COS 461/561: Computer Networks

Kyle Jamieson (461), Jennifer Rexford (561)

Fall 2020

Lectures: TR 10:00-10:50 AM

www.cs.princeton.edu/courses/archive/fall20/cos461
THIS LECTURE IS BEING RECORDED FOR STUDENTS UNABLE TO ATTEND
Today

1. Origins of the Internet
   – Concurrent Q&A live

2. Mentimeter Q&A, Live

3. Course Policies (461 & 561)
What are the Origins of Today’s Internet?
<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>29 Oct 69</td>
<td>2100</td>
<td>Loaded op. program CSK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>To Ben Barker BBV</td>
</tr>
<tr>
<td>22:30</td>
<td></td>
<td>Talked to SRT CS6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Host to Host</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Left top inp. program CS6</td>
</tr>
</tbody>
</table>
|        |       | Running after sending a host dead message to inp.
How does the design of the Internet support growth and foster innovation?
The Internet is a Tense Place
Cybersecurity

Cyber-Attack Hits U.S. Health Agency Amid Covid-19 Outbreak

By Shira Stein and Jennifer Jacobs
March 16, 2020, 8:37 AM EDT  Updated on March 16, 2020, 4:35 PM EDT

- NSC tweet on disinformation Sunday was connected to attack
- Cyber intrusion comes as U.S. battles the coronavirus pandemic

2018:
How does the design of the Internet create or exacerbate these tensions?
What *is* the Internet?
The Internet is the worldwide, publicly accessible network of interconnected computer networks that transmit data by packet switching using the standard Internet Protocol (IP).

It is a "network of networks" that consists of millions of smaller domestic, academic, business, and government networks, which together carry various information and services.

http://en.wikipedia.org/wiki/Internet
“Best-Effort Packet Delivery Service”
Power at the Edge

End-to-End Principle
Whenever possible, communications protocol operations should be defined to occur at the end-points of a communications system.

Programmability
With programmable end hosts, new network services can be added at any time, by anyone.

And end hosts became powerful and ubiquitous....
“A Network of Networks”

THE
INTERNET

- How do you name?
- How do you find a name?

Client
Browser
@ Princeton

Web server
@ Google
Announcing a Route

“Princeton is in this direction”
Forwarding Traffic

Client
Browser
@ Princeton

Web server
@ Google
Withdrawing a traffic route

“Princeton is NOT in this direction”
At 22:34 UTC (00:34am local time), Renesys observed the virtually simultaneous withdrawal of all routes to Egyptian networks in the Internet's global routing table. Approximately 3,500 individual BGP routes were withdrawn, leaving no valid paths by which the rest of the world could continue to exchange Internet traffic with Egypt's service providers. Virtually all of Egypt's Internet addresses are now unreachable, worldwide.
Central concepts in networking
Abstraction through Protocol Layering

• Layers partition the system
  – Each layer *solely* relies on services from layer below
  – Each layer *solely* exports services to layer above

• Interface between layers defines interaction
  – Hides implementation details
  – Layers can change without disturbing other layers
The Internet Protocol Suite

The thin Network layer facilitates interoperability
Application: HyperText Transfer Protocol

Request:

GET /courses/archive/spr20/cos461/ HTTP/1.1
Host: www.cs.princeton.edu
User-Agent: Mozilla/4.03
CRLF

Response:

HTTP/1.1 200 OK
Date: Mon, 4 Feb 2013 11:09:03 GMT
Server: Netscape-Enterprise/3.5.1
Last-Modified: Mon, 2 Feb 2013 19:12:23 GMT
Content-Length: 21
CRLF
Site under construction
Layer Encapsulation in HTTP

User A
- Application
- App-to-app channels
- Host-to-host connectivity
- Link hardware

User B
- Application
- App-to-app channels
- Host-to-host connectivity
- Link hardware

Get index.html
Connection ID
Source/Destination
Link Address
End Hosts vs. Routers

HTTP message
TCP segment

HTTP
TCP
IP
Ethernet

router

router

HTTP
TCP
IP
Ethernet

SONET

host

host

HTTP
TCP
IP
Ethernet

SONET

interface

interface

interface

interface

interface
Socket and Process Communication

The interface that the OS provides to its networking subsystem
Socket and Process Communication

• Receiving host
  – Destination **address** that uniquely identifies host
  – **IP address**: 32-bit quantity (“1.2.3.4”)

• Receiving socket
  – Host may be running many different processes
  – Destination **port** that uniquely identifies socket
  – **Port number**: 16-bits (“80”)
Key Concepts in Networking

• Naming
  – What to call computers, services, protocols, ...

• Layering
  – Abstraction is the key to managing complexity

• Protocols
  – Speaking the same language
    – Syntax and semantics

• Resource allocation
  – Dividing scare resources among competing parties
    – Memory, link bandwidth, wireless spectrum, paths
Mentimeter: Quick Surveys

Topic: Growth/innovation vs. create/exacerbate tensions

• Does Internet design prevent misuse?
  1. Individual endpoints can only use addresses given to them when connect to the network
  2. Individual end-points can “spoof” any IP address
Mentimeter: Quick Surveys

Topic: Growth/innovation vs. create/exacerbate tensions

Networks are assigned unique IP address blocks from a central authority (“IANA”): Princeton has 128.112.*

• Which of the following is true:
  1. Network can only announce assigned addresses
  2. Networks can spoof any address
Mentimeter: Quick Surveys

Topic: Growth/innovation vs. create/exacerbate tensions

• Does the Internet provide reliable packet delivery?
  1. Yes, that’s necessary for protocols like HTTP that require in-order streams
  2. No, packets may be arbitrary dropped or reordered
461, 561: Class Summary
461: What You Learn in This Course

• **Knowledge:** how the Internet works, and why
  – Protocol stack: link, network, transport, application
  – Resource allocation: congestion control, routing
  – Applications: Web, P2P, …
  – Networks: enterprise, cloud, backbone, wireless, …

• **Insight:** key concepts in networking
  – Naming, layering, protocols, resource allocation, …

• **Skill:** network programming
  – Many nodes are general-purpose computers
  – Can innovate and develop new uses of networks
561: What You Learn in This Course

- **Knowledge:** how the Internet works, and why
- **Insight:** key concepts and state of the art in networking
  - Naming, layering, protocols, resource allocation, ...
  - Discuss classic & state of the art networking research papers, in depth. Tied to lecture topics in 461

- **Skill:** network programming
- **Skill:** network research
  - Semester systems-building/research project, in groups
  - Reproduce a result (more common), or build a novel project
Course Organization: 461, 561
Learning the Material: 461 People

• Lectures: Prof. Kyle Jamieson
  – Tues/Thurs 10:00 – 10:50 AM
  – Slides and video media available online at course Web site

• TAs: Ryan Amos, Kun Woo Cho, Abhisheek Kumar, Fan Yi

• Main Q&A forum: Ed Discussions
  – Setting expectation: TAs will monitor/respond to questions 1-2 times per day in a burst of activity
Learning the Material: 561 People

• Precepts: Prof. Jennifer Rexford
  – Fri 10am, 11am, and 1:30pm

• TAs: Mary Hogan and Srikar Kasi

• Main Q&A forum: Piazza
  – Setting expectation: TAs will monitor/respond to questions 1-2 times per day in a burst of activity
Learning the Material: 461 & 561 Lectures! (primary)

• Lectures: TR 10:00 – 10:50

• Both 461 AND 561 attend lectures, participate in Q&A
  – Bit-sized lecture topic videos and slides posted day/night before, for those in other time zones
  – Recommendation: print slides and take notes
  – Not everything covered in class is on slides
  – You are responsible for everything covered in class
Learning the Material: Precepts

• 461 precepts focus on programming assignments
  – Led by TAs

• 561 precepts discuss papers in depth
  – Precept attendance critical
  – Let instructor know if you must miss, accommodations made
  – Zoom precepts, mute yourself if you’re not speaking, video if ok with you, set your Zoom name
Learning the Material: Books (secondary)

• Main textbook
  – *Computer Networks: A Systems Approach*, by Peterson and Davie
  – Also online:  [https://book.systemsapproach.org/](https://book.systemsapproach.org/)

• Additional books (may be of interest)
  – Networking textbooks
    • *Computer Networking: A Top-Down Approach Featuring the Internet*, by Kurose and Ross
    • *Computer Networks*, by Tanenbaum
  – Network programming references
    • *TCP/IP Illustrated, Volume 1: The Protocols*, by Stevens
    • *Unix Network Programming, Vol 1: Sockets Networking API*, by Stevens, Fenner, & Rudolf
Grading in UG COS 461

• Five assignments (50% total)
  – 90% 24 hours late, 80% 2 days late, 50% >5 days late
  – Three free late days (we’ll figure which one is best)
  – Only failing grades I’ve given are for students who don’t / try to do assignments

• Two at-home midterm exams (45% total)
  – Midterm 1 exam (20%)
  – Midterm 2 exam (25%)

• Class participation (precept, 5%)
Grading in Graduate-Level COS 561

• Semester Project (40% total)

• Two at-home midterm exams (45% total)
  – Midterm 1 exam (15%)
  – Midterm 2 exam (15%)

• Class participation (precept, 30%)
Policy: Write Your Own Code

Programming is an individual creative process. At first, discussions with friends is fine. When writing code, unless stated otherwise, the program must be your own work.

Do not copy another person’s programs, comments, or any part of submitted assignment. This includes character-by-character transliteration but also derivative works. Cannot use another’s code, etc. even while “citing” them.

Writing code for use by another or using another’s code is academic fraud in context of coursework.

Do not publish your code e.g., on github, during/after course!
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Don’t Plagiarize!
Setting Expectations:
Don’t expect 24x7 answers

• Try to figure out yourself
• Forums are not for debugging
  – Utilize right venue: Go to TA office hours
  – Send detailed Q’s / bug reports, not “no idea what’s wrong”
• Instructors are not on pager duty 24 x 7
  – Don’t expect response before next business day
  – Questions Friday night @ 11pm should not expect fast responses. Be happy with something before Monday.

• Implications
  – Students should answer each other; start your assignments early!