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)
  - Melissa Reardon, melissa@rpi.edu
  - Room: JEC 6049, Phone: x6313
- **TA:**
  - Yong Xia, xiay@rpi.edu
  - Room: JEC 6037, Phone: x8231
- Other research students (esp. Dr. Murat Yuksel and Ranjit Vadakkan) will help from time to time
Networking Courses @ RPI

- CANOS
- Network Programming (CS)
- CCN
- Mobile & Wireless Networking
- Internet Protocols
- Network Modeling
- Experimental Networking (Lab Course)
- Network Operations (CS)

“Topics Courses”

“Core Networking Sequence”

- Design, Analysis, Operations
- Tools for Networking Research

Shiykumar Kalyanaraman
Prerequisites

- **Required** *(no exceptions):*
  - VERY GOOD C programming knowledge

- **Co-requisites:**
  - ESCE-4670 Computer Communication Networks or equivalent
  - Probability Class (usually required for CCN)

- **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.
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 graded by 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: {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
Simplest System Model

Parameters

System

Metrics
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*.

   [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’03, Aug 25 ~ Dec 17

Basic Labs: Tools and Techniques

**Week 1** Aug 28
Lab 1, Networking commands and socket programming

**Week 2-5** Sept 4,11,18,25
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 2
Lab 6, TCP traffic experiment: how to encode/setup/measure real TCP dynamics

**Week 7-8** Oct 9, 16
Lab 7, Routing protocols (RIP, OSPF, BGP etc.)
Lab 8, BGP routing table analysis, Internet Mapping

[ MID-TERM EXAM: Oct 16th ]

**Week 9-10** Oct 23, 30
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 6, 13, 20, 27
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 27th; Submission of Project Reports]

Week 15-16 Dec 4, 11
Presentations: Sharing Ideas, Experiences and Frustrations 😊
Caveat!

- 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

- If you cannot live with some uncertainty; trying out some realistic hacking; and/or do not have the time to spend a larger-than-average effort on the class…
  - Please drop the class!
Logistics

- Restart machine to Linux when you come
  - Username: net
  - Password: netnet
- Restart machine to Windows before you leave
  - Grading will be sensitive to such issues

- Openshop hours: Sunday 9pm-11:55pm
  - Starting from the 2nd week

- Project due: Sunday 11:55pm