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 offical 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?

Speaker: Keith and Phil

No readings

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.