CS244: Advanced Topics in Networking, Spring 2024

CS244 is a graduate course in computer networks. In this class we'll explore the principles and design decisions which underly the Internet. We'll explore the pros and cons of the current design, and give some thought to how we can make the Internet better in future.

The goals for this class are:

- To become familiar with the state of the art in networking research: network architecture, protocols and systems.
- To gain some practice in reading research papers and critically understanding the research of others.
- To gain experience with implementing and evaluating research systems by replicating a prior result.

Course Information

Professors: Keith Winstein and Philip Levis

TA: Colin Drewes and Qizheng Zhang

Lectures: Tue, Thu 1:30PM - 2:50PM in 300-300

Office Hours:

- Keith: TBA
- Philip: TBA
- Colin: TBA

Communication: Course announcements will be disseminated via the official course mailing list. We use Canvas for discussion.

Assignments: All course assignments should be submitted via Canvas.

Prerequisites: This course assumes a basic understanding of topics in networking, such as packet-switching, routing, socket programming, and congestion control. It is also helpful to know how to program in Python. We suggest taking CS 144, EE 284, or equivalent. For a refresher, you could look at the textbook “Computer Networking: A Top-Down Approach” by J. Kurose and K. Ross or “Computer Networks: A Systems Approach” by L. Peterson and B. Davie.

Schedule and Papers

4/2 - Introductions: Why internet?
4/4 - Internet Architecture

**Speaker:** Keith and Phil

*The Design Philosophy of the DARPA Internet Protocols*
Clark  
SIGCOMM 1988

*A Brief History of the Internet*
Leiner et al.  
CCR 2009

**Assignments**
Group formation due Monday, April 8 11:59PM

4/9 - End-to-End

**Speaker:** Keith and Phil

*End-to-End Arguments in System Design*
Saltzer et al.  
Distributed Computing Systems 1981

*RFC 1958*
Carpenter  
Network Working Group 1996

4/11 - Switches (Scheduling and Buffering)

**Speaker:** Phil

*High-Speed Switch Scheduling for Local-Area Networks*
Anderson et al.  
ACM Transactions on Computer Systems 1993

**Assignments**
Selected figure and project proposal due Monday, April 15 11:59PM

4/16 - WAN and LAN

**Speaker:** Phil
**Ethane: Taking Control of the Enterprise**
Casado et al.
SIGCOMM 2007

**VFP: A Virtual Switch Platform for Host SDN in the Public Cloud**
Firestone
NSDI 2017

**B4: Experience with a Globally-Deployed Software Defined WAN**
Jain et al.
SIGCOMM 2013

### 4/18 - Programs and Programmability

**Speaker:** Phil

*Active network vision and reality: lessons from a capsule-based system*
Wetherall
SOSP 1999

*Packet Transactions: High-Level Programming for Line-Rate Switches*
Sivaraman et al.
SIGCOMM 2016

### 4/23 - Datacenter Networks

**Speaker:** Keith + Omid

*A Scalable, Commodity Data Center Network Architecture*
Al-Fares et al.
SIGCOMM 2008

*Jupiter Evolving: Transforming Google's Datacenter Network via Optical Circuit Switches and Software-Defined Networking*
Poutievski et al.
SIGCOMM 2022

### 4/25 - Congestion Control

**Speaker:** Keith

*Congestion Avoidance and Control*
Jacobson and Karels
SIGCOMM 1988

Analysis of the Increase and Decrease Algorithms for Congestion Avoidance in Computer Networks
Chiu and Jain
Computer Networks and ISDN Systems 1989

4/30 - Delay-based Congestion Control
Speaker: Keith

TCP Vegas: end to end congestion avoidance on a global Internet
Brakmo and Peterson
IEEE Journal on Selected Areas in Communications 1995

A Survey of Lower-than-Best-Effort Transport Protocols
Welzl and Ros
Internet Engineering Task Force 2011

5/2 - Delay-based Problems
Speaker: Keith

BBR
Cardwell et al.
ACM Queue 2016
Starvation in End-to-End Congestion Control
Arun et al.
SIGCOMM 2022

5/7 - Measurement and Monitoring
Speaker: Phil + Zakir

Wide area traffic: the failure of Poisson modeling
Paxson and Floyd
IEE/ACM Transactions on Networking 1995

ZMap: Fast Internet-wide Scanning and Its Security Applications
Durumeric at al.
USENIX Security 2013

5/9 - Internet Governance
Speaker: Phil + Jon Peterson
No readings

**Assignments**
Midterm report due Monday, April 13 11:59PM

**5/14 - Surveillance and Privacy**

**Speaker:** Keith

*Examining How the Great Firewall Discovers Hidden Circumvention Servers*
Ensafi et al.
IMC 2015

*Encore: Lightweight Measurement of Web Censorship with Cross-Origin Requests*
Burnett and Feamster
SIGCOMM 2015

*How the Great Firewall of China Detects and Blocks Fully Encrypted Traffic*
Wu et al.
USENIX Security 2023

**Assignments**
Pick just two of the above papers!

**5/16 - NIC/Host Interfaces**

**Speaker:** Phil

*(Selected sections of) Understanding PCIe performance for end host networking*
Neugebauer et al.
SIGCOMM 2018

*Ensō: A Streaming Interface for NIC-Application Communication*
Sadok et al.
OSDI 2023

*CC-NIC: a Cache-Coherent Interface to the NIC*
Schuh et al.
ASPLOS 2024

**5/21 - Wireless**

**Speaker:** Phil

*Architecture and Evaluation of an Unplanned 802.11b*
Mesh Network
Bicket et al.
MobiCom 2005

See through walls with WiFi!
Adib and Katabi
SIGCOMM 2013

5/23 - Simulation
Speaker: Keith

Why We Don't Know How To Simulate The Internet
Floyd and Paxson
Winter Simulation Conference 1997
Pantheon: the training ground for Internet congestion-control research
Yan et al.
ATC 2018

5/28 - ML for Networking
Speaker: Keith

An Experimental Study of the Learnability of Congestion Control
Sivaraman et al.
SIGCOMM 2014
Neural Adaptive Video Streaming with Pensieve
Mao et al.
SIGCOMM 2017

5/30 - ML for Networking
Speaker: Keith

Learning in situ: a randomized experiment in video streaming
Yan et al.
NSDI 2020

6/4 - Final Presentations
Speaker: You!
No readings
Assignments
Final report due Sat June 8th, 6:30PM

6/6 - Final Presentations
Speaker: You!
No readings
Assignments
Final report due Sat June 8th, 6:30PM

Organization
The class consists of two main activities:

Papers and discussions: We will read 1-2 papers for each class (i.e. 2-4 papers per week), and discuss them in class. You will likely need to spend a few hours reading each paper and making notes, to prepare you to discuss them in class. This class only works if you come prepared to discuss the papers in detail, which is why 20% of your grade is for in-class participation. Do not take this course unless you are willing and able to do a lot of reading.

Replicating research:
You will complete one open-ended project replicating a major networking research result, with a few milestones through the quarter. We've found that replicating research results is a good way to get started doing networking research and contributing to the networking community.

For research to be replicated, an independent group has corroborated the original result using code and experiments developed completely independently.

You can see example replications on the Replicating Network Research blog.

Grading Policy
Reading and Participation:
- Critiques before class (20%)
- In-class Participation (20%)

Replicating Research:
- Midterm Report (20%)
- Final Report (30%)
- Final Presentation (10%)

Critiques
Before each class, you must submit a short critique of the required readings. Each critique should be about a half a page and should roughly cover the following questions:

- What is the paper about? What is the issue the authors are trying to solve?
- What was the state of the world before this paper? How did this change that?
- How do the authors go about trying to solve the issue? What’s the main idea? What are the paper’s main contributions?
- How did the authors do? Is the evaluation sound and unbiased? Are the authors’ results sufficiently justified in the paper?
- Who does the issue/paper affect? Will this paper be relevant in 10 years, or alternatively, has the paper stood the test of time?
- What do you think about the paper? Is it well written?

Critiques will be submitted through email to the TA (chdrewes@stanford.edu) with the subject “CS 244: <student name> <day>”. For example, the critiques due on 4/4 would be sent in an email with the subject “CS 244: Colin Drewes 4/4”. Clearly separate text belonging to different papers. Critiques will be accepted until 12am (midnight) the night before class. If you do not strictly adhere to the structure of this subject line your response may get lost. This is the hard deadline.

It is not possible to make up for a missed critique so please do not email the staff for late day requests.

Critiques will be graded as check, check+, or check-. If all of your critiques are check, you will receive the full 20% credit. There is a 5% of extra credit one can receive for check++; writing several critiques that make valuable observations or provide a good insight can bump your grade one notch (e.g., from a B+ to an A-). Critiques that merely restate or rephrase sentences in the paper and abstract (e.g., could have been written without reading the paper) will receive a check-.

**In-class Participation**

Is class participation based solely on attendance? No. Attendance is a necessary but not sufficient condition for good class participation. We will not take official roll during lecture, but because we make the effort to know everyone in the class we will notice if a student is frequently absent. Beyond attendance, we evaluate class participation by observing how prepared students are to discuss the covered paper when they come to class.