CompSci514/ECE558: Computer Networks

Lecture 1: Introduction and Course Overview
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Roadmap

• Course introduction: what and why
• Audience
• Topics
• Workload
• Grading policy
• Staff
• How to read a paper
• Other questions?
Emergency procedures

- Identify all classroom/lab exits and options for securing the room.
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: 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;358a4e4-56000-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>
TCP/IP Header Formats in Lego
A Big Bunch of Boxes
A place to apply theory?

- Algorithms and data structures
- Control theory
- Queuing theory
- Optimization theory
- Game theory and mechanism design
- Formal methods
- Information theory
- Cryptography
- Programming languages
- Graph theory
A place to build systems?

- Distributed systems
- Operating systems
- Computer architecture
- Software engineering
- …
An Application Domain?
“There is a tendency in our field to believe that everything we currently use is a paragon of engineering, rather than a snapshot of our understanding at the time. We build great myths of spin about how what we have done is the only way to do it to the point that our universities now teach the flaws to students (and professors and textbook authors) who don't know better.”  -- John Day (Internet pioneer)
My two cents ...
Networking = “Plumbing”

Networking is the “plumbing” of computing
Almost all areas of computing are network-based.
  Distributed computing
  Big Data
  Cloud Computing
  Internet of Things
  Smart Cities

Networking is the backbone of computing.

Source: Raj Jain Keynote speech at SIGCOMM 2017
Smart Everything

<table>
<thead>
<tr>
<th>Smart Watch</th>
<th>Smart TV</th>
<th>Smart Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Health</td>
<td>Smart Home</td>
<td>Smart Kegs</td>
</tr>
<tr>
<td>Smart Space</td>
<td>Smart Industries</td>
<td>Smart Cities</td>
</tr>
</tbody>
</table>

Source: Raj Jain Keynote speech at SIGCOMM 2017
What’s Smart?

Old: Smart = Can think       Computation
       = Can Recall       Storage

Now: Smart = Can find quickly, Can Delegate
       Communicate = Networking

Smart Grid, Smart Meters, Smart Cars, Smart homes, Smart Cities, Smart Factories, Smart Smoke Detectors, …
Networking redefines CS

• All disciplines in the pre-networking CS field aim to solve problems for computing, storage, and the combination of two

• Networking adds a third dimension to problem space: computing, communication, and storage

• Old disciplines may apply

• New disciplines emerge
Metcalf’s law

• Metcalfe's law states the effect of a telecommunications network is proportional to the square of the number of connected users of the system ($n^2$).

• Network effects

• https://en.wikipedia.org/wiki/Metcalfes_law
Why study networking?

Relevant

– Can measure/build things
– Can impact the real world
Why studying networking?

• Young, relatively immature, and fast changing field
  – Many unsolved problems
Why studying networking?

- Lots of platforms for building your ideas
  - Testbeds: Emulab, PlanetLab, Orbit, GENI
  - Programmability: Click, NetFPGA, Mininet
  - Routing software: Quagga, XORP, and Bird
  - Measurements: RouteViews, traceroute, Internet2
Networks change lives

Our Impact

Through our connectivity efforts we've brought more than 25 million people online who otherwise would not be and introduced them to the incredible value of the internet. They're doing better in school, building new businesses, and learning how to stay healthy. Here are a few stories of how Free Basics is having an impact.

Networking is Fueling All Sectors of Economy

Networking companies are among the most valued companies: Apple, AT&T, Samsung, Verizon, Microsoft, China Mobile, Alphabet, Comcast, NTT, IBM, Intel, Cisco, Amazon, Facebook, …

All tech companies that are hiring currently are networking companies

Note: Apple became highly valued only after it switched from computing to communications (iPhone)

Networking = Economic Indicator

Source: Raj Jain Keynote speech at SIGCOMM 2017
Networks foster innovations

• Google, Facebook, Internet of Things, online games, e-commerce, cloud computing

• Fun examples: test of time paper awards
     Ethane ushered in the age of Software-Defined Networking (SDN) and a new generation of research that inspired both academia and industry to design network control planes that we can reason about.
• You could be the next!
Architectural questions tend to dominate CS networking research
Decomposition of Function

Definition and placement of function

– What to do, and where to do it

The “division of labor”

– Between the host, network, and management systems

– Across multiple concurrent protocols and mechanisms
Course overview: who should be taking this class

• Interested in computer networks
• Has some undergraduate level networking/OS knowledge
  – Taken 356 or equivalent
List of topics

• The original Internet design
• Congestion control
• Routing
• Software defined networking
• Datacenter networks
• Programmable switches
• Remote direct memory access
• Measurement
• ...

Approach

• Materials
  – Read research papers
  – Lecture notes, available online
Course overview: your work

• Readings
  – Read papers before class (ideally)

• Homework
  – 3~4 homework sets
  – Programming assignments

• Projects (more later)
  – A self-chosen project that reproduces the results from a research paper
    • Talk to me if you want to do original research
  – Code, report, and presentation (Nov 21 & 26)

• Exams
  – Midterm: Oct 15
  – Final: Dec 16
Course overview: collaboration policy

• Encouraged to work with each other

• Team work: projects
  – 1~4 persons per team; recommended size is 2
  – Turn in one copy of code and report
Course overview: late and grading policy

• **Late**
  – The deadline for any assignment can be extended with a 10% penalty per day.
  – No deadline can be extended by more than two days. Assignments will NOT be accepted 48 hours after the due date.
  – The project presentations must be given on the day they are scheduled.
  – If you are ill: Contact the instructor and get a medical note.

• **Grading Policy**
  – Exams 40%
  – Project 40%
  – Homework 20%
Course staff

• Instructor
  – Xiaowei Yang (xwy@cs.duke.edu)
  – Office hours: TuTh 2-3pm

• TAs
  – Zhenyu Zhou (zzy@cs.duke.edu)
    • Office hours: Fridays 3-5pm @ LSRC D305
  – Jiyao Hu (jiyao.hu@cs.duke.edu)
    • Office hours: Wednesdays 3-5pm @ LSRC D305
Looking forward

The Design Philosophy of the DARPA Internet Protocols

David D. Clark
Massachusetts Institute of Technology
Laboratory for Computer Science
Cambridge, MA. 02139

(Originally published in Proc. SIGCOMM '88, Computer Communication Review Vol. 18, No. 4,
August 1988, pp. 106–114)

Abstract
The Internet protocol suite, TCP/IP, was first proposed fifteen years ago. It was developed by the Defense Advanced Research Projects Agency (DARPA), and has been used widely in military and commercial systems. While there have been papers and specifications that describe how the protocols work, it is sometimes difficult to deduce from these why the protocol is as it is. For example, the Internet protocol is based on a connectionless or datagram mode of service. The motivation for this has been greatly misunderstood. This paper attempts to capture some of the early reasoning which shaped the Internet protocols.

1. Introduction
For the last 15 years¹, the Advanced Research Projects Agency of the U.S. Department of Defense has been developing a suite of protocols for networking. This has included moving the ISO 7-layer architecture into the IP and TCP layers. This seems basic to the design, but was also not a part of the original proposal. These changes in the Internet design arose through the repeated pattern of implementation and testing that occurred before the standards were set.

The Internet architecture is still evolving. Sometimes a new extension challenges one of the design principles, but in any case an understanding of the history of the design provides a necessary context for current design extensions. The connectionless configuration of ISO protocols has also been colored by the history of the Internet suite, so an understanding of the Internet design philosophy may be helpful to those working with ISO.

This paper catalogs one view of the original objectives of the Internet architecture, and discusses the relation between these goals and the important features of protocols.
David D. Clark (MIT)

- Chief Protocol Architect for the Internet from 1981.
- Continues to be a network visionary today.
- My PhD advisor 😊
- At the time of writing (1987)…
  - (Almost) no commercial Internet
  - Number of hosts reaches 10,000
  - NSFNET backbone 1 year old; 1.5Mb/s
  - 1 yr after Cisco’s 1st product, IETF started
How to Read*

You May Think You Already Know How To Read, But…

* Paper listed on class website. Some slides borrowed from Prof. Rexford’s lecture.
You Spend a Lot of Time Reading

• Reading for grad classes
• Reviewing conference submissions
• Giving colleagues feedback
• Keeping up with your field
• Staying broadly educated
• Transitioning into a new area
• Learning how to write better papers 😊

It is worthwhile to learn to read effectively
Keshav’s Three-Pass Approach: Step 1

• A ten-minute scan to get the general idea
  – Title, abstract, and introduction
  – Section and subsection titles
  – Conclusion
  – Bibliography

• What to learn: the five C’s
  – Category: What type of paper is it?
  – Context: What body of work does it relate to?
  – Correctness: Do the assumptions seem valid?
  – Contributions: What are the main research contributions?
  – Clarity: Is the paper well-written?

• Decide whether to read further…
Keshav’s Three-Pass Approach: Step 2

• A more careful, one-hour reading
  – Read with greater care, but ignore details like proofs
  – Figures, diagrams, and illustrations
  – Mark relevant references for later reading

• Grasp the content of the paper
  – Be able to summarize the main idea
  – Identify whether you can (or should) fully understand

• Decide whether to
  – Abandon reading in greater depth
  – Read background material before proceeding further
  – Persevere and continue for a third pass
Keshav’s Three-Pass Approach: Step 3

• Several-hour virtual re-implementation of the work
  – Making the same assumptions, recreate the work
  – Identify the paper’s innovations and its failings
  – Identify and challenge every assumption
  – Think how you would present the ideas yourself
  – Jot down ideas for future work

• When should you read this carefully?
  – Reviewing for a conference or journal
  – Giving colleagues feedback on a paper
  – Understanding a paper closely related to your research
  – Deeply understanding a classic paper in the field
Other Tips for Reading Papers

• Read at the right level for what you need
  – “Work smarter, not harder”
• Read at the right time of day
  – When you are fresh, not sleepy
• Read in the right place
  – Where you are not distracted, and have enough time
• Read actively
  – With a purpose (what is your goal?)
  – With a pen or computer to take notes
• Read critically
  – Think, question, challenge, critique, …
Doing a literature survey

• Reading tens of papers in an unfamiliar field
1. Search keyword in GoogleScholar or CiteSeer or ask your advisor
   – If you find a survey paper, you are done
2. Find shared citations and repeated author names
   – Go to key authors’ websites to find recent papers
3. Go to top conferences to find related work
20-paper rule

- Find twenty papers to read to find new ideas
Today

• Course Overview

• Last 15-20 minutes:
  – Talk to each other to find potential group partners