

# **EECS 489**

# **Computer Networks**

**Fall 2019**

Mosharaf Chowdhury

*Material with thanks to Aditya Akella, Sugih Jamin, Philip Levis, Sylvia Ratnasamy, Peter Steenkiste, and many other colleagues.*

# Agenda

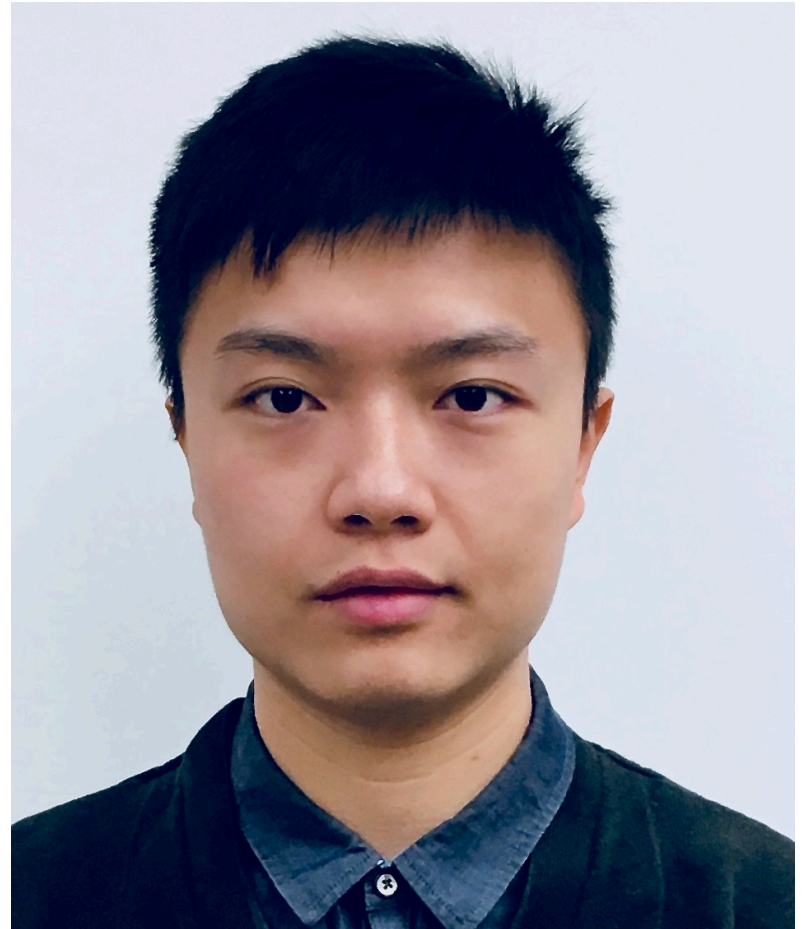
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- Introductions
- What is (this course on) networking about?
- Class policies, logistics, and roadmap

# GSI: Leonard Lin

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- PhD student in EECS
- Office hours: See course webpage
- No office hours or discussions this week



# GSI: Joseph Buiteweg

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- Master's student in EECS
- Office hours: See course webpage
- No office hours or discussions this week



# Mosharaf Chowdhury

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- Ph.D. in Computer Science from Berkeley in 2015
- On the Michigan faculty since 2016
- Research focus on application-infrastructure symbiosis in large-scale networked systems
- Office hours: Wednesday 2PM – 4PM in 4820 BBB, starting from **September 11\***
  - Also, by appointment (pre-scheduled via email)

# My teaching style

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- Third-time teaching an undergraduate course!
  - I'm *still* learning!
  - I will listen to (constructive) feedback
    - » “*Speak faster/s-l-o-w-e-r/LOUDER*”
    - » “*Pace is too fast/too s-l-o-w*”
    - » “*I’m falling asleep...*”
  - Interrupt me as needed
- For the first time, **all lectures will be recorded**

# 489 in EECS curriculum

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- **EECS 281**

- High-level logic  $\Rightarrow$  Programs
- Coding skills learned in 281 are critical for 489 assignments

- **EECS 482**

- How do machines work?
- Execute programs, interact with users, etc.
- Some concepts of 482 may be useful, but are optional

# What is missing?

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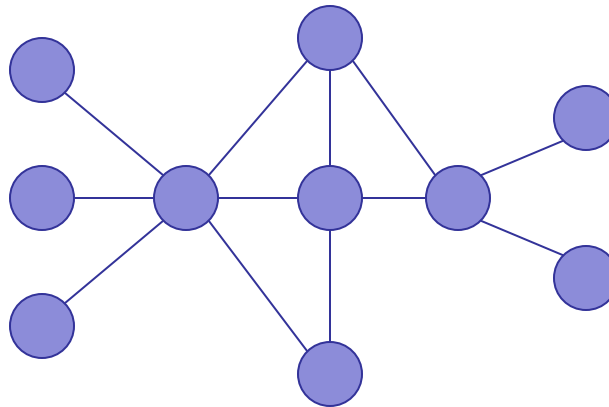
- How do we access *most* services?
  - Examples include search engines, social networks, video streaming, etc.
- How do two machines communicate?
  - When they are directly connected
  - When they are not directly connected
- Using a network



# What is a network?

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- A system of “links” that interconnect “nodes” in order to move “information” between nodes



- Yes, this is very vague

# There are many different types of networks

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- Internet
- Telephone network
- Transportation networks
- Wireless networks
- Optical networks
- Datacenter networks

We will focus primarily on *the Internet*

# The Internet is transforming everything

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- The way we do business
  - E-commerce, advertising, cloud-computing
- The way we have relationships
  - Facebook friends, E-mail, IM, virtual worlds
- The way we learn
  - Wikipedia, MOOCs, search engines
- The way we govern and view law
  - E-voting, censorship, copyright, cyber-attacks

# The Internet consists of many end-systems

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● ● ● car navigator

● heart pacemaker

smartphone ●

end-system



iPad



● Linux server

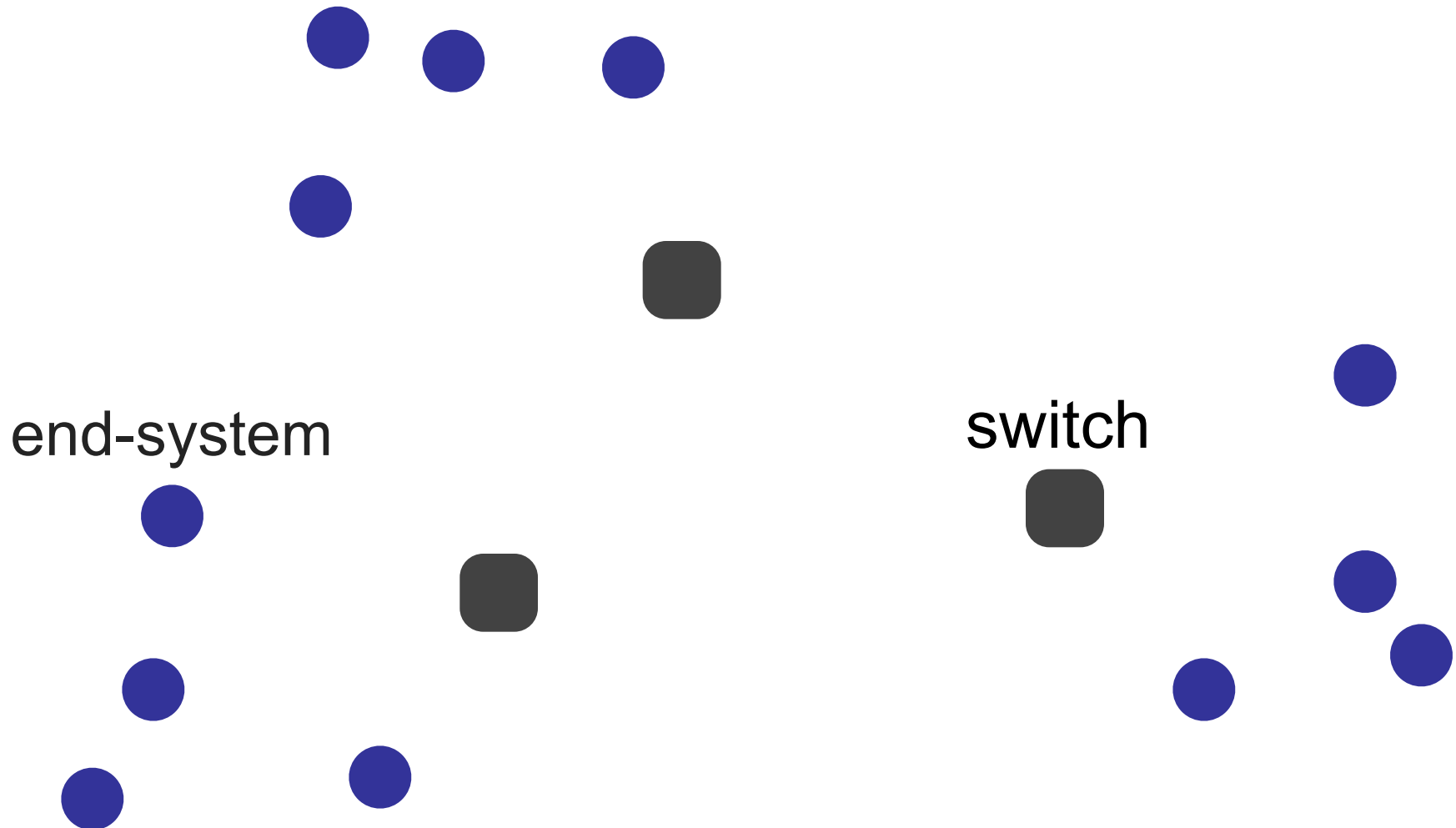
MAC laptop ●



Windows PC

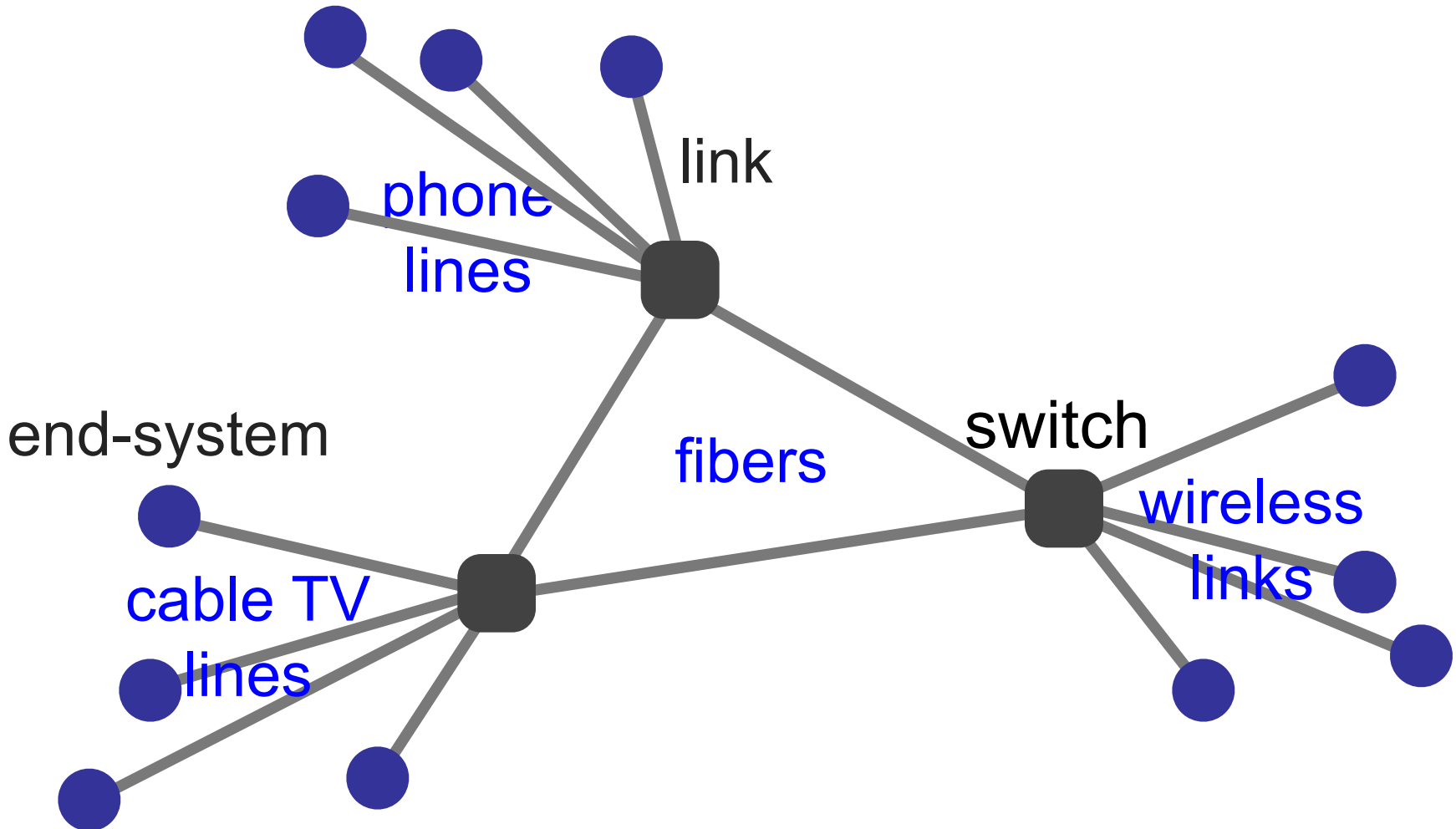
# Connected by switches

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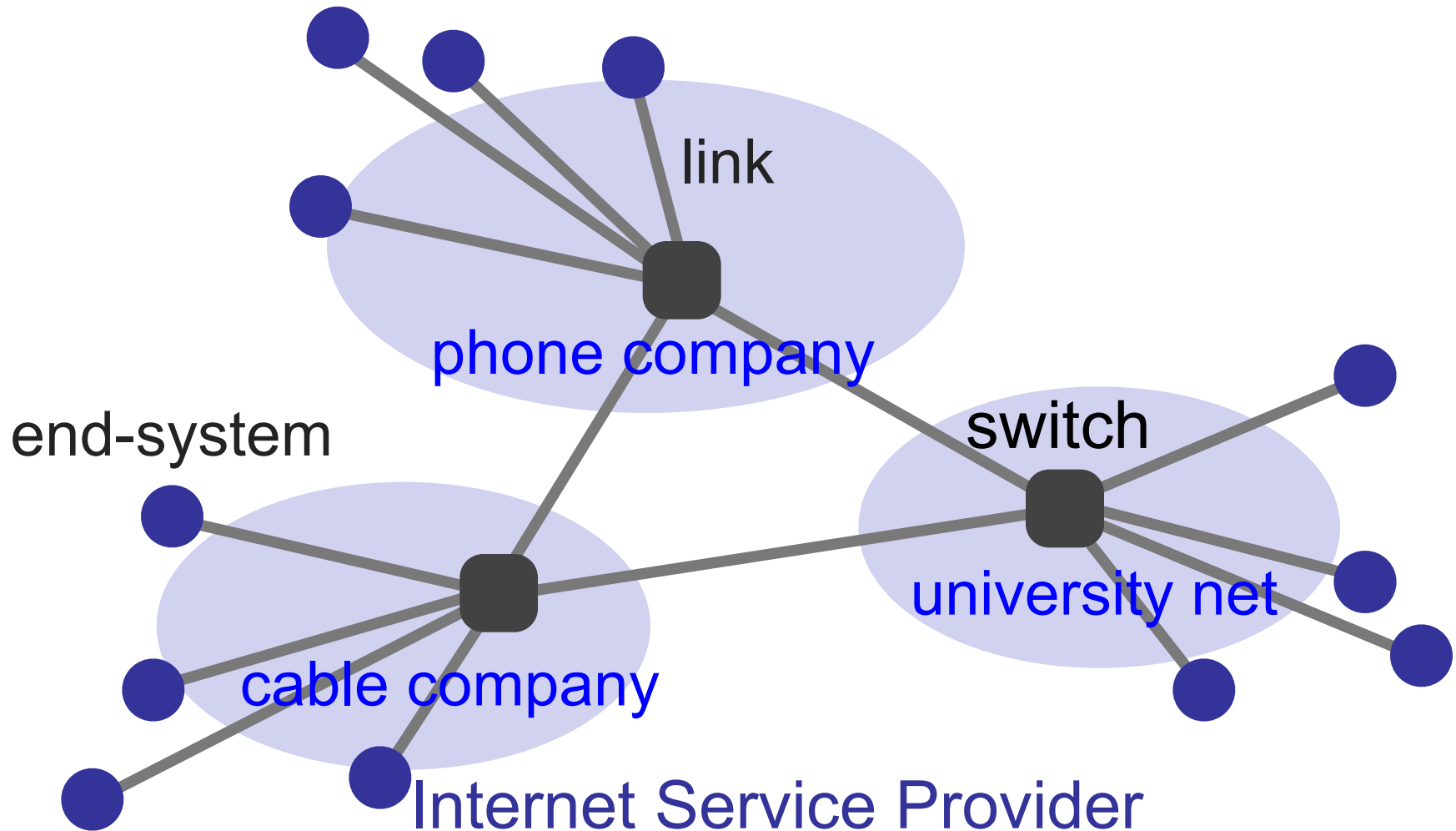
# And links

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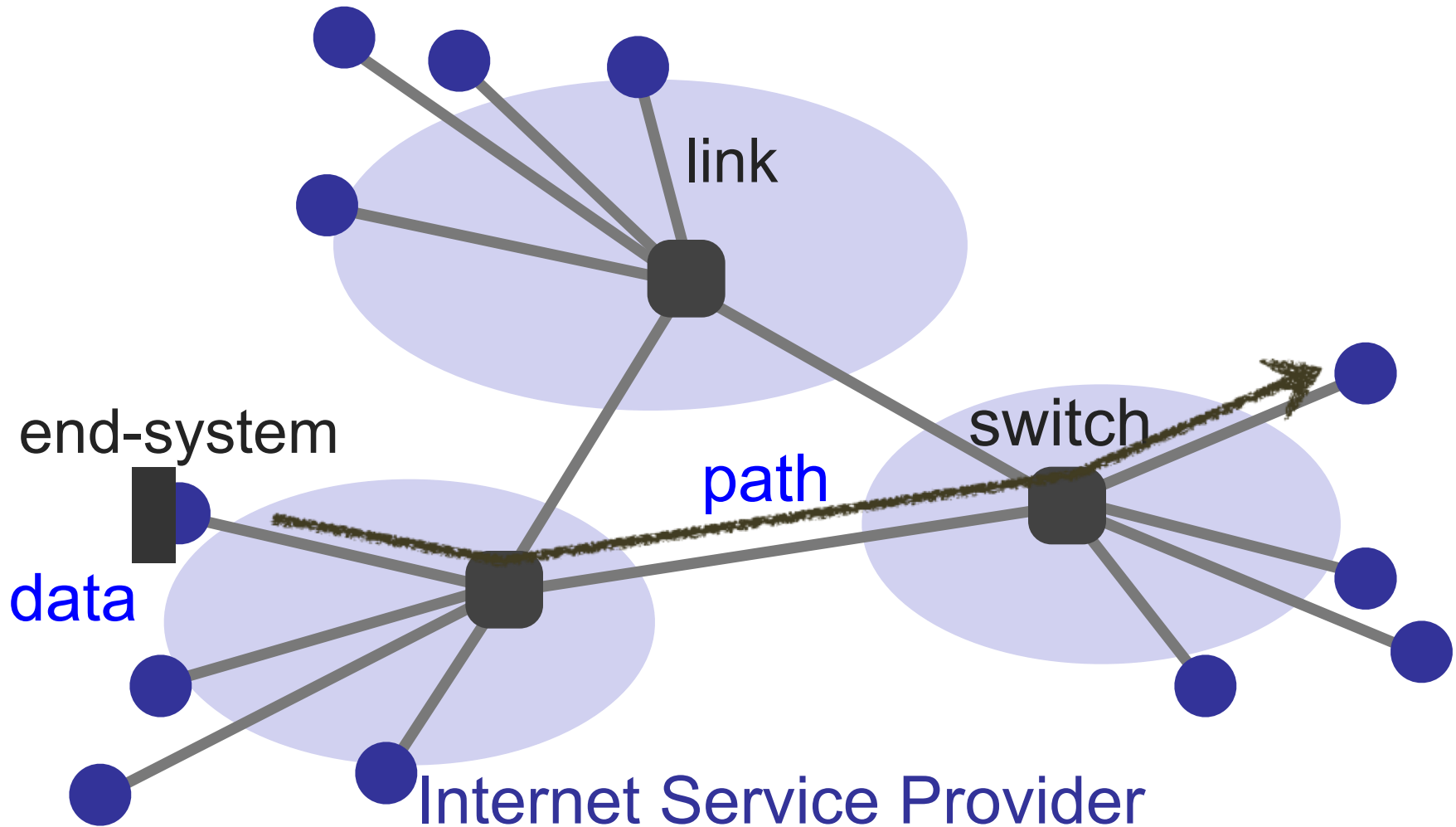


# Managed by many parties

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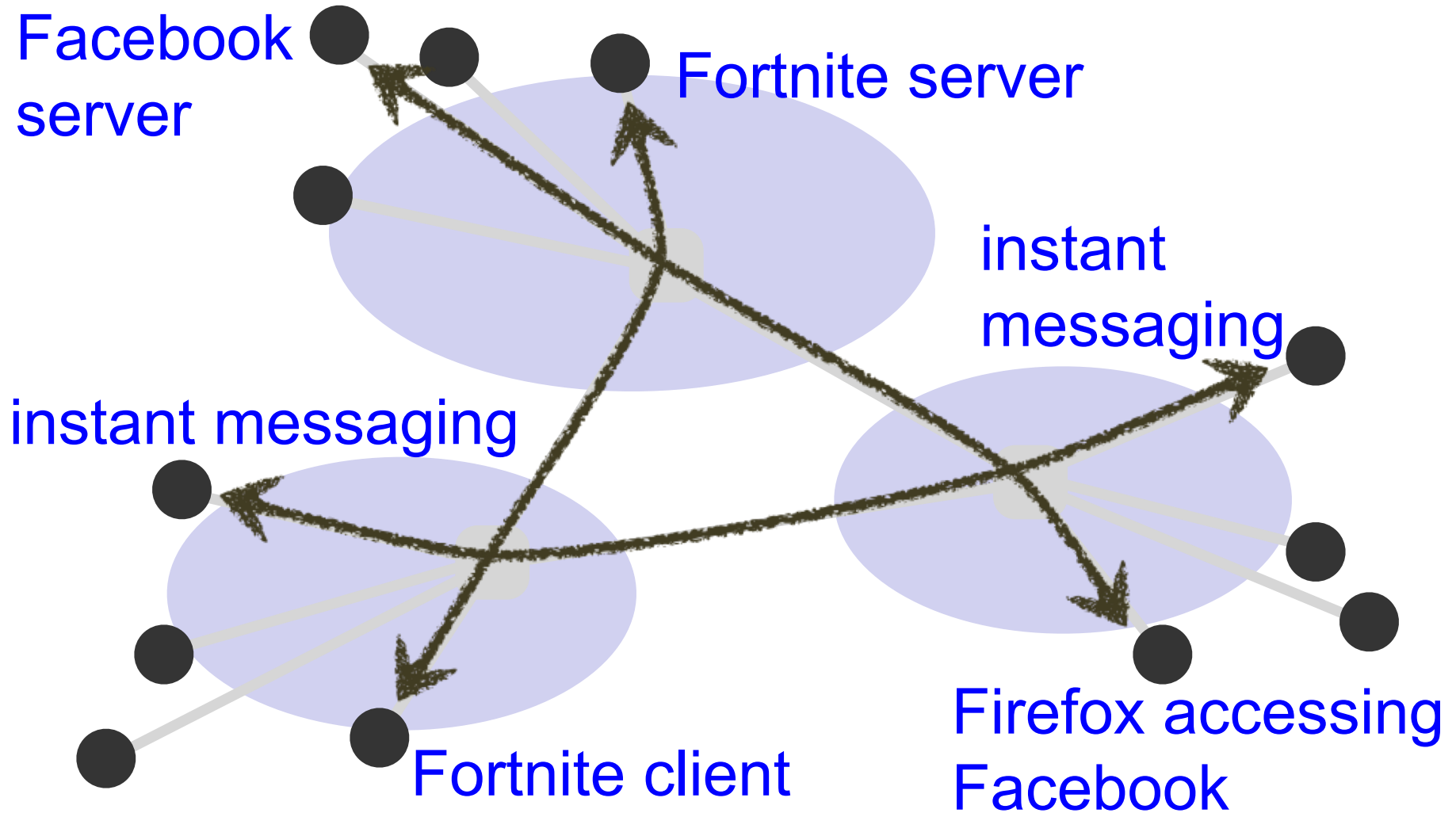


# Transfers data





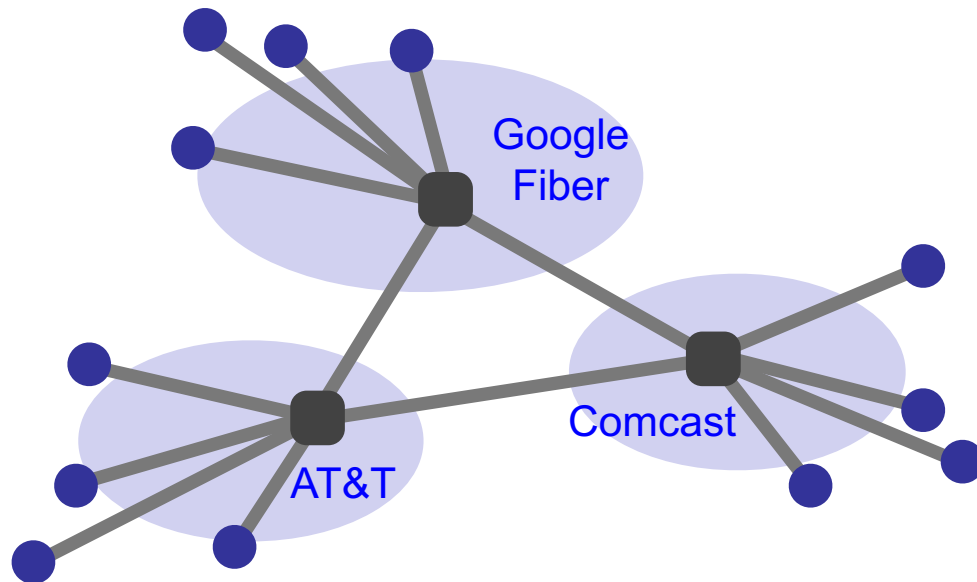
# Shared among many services



# A federated system

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- The Internet ties together different networks **by the IP protocol**
  - *One interface to bind them all together*



# Why a common interface?

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- The Internet ties together different networks
  - ▣ >18,000 ISP networks
- Interoperability between users and networks as well as between different networks

# MASSIVE Scale

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- 4.3 Billion users
- >1.8 Billion websites
- >200 Billion emails sent per day
- >2 Billion smartphones
- >2.4 Billion Facebook users
- >1 Billion hours of YouTube watched per day
- Routers that switch 10 Terabits/second
- Links that carry 100 Gigabits/second

# Diversity in all dimensions

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- Technology
  - Optical, wireless, satellite, copper
- Endpoint devices
  - From wearable devices and cell phones to datacenters and supercomputers
- Applications
  - Video streaming, social networking, file transfer, Skype, live TV, gaming, remote medicine, IM
- Users
  - Malicious, naïve, savvy, embarrassed, paranoid

# The Internet is also

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- Constantly evolving
- Decentralized
  - Many parties with (often conflicting) interests
- Failure-prone
  - Physical errors, logic errors, human errors, etc.
- Constrained by technology
  - Speed of the light is the limit (so far!)

# Have we found the right solution?

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- We don't really know
- What we do know
  - The early Internet pioneers came up with a solution that was successful beyond all imagining
  - Several enduring architectural principles and practices emerged from their work
- Still, it is just one design with many questions

# The Internet is a lesson

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- In how to reason through the design of a very complex system
  - What are our goals and constraints?
  - What's the right prioritization of goals?
  - How do we decompose a problem?
  - Who does what? How?
  - What are the interfaces between components?
  - What are the tradeoffs between design options?



# What is EECS 489 about?

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- To learn about (at a high level)
  - How the Internet works
  - Why it works the way it does
  - How to reason about complicated design problems
- What it's not about
  - How to write web services
  - How to design web pages
  - ...

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**5-MINUTE BREAK!**

# Class workload

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- Four assignments
  - First one is an individual assignment
  - The rest are in groups of 3
- Exams:
  - Midterm: October 21/23 (TBA)
  - Final: December 19 1:30 PM – 3:30 PM (TBA)

# Grading

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	Allocation
Assignment 1	5%
Assignment 2	15%
Assignment 3	15%
Assignment 4	15%
Midterm	25%
Final	25%

# Topics we will cover

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- Basics
  - Packets, circuits, multiplexing, delay, loss, protocols
- How do endpoints/applications use the network
  - DNS, CDN, HTTP, TCP
- What make networks tick
  - IP, routing protocols, BGP
- Lower-level technologies
  - Ethernet, wireless
- Emerging/hot topics
  - Datacenters, management, SDN

# The ALL-NEW\* assignments

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- **Assignment 1:** measure end-to-end throughput and delay of networks (i.e., simple speed test)
- **Assignment 2:** video streaming from CDNs (i.e., simple Netflix)
- **Assignment 3:** reliable transport (i.e., how to transfer data over an unreliable network)
- **Assignment 4:** router design (i.e., how do internal elements of the network work)

All on (emulated) realistic networks using *mininet*

# Optional Textbook

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- Kurose and Ross, **Computer Networking: A Top-Down Approach**, 7<sup>th</sup> Edition, Pearson, 2017. ISBN 978-0133594140.
  - 6<sup>th</sup> Edition is ok, but translate reading assignments
- **You will not be tested on material we didn't cover in lecture or section**
  - Use as a reference and a source of examples

# Enrollment and wait list

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- Class size capped at 146
  - ▣ Room capacity
- Wait-listed students will be admitted in the order of wait list
- If you're planning to drop, please do so soon!



# Communication protocol

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- Course website: <http://mosharaf.com/eecs489/>
  - Assignments, lecture slides
- Piazza for all communication
  - Sign up if you haven't already
  - <https://piazza.com/umich/fall2019/eecs489/>
- Assignment submission via Github
  - Start forming groups
  - Details will be sent out soon

# Policies on late submission, re-grade request, ...

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- Detailed description in the course webpage
- Summary:
  - Assignments must be submitted within deadline to be graded
  - **Three late days** for the **ENTIRE** semester
    - » Use them judiciously
  - You can submit requests to re-grade exams or assignments, but the entire exam will be re-graded and may cost you

# Policies on cheating

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- Just DON'T
  - ▣ We had four cases last fall, and the outcome was unpleasant for everyone involved ☹

# Participation

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- Ask and answer questions!!
  - It helps you understand and others too
  - It helps you stay awake
  - It helps me stay awake
- Sit toward the front
  - Electronic-free zone
- In general, limit electronic use for ~80 minutes
  - You will have a 5 minute break in the middle to get online

# Summary

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- Learning about the Internet and networking in general is
  - important and relevant
  - lots of fun – challenging real-world problems
- Next lecture
  - Read 1.1 and 1.3 of K&R
- No discussion and office hours this week