COS 461/561: Computer Networks

Kyle Jamieson (461), Jennifer Rexford (561)

Fall 2020

Lectures: TR 10:00-10:50 AM

www.cs.princeton.edu/courses/archive/fall20/cos461
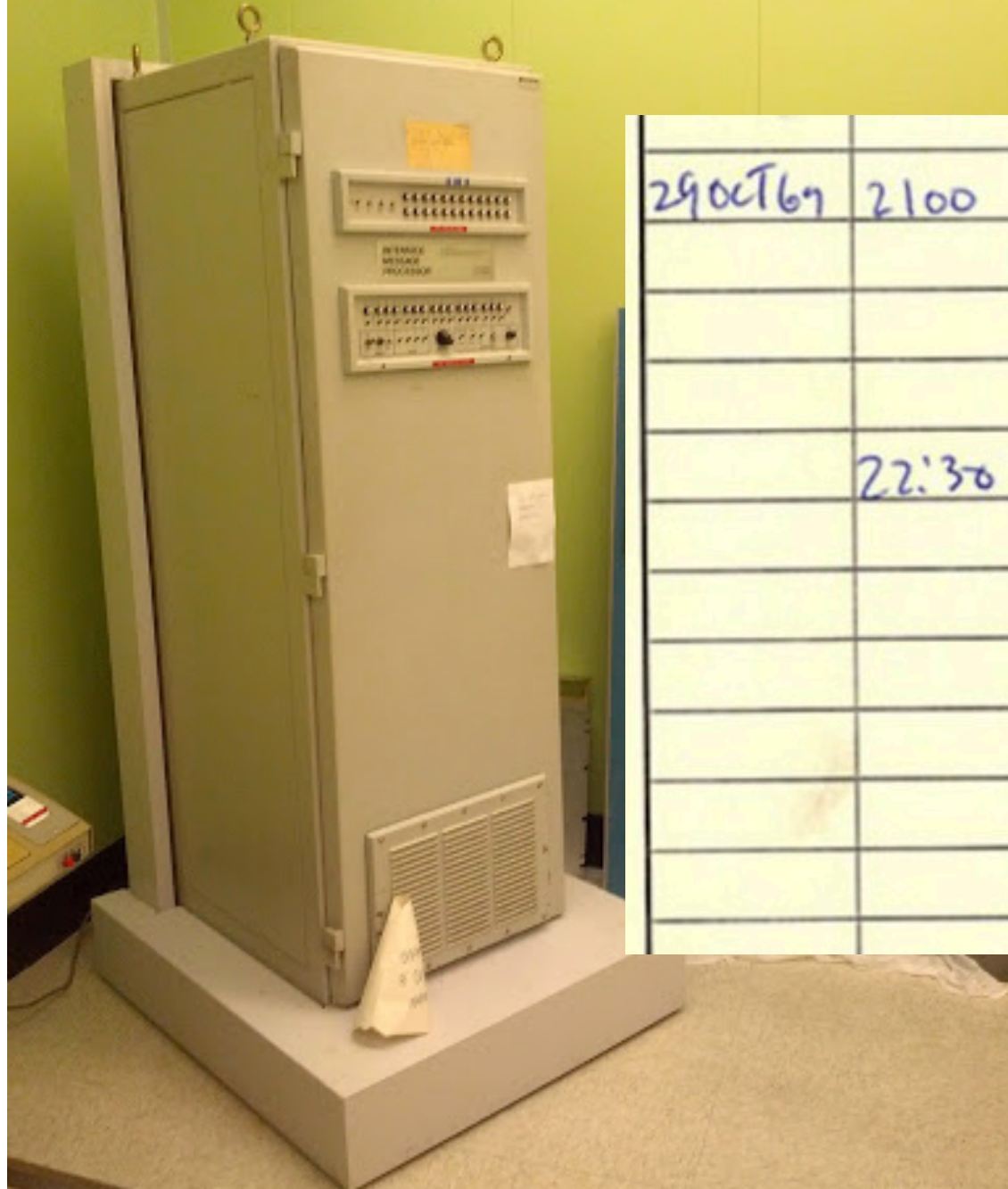
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THIS LECTURE IS BEING RECORDED FOR STUDENTS UNABLE TO ATTEND

Today

1. Origins of the Internet
   – Concurrent Q&A live

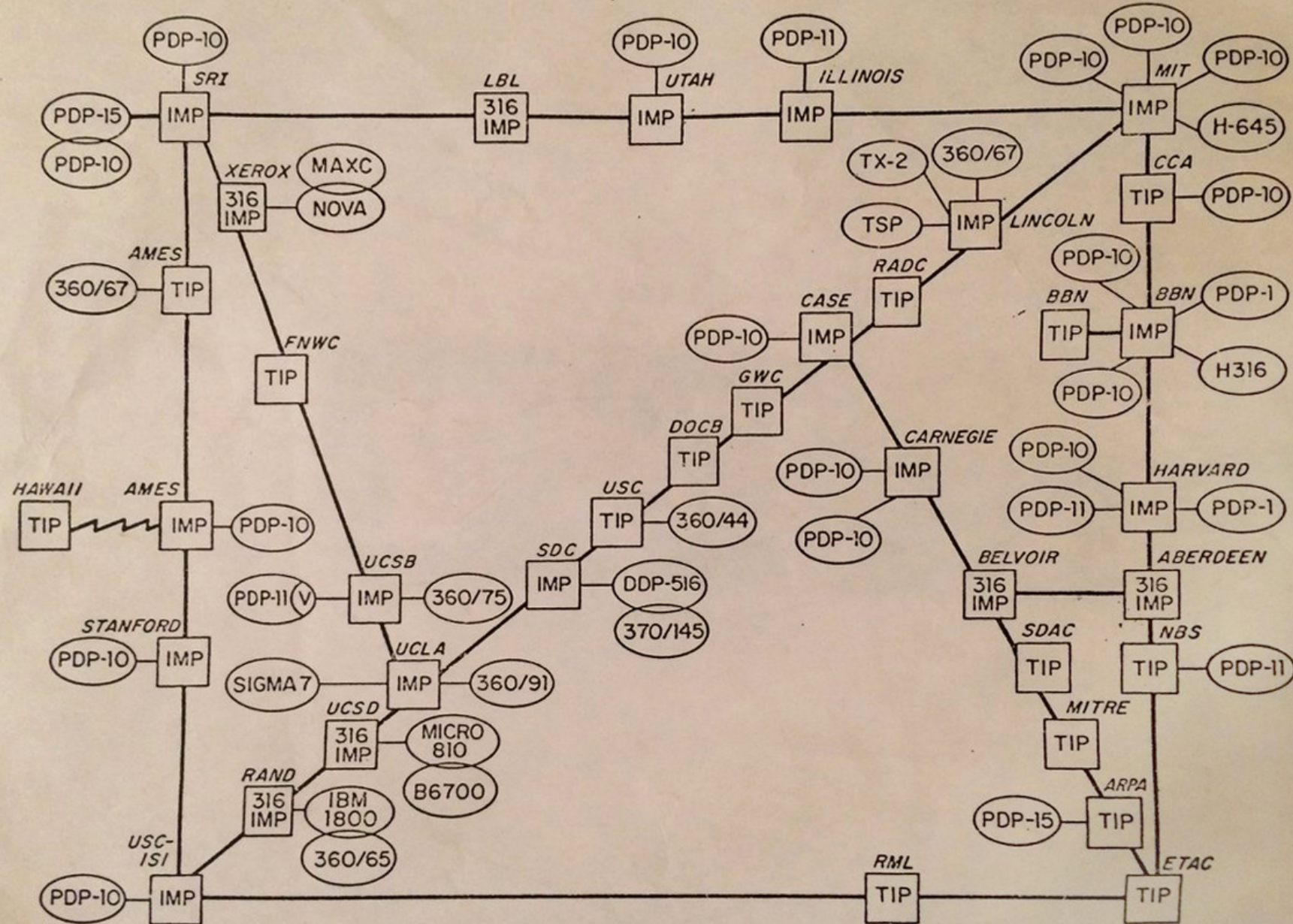2. Mentimeter Q&A, Live

3. Course Policies (461 & 561)

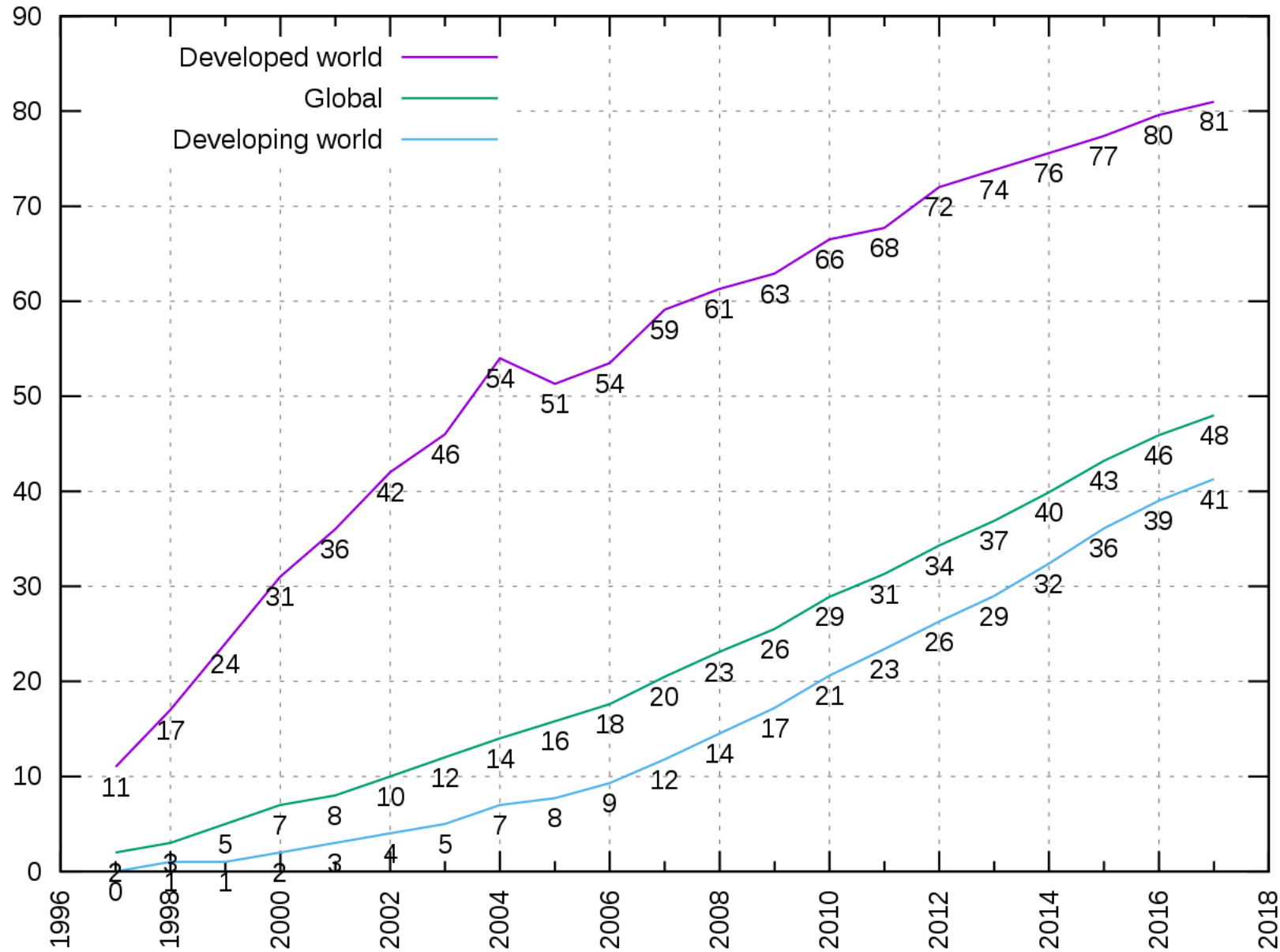# What are the Origins of Today's Internet?

Interface Message Processor

29 OCT 69	2100	LOADED OP. PROGRAM	CSK
		FOR BEN BARKER	
		BBN	
	22:30	Talked to SRI	CSK
		Host to Host	
		Left op. imp. program	CSK
		running after sending	
		a host dead message	
		to imp.	

ARPA NETWORK, LOGICAL MAP, MAY 1973

Internet Users Per 100 Inhabitants

How does the design of the Internet support growth and foster innovation?
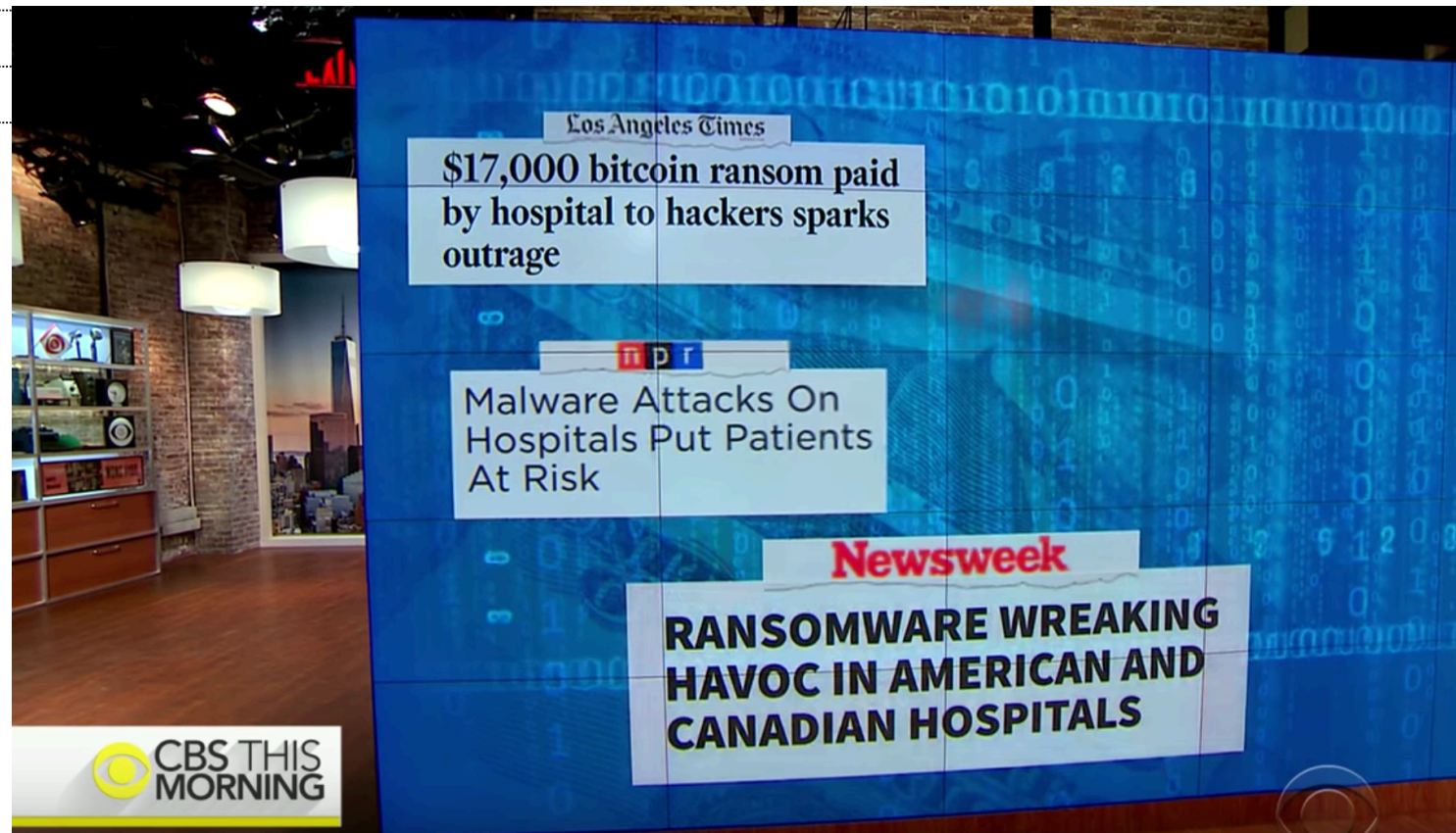
The Internet is a Tense Place

Cybersecurity

Cyber-Attack Hits U.S. Health Agency Amid Covid-19 Outbreak

By <u>Shira Stein</u> and <u>Jennifer Jacobs</u>

March 16, 2020, 8:37 AM EDT *Updated on March 16, 2020, 4:35 PM EDT*

▶ NSC tweet on disinformation Sunday was connected to attack

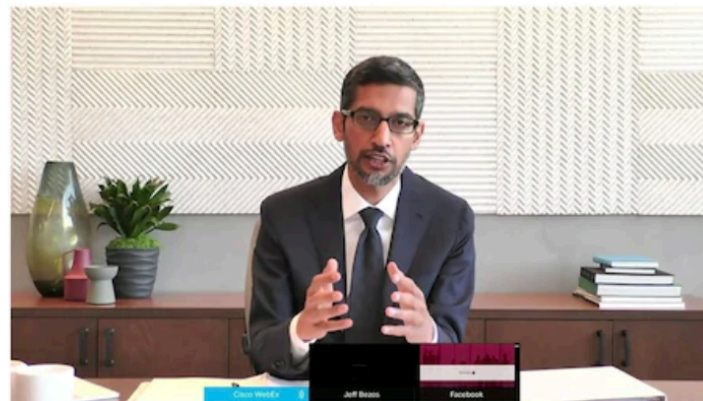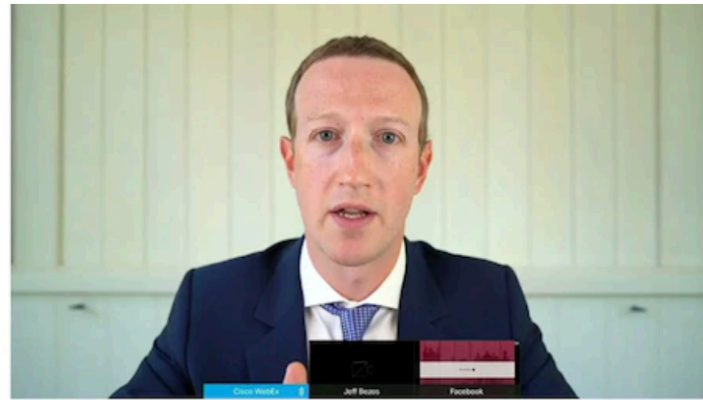▶ Cyber intrusion comes as U.S. battles the coronavirus pandemic

NET NEUTRALITY

July 2020

October 2019

MARK ZUCKERBERG TESTIFIES ON CAPITOL HILL
FACEBOOK CEO ADDRESSES "LIBRA" GLOBAL CRYPTOCURRENCY PROJECT, ELECTION INTERFERENCE

CBSN
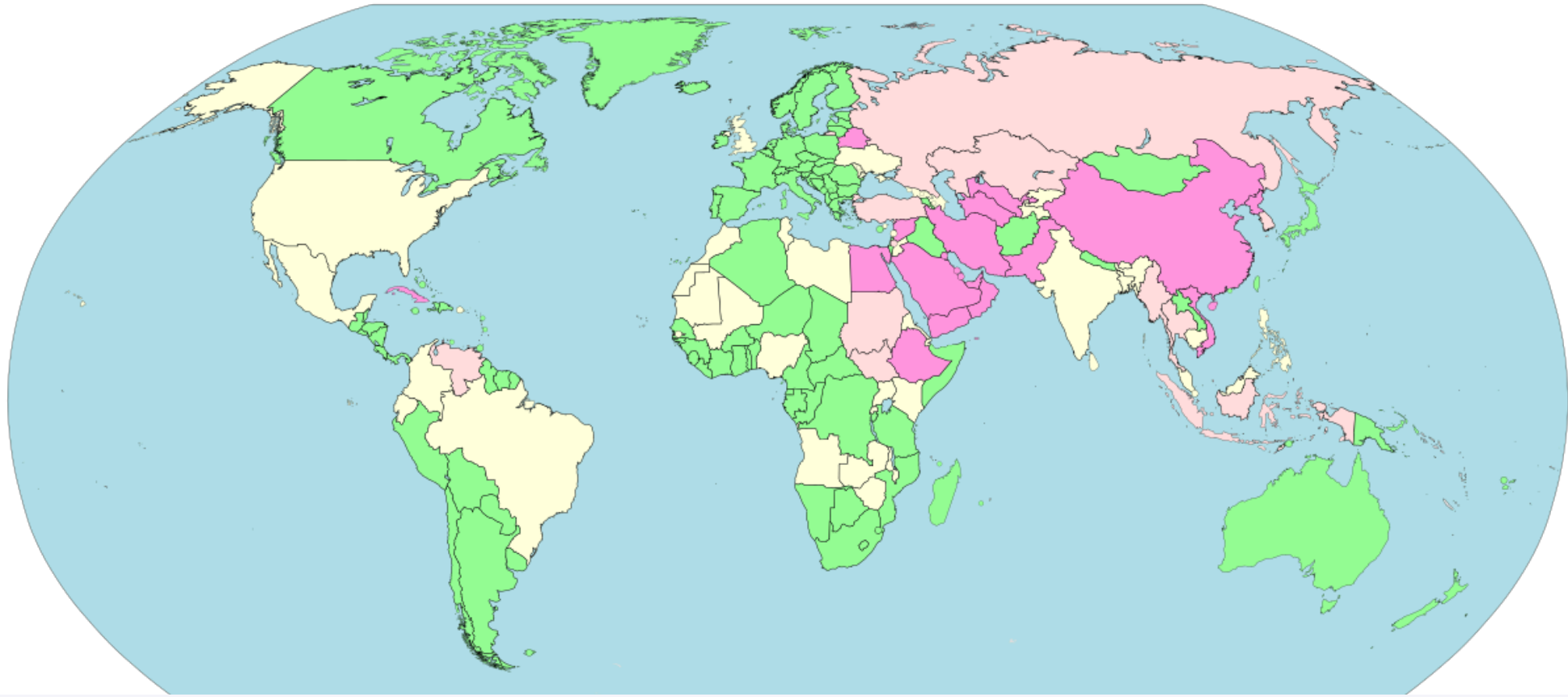
Internet censorship and surveillance by country (2018)

Pervasive censorship and/or surveillance	Little or no censorship and/or surveillance
Substantial censorship and/or surveillance	Not classified / No data
Selective censorship and/or surveillance	
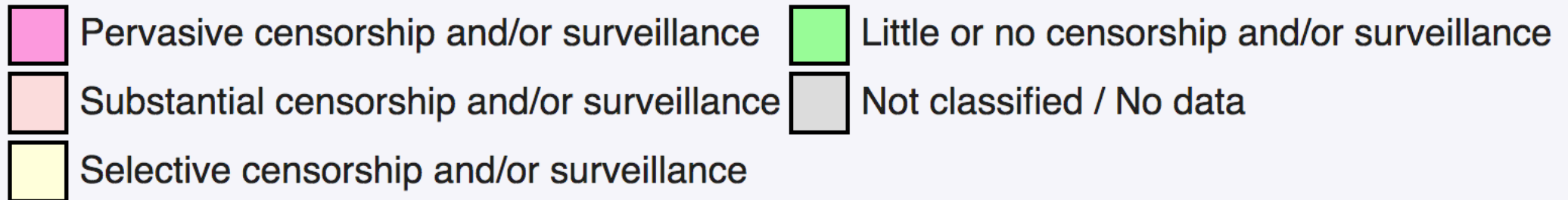
How does the design of
the Internet create or
exacerbate these tensions?

# What *is* the Internet?

The Internet is the worldwide, publicly accessible network of interconnected computer networks that transmit data by packet switching using the standard Internet Protocol (IP).

It is a "network of networks" that consists of millions of smaller domestic, academic, business, and government networks, which together carry various information and services.

"Best-Effort Packet Delivery Service"

packets

THE
INTERNET
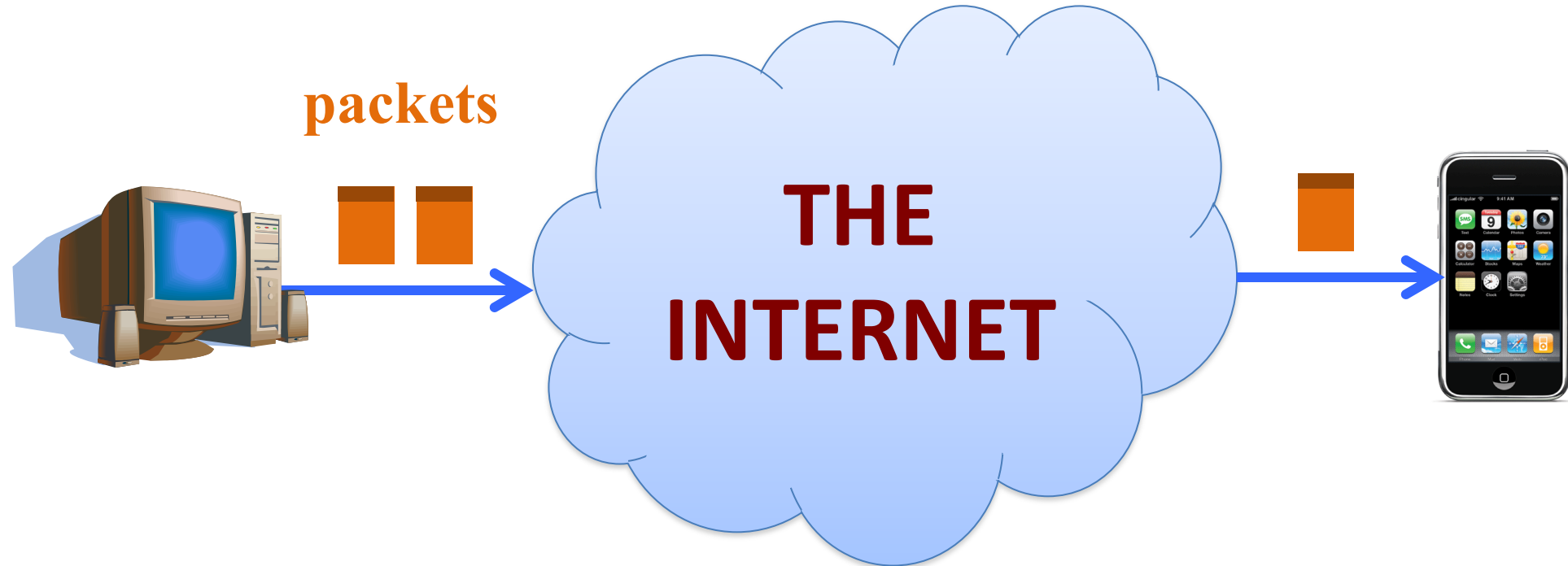
Power at the Edge

End-to-End Principle
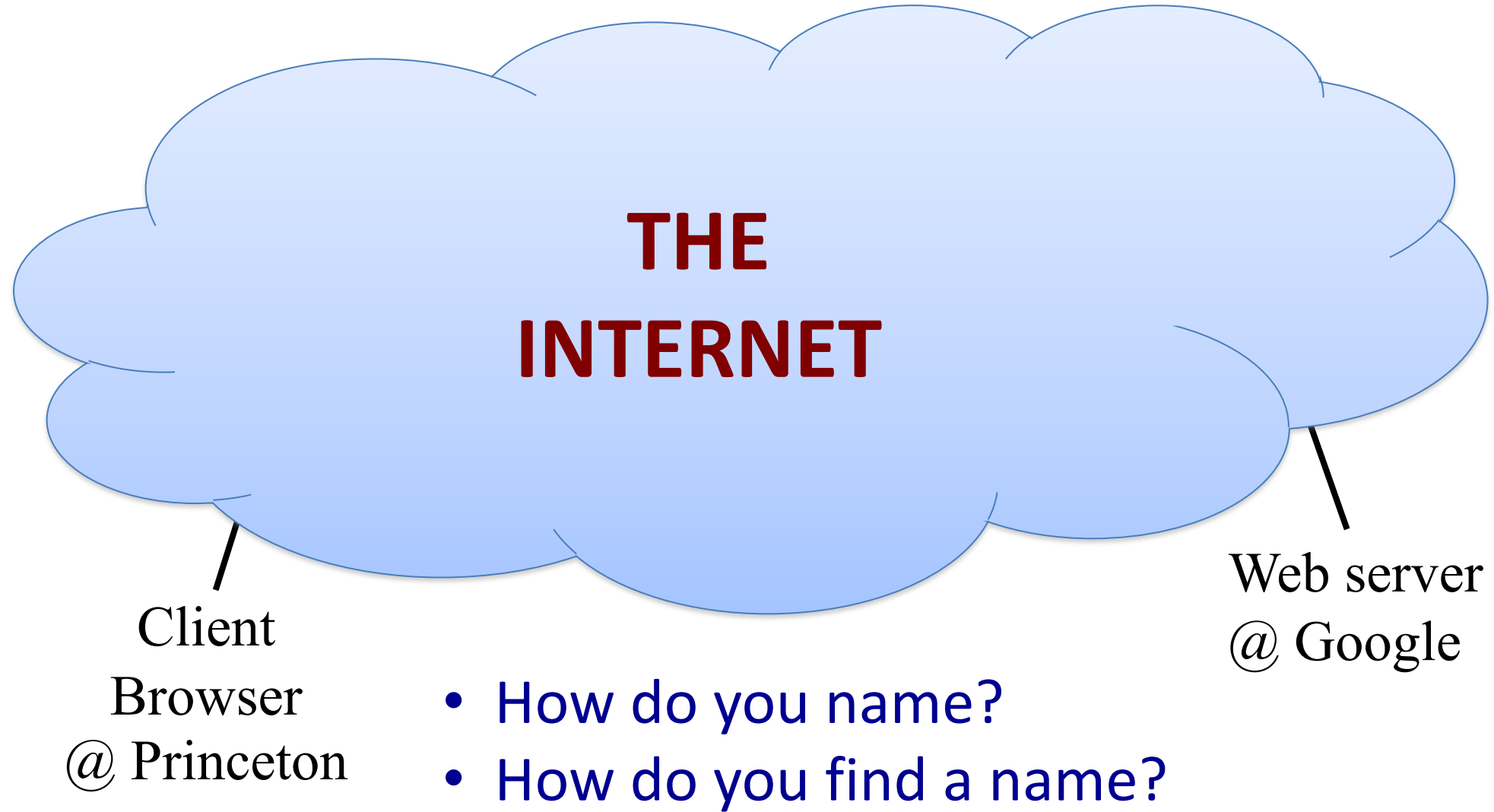Whenever possible, communications protocol operations should be defined to occur at the end-points of a communications system.

Programmability
With programmable end hosts, new network services can be added at any time, by anyone.

And end hosts became powerful and ubiquitous....

"A Network of Networks"

THE INTERNET

Client
Browser
@ Princeton

Web server
@ Google

- How do you name?
- How do you find a name?

Announcing a Route

Client
Browser
@ Princeton

Web server
@ Google

"Princeton is in this direction"

Forwarding Traffic

Client
Browser
@ Princeton

Web server
@ Google
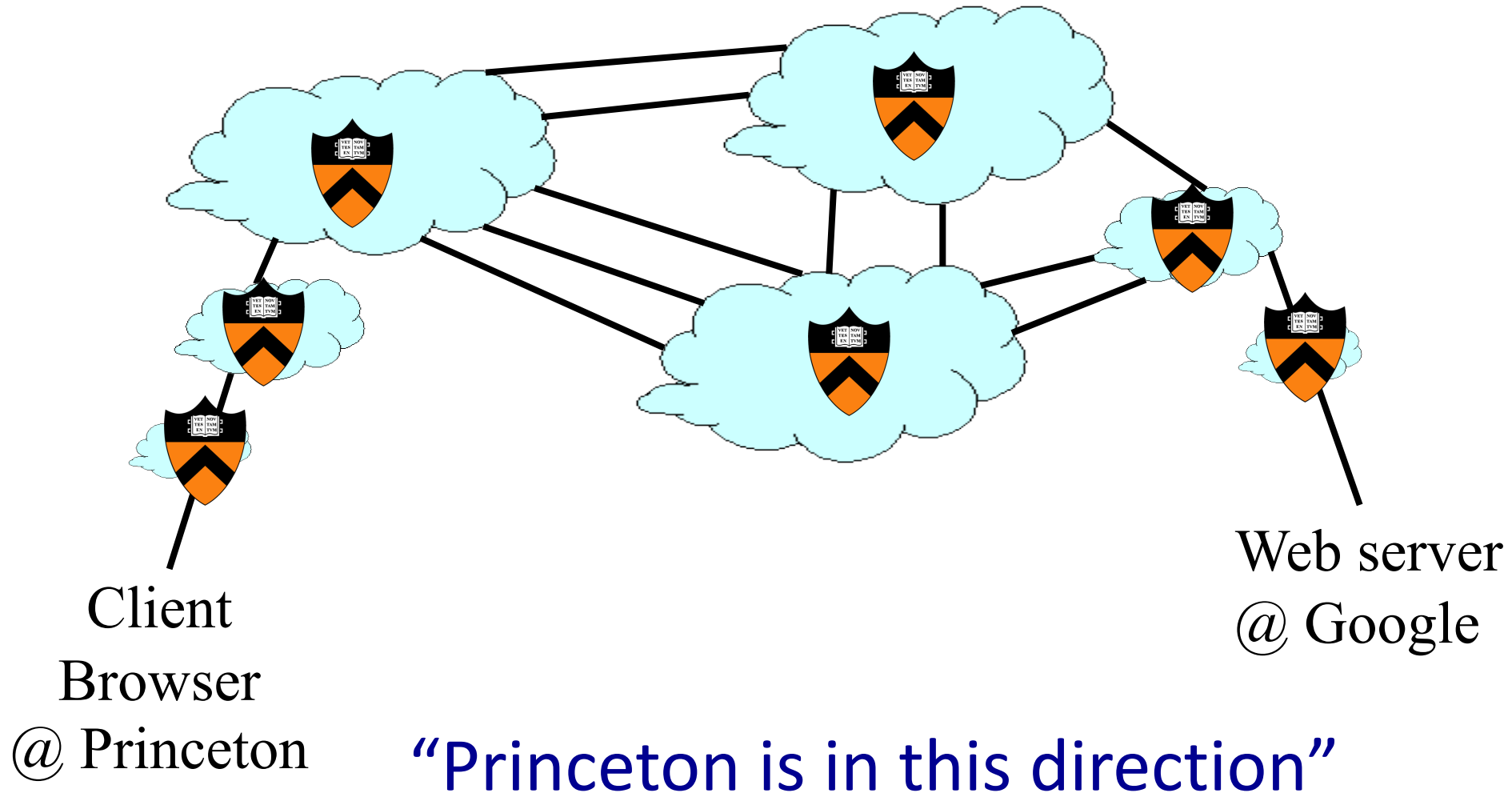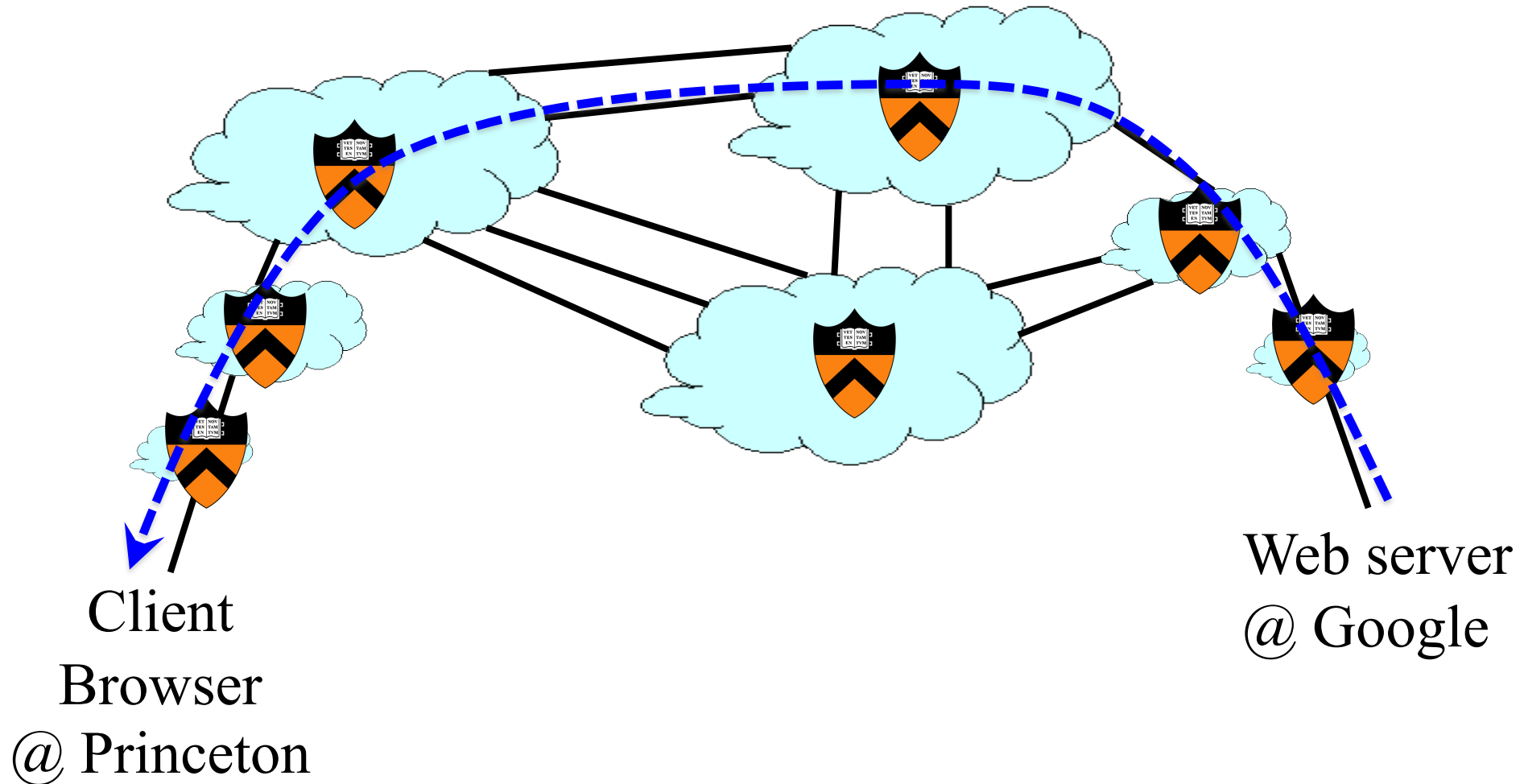
Withdrawing a traffic route

Client
Browser
@ Princeton

Web server
@ Google

???

"Princeton is NOT in this direction"

renesys | blog
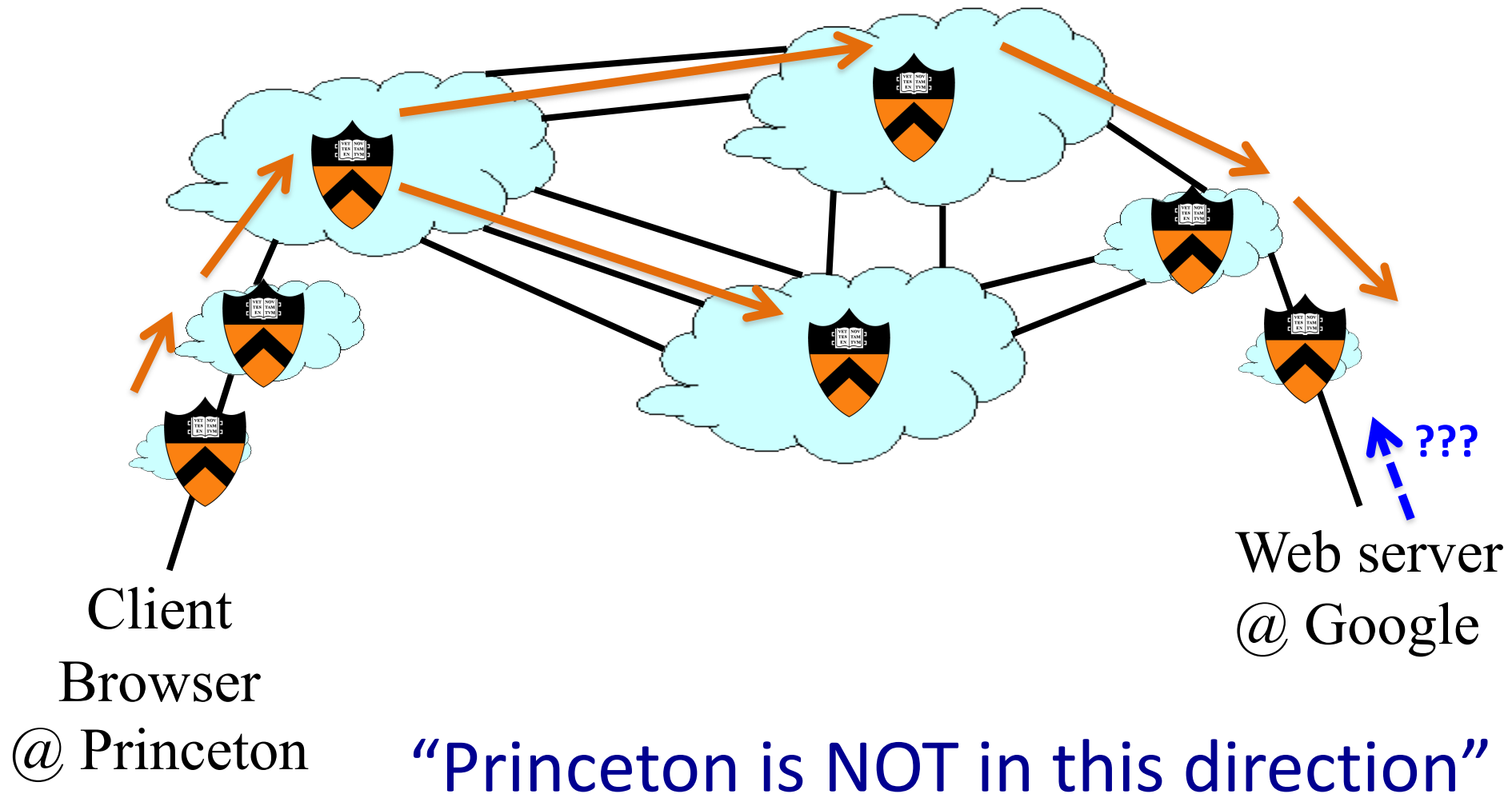
Egypt Leaves the Internet

By James Cowie on January 27, 2011 7:56 PM

At 22:34 UTC (00:34am local time), Renesys observed the virtually simultaneous withdrawal of all routes to Egyptian networks in the Internet's global routing table. Approximately 3,500 individual BGP routes were withdrawn, leaving no valid paths by which the rest of the world could continue to exchange Internet traffic with Egypt's service providers. Virtually all of Egypt's Internet addresses are now unreachable, worldwide.

Withdrawn Egyptian Prefixes (Jan 2011)

Jan 27, 2011
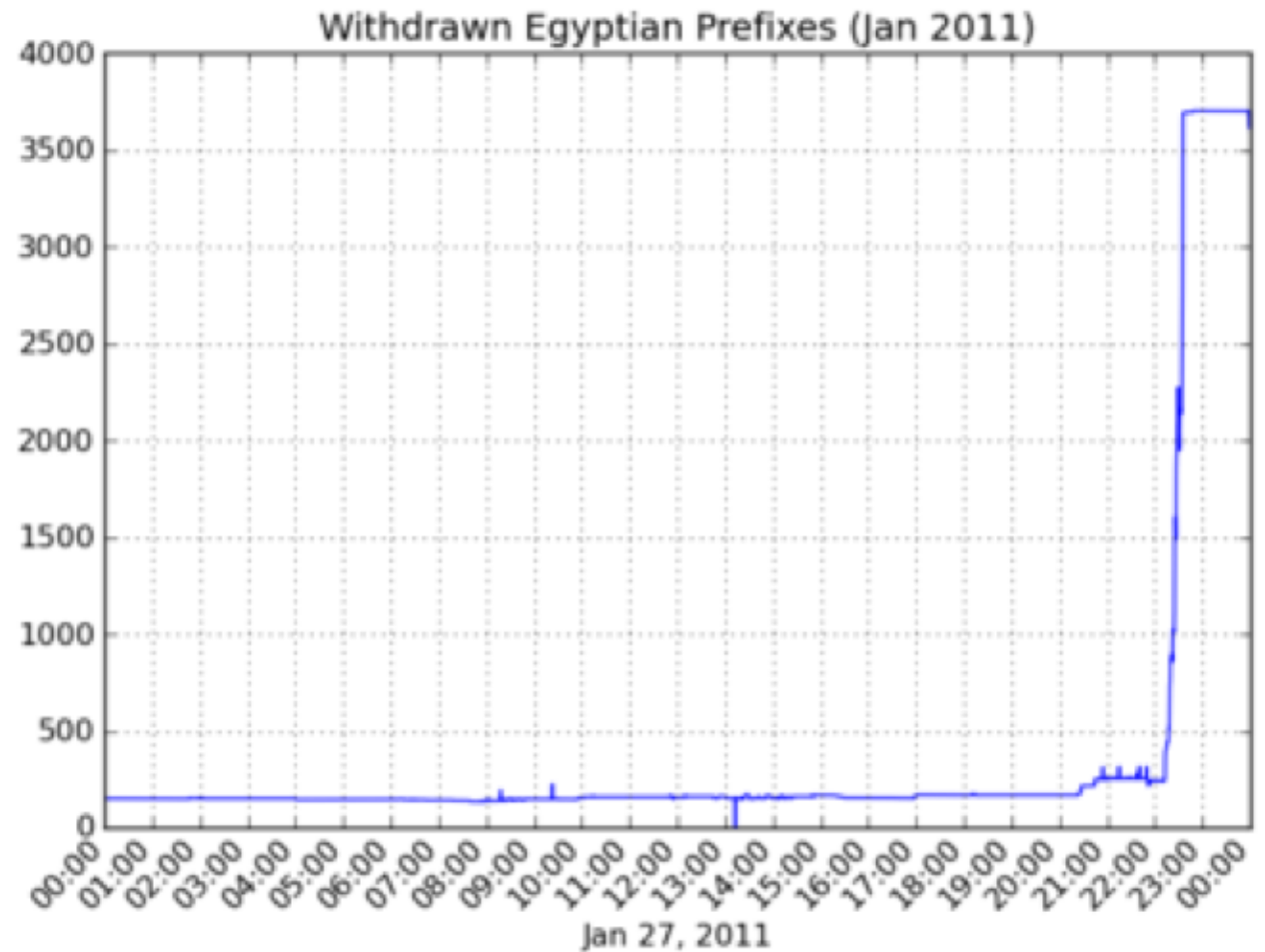
Central concepts in networking

Abstraction through Protocol Layering

- **Layers partition the system**

  – Each layer solely relies on services from layer below

  – Each layer solely exports services to layer above

- **Interface between layers defines interaction**

  – Hides implementation details

  – Layers can change without disturbing other layers

| Application |
| Application-to-application channels |
| Host-to-host connectivity |
| Link hardware |
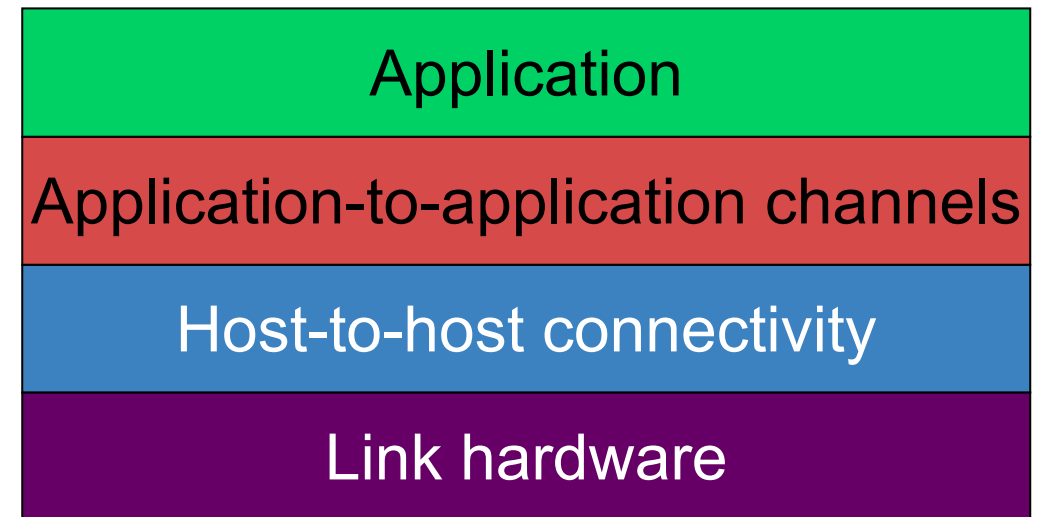
The Internet Protocol Suite
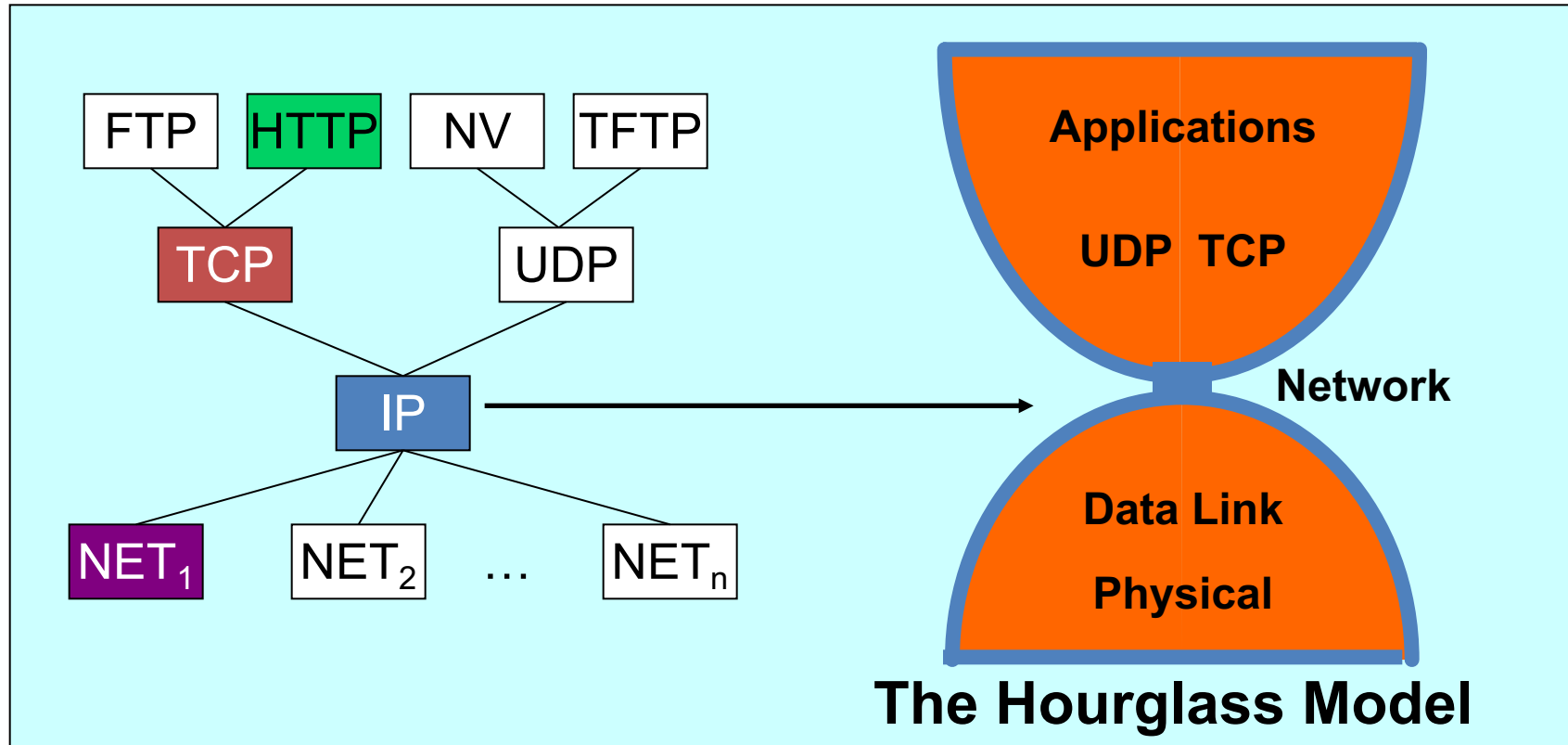
The thin Network layer facilitates **interoperability**

Application: HyperText Transfer Protocol

GET /courses/archive/spr20/cos461/ HTTP/1.1
Host: www.cs.princeton.edu
User-Agent: Mozilla/4.03
CRLF

Request

Response

HTTP/1.1 200 OK
Date: Mon, 4 Feb 2013 11:09:03 GMT
Server: Netscape-Enterprise/3.5.1
Last-Modified: Mon, 2 Feb 2013 19:12:23 GMT
Content-Length: 21
CRLF
Site under construction

Layer Encapsulation in HTTP
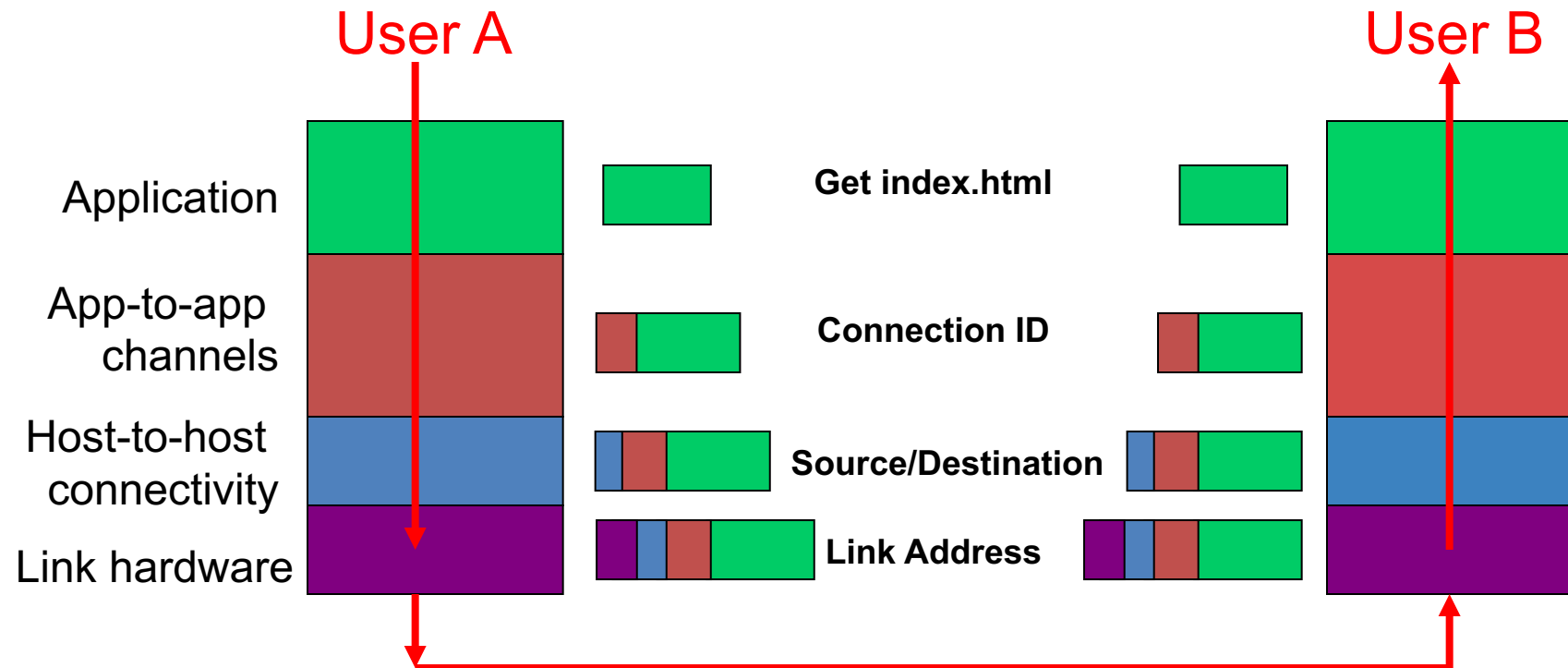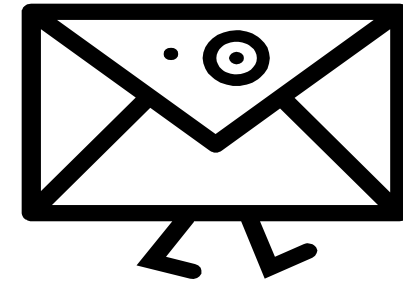
End Hosts vs. Routers
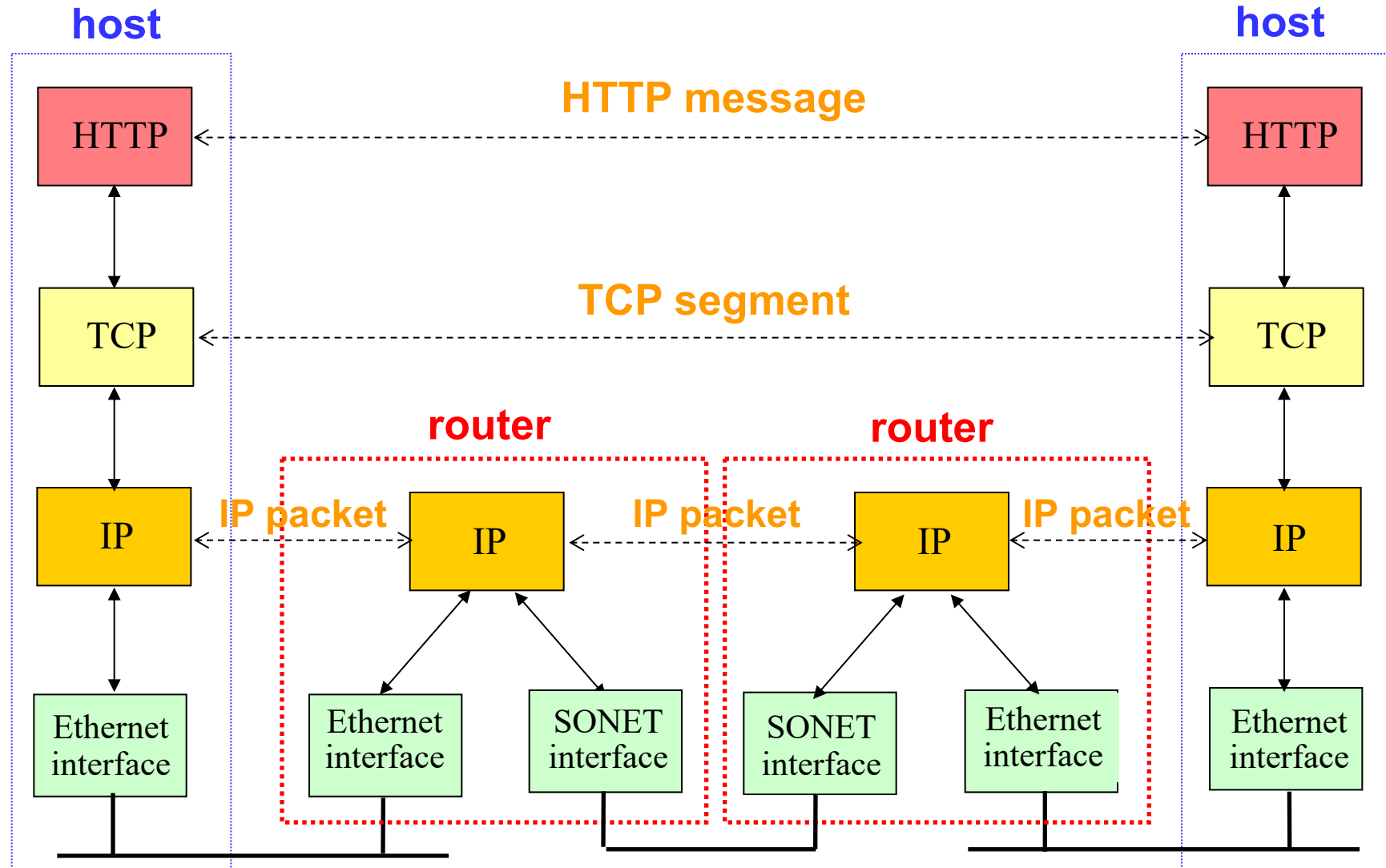
Socket and Process Communication
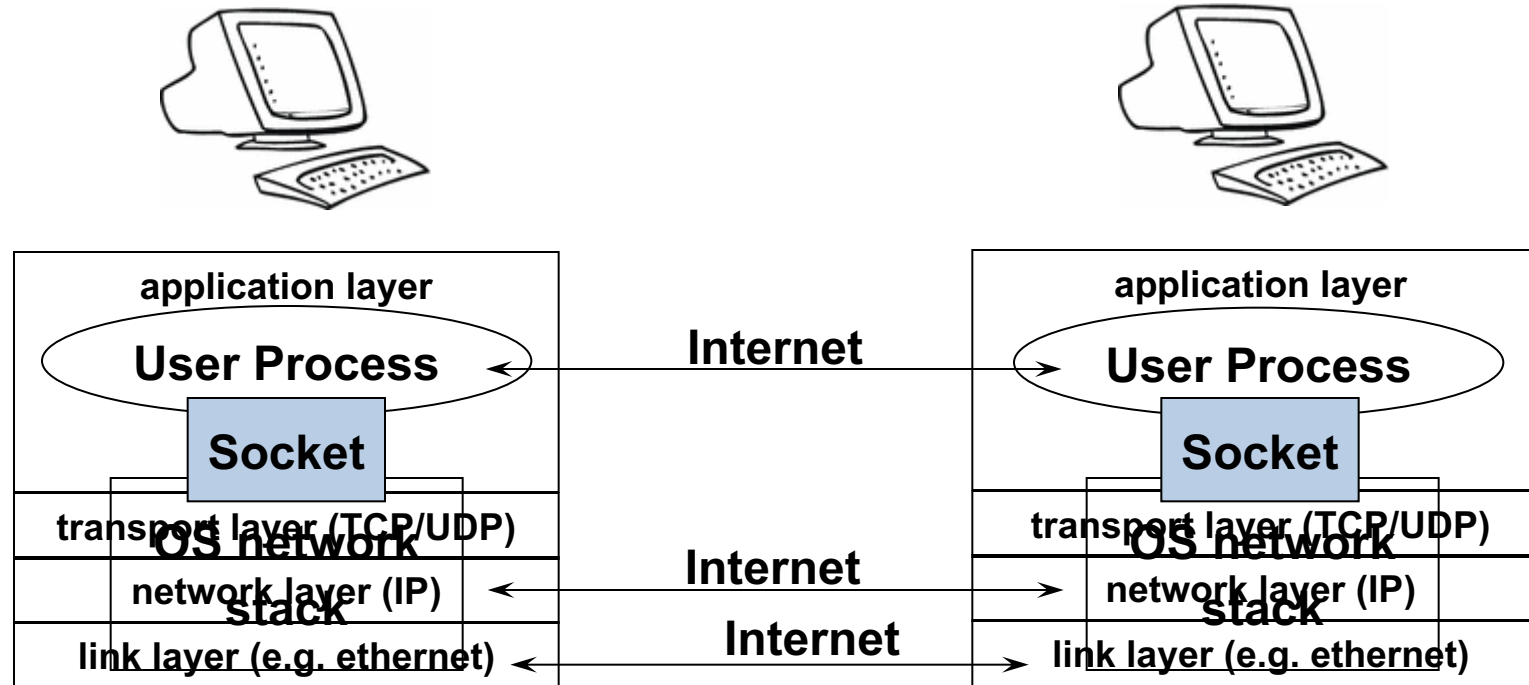
The interface that the OS provides to its networking subsystem

Socket and Process Communication

- Receiving host
  - Destination **address** that uniquely identifies host
  - **IP address**: 32-bit quantity ("1.2.3.4")

- Receiving socket
  - Host may be running many different processes
  - Destination **port** that uniquely identifies socket
  - **Port number:** 16-bits ("80")
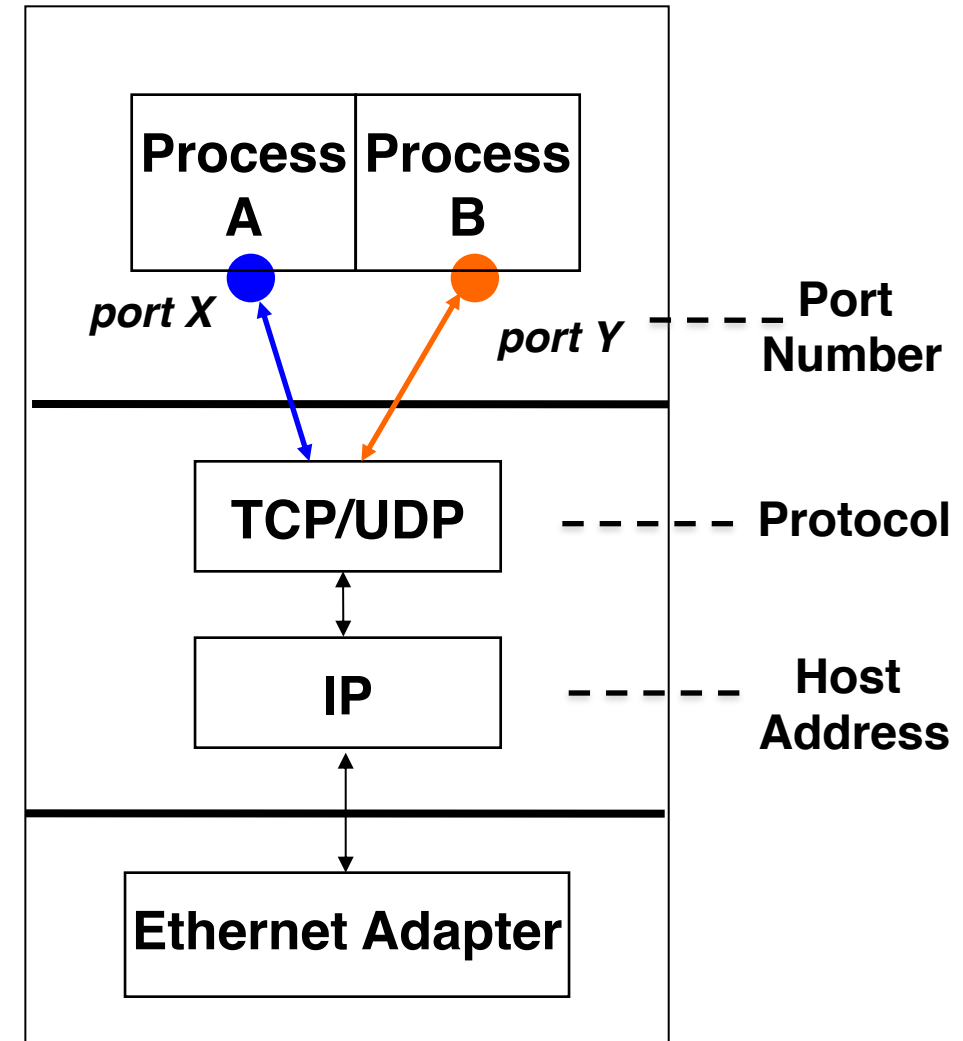
Key Concepts in Networking

- Naming
  - What to call computers, services, protocols, …
- Layering
  - Abstraction is the key to managing complexity
- Protocols
  - Speaking the same language
  - Syntax and semantics
- Resource allocation
  - Dividing scare resources among competing parties
  - Memory, link bandwidth, wireless spectrum, paths

Mentimeter: Quick Surveys

Topic: Growth/innovation vs. create/exacerbate tensions

- Does Internet design prevent misuse?

  1. Individual endpoints can only use addresses given to them when connect to the network

  2. Individual end-points can "spoof" any IP address

Mentimeter: Quick Surveys

Topic: Growth/innovation vs. create/exacerbate tensions

Networks are assigned unique IP address blocks from a central authority ("IANA"): Princeton has 128.112.*

- Which of the following is true:

1. Network can only announce assigned addresses

2. Networks can spoof any address

Mentimeter: Quick Surveys

Topic: Growth/innovation vs. create/exacerbate tensions

- Does the *Internet* provide reliable packet delivery?

  1. Yes, that's necessary for protocols like HTTP that require in-order streams

  2. No, packets may be arbitrary dropped or reordered

461, 561: Class Summary

461: What You Learn in This Course

- **Knowledge:** how the Internet works, and why
  - Protocol stack: link, network, transport, application
  - Resource allocation: congestion control, routing
  - Applications: Web, P2P, …
  - Networks: enterprise, cloud, backbone, wireless, …

- **Insight:** key concepts in networking
  - Naming, layering, protocols, resource allocation, …

- **Skill:** network programming
  - Many nodes are general-purpose computers
  - Can innovate and develop new uses of networks

561: What You Learn in This Course

- **Knowledge:** how the Internet works, and why

- **Insight:** key concepts and state of the art in networking
  - Naming, layering, protocols, resource allocation, …

  - Discuss classic & state of the art networking research papers, in depth. Tied to lecture topics in 461

- ~~Skill: network programming~~

- **Skill:** network research
  - Semester systems-building/research project, in groups
  - Reproduce a result (more common), or build a novel project

Course Organization: 461, 561

Learning the Material: 461 People

- ## Lectures: Prof. Kyle Jamieson
  - Tues/Thurs 10:00 – 10:50 AM

  - Slides and video media available online at course Web site

- ## TAs: Ryan Amos, Kun Woo Cho, Abhishek Kumar, Fan Yi

- ## Main Q&A forum: Ed Discussions
  - Setting expectation: TAs will monitor/respond to questions 1-2 times per day in a burst of activity

Learning the Material: 561 People

- Precepts: Prof. Jennifer Rexford
  - Fri 10am, 11am, and 1:30pm

- TAs: Mary Hogan and Srikar Kasi

- Main Q&A forum: Piazza
  - Setting expectation: TAs will monitor/respond to questions 1-2 times per day in a burst of activity

Learning the Material: 461 & 561 Lectures! (primary)

- Lectures: TR 10:00 – 10:50

- **Both 461 AND 561** attend lectures, participate in Q&A
  - Bit-sized lecture topic videos and slides posted day/night before, for those in other time zones
  - Recommendation: print slides and take notes
  - Not everything covered in class is on slides
  - You are responsible for everything covered in class

Learning the Material: Precepts

- 461 precepts focus on programming assignments
  - Led by TAs

- 561 precepts discuss papers in depth
  - Precept attendance critical
  - Let instructor know if you must miss, accomodations made
  - Zoom precepts, mute yourself if you're not speaking, video if ok with you, set your Zoom name

Learning the Material: Books (secondary)

- ## Main textbook
  - *Computer Networks: A Systems Approach*, by Peterson and Davie
  - Also online: https://book.systemsapproach.org/

- ## Additional books (may be of interest)
  - Networking textbooks
    - *Computer Networking: A Top-Down Approach Featuring the Internet*, by Kurose and Ross
    - *Computer Networks*, by Tanenbaum
  - Network programming references
    - *TCP/IP Illustrated, Volume 1: The Protocols*, by Stevens
    - *Unix Network Programming, Vol 1: Sockets Networking API*, by Stevens, Fenner, & Rudolf

Grading in **UG COS 461**

- ## Five assignments (50% total)
  - 90% 24 hours late, 80% 2 days late, 50% >5 days late
  - **Three** free late days (we'll figure which one is best)
  - Only failing grades I've given are for students who don't / try to do assignments

- ## Two at-home midterm exams (45% total)

  - Midterm 1 exam (20%)
  - Midterm 2 exam (25%)

- ## Class participation (precept, 5%)

Grading in **Graduate-Level COS 561**

- Semester Project (40% total)

- Two at-home midterm exams (45% total)
  - Midterm 1 exam (15%)
  - Midterm 2 exam (15%)

- Class participation (precept, 30%)

Policy: Write Your Own Code

Programming is an individual creative process. At first, discussions with friends is fine. When writing code, unless stated otherwise, the program must be your own work.

Do not copy another person's programs, comments, or any part of submitted assignment. This includes character-by-character transliteration but also derivative works. Cannot use another's code, etc. even while "citing" them.

Writing code for use by another or using another's code is academic fraud in context of coursework.

Do not publish your code e.g., on github, during/after course!

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Don't Plagiarize!

Setting Expectations:
Don't expect 24x7 answers

- Try to figure out yourself

- Forums are not for debugging
  - Utilize right venue: Go to TA office hours
  - Send detailed Q's / bug reports, not "no idea what's wrong"

- Instructors are not on pager duty 24 x 7
  - Don't expect response before next business day
  - Questions Friday night @ 11pm should not expect fast responses. Be happy with something before Monday.

- Implications
  - Students should answer each other; start your assignments early!