?

• Global scale, general purpose, heterogeneous technologies, public, computer network

• Vast distributed system comprising
  – 650 million hosts (potentially malicious)
  – >26,000 ISPs (potentially competing)
How can two hosts communicate?

- Encode information on modulated “Carrier signal”
  - Phase, frequency, and amplitude modulation, and combinations thereof
  - Ethernet: self-clocking Manchester coding ensures one transition per clock
  - Technologies: copper, optical, wireless
How can many hosts communicate?

- Naïve approach: full mesh
- Problem:
  - Obviously doesn’t scale to the 570,937,778 hosts in the Internet (estimated, Aug 2008)
How can many hosts communicate?

- Multiplex traffic with routers
- Goals: make network robust to failures, maintain spare capacity, reduce operational costs
  - More on “topology” in Lectures 2,3
2. How can routers find paths?

- Hosts assigned topology-dependent addresses
- Routers advertise address blocks ("prefixes")
- Routers compute "shortest" paths to prefixes
- Map IP addresses to names with DNS
- More on "Routing" and "Naming" in Lectures 3, 4, 7
Intra- vs. Inter-domain routing

- Run “Interior Gateway Protocol” (IGP) within ISPs
  - OSPF, IS-IS, RIP
- Use “Border Gateway Protocol” (BGP) to connect ISPs
  - To reduce costs, peer at exchange points (AMS-IX, MAE-EAST)
In some sense, yes:
- TCP senders send less traffic during congestion
- Routing protocols adapt to topology changes

But, does the network run efficiently?
- Congested link when idle paths exist?
- High-delay path when a low-delay path exists?

How should routing adapt to the traffic?
- Avoiding congested links in the network
- Satisfying application requirements (e.g., delay)

... essential questions of traffic engineering
What if hosts misbehave?

• Easy to send traffic to anyone else: even if they don’t want it!
  – spam, DoS, phishing, worms,

• Possible defenses:
  – Monitoring+filtering: detect attack and install filters to drop traffic
  – Capabilities: only accept traffic that carries a “capability”

• More in Lectures 20-21
How can researchers study the Internet?

- Techniques: Measurement, Simulation, Emulation, Deployment
- Testbeds: Planetlab, Emulab, ns-2,
- Data sources: Abilene Observatory, Routeviews, CAIDA
- Software: Click, Quagga, and XORP software routers
- If you’ve got an idea, this course will help you figure out how to evaluate it
Summary

- Course administrivia
- Course topic highlights
- Details on web site:
  http://www.cs.uiuc.edu/homes/caesar/classes/CS598.S11
Backup slides