Course Overview

CS 438: Spring 2014
Matthew Caesar
http://courses.engr.illinois.edu/cs438/
Target: Hacking hit 70 million customers

NEW YORK (CNNMoney)

The data breach at Target was significantly broader than originally reported: The company said Friday that 70 million customers had information such as their name, address, phone number and e-mail address hacked in the breach.

Target said the personal data stolen could affect its past shoppers -- not just those who have visited the store recently.

Customers who shopped in the weeks following Thanksgiving may have had credit or debit card information stolen, with as many as 40 million people affected. Some of those people may also be included in the 70-million group revealed Friday.

Target said it would try to reach customers for whom it has e-mail addresses to inform them of the breach. It cautioned that it would not ask customers to provide any personal information and warned customers not to respond to any e-mail claiming to be from Target.

"I know that it is frustrating for our guests to learn that this information was taken and we are truly sorry they are having to endure this," said Target CEO Gregg Steinhafel.

Customers will not be liable for the cost of any fraudulent charges. Target is also offering one year of free credit monitoring and identity theft protection to all customers who...
FCC blastas for 911 outages

United’s global systems fail, major flight delays

The airline described the problems as a "network outage." The extent of the outage was down for roughly two hours, to its airline to rely on hand-written boarding.

National broadband outage caused by router bug

A vast number of Time Warner Cable customers arose from bed this Monday morning to discover that their Internet connections were down. Other ISPs have been affected as well, but TWC customers are clearly the loudest.

Trio of Cisco flaws may threaten network

Three security holes in the software that runs Cisco routers and switches could let miscreants disrupt networks, including the Internet.

Power-Grid Cyber Attack Seen Millions in Dark for Months

A blackout that swept parts of North America in August 2003, leaving millions in the dark.
Building Networks is Challenging

- **Networks are large and complex**
- Tremendous scale
  - 2.4 Billion users (34% of world population)
  - 1 Trillion objects
  - 2 Million routers, 20,000 ISPs
  - Routers that switch 10TB/second
- Incessant rapid growth
- Run by parties with competing interests
Building Networks is Challenging

• *Networks are hard to change*

• Complex intertwinnings, dependencies across protocols/systems, networks

• But you cannot reboot the Internet

• Akin to changing engine of a plane while you are flying it
Building Networks is Challenging

• *Networks are under continuous attack*

• As network population grows in size so does number of
  • Vandals
  • Crazies

• Size makes it attractive target to crooks, spies, and militaries
  • Network crime is a $114B industry

• Continuous flood of DoS, sniffing, compromise, phishing, extortion,...
Building Networks is Challenging

• Networks are big, complex
• Distributed over global scales
• Undergoing continuous failure
• Run by parties with competing interests
• Under continuous attack
• Hard to introduce fixes, changes
• Incessant rapid growth
Networks are Important

• Networks are changing...
• *The way we do business*

- E-Commerce
- Marketing
- Cloud Computing
Networks are Important

- Networks are changing...
- *The way we have relationships*

Social Networking

Virtual Worlds

Matchmaking
Networks are Important

- Networks are changing...
- *The way we interact*

![skype logo](image1)
![at&t logo](image2)
![Augmented reality](image3)
![Remote presence](image4)
Networks are Important

- Networks are changing...
- *The way we learn*

**Online Learning**

- Coursera
- Khan Academy

**Online Content**

- Wikipedia

**Search Engines**

- Google
- Yahoo!
- Bing
Networked Medical Devices

Military Networks

Emergency Response

Finance/trading Networks

Telesurgery

Critical Infrastructures

Cyber Physical Networks
This class

• Goal: teach tools and techniques to build, operate, manage, and deploy application services for modern computer network

• This class is a first step towards exciting careers
  • An operator of a large ISP network
  • Architect at a major network device manufacturer
  • Designer of a next-generation Internet protocol
  • Founder of the next hot network tech startup
  • Builder of a major datacenter network
  • And much more!...
This class

• Key concepts:
  • History and overall “architecture” of the Internet
  • Routing and addressing
  • Data packetization and transport
  • Network services
  • Security
  • Network application programming
  • Recent trends (datacenters, SDN, …)
The Team
Instructor: Matthew Caesar

- CS Faculty at Univ. Illinois
- PhD from UC Berkeley, 2007
- Over 10+ years experience working in computer networks/systems
- NSF CAREER Award, AT&T VURI award, PI in DARPA MRC and CSSG programs, over 50 academic pubs
- I like to build things that people use
  - Industrial experience at AT&T Labs, Microsoft Research, HP, Nokia DSL; helped found two startups on core networking/security systems; partnerships/tech transfer with Cisco, AT&T, Microsoft
TA: Siting Chang

• Brings expertise in data traffic (monitoring, prediction), vehicle networks
• BE+MS in transportation engineering; PhD student at UIUC
• Research on Sustainable and Resilient Infrastructure systems
• Illinois Traffic Engineering Student Chapter Host
TA: Fred Douglas

- Brings expertise in **network theory** and **data center networking**
- BA (Math+CS, Case Western), PhD student at UIUC
- Awards: 1\textsuperscript{st} place MAA math competition, NSF REU
- Currently building proposed technical infrastructure to power HP’s cloud computing offerings
- Previous focus “secure multi-party computation”
TA: Lingyu (Ivory) Xu

- Brings expertise in network security, privacy, and mobile devices
- MS student at UIUC, BE in CS from Beijing Univ.
- Developed several real-world security solutions: cross-site scripting vulnerability detection tool, privacy platform for Android OS, time-interleaved allocation alg for data centers
How can we build networks?
There’s a lot we don’t know about how to build networks

• No consensus on what constitutes the “correct” or “best” network design
• No consensus on “top problems”
• No consensus on the right prioritization of goals
• Not even a well-developed theory to draw from
What we do know

• The early Internet pioneers came up with a solution that was successful beyond all imagining
• Several enduring architectural principles and practices emerged from their work
Some key principles

• Statistical multiplexing [lecture 2]
• Packets [lecture 2]
• The network is “application neutral” [lecture 3]
• Best effort service [lecture 3]
• A layered protocol architecture [lectures: all]
• A “narrow API” at the network layer [lecture 8]
• The “end to end” design principle [lecture 8]
• Decentralization [lecture: 2, 3, 6, 8, 9, 21]
What we do know

• The early Internet pioneers came up with a solution that was successful beyond all imagining

• Several enduring architectural principles and practices emerged from their work

• But it is just one design

• And numerous cracks have emerged over time
  • want to diagnose problems but IP hides federation
  • want to block unwanted traffic but the network doesn’t authenticate
  • can’t optimize for different applications or customers
  • complex and buggy protocols
  • upgrading protocols is deeply painful
What we do know

• The early Internet pioneers came up with a solution that was successful beyond all imagining

• Several enduring architectural principles and practices emerged from their work

• But it is just one design

• And numerous cracks have emerged over time

• As have new requirements
  • Mobility, reliability, data centers, sensors, ...
Hence, networking today is still debating the big questions...

- Packets \(\rightarrow\) “circuits”
- Statistical multiplexing \(\rightarrow\) “reservations”
- Protocol layers
- A “narrow waist” at the network layer
- Best-effort service
- The “end to end” design principle \(\rightarrow\) “middleboxes”
- Decentralization \(\rightarrow\) “centralize”
Backing up a level

• The Internet offers us a lesson in how to reason through the design of a very complex system
  • What are our goals and constraints?
  • What's the right prioritization of goals?
  • How do we decompose a problem?
  • Who does what? How?
  • What are the interfaces between components?
  • What are the tradeoffs between design options?

• In short: a lesson in how to architect a system
Network “Architecture”

• More about thinking rigorously than doing rigorous math

• More about understanding tradeoffs than running benchmarks

• More about practicality than optimality
What CS 438 Will Teach You

• How the Internet works

• Why it works the way it does

• How to **think** through a complicated (networking) design problem
Administrative Details
Prerequisites

• Operating Systems Concepts
  • CS 241 or equivalent

• C or C++ Programming
  • Preferably Unix

• Probability and Statistics
Grading Policy

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 Homeworks</td>
<td>15%</td>
</tr>
<tr>
<td>3 MPs</td>
<td>35% (10+10+15)</td>
</tr>
<tr>
<td>Midterm exam</td>
<td>25%</td>
</tr>
<tr>
<td>“High-level” exam</td>
<td>2% (extra credit)</td>
</tr>
<tr>
<td>Final exam</td>
<td>25%</td>
</tr>
</tbody>
</table>
Homework and Projects

- **Homework:** Due Wednesdays at start of class.

- **Projects:** Due Fridays at 9:00pm.
  - 2% off per hour late
  - MP1 is solo
  - MP2 and MP3 are 2 person teams
  - TAs will handle all project-related questions
Academic Honesty

- Your work in this class must be your own.
- All infractions reported to the department
- If students are found to have collaborated excessively or to have blatantly cheated (e.g., by copying or sharing answers during an examination or sharing code for the project), all involved will at a minimum receive grades of 0 for the first infraction.
  - We will run a similarity-checking system on code and binaries
- Further infractions will result in failure in the course and/or recommendation for dismissal from the university.
Graduate Students

- Graduate students MAY take an extra one hour project in conjunction with this class.

- Undergraduates may not take this project course.
  - However, if you are interested in networking research, please contact me or another faculty here at UIUC.
Class Communications

• Web site: http://courses.engr.illinois.edu/cs438
  • Assignments, lecture slides, announcements
• Use your instructional account to hand in homework and projects
• Email list:
  • Make sure you are on cs438-sp14@illinois.edu
• Use Piazza for all other intra-class communication
  • You should all be signed up by now
• Cc our staff (cs438-staff@illinois.edu) on any non-private emails sent directly to me (caesar@illinois.edu)
Class Participation

• Ask and answer questions!!
  • it helps you understand
  • it helps others understand
  • it helps you stay awake
  • it helps me stay awake
  • it’s just more fun for all of us

• Sit towards the front

• Limit electronic access for < 90 minutes
Thanks to

• Slide decks include content developed at UC Berkeley (Scott Shenker, Ion Stoica, Sylvia Ratnasamy), Princeton University (Jennifer Rexford), University of Massachusetts (Jim Kurose), Stanford (Nick McKeown), and others
Any questions?