Experimental Networking ECSE-4963

I hear and I forget.
I see and I remember.
I do and I understand.
-- Chinese Proverb

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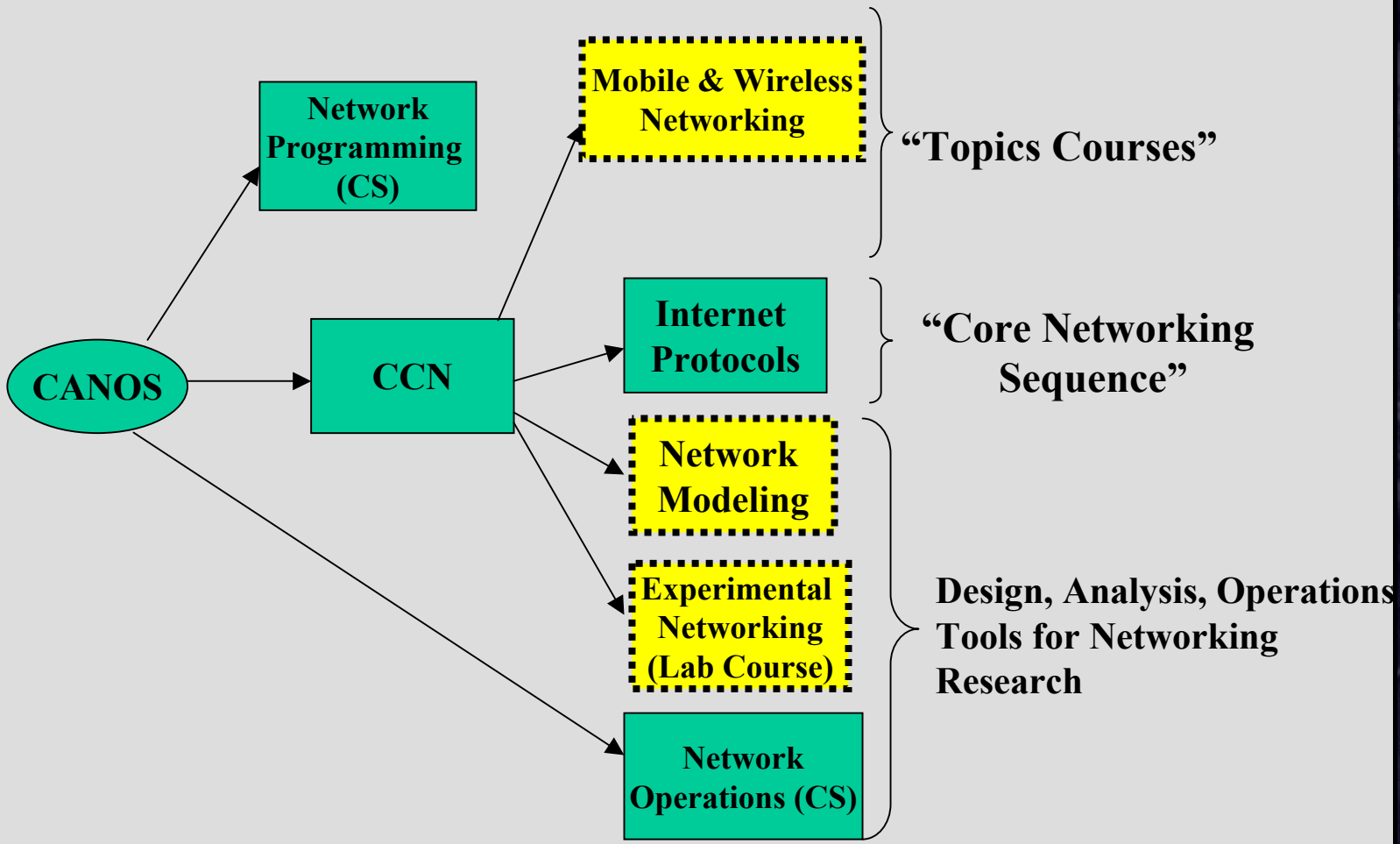
Who's Who

- **Instructor:** Shiv Kalyanaraman; kalyas@rpi.edu,
  - Room: JEC 6042, Phone: x8979
- **Course secretary:** (on-campus)
  - Jeanne Denue-Grady; denuej@rpi.edu,
  - Room: JEC 6049, Phone: x6313
- **TA:**
  - Yong Xia; xiay@rpi.edu,
  - Room: JEC 6037, Phone: x8231
  - Other research students will help from time to time

Networking Courses @ RPI



Prerequisites

- Required ***(no exceptions):***
  - ESCE-4670 Computer Communication Networks or equivalent
  - Probability Class (usually required for CCN)
  - VERY GOOD C programming knowledge

- Desirable:
  - Operating Systems
  - Computer Architecture (ECSE-4730 or equivalent)
  - Basic ideas of statistics

- If you **do not have the required prerequisites**, you **must drop the course** and take it later (next year).

Course/Grading Format

- **Lab time:** 1 hr Lecture + 2.5 hr Lab Work
  - Lab Report for Each Day (groups of 2) submit via WebCT
  - Solutions/grading policy will be posted and you will self-grade and submit your graded copy to TA
  - WebCT bulletin board: Post your questions!
- **1 term project** in the last month (complete design exercise)
- **2 exams:** mid-term and final, on concepts, theory, etc.
  - Term project and exams will be graded by TA/instructor
- **Grading:**
  - **Lab Work/Reports: Self-Grading {50 pts}**
  - **Term Project: {20 pts}**
  - **Mid-Term and Final Exam: {30 pts}**

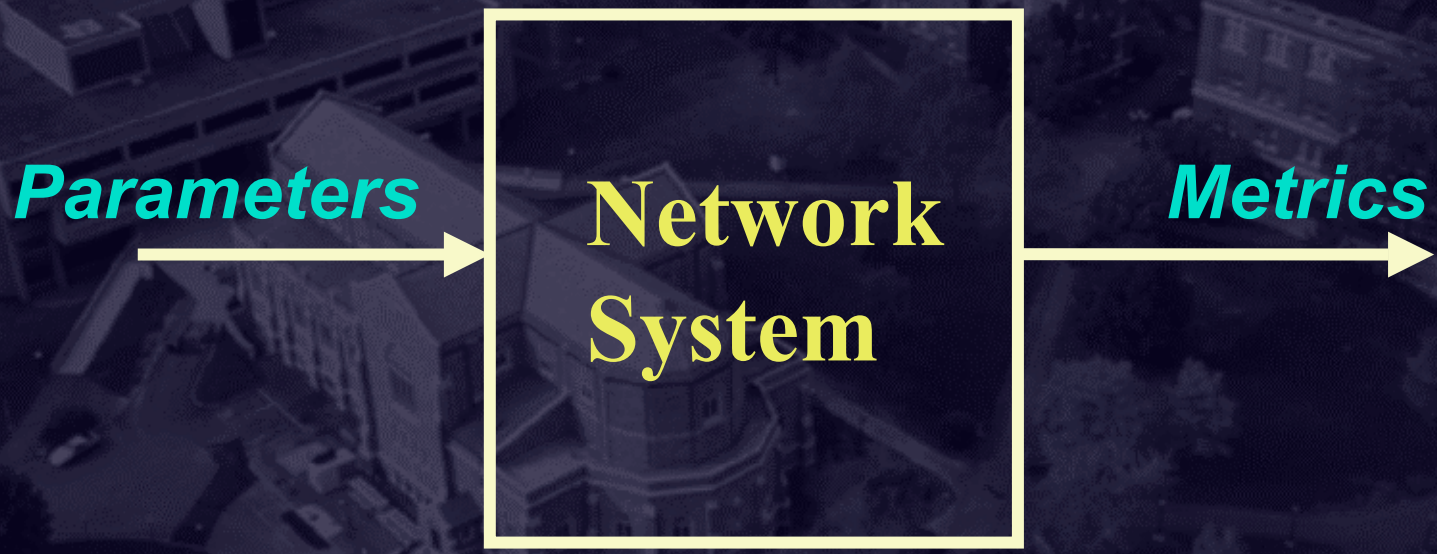
I do and I understand…

- ***What*** to do?
  - **Play** around with **real & messy stuff**: wires, routers, real networking code: builds character!
  - **Simulate/animate** it: avoid the mess, focus on basic understanding of a subset of properties
  - **Poke/Peek around** the network: peek at packets, measure n/w performance, collect/analyze traces/routing tables etc
  - Structure a ***large set*** of above activities to maximize information derived with minimum effort
- ***Why***?
  - Semantic behavior of protocols/networks: ***how does it work?***
  - Performance behavior of protocols/networks: ***how good is it?***
  - Use such techniques in the design process: ***design your own new protocols/networks !***

Course Objectives

- **Hands-on networking:** "do networking" at the hardware, software, simulation, configuration (a.k.a. messy!) levels
- **Experimental Method**: How to correctly use a variety of abstract tools (measurement, simulation, animation, experiment) for design and analysis of computer/network systems
- **Tools**: specific tools/platforms useful for networking research and advanced development

Network-in-a-Box Model



Course Description Highlights

1. **Simulation and animation tools:** understand complex networking concepts by viewing the system as a **black box**
   - Vary *external* "knobs" (parameters)
   - Someone else has designed the system!
   - Why? Limited views of protocols allows a self-paced, visual understanding…

2. **Simulation development:** develop the networking protocol code, in a controlled environment, the simulator.
   - Run simulations and vary parameters to **incrementally refine** design.
   - You are designing & building the system!
   - Why? Understand what it takes to *embed your idea* in an existing event-driven system.

Course Description Highlights

3. **Experiment design:** one simulation does not give you the answer (i.e. characterize system behavior)
   - Systematic design of a *set of experiments* to maximize information extracted
   - Fit regression or other functional models to *correlate parameters to observed metrics*.
   - Why? A practical tool for incremental design and performance analysis. Understand the nature of protocols in-depth.

   [Some applied probability, statistics and simulation theory will be covered as necessary.]

4. **Linux-based protocol development:** Develop variants of protocols on a real OS platform (Linux)
   - Set up experiments to instrument, measure and visualize system behavior.

Course Description Highlights

5. **Measure, Model and Analyze the Internet:**
   - Understand tools to observe and measure network/protocol properties
   - Develop and analyze measurement archives to understand protocol and network behavior

6. **Experimentation with a combination of Linux and Cisco routers:**
   - Learn how to create experimental scenarios with a combination of customized/prototyped systems and off-the-shelf networking equipment.

Course Description Highlights

7. **Development on modular platforms (Click router and Intel IXA):**
   - Recent developments include modular code development inside the OS kernel (Click), and network processor platforms (Intel IXA)
   - Powerful, realistic prototypes can be created rapidly!

8. **Term project:** Take a problem and use a mix of relevant tools to incrementally design, prototype, test and validate solutions
   - Students are welcome to define a project of their own; and should get a written project definition approved by the instructor. Approval will require a critical mix of key ingredients to be present.

Schedule

Every Thursday 4pm – 8pm in Fall'02, Aug 29 ~ Dec 5

Basic Labs: Tools and Techniques

Week 1 Aug 29
Lab 1, Networking commands and socket programming
Week 2-5 Sept 5,12,19,26
Lab 2, Network simulator NS2 (and NAM)
Lab 3, TCP Tahoe, Reno, and SACK comparisons in simulation
Lab 4, Experiment design
Lab 5, Active queue management (AQM): RED scheme
Week 6 Oct 3
Lab 6, TCP traffic experiment: how to encode/setup/measure real TCP dynamics
Week 7-8 Oct 10, 17
Lab 7, Routing protocols (RIP, OSPF, BGP etc.)
Lab 8, BGP routing table analysis, Internet Mapping

[MID-TERM EXAM: Oct 17th]

Week 9-10 Oct 24, 31
Lab 9, MIT Click modular router, Linux kernel programming, Intel IXA Network Processor Platform, Introduction to the Utah Emulab facility

Term Project Ideas

Week 11-14 Nov 7, 14, 21, 28

1. Design and Comparison of Active queue management (AQM) approaches: e.g.: ARED, BLUE, AVQ, REM…
2. TCP+AQM traffic dynamics: Various Flavors of TCP/Binomial/Uncooperative End-system schemes w/ AQM: (RED, ARED, REM, AVQ)
3. Implementation and experimentation of routing/AQM etc on Intel IXA platform project
4. Cisco routing configuration and mix of Linux/Cisco equipment to design new routing/traffic engineering algorithms
5. Using SSFNet to test a mix of new OSPF/BGP related concepts and perform larger scale simulation experiments
6. Multimedia Streaming: understanding effect of various system components
7. Mixed Wireless (802.11) and Internet Experiments/Simulations
8. Large-scale Internet Measurement Studies: TCP Latency/Bandwidth, Internet Mapping, Feeding online measurement and models into design

Other ideas welcome!

[FINAL EXAM: Nov 28th; Submission of Project Reports]

Week 15 Dec 5

Presentations: Sharing Ideas, Experiences and Frustrations ☺

Caveat!

- This is the first offering of the class.
- A lot of lab development has been done and labs have been tested
- Things could go wrong, and you may have to discover things on your own at times.
  - We will try to provide maximum help
  - Grading will be sensitive to such issues
- Be prepared to live with some uncertainty; try out some realistic hacking; and spend a larger-than-average effort on the class…