EECS 489
Computer Networks

Winter 2017

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

Agenda

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

GSI: Nitish Paradkar

- Graduate student in EECS
- Interested in all things networking

- Office hours: See course webpage

Mosharaf Chowdhury

- 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 **January 11**
  - Also, by appointment (pre-scheduled via email)

My Teaching Style

- First-time teaching an undergraduate course!
  - I will be learning on the job
  - 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…"*

489 in EECS curriculum

- 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.
  - Many concepts of 482 will be useful

What is missing?

- 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?

- A system of "links" that interconnect "nodes" in order to move "information" between nodes
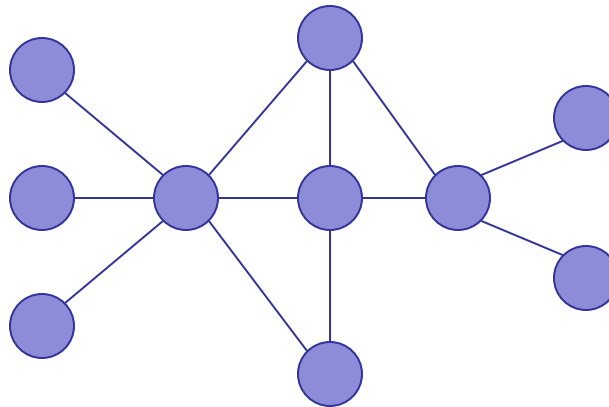
- Yes, this is very vague

There are many different types of networks

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

We will focus primarily on *the Internet*

The Internet is transforming everything

- 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

car navigator

heart pacemaker

smartphone

end-system

iPad

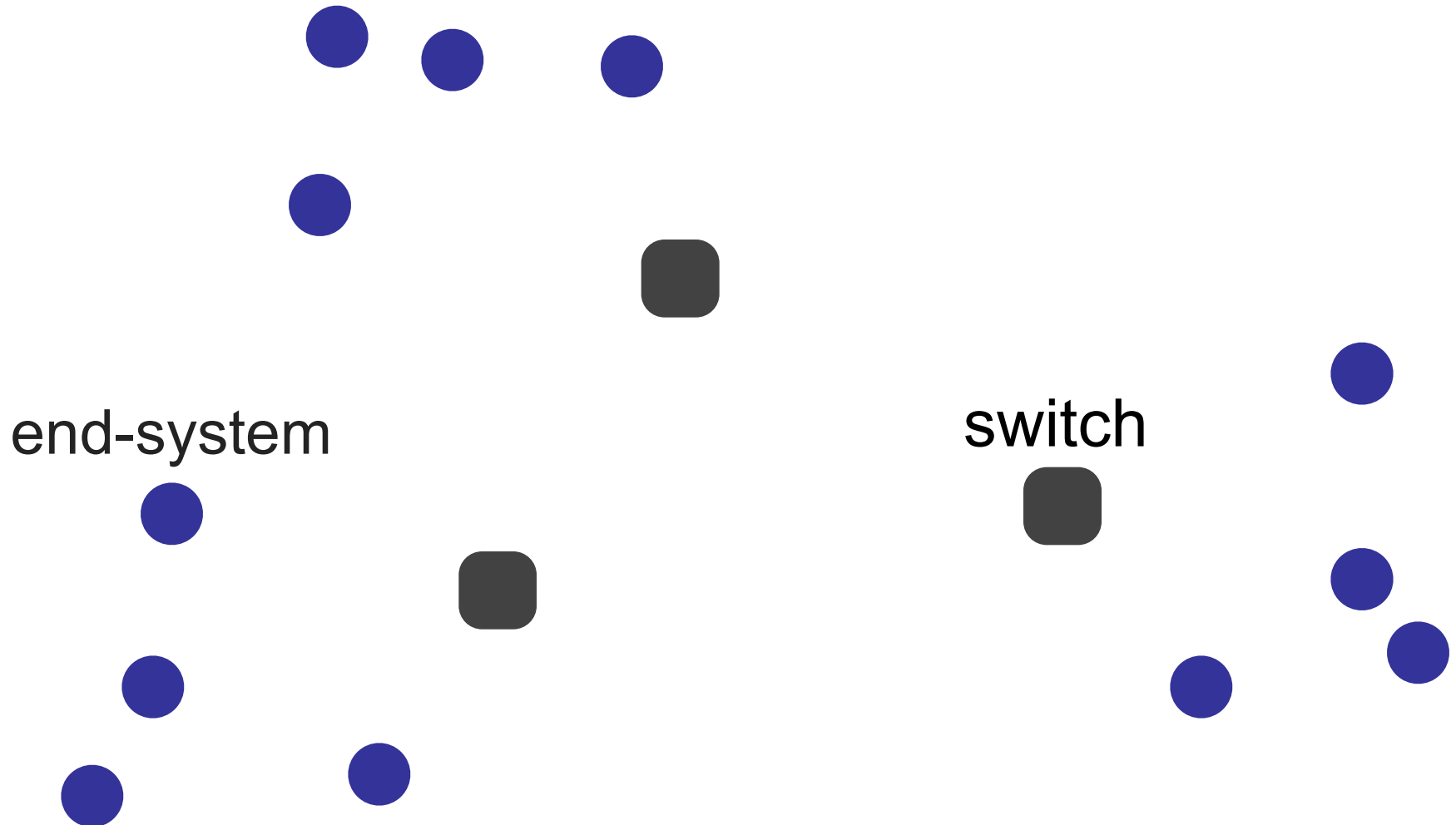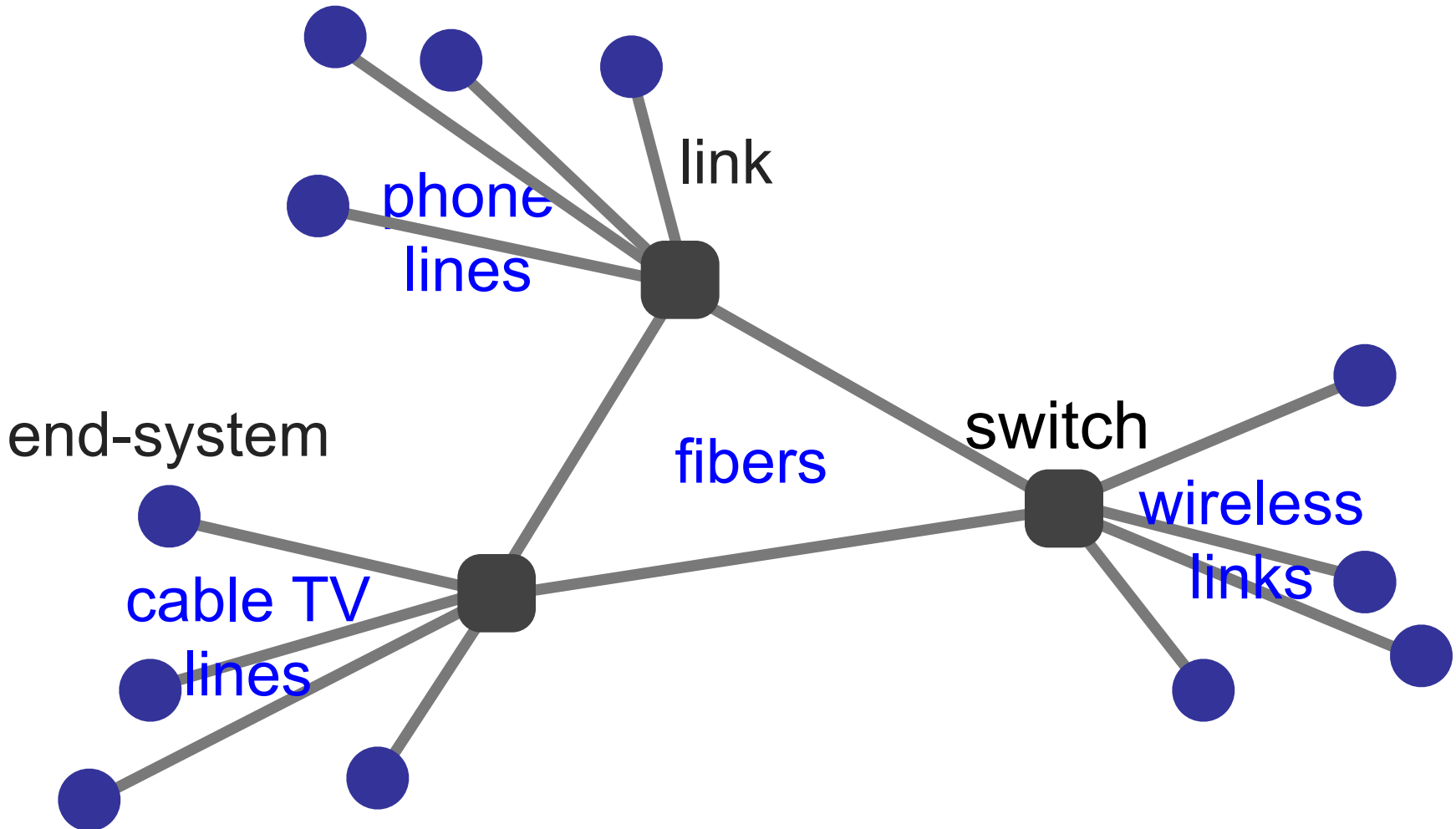Linux server

MAC laptop

Windows PC

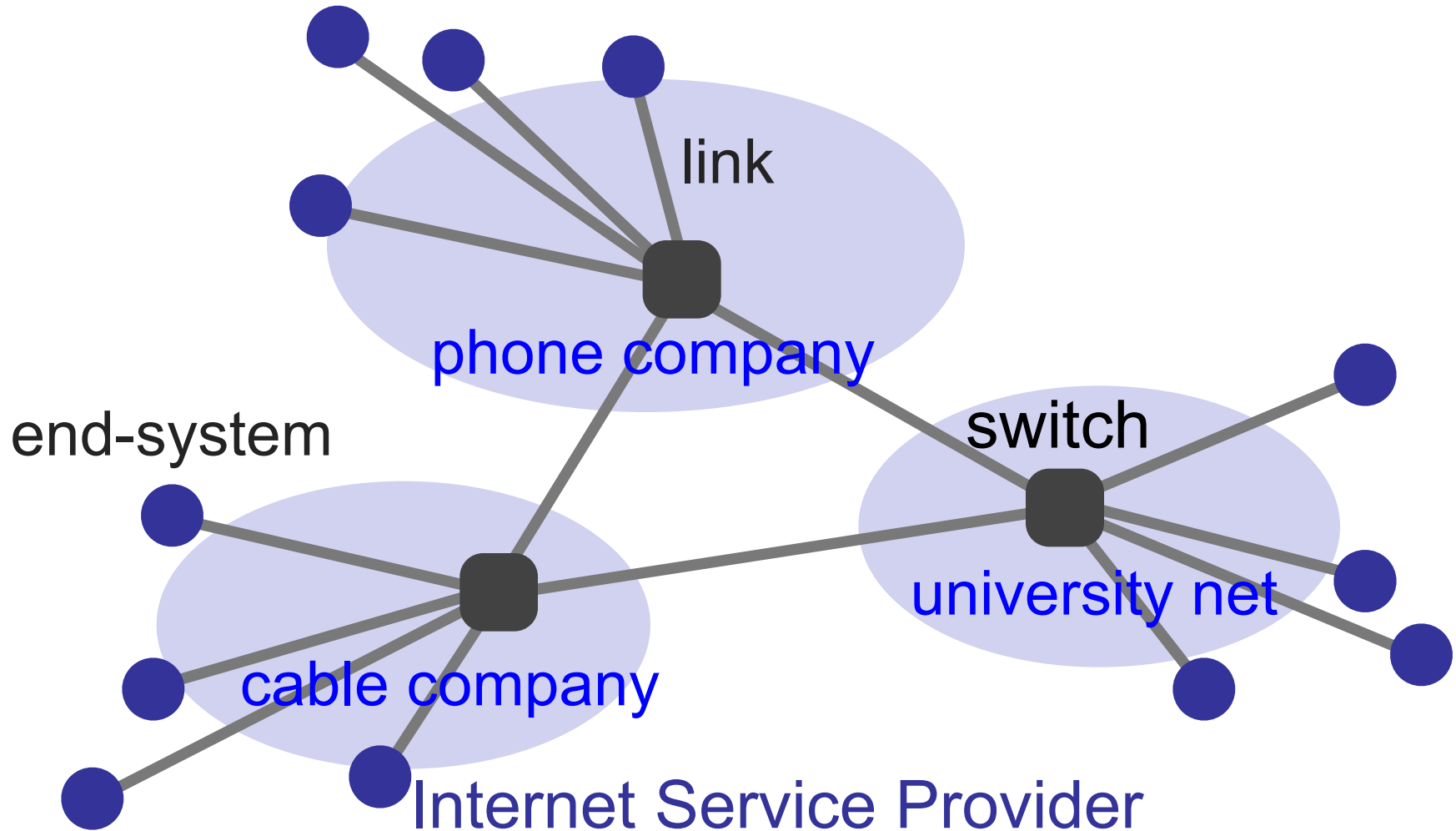# Connected by switches

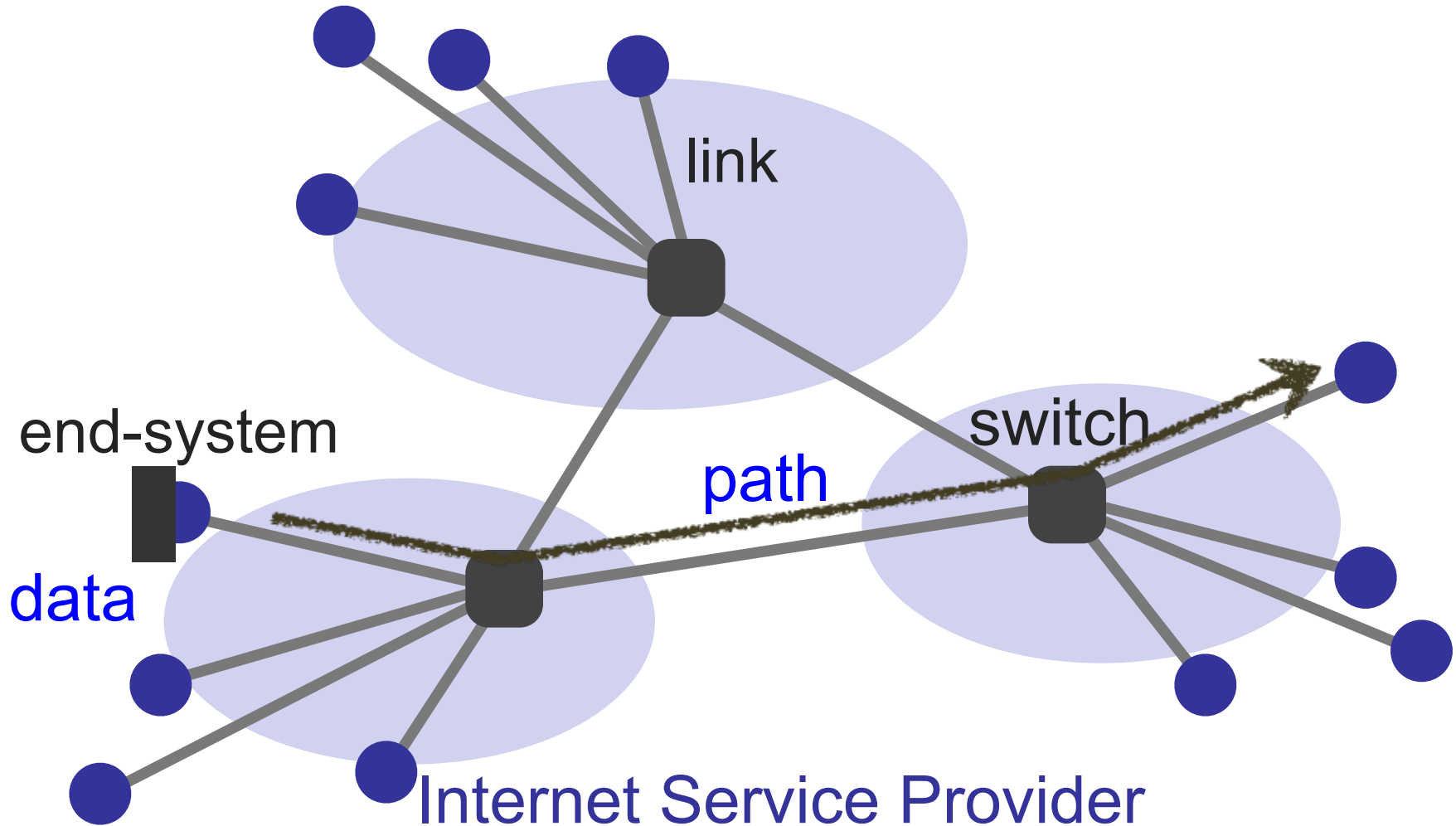end-system

switch

And links

link

phone
lines

end-system

fibers

switch

wireless
links

cable TV
lines

Managed by many parties

link

phone company

end-system

switch

university net

cable company

Internet Service Provider

Transfers data

link

end-system

switch

path

data

Internet Service Provider

Shared among many services

Facebook server

World of Warcraft server

instant messaging

instant messaging

World of Warcraft client

Firefox accessing Facebook
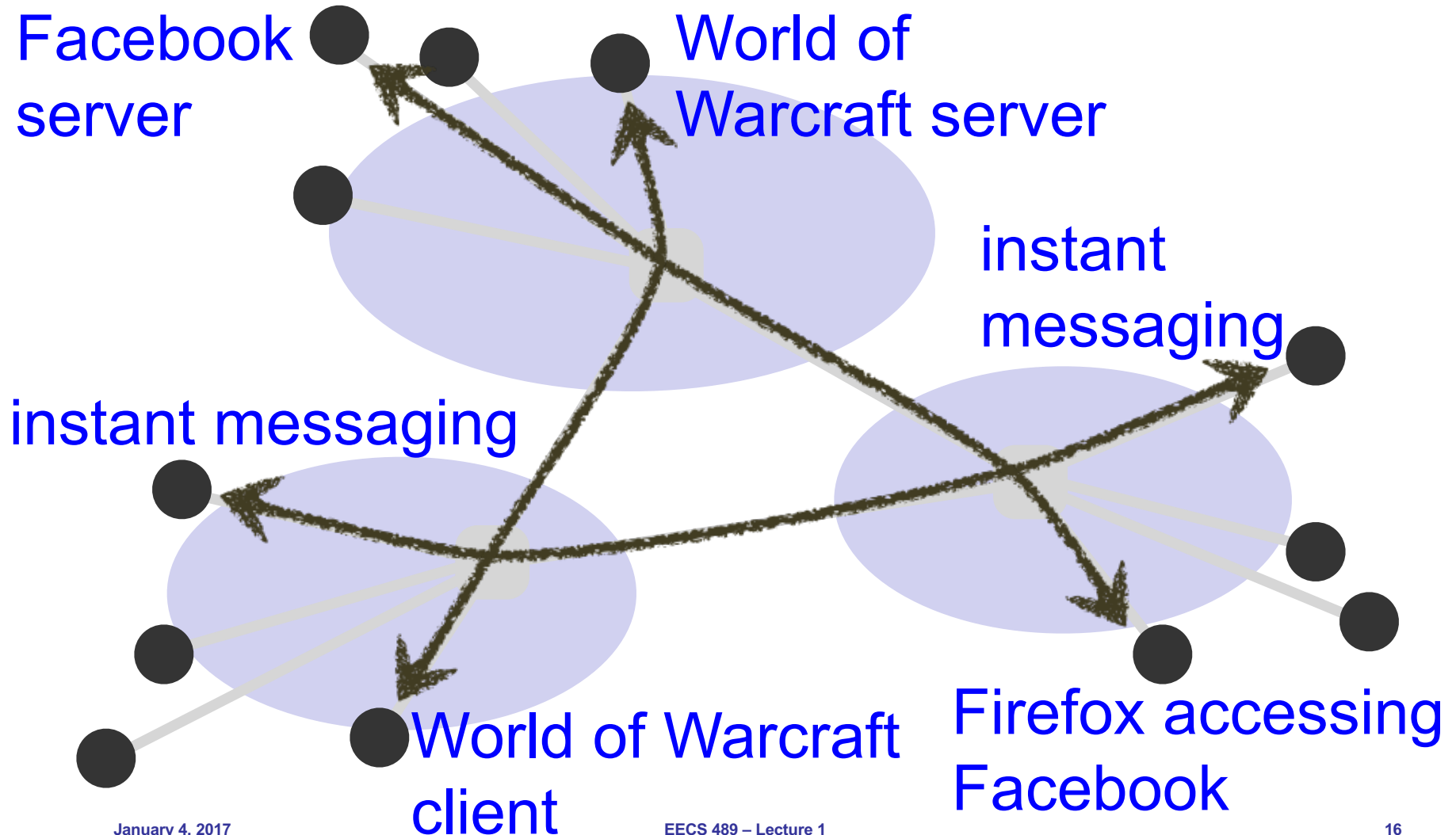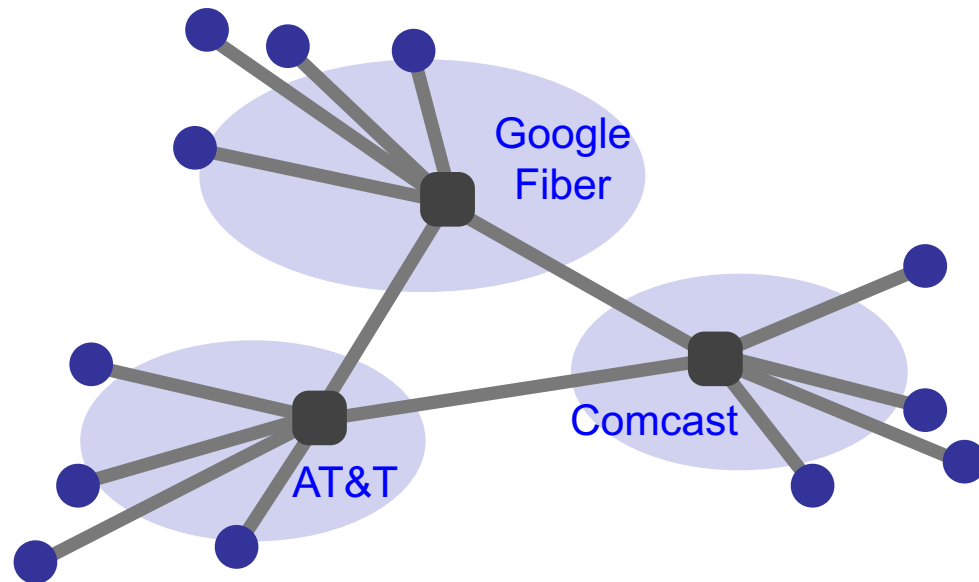
A federated system

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

Why a common interface?

- The Internet ties together different networks
  - \>18,000 ISP networks

- Interoperability between users and networks as well as between different networks

MASSIVE Scale

- 3.5 Billion users (34% of world population)
- 1 Trillion websites
- 200 Billion emails sent per day
- 2 Billion smartphones
- 1.8 Billion Facebook users
- 4 Billion YouTube videos watched per day
- Routers that switch 10 Terabits/second
- Links that carry 100 Gigabits/second

Diversity in all dimensions

- 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

- 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?

- 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

- In how to reason through the design of a <u>very</u> 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?

- 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
  - …

5-MINUTE BREAK!

Class workload

- Four assignments
  - First one is an individual assignment
  - The rest are in groups of 2
- Exams:
  - Midterm: February 22
  - Final: April 20 1:30PM – 3:30PM

Grading

	Allocation
Assignment 1	5%
Assignment 2	15%
Assignment 3	15%
Assignment 4	15%
Midterm	24%
Final	26%

Topics we will cover

- 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, security, SDN

The ALL-NEW assignments

- **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*

Textbook

- Kurose and Ross, Computer Networking: A Top-Down Approach, 7th Edition, Pearson, 2017. ISBN 978-0133594140.
  - 6th 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

- Class size capped at 84
  - Room capacity

- Wait-listed students will be admitted as and when registered students drop the class
  - If you're planning to drop, please do so soon!

Communication protocol

- Course website: http://mosharaf.com/eecs489/
  - Assignments, lecture slides
- Piazza for all communication
  - Sign up if you haven't already
  - https://piazza.com/umich/winter2017/eecs489/

- Assignment submission via Github
  - Start forming two-person groups
  - Details will be sent out soon

Policies on late submission, re-grade request, cheating, …

- 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
  - DO NOT cheat

Participation

- 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
- Limit electronic access for ~80 minutes
  - You will have a 5 minute break in the middle to get online

Summary

- 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 sections this week