Undergraduate Networking at Small Colleges

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Undergraduate networking at one particular small college

- Colgate University
  - 2,900 students, 10-25 CS graduates
- Two example networking courses at Colgate
  - COSC 465: Computer networking
    - Advanced undergraduate networking course
  - CORE 135: The underside of the internet
    - Technical and social issues around networking; for non-majors

What should students learn?

- Learning goals should be primary concern
  - Driven by several factors: fundamental ideas of the discipline, curricular constraints, student expectations and interests, industry trends, ...
- Structure: bottom-up, top-down, topic/theme-oriented
  - Various texts support one or more of these approaches
  - Some example course materials at http://education.sigcomm.org

What should students do?

- How to achieve the learning goals?
  - What laboratory activities to support student learning?
- Many tools, environments, and approaches developed for practical, hands-on experiences
- Two basic approaches
  - Simulation
    - Unclear how student learning translates to broadly useful skills
  - Laboratory, emulation-, and testbed-based approaches
    - Directly grapple with important scientific & engineering issues in networking
    - Realism counts a lot!

Examples of labs I've used

- Applications
  - DNS cache / IP longest prefix match lookup (surprisingly popular)
  - Simplified Twitter clone (fun; used as a backchannel during a couple classes)
  - HTTP proxy, with or without bells & whistles (students loved node.js)
  - Implement a reliable transport-layer protocol (in Schooner/Emulab)
- Measurement and analysis
  - Use their own measurement tool (and others) to evaluate characteristics of a small number of Internet paths (in Planetlab)
  - Evaluate passively collected network measurements (e.g., tcpdump traces, BGP session traces)
- Living above the sockets API isn't enough to get into gooey & interesting details
  - How to expose students to enough of the guts without overwhelming/horrifying them?

In the works: "Build an Internet Router" for undergraduates

- BIR: grad-level course in which teams of students build a functional IPv4 router
  - Includes hardware (Verilog) and software components
  - Based around NetFPGA and VNS
  - Many networking and software development skills addressed
- Ongoing work (with Andrew Moore of Cambridge U.) to develop a set of lab modules based on BIR that address multiple levels of understanding
- Examples of modules in progress/planned
  - Observation: simulation and visualization of a congested queue
  - Constrained: build ARP functionality; develop and test IP longest prefix match lookup; develop and test intra-domain routing protocol
  - Semi-constrained: support for traffic monitoring/measurement; integrate firewall functionality

What about non-majors?

- "The underside of the internet": a core scientific perspectives course at Colgate
  - Technical and scientific underpinnings of the internet
  - Challenges related to production and consumption of internet-enabled devices
  - Security and privacy-related challenges
- Mainly a discussion-oriented course, but ...
- Students get hands-on practice with course concepts in periodic in-class labs
  - No coding
  - E.g.: web performance measurement, spam filter investigation, measuring power consumption, scanners and intrusion detection
- How to create compelling hands-on experiences for non-majors?

Challenges / thoughts for discussion

- Laboratory resources, setup and maintenance
  - Lab staff (if they exist) may not have expertise to help
  - Shared and openly available testbeds can help to address lack of resources
  - Account creation, management, and system configuration can be (surprisingly?) painful
- Depth of student background
  - Smaller departments can only offer a limited range of systems courses
  - Debugging on real systems can be hard, even for advanced students
- Larger class sizes pose a variety of challenges
  - No student tutors (TAs) with appropriate experience to assist
- Balancing practical (and marketable) skills with helping students develop broad and deep understanding
  - How to ensure that students are appropriately challenged, and on the "right" things?