

# COS 561: Advanced Computer Networks

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<https://cos561.princeton.systems/>

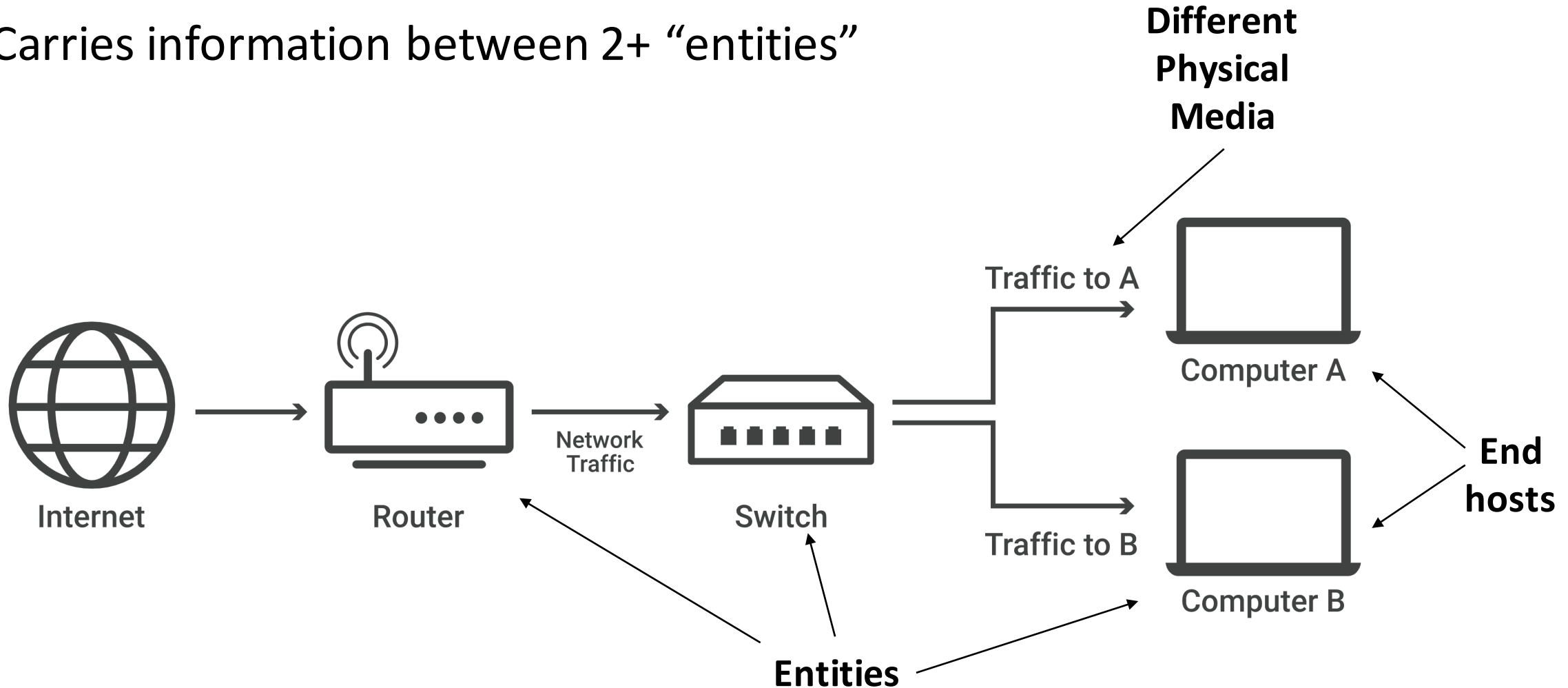
# Today's Agenda

- Brief course motivation and topic overview
- Course logistics + Intros
- “Design Philosophy” paper by David Clark

**Computer networking:** the study of how the Internet (and more generally, any inter-network) is designed and operated

# What is a network?

- Carries information between 2+ “entities”



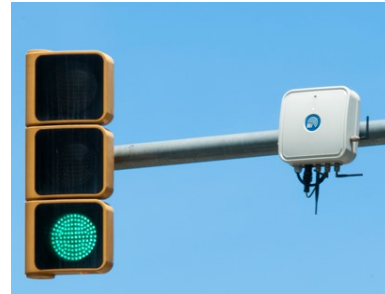
# Why Study Networking?

- A means of connecting people with each other, and with content!



# Why Study Networking?

- Alternately: connects devices of all forms



# Constantly Evolving

- Internet started as experiment, with military focus
- Now services >3 Billion people worldwide (and counting!)
- Driven by new applications and services, and low barrier to entry
  - In-body networks, 5G/6G, your next app...

# Interdisciplinary

- **Operating Systems:** how does end host share network interface amongst competing apps?
- **Programming Languages:** how to program the network? How to effectively write networked applications?
- **Formal Verification:** how to ensure that the network (and network protocols) do what they are intended to do (and nothing else)?
- **Machine Learning:** ML-for-networking (e.g., learning routing policies, anomaly detection), Networking-for-ML (e.g., efficient distributed training)

And more... e.g., HCI (application-user interfaces), hardware, physics, etc.



# Studying Networking

	OSI Layer	TCP/IP	Datagrams are called
Software	<b>Layer 7</b> Application	HTTP, SMTP, IMAP, SNMP, POP3, FTP	Upper Layer Data
	<b>Layer 6</b> Presentation	ASCII Characters, MPEG, SSL, TSL, Compression (Encryption & Decryption)	
	<b>Layer 5</b> Session	NetBIOS, SAP, Handshaking connection	
	<b>Layer 4</b> Transport	TCP, UDP	Segment
	<b>Layer 3</b> Network	IPv4, IPv6, ICMP, <u>IPSec</u> , MPLS, ARP	Packet
Hardware	<b>Layer 2</b> Data Link	Ethernet, 802.1x, PPP, ATM, <u>Fiber Channel</u> , MPLS, FDDI, MAC Addresses	Frame
	<b>Layer 1</b> Physical	Cables, Connectors, Hubs (DLS, RS232, 10BaseT, 100BaseTX, ISDN, T1)	Bits

# Goals of this class

- **Principles** used to build computer networks and services
- Study core network concepts **in the context of today's goals/problems**
- Learn how to read network/systems research papers critically
- Articulate understanding and thoughts about paper
- Formulate and carry out research projects
- Present research results

# Topics

- Internet Design + Architecture
- Layer operation (e.g., network, transport, congestion control)
- Routing and network programming (e.g., SDN)
- Applications (e.g., video systems, ML training)
- Infrastructure (e.g., middleboxes, CDNs)

# Course Logistics

# Tie to COS 461

- Unlike previous year, 561 students do not have to do 461 assignments/lectures/exams
- 561 students, however, are responsible for 461 material
  - Will be important *background* for papers + discussions
  - Assumed knowledge for discussions and exams
- The schedule mirrors 461; you are responsible for attending 461 lectures and office hours as needed

# Grading

- 30% Participation (during precepts, Perusall, paper presentation)
- 30% Midterm Exam
- 40% Research Project

# Reading/Discussing Papers

- ~1 paper per week
- Topic related to COS 461 lectures during the same week
- Upload  $\geq 5$  insightful comments to Perusall by Wednesday at 11pm
  - Follow-on research
  - Generalize/specialize to different settings
  - Thoughts on improving evaluation
  - Deployment considerations
  - Connections to previously studied topics/papers

# Paper Presentation

- Discussion will start with a group of students presenting the paper in depth. Presentations should be 20-25 mins, and cover:
  - What problem is it solving and why is it important?
  - What is prior work and where does it fail?
  - How does the solution work (in detail) and what are the key insights?
  - Evaluation setup and results?
  - Open questions remaining after this solution?
  - Seed discussion: cover Perusall notes and more
- Everyone is expected to participate!



# Exam

- Take home: April 11-12 (Tuesday-Wednesday)
- Short answers testing:
  - Understanding of the settings/solutions in research papers
  - Ability to apply solutions to new settings, tweak them for different goals, etc.
- COS 461 background is assumed

# Research Project

- In groups of 3-4 students; must involve programming
  - **Start early!!!**
- **Reproducing research**
  - Implement solution described in paper
  - Evaluate implementation to (1) reproduce findings (or explain why they could not be reproduced), and (2) evaluate in new conditions or on new metrics
  - Can be covered paper or another networking-related one
- **Novel research**
  - Establish problem, limitations of prior work, new solution, implementation, and evaluation
  - Must \*directly\* relate to networking topics

# Research Project Timeline/Deliverables



- **Project proposal** (2-3 pages): describe the elements on the previous slide, e.g., for novel research: list problem of focus, related work and its limitations, proposed solution, and implementation plan
  - Okay to pivot!
- **Project presentations**: ~10 minute in-class presentations
- **Final report** (6 pages): conference-style paper detailing problem, challenges, solution, results, and related work

Questions?

# The Design Philosophy of the DARPA Internet Protocols

David D. Clark