Scaling the Practical Education Experience

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Motivation

- Many tools, environments, and approaches developed for practical, hands-on experiences
- Provide realistic, applied setting for teaching, learning and research
- Many focus on relatively small graduate-level courses
- How to adapt and scale to larger classes and to undergraduate settings?
Position

• Practical exercises are essential for students at both undergraduate and graduate levels

• Directly grapple with important scientific & engineering issues in networking

• Realism counts a lot!

• We treat “Building an internet router” as a successful example with a coherent and compelling set of exercises

• How to adapt to undergraduate institutions? Scale up? Scale out?
Building an internet router

• Goal: in one semester/term, build a functional IPv4 router and design and implement some advanced router functionality
• Project-based course with groups of students (2)
• Hardware (Verilog) and software components
• Based around NetFPGA and VNS
• Many networking and software development skills addressed
  • Algorithms, data structures, concurrency, version control, testing
  • Routing, forwarding, ICMP and ARP processing, interoperability
• Highly compelling and rewarding
Undergraduate approaches and constraints

- Two basic approaches
  - Simulation and trace-based approaches
  - Laboratory and emulation-based approaches
- Constraints
  - Instructor overhead, laboratory setup and maintenance
  - Depth of student background
  - Larger course sizes
    - Assessment and grading
    - Open-ended versus more constrained exercises
Challenges in scaling

- Laboratory setup and maintenance
- Cost, space, instructor overhead
- Shared and openly available testbeds can help
- Assessment and grading
- Need appropriate scaffolding and support for undergraduates
- Smaller departments can only offer a limited range of systems courses
- Requires a variety of exercises to address different levels of understanding
Looking ahead

- Goal: develop a range of activities based on BIR that address multiple levels Bloom’s taxonomy
- Current BIR activities are somewhat open-ended
- Address highest levels of learning
- Examples of possible projects that could be developed
  - Observation: simulation and visualization of a congested queue
  - Constrained: develop and test IP longest prefix match lookup
  - Loosely constrained: develop novel built-in router support for traffic measurement