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?