My Information

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  - Include “CE151” in subject!
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TA Information

- Lincoln Thurlow
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  - Include “CE151” in subject!

- Sections: Baskin 109
  - Monday 11-1, Friday 12-1:45, and on-demand
  - First section – “how to use the virtual environment”
    - Mandatory!
  - Can everyone make one of these?

- Office hours: TBD
Course Information

- Lab: Baskin Engineering 301a
  - Sign up sheet for code
  - Get code from 1-3pm in Baskin 399C

- Piazza used for discussion/questions/etc.

  - No longer required for course
  - Might be good reference for (new) labs
  - On (2hr) reserve at the Science Library
Grading

- 40% labs
  - Submit via e-mail by midnight of due date
  - Worst score thrown out

- 25% project
  - Create new labs

- 25% quizzes
  - 8 quizzes
  - Worst score thrown out

- 10% class participation
Why are you here?

- Why study networking?
- Why take this class?
Why study networking?

- Bureau of Labor Statistics
  - http://www.bls.gov/oco/ocos305.htm

- For Network and Computer Systems Administrators
  - Median salary for was $69K in May, 2010
  - Projects 28% growth between 2010 and 2020.
  - “Demand for these workers is high and should continue to grow as firms invest in newer, faster technology and mobile networks.”
Employment

- **Computer and information technology** occupations are projected to grow by 22 percent, adding 758,800 new jobs from 2010 to 2020. Demand for workers in these occupations will be driven by the continuing need for businesses, government agencies, and other organizations to adopt and utilize the latest technologies. Workers in these occupations will be needed to develop software, increase cybersecurity, and update existing network infrastructure.


- *It’s a good career path.*
Why study networking?

- Interesting, and important… but implies something bigger
  - “Revenues from POTS are plummeting as customers cut their landlines in favor of the convenience and advanced features of wireless and VoIP services. At the same time, due to the high fixed costs of providing POTS, every customer who abandons this service raises the average cost-per-line to serve the remaining customers. With an outdated product, falling revenues, and rising costs, the POTS business is unsustainable for the long run.”

- Who do you think wrote this?

- There is a fundamental shift in communications taking place!
Why study networking?

- Also interesting, and important… but implies something even bigger
  - Analyzes Democracy in terms of Economic “rationality”.
  - Cost of information is the ultimate driver of the system!

- Differential access to information creates advantage
  - Commerce (Amazon, WalMart, FedEx, …)
  - Politics (recent elections…)
  - Education
  - Health
  - Military ("infostructure” for “network-centric warfare”)
  - Lifestyle… cell phones, smart phones, …

- IT is the banking system of the future…

- Any information, any time, anywhere… the network is the competitive advantage!
Why study networking?

- Communications technology is still evolving!
  - Big Data
  - Wireless
  - QoS
  - Policy
  - *the Internet is still a toddler!*

- **Huge opportunities still exist to…**
  - *use the technology to do completely new things*
  - *make fundamental contributions to advancing the technology*
Why take this class?

- What is “advanced networking?”
  - USE focus… understand how to use networks.
  - DEPTH focus… deeper pass at CE150 topics.
  - TOPICS focus… study topics not in CE150.
  - THEORY focus… how to design network protocols.
USE focus...

- UCSC is a “research university”

- Purpose
  - Research, teaching, public service.
  - Creation, dissemination, application of new knowledge.

- 4388 colleges and universities in the US… how many research universities?
  - 96 (2.2%) total, 63 (1.4%) public

- The taxpayers fund UC to discover “new knowledge”…
- …and train new researchers!
USE focus…

- Focus is less on using the existing Internet…
- …and more on designing the next one!

- But we want to give you as broad a range of skills as possible
- …and you need to know how to fly a plane to design a better one 😊.

- *While USE isn’t the focus, we try to address it.*
DEPTH focus…

- CE150 covered a lot of material!

- By necessity, it had to go shallow.

- *Covering CE150 topics in more depth is a focus.*
TOPICS focus…

- There are many interesting topics you haven’t seen
  - Security
  - Cloud computing
  - Peer-to-peer
  - Wireless
  - Networking in the data center

- Still not much time in CE151…

- But adding TOPICS is a priority.
THEORY focus...

- Given UC’s mission, theory is clearly important!

- Network communication is an extremely challenging distributed computation!

- The Internet pushed this to whole new levels

- Network resources
  - Data rates spanning 8 orders of magnitude (Kbps to 100Gbps)
  - Latency spanning 5 orders of magnitude (10µsecs to seconds)
  - Queuing delays from 0 to seconds
  - Packet loss from 0 to 90%
THEORY focus...

- Diversity of applications
  - Data transfer requirements
  - Sensitivity to latency (or not)
  - Tolerant of jitter (or not)
  - Tolerant of loss (or not)
  - ...

- Throw it all together… and it should just work!

- The days of trial-and-error protocol design are largely gone…
  - …a more analytical, theory-based approach is required.

- **Begin to introduce the challenges of protocol design in CE151.**
  - …CE 252
Why are network classes... painful?

- Same problem as aeronautics (I imagine:)
- Lots of abstractions...
- Hard to relate to anything of practical value...
- ...until you get in the plane!
Solution(?) – hands-on

- I’m working in hands-on wherever I can
- In-class exercises
- Network labs
Last Year...
“Problems with labs...”

- Yes, we know:)!
- Too “monkey-see-monkey-do”
- How to fix this?
  - Preview and review labs in class..?
    - Try this quarter.
  - Project-oriented labs
    - “Pretend you’re an ISP... design a network for these customers.”
    - Need to be able to save configuration?
    - I believe (suspect) we need virtual lab technology

- Show me a better way in the class project!!
This Year...

- **We are using virtual labs(!)**
- You get your own VM on an SoE server
- GNS3 software used to simulate networks
  - Dynamips runs same IOS code in Baskin 301a
  - VirtualBox runs same Linux as in Baskin 301a
  - You each get your own lab environment!
- Labs redone to use new environment…
- **Work in progress!!**
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```
[root@PC4 ~]#
```

GNS3 management console. Running on GNS3 version 0.10.12
Copyright (c) 2006-2012 GNS3 Project
Review

- Why study networking?
  - Because it is changing the world!

- Why take this class?
  - We teach you how to USE networks.
  - We go into more DEPTH on topics
  - We try to cover more TOPICS
  - We introduce you to the THEORY behind networks
  - We use hands-on experience to motivate the material

- We know the labs need improving…
  - If you think you have a better idea, use it in your project!
My Goal

- In the end you will have the background to be either
  - An engineer with a fundamental view of the technology, or
  - An academic with a good sense of how things really work
- Whichever you choose…
Class Schedule

- Lectures as fast as possible
- Labs due as late as possible
  - Do them early!
- Project proposals due *Tuesday, 4/30*
- Guest lecturers as I can fit them in
  - Server load balancing
  - ...
- Project presentations last week of classes and final
  - Everyone attend
  - Early presenters will be given due consideration…
Topics Covered

- Link Layer
  - Repeaters, Hubs, Bridges, and Switches
  - Spanning Tree Protocol (STP)
  - Address Resolution Protocol (ARP)

- Network Layer
  - Internet Protocol (IP)
  - Internet Control Message Protocol (ICMP)
  - Routing and forwarding

- Routing
  - Distance vector and RIP
  - Link state and OSPF
  - Path vector and BGP
  - Advanced topics

- Multicast
Topics NOT Covered

- Assume covered in CE150
  - Transport Layer
    - User Datagram Protocol (UDP)
    - Transmission Control Protocol (TCP)
  - Network Address Translation (NAT)
  - Dynamic Host Configuration Protocol (DHCP)
  - Domain Name System (DNS)

- There are many things we’d like to cover… candidates for projects!
Quizzes

● 8 quizzes
  ● Network layer
  ● Link layer
  ● Routing: link-state, distance-vector, STP, BGP
  ● IPv6
  ● Multicast

● Cover material highlighted on Review slides
Lab facilities

- 9 working stations
  - 4 PCs
  - Network rack

- PCs
  - Mouse problem
  - Monitor input (“-”)

- Shutdown when done
Network equipment
Labs using Baskin 301a

- Structure
  - Prelab
  - Lab
  - Report
  - Look for floppy and notepad symbols
Off Hours Access

BE THIRD FL - CURRENT
Virtual Labs

- Access them from anywhere… all you need is an Internet connection😊
- Access them whenever you want😊
- Goal is to structure lab as solving a problem.
- Most are based on labs in Mastering Networks book…
- …except for significant upgrade to BGP lab😊
Lab mechanics

- **At your pace…**
  - No scheduled lab sections… do them on your schedule, at your pace.
  - You can do them early, and should do them as early as possible

- Pair labs (like “pair programming”…)
  - Two people can work together on the lab
  - Must submit own report (same data, separate reports)

- All labs linked to from web site

- Submit by e-mail to both and Lincoln… **no late labs!**
  - Lowest score will be dropped in final grading
  - Incomplete is better than nothing
  - Due by midnight of due date…

- **EE 215 is scheduled in the lab MWTh 2-4pm, Tu 6-8pm**
Assume CE150 Labs

- Recommend following labs as refresher
  - In BE 301a
  - No grading or credit

- **Lab 1** – Linux commands, ping, tcpdump, Wireshark

- **Lab 2** – “arp”, using Wireshark
CE151 Labs

- **Lab 1** – Single Segment Network: network config, IP addresses
- **Lab 2** – Static routing: netstat, Linux and Cisco routers, ICMP, ARP
- **Lab 3** – LAN Switching: Linux as a switch, Cisco VLANs, monitoring ports
- **Lab 3** – RIP - basic config; experiment with counting-to-infinity problem.
- **Lab 4** – OSPF - basic config; hierarchical routing.
- **Lab 5** – BGP – basic configuration, and basic policies.
- **Lab 6** – Spanning Tree Protocol: how it works
- **Lab 7** – Multicast - IGMP; multicast forwarding; PIM-SM and PIM-DM.
Project Ideas (new projects)

- Firewall
- IPSec
- TLS/HTTPS
- IPv6
- EIGRP
- Server load balancing(?)

- QoS
- L2 security features
- MPLS (vs. VLANs)
- Rapid Spanning Tree Protocol
- “Buffer bloat”(?)

- Jean-Luc Doumont “Making the most of your presentation”
  Wednesday, 4/3, 10am-Noon, E2 180 “Simularium”
Academic integrity

- UCSC’s academic integrity policies strictly enforced.
- See the course web site for details

Bottom line
- Don’t present someone else’s work as your own
- Including cut and paste from web sites!
- Do your own lab
- Write your own lab report
- Use your own data
- Give attribution for any quotes, pictures, etc.
Projects I’m Working On

- “Connected Central Coast”
- Multipath routing
- NMO Lab
Case Study: Cisco NMO Lab

Network Management & Operations (NMO) Lab
- Collaboration between Cisco Technical Support & Customer Advocacy and SoE
  - Facilitate collaborations between SoE and Cisco
  - Real world problems for students and researchers
  - Pre-professional experience for students
  - Cisco access to expertise and new perspectives
  - Formally started August 2008

Leadership
- Cisco: Joe Pinto, Senior VP TS&CA
- UCSC: Profs. Patrick Mantey and Brad Smith

Logistics
- Network “teaching hospital”
- Assume no IP will result from NMO lab work
- Project proposals from either Cisco or UCSC; project team of students, researchers, managers
- Work performed in space provided by CITRIS in E2
- Biannual NMO Lab retreats (Winter and Summer); includes managers, faculty, and students, students present status update of their work
- Cisco provides funding and equipment

NMO Lab experience
- Problems have ranged from QA and release testing to large research projects.
- A number of significant contributions
- To date 32 students, ~6 faculty

UCSC benefits
- Researchers access to new, real world problems
- Students have a “life changing experience”

Cisco benefits
- Improved recruiting pipeline
  - Accelerated hiring and on-boarding
  - Better sense of student’s capabilities
- More efficient and effective project staffing
- Faster project spin-up
- Disruptive influence…
  - “Think outside the box”
  - Less bound to corporate culture
  - More risk tolerant
- Less expensive and more effective alternative to professional consultants
- Increases the “agility” of an organization’s workforce.