Computer Networks
COSC 6377
Lecture 1

Spring 2021

January 20, 2021
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/AWS server
  – Use your own machine
• Willingness to catch up if you don’t have these experiences
Structure

- Lectures
- Paper discussions
- Homework
- Project
- Exams
- Class participation
Homework

• Several short assignments
• Concepts and calculations
• Some hands-on (incl. programming) work
• Allowed to discuss with other students, but you should turn in your own hw
• Submit on Blackboard
Project

• One project with one mid-term checkpoint
• 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

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Exams</td>
<td>40%</td>
</tr>
<tr>
<td>Homework</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
• Research papers
• Standards
• Wikipedia
Academic Honesty

• The work you turn in should be yours

• Acknowledge
  – Group discussions
  – Internet sources

• Plagiarism results in an F
Course Staff

• Instructor: Omprakash Gnawali
• Office Hours: Tuesday 2-3pm

• TA: Alireza Ansaripour
  – Office hour: Thursday 4-5pm
• TA: Nour Smaouï
  – Office hour: Friday 11-12 noon
Communication

• Teams for discussions
• Personal message for private matters
  – Examples...
• Emails MUST have COSC6377 in the subject if you MUST send email
• Check course website regularly

http://www2.cs.uh.edu/~gnawali/courses/cosc6377-s21/
Some Questions

• How difficult is this course?
• What is the workload?
• Will I learn anything useful?
• Any other questions?
Why are you taking this course?

What do you want to do?
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: 5 billion users
  – Tomorrow: more users, computers, things, …

• Near-constant innovation
  – Apps: Web, P2P, social networks, virtual worlds
  – Links: optics, WiFi, cellular, 5G, …

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>

- **1995**: Doubled every 1.3 years
- **2000**: Doubled every 1.4 years
- **2011**: 10B
- **2020**: 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-understood impact
  – Can discuss technologies with your grandfather!
But, What *is* Networking?
A Plethora of Protocol Acronyms?

- BGP
- ARP
- HTTP
- DNS
- PPP
- OSPF
- DHCP
- TCP
- UDP
- SMTP
- FTP
- SSH
- MAC
- IP
- RIP
- NAT
- CIDR
- VLAN
- VTP
- WAP
- SIP
- PPP
- IMAP
- IGMP
- ECN
- SACK
- SNMP
- TFTP
- TLS
- WAP
- SIP
- RTP
- RED
- BGP
- HTTP
- ARP
- IP
- ICMP
- MPLS
- BFD
- RTCP
- RTP
- RTSP
- SMTP
- TLS
- NAT
- STUN
- DNS
- SACK
- SSH
- VLAN
- LISP
- VTP
- TCP
- RTCP
- MAC
- LLDP
- OSPF
- PIM
- RIP
- NNTP
- POP
- VLAN
- LDP
- STUN
- HIP
- ECN
- CIDR
- NAT
- DHCP
- LDP
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: HTTP/1.1 200 OK</td>
<td></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-df5c680&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?

- Router
- Switch
- Load balancer
- Scrubber
- Repeater
- Gateway
- Bridge
- Route Reflector
- Intrusion Detection System
- DHCP server
- Packet shaper
- Switched Router
- Hub
- Base station
- Packet sniffer
- Proxy
- Deep Packet Inspection
- NAT
- WAN accelerator
- DNS server
- Firewall
- WAN accelerator
- Scrubber
- Route Reflector
A Ton of Tools?

arpwatch  tcpdump
syslog  wget
traceroute  nslookup
snort
nmap  ipconfig
rancid
whois
nmap
dig
net-snmp
ping
ntop
NDT
dummynet
bro
iperf
mrtg
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…)
Internet as human right?

Politics

Business
Types of things we will study
Internet Architecture

• 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
Congestion

• How to know how much traffic is being used for what purpose?
• How to ensure we can service the competing traffic demand sharing the infrastructure

• How to design applications to run “fast”
Reliability

• How reliable is the Internet?
• How can we measure different aspects of reliability in networking?
• What causes it to break?
Security

• How secure is the Internet?
• Security challenges in the Internet (DDoS, bots, etc.)
• Technologies to make Internet secure and their limitations

• How to make your application secure?
Back to the two questions

Why are you taking this course?

What do you want to do?
Will I learn anything useful?

- Architect data communication
  - IoT
  - Online software
  - Apps on different platforms
  - Information consumption and production

- Some peripheral skills
  - Presentation
  - Project formulation
  - Checkpoints
  - Code review
Project Ideas

• Study Wireless, Internet, ... adoption, use
• Extend existing technology
• Explore new and popular ideas
  – IoT
  – Blockchain
• Create impact using Internet or Wireless
  – Low-resource setting (edu, health, etc.)
  – Access to information
Plan for next four weeks

• Rapid review of undergraduate material
  – Understand how the basic building blocks work
• Watch lectures/read slides from COSC4377
  – Cover 3-5 lectures per week
• Discuss the material in the class
• Grab lectures from:
  http://www2.cs.uh.edu/~gnawali/courses/cosc4377-s12/