CS 43: Computer Networks Course Introduction

Kevin Webb Swarthmore College September 5, 2017

Please sit towards the front, next to other students!

What This Class Is About

- How networks (focus on the internet) work
- How applications that use networks work
 HTTP, DNS, Email, etc.
- How to write programs that communicate over networks
- How different protocols, policies, and mechanisms interact to provide an effective communication medium

Instructor: Kevin Webb

- <u>http://www.cs.swarthmore.edu/~kwebb/</u>
- Please call me Kevin (or Professor Webb)
- Research: Control platforms for networks

Instructor Kovin Wahh



Office Hours

- Wednesday 11:00 AM Noon
- Thursday Noon 2:00
 NOTE: Faculty dept. meeting at 4:15 on Thursdays

• By appointment

• 255 Science Center

Resources

- Piazza Q&A Forum, Github Enterprise
 - <u>https://piazza.com/swarthmore/fall2017/cs43/home</u>
 - <u>https://github.swarthmore.edu</u>
- Slides & audio recordings on course website
- Lab sections:
 - Science Center 256
 - Friday 2:15-3:45, Friday 4:00-5:30

Email Policy

- For public questions: use Piazza!
 - Your classmates benefit from your questions
 - Your classmates can answer your questions
 - I will check the forum frequently
- For private questions: use email (kwebb@cs)
- I will attempt to respond to within 24 hours

How does this class work?

- This class is designed a bit differently from what you might normally be used to
 - Class will be centered around you
 - Requires your participation
- Ever considered why we have lectures?

Traditional Lectures:



• Roughly one millenium old

Traditional Lectures:



- Little opportunity for expert feedback
- Might as well skip class and watch video lectures!
 - (I am not actually suggesting this. Please attend your classes!)

Interactive Classes with Peer Instruction

• You do the "easy" part before class.



- Class is reserved for interactive, customized experiences
- Research on how people learn:
 - Everyone constructs their own understanding
 - To learn, YOU must actively work with a problem and construct your own understanding of it



- Lets you vote on questions in real time.
- Like pub trivia, but the subject is always networks.
- You NEED one of these for the course!

Peer Instruction

- Short quiz at the beginning of class
- During class: pose carefully designed questions
 - Solo vote: Think for yourself and select answer
 - Discuss: Analyze problem in teams of 3
 - Practice analyzing, talking about challenging concepts
 - Reach consensus
 - If you have questions, raise your hand and I'll come over
 - Group vote: Everyone in group votes
 - You must all vote the same to get your point
 - Class wide discussion:
 - Led by YOU (students) tell us what you talked about in discussion that everyone should know!

Why Peer Instruction?

- You get a chance to think.
- I get feedback as to what you understand.
- It's less boring!
- Research shows it promotes more learning than traditional lecture.

Giving out Candy

- To people willing to
 - Ask a question
 - Share an explanation
 - Summarize what their group talked about
- Your explanations are CRITICAL for fellow students' learning

Example Question

• Individual vote

Group discussion / group vote
 – Room should be LOUD

Class discussion

The most useful super power for a college student would be:



E: Some other power (be prepared to discuss)

Grading

- 5% Reading Quizzes
- 5% Class participation
- 25% Midterm Exam
- 30% Final Exam
- 35% Programming Assignments

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- 25% Midterm Exam
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- 35% Programming Assignments

• I will drop your three lowest quizzes/no-shows.



- Computer Networking: A Top-Down Approach (7th Edition)
- You need this book!

Policies

- Collaboration
 - You may discuss approaches, not solutions
 - You must submit your own work
 - Exams will include questions on programming
- Cheating
 - Zero tolerance for cheating, don't do it!
- Lab Lateness
 - 2 days of extra (at the granularity of days)
 - Let me know when you've submitted

Tentative Schedule

• Midterm – October 26, in class

• Final - TBD

- Labs
 - Out on Fridays (lab section)
 - Due on Thursdays
 - First lab: solo, others in pairs

Administrative Questions?

• All of this info (should be) on class website

• Feel free to ask on Piazza discussion board

Clicker Registration

• <u>https://cs.swarthmore.edu/clickers/</u>

• Please register ASAP

What is the goal of a network?

• Allow devices communicate with one another and coordinate their actions to work together.

• Piece of cake, right?

A "Simple" Task

- Send information from one computer to another •
- Endpoints are called hosts •
 - Could be computer, iPod, cell phone, etc.
- The plumbing is called a link •
 - Many different physical technologies: ٠ Ethernet, wireless, cellular, etc.





Link

(Server)











- Manage complexity and scale up
 - Layering abstraction: divide responsibility
 - Protocols: standardize behavior for interoperability

- Manage complexity and scale up
- Naming and addressing
 - Agreeing on how to describe/express a host, application, network, etc.

- Manage complexity and scale up
- Naming and addressing
- Moving data to the destination
 - Routing: deciding how to get it there
 - Forwarding: copying data across devices/links

- Manage complexity and scale up
- Naming and addressing
- Moving data to the destination
- Reliability and fault tolerance
 - (How) can we guarantee that the data arrives?
 - How do we handle link or device failures?

- Manage complexity and scale up
- Naming and addressing
- Moving data to the destination
- Reliability and fault tolerance
- Resource allocation
 - How do we share the network's capacity?

- Manage complexity and scale up
- Naming and addressing
- Moving data to the destination
- Reliability and fault tolerance
- Resource allocation

(Lots of others too.)

Pull back the curtain on the Internet



Why should you care?

- To know how the Internet works
 - What may be wrong with your networks
 - When was the last time you went 24 hours without going online?
- Network programmers get respect
 In high demand, get paid well

- Rapid growth and success.
 - 1977: 111 machines on Internet
 - 1981: 213
 - 1983: 562
 - 1986: 5000
 - 1989: 10,000
 - 1992: 1,000,000
 - 2001: 150 175 million
 - 2002: > 200 million
 - 2011: > 2 billion (~1B are phones/tablets)

Global Internet Device Sales



CAIDA's IPv4 and IPv6 AS Core AS-level Internet Graph

http://www.caida.org/research/topology/as_core_network/

Archipelago January 2015

lPv4

During a two-week period in January 2015, CAIDA researchers connected data using our distributed measurement infrastructure, Archipelago (Ark). For the IPv4 map, 118 Ark monitors in 42 countries on 6 continents probed paths toward 281 million /24 IPv4 networks. For the IPv6 map, the subset 17 IPv6-connected Ark monitors located in 25 countries on 6 continents. Internets currently probed patts toward 4 p sillion (IPv6 addresses. These assumements covered, corresponding), 92 7% of the (IPv4 noutable maps as finds and 80 3% of the globally routed (IPv6 preferes as seen in the origin (I dataway) Produced (ISGP) pump tables collected by this dow assemble the cathereal (IPv4 data 50 context) (IPv4 and IPv6 Figure 9).

Internet contectivity grapping at the Audindership (1997), between Locky (1997), between Locky (1997), We map each observed IP address to the AS which announced (1, 1, e., to the origin (1end-d-path) AS for the IP prefix representing the best match for the address in the BCP routing tables. The position of each AS node is potted in point coordinates (radius, angle) addressed and AS node is noted.

longitude of the AS's BGP

As in periods years, the IHV graph entitled states relative growt than BrV4 graph. From January 2015, the number of IHV SSes increased by X2, the number of IHV sector period of the number of IHV sector period in the same probability of the sector period relation of IHV sector period in the same probability of the sector period relation of the same probability of the sector period relation of the same period relation of the same period relation of the sector period relation of the same period relation

relieds Califies pids in right as and of linearies of distributions of relative AS degree changes that occurred between 2014 and 2015. Each bin in house pids either includes at ASBs that had the same degree 2014 data or gena several degree values to include at least 25 ASEs for each bin, the black line in the middle atworks the medium parcentage change, the durated ad the demonstration between the 25th and 25th parcents

Figure 4 (Left) and 5 (Right). (IPv4/IPv6 Top Ranked ASes) Figures and 5 show changes in connectivity for the 10 IPv4 and 11 IPv6 ASes th were ranked in the "Top 10" by transit degree in either 2014 or 2015. the IPv4 graph, 8 ASes increased their degree while 2 decreased, the



median observed change was a 12% degree increase. The maximum degree growth 05% was observed by Brank Artlet (38 2496). This size junce increase moved Bhartl Airtel from 10th to 5th position in the ranking or AGes by transit degree. The only document in degree from 2014 to 2015 came from AST 016 and AS 3540, both degrees dorpode by 4% each which had a marginal impact on the Top 10 rankings. In the IPv6 graph 10 out of 11 ASE increased their degree, with a madian increase d 20% AS 6939 Huricane Electric remained the largest-degree IPr6 AS increasing its degree from 1740 in 2014 to 2199 in 2015. The larges relative degree increase in the IPv6 graph canne from AS 12552 IP-CP0 Networks, with an increase of 1251% from 37 to 511, making it the 9th highest raiked AS by degree in 2015. The AS that decreased mote in degree in the IPv6 graph was AS 20965 Geant, its 45% drop from 398 to 2022 removed if tom Too 10.



Cooperative Association for Internet Data Analysis (CAIDA)

• Rapid growth and success.



• Rapid growth and success.

- We're here at the beginning.
 - Most of the growth happened in our lifetime.
 - Still TONS of untapped potential.



Founded 1998



Founded 2004

- Rapid growth and success.
- We're here at the beginning.
- Communication is empowering.











- Rapid growth and success.
- We're here at the beginning.
- Communication is empowering.





(Late 60s)

TODO List

- Reading: Protocols - Sections 1.1, 1.5
- Sign up on Piazza!
- Register your clicker!
- Please let me know about:
 - Your preferred name/pronouns, if different than roster information
 - Academic accommodations