Course Goals

• Overview of the basics
• Principles and Philosophies
• Read research papers
• Hands-on experience with networked systems
Prerequisites

• Undergraduate level networking/OS course
• Some systems programming
• Familiar with Linux environment
• Access to a Linux environment
  – Use department server
  – Use your own machine
• Willingness to catch up if you don’t have these experiences
Structure

• Lectures
• Paper discussions
• Homeworks
• Project
• Exams
• Class participation
Homeworks

• 3-4 homeworks
• Concepts
• Calculations
• Some hands-on work
• Allowed to discuss with other students, but you should turn in your own writeup
• Submit through Moodle
Project

- One project with intermediate checkpoints
- Build a networked system

- Possible to propose your own project
  - Strongly encouraged for PhD students
  - Talk to the instructor
Exams

• No final exam!
• Open notes
• In-class scheduling
### Grades

<table>
<thead>
<tr>
<th></th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exams</td>
<td>40%</td>
</tr>
<tr>
<td>Homeworks</td>
<td>15%</td>
</tr>
<tr>
<td>Project</td>
<td>40%</td>
</tr>
<tr>
<td>Class Participation</td>
<td>5%</td>
</tr>
</tbody>
</table>

- It is possible to get a C or lower grades
- No incompletes
Readings

• No required textbook
• Recommended texts
  – Computer Networks: A Systems Approach
  – Computer Networking: A Top-Down Approach
  – UNIX Network Programming
• Research papers
• Standards
• Wikipedia
Academic Honesty

• The work you turn in should be yours

• Acknowledge
  – Group discussions
  – Internet sources

• Plagarism results in an F
Course Staff

• Instructor: Omprakash Gnawali
• Office Hours: MW 230-330

• TA: Milad Heydariaan
Communication

- Send questions and answers to Piazza
- Emails MUST have COSC6377 in the subject
- Check course website and Piazza regularly

http://www2.cs.uh.edu/~gnawali/courses/cosc6377-f16/
Some Questions

• How difficult is this course?
• What is the workload?
• Will I learn anything useful?
• Any other questions?
The Internet: An Exciting Time

• One of the most influential inventions
  – A research experiment that escaped from the lab
  – … to be a global communications infrastructure

• Ever wider reach
  – Today: 3 billion+ users
  – Tomorrow: more users, computers, things, …

• Near-constant innovation
  – Apps: Web, P2P, social networks, virtual worlds
  – Links: optics, WiFi, cellular, WiMax, …

With thanks to Jennifer Rexford
Transforming Everything

• The ways we do business
  – E-commerce, advertising, cloud computing, ...
• The way we have relationships
  – E-mail, IM, Facebook, virtual worlds, online dating
• How we think about law
  – Interstate commerce? National boundaries?
• The way we govern
  – E-voting and e-government
  – Censorship and wiretapping
• The way we fight
  – Cyber-attacks, including nation-state attacks
Internet Growth Occurring in Accelerating Waves

<table>
<thead>
<tr>
<th>“Fixed” computing</th>
<th>Mobility / BYOD</th>
<th>Internet of Things</th>
<th>Internet of Everything</th>
</tr>
</thead>
<tbody>
<tr>
<td>(you go to the device)</td>
<td>(the device goes with you)</td>
<td>(age of devices)</td>
<td>(people, process, data, things)</td>
</tr>
</tbody>
</table>

- Doubled every 1.3 years
- Doubled every 1.4 years
- 200M
- 10B
- Doubles every (?) years
- 50B things

Source: Cisco IBSG, 2012
The Study of Networking is Cool

• Tangible, relates to reality
  – Can measure/build things
  – Can truly effect far-reaching change in the real world

• Inherently interdisciplinary
  – Well-motivated problems + rigorous solution techniques
  – Interplay with policy, economics, and social science

• Widely-read papers
  – Many of the most cited papers in CS are in networking
The Study of Networking is Cool

• Young, relatively immature field
  – Great if you like to make order out of chaos
  – Tremendous intellectual progress is still needed
  – You can help decide what networking really is

• Defining the problem is a big part of the challenge
  – Recognizing a need, formulating a well-defined problem
  – ... is at least as important as solving the problem...

• Lots of platforms for building your ideas
  – Programmability: Click, OpenFlow, NetFPGA
  – Routing software: Quagga, XORP, and Bird
  – Testbeds: Emulab, PlanetLab, Orbit, GENI, ...
  – Measurements: RouteViews, traceroute, Internet2, ...
But, What *is* Networking?
A Plethora of Protocol Acronyms?
A Heap of Header Formats?

HTTP Response Header

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTTP Status Code:</td>
<td>HTTP/1.1 200 OK</td>
</tr>
<tr>
<td>Date</td>
<td>Thu, 27 Mar 2008 13:37:17 GMT</td>
</tr>
<tr>
<td>Server</td>
<td>Apache/2.0.55 (Ubuntu) PHP/5.1.2</td>
</tr>
<tr>
<td>Last-Modified:</td>
<td>Fri, 21 Mar 2008 13:57:30 GMT</td>
</tr>
<tr>
<td>ETag</td>
<td>&quot;359a4e4-56000-ddf5c680&quot;</td>
</tr>
<tr>
<td>Accept-Ranges:</td>
<td>bytes</td>
</tr>
<tr>
<td>Content-Length:</td>
<td>352256</td>
</tr>
<tr>
<td>Connection:</td>
<td>close</td>
</tr>
<tr>
<td>Content-Type:</td>
<td>application/x-msdos-program</td>
</tr>
</tbody>
</table>
A Big Bunch of Boxes?
A Ton of Tools?

arpwatch  syslog  tcpdump
traceroute  nslookup  wget
nmap  snort  trat
rancid  whois  ipconfig
nmap  snort  bro
dig  net-snmp  iperf
NDT  ping  mrtg
dummynet  wireshark

But, That Doesn’t Say What Networking Really Is

Or, What Will This Course is About
Nor does that...
We want to understand how the Internet works

Technical issues (protocols, architectures…)

Non-technical topics you will encounter (net-neutrality, access, rights…)
One Take on Defining Networking

• How to
  – Design and manage protocols
  – That can be used and combined in many ways
  – To do many things

• Definition and placement of function
  – What to do, and where to do it

• The “division of labor”
  – Across multiple protocols and mechanisms
  – Across components (hosts, routers, administrators)

• Goal: search for general principles
  – Of protocol design, evaluation, and composition
“The internet is essential to growing the knowledge we have and sharing it with each other. And for many of us, it’s a huge part of our everyday lives. But most of the world does not have access to the internet. Internet.org is a Facebook-led initiative with the goal of bringing internet access and the benefits of connectivity to the two-thirds of the world that doesn’t have them.

Imagine the difference an accurate weather report could make for a farmer planting crops, or the power of an encyclopedia for a child without textbooks. Now, imagine what they could contribute when the world can hear their voices. The more we connect, the better it gets.”

Internet.org (part of Facebook)
“1.5 million people access the Internet via Google's free Wi-Fi at 19 Indian railway stations”

mashable.com
Of the over 7 billion people in the world, fewer than half are connected to the Internet. And for many who are online, inadequate or nonexistent infrastructure offers slow and unreliable connections.

Google launched Project Link to bring faster, more reliable Internet to the people and places that need it. We first built a metro fiber network in the city of Kampala, Uganda, a dense urban center that was limited to pre-broadband speeds. Since then, we have expanded Project Link to Ghana, where we expect to build over 1,000 kilometers of fiber in Accra, Tema and Kumasi.

In Uganda, we also offer wholesale last-mile Wi-Fi access. Internet Service Providers (ISPs) and Mobile Network Operators (MNOs) can leverage our network to bring high-quality Wi-Fi to homeowners, small businesses and mobile users on-the-go. We continue to explore opportunities for expanding Project Link Wi-Fi networks to future markets.

https://www.google.com/get/projectlink/
Plan for next four weeks

• Rapid review of undergraduate material
• Watch lectures/read slides from COSC4377
  – Cover approx. 5 lectures per week
• Discuss the material in the class
• Grab lectures from:
  http://www2.cs.uh.edu/~gnawali/courses/cosc4377-s12/