

CS4450

Computer Networks: Architecture and Protocols

Rachit Agarwal



Goal of Today's Lecture

- Tell you about the course
 - What we will cover
 - How I teach
 - What I expect from you
- You can then decide whether you want to take the course
- If you stay:
 - you have been forewarned, and
 - you are agreeing to my conditions

Today's lecture: 10 basic questions

1. **What do I mean by “computer networks”?**
2. **What do computer networks do?**
3. What do computer networks look like?
4. Why study computer networks?
5. **What is this course about?**
6. What is the course workload, grading policies, etc.?
7. How will this course be organized?
8. Who am I?
9. **How do I teach?**
10. **Is CS4450 the right class for you?**

#1: What do I mean by “computer networks”?

What is a computer network?

A set of network elements connected together, that implement a set of protocols for the purpose of sharing resources at the end hosts

- **Three important components:**

- **Core infrastructure:**

- A set of network elements connected together

- **Protocols:**

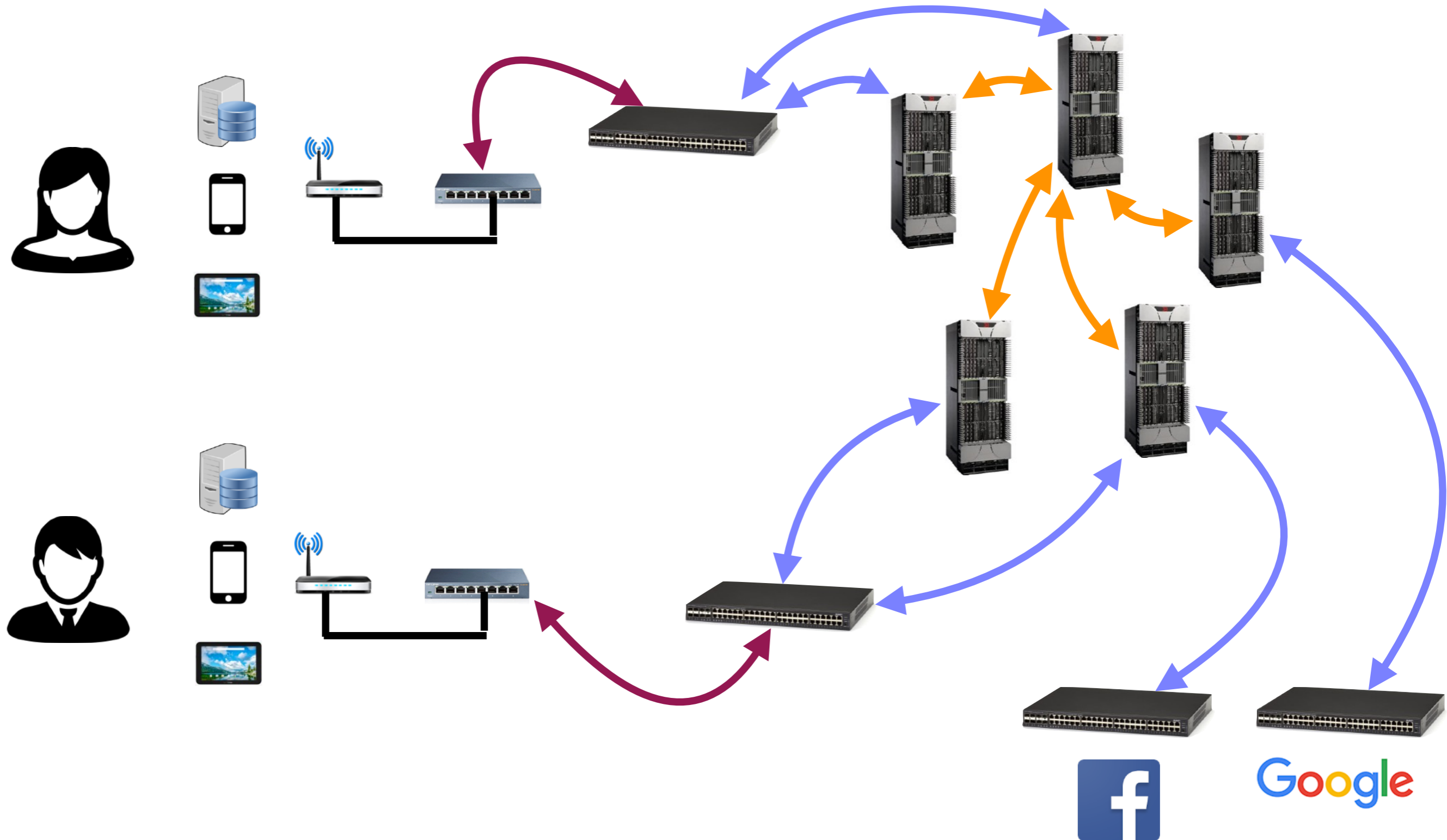
- Needed to use the network

- **Purpose:**

- Sharing resources at the end hosts (computing devices)

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Questions?

#2: What do computer networks do?

What do computer networks do?

A computer network delivers data between the end points

- **One and only one task:** Delivering the data
- **Read that sentence again. Remember it forever.**
- This delivery is done by:
 - Chopping the data into **packets**
 - Sending individual packets across the network
 - Reconstructing the data at the end points
- **That is all! This course:**
 - Evolution of three components of computer networks!
 - Infrastructure, protocols, purpose
 - Why the *&#@ has it taken 40 years of research (and counting) to design a data delivery system

Data delivery as a fundamental goal

- **Support the logical equivalence of Interprocess Communication (IPC)**
 - Mechanism for “processes on the same host” to exchange messages
- **Computer networks allow “processes on two different hosts” to exchange messages**
- **Clean separation of concerns**
 - Computer networks deliver data
 - Applications running on end hosts decide what to do with the data
- **Keeps networks simple, general and application-agnostic**

Questions?

#3: What do computer networks look like?

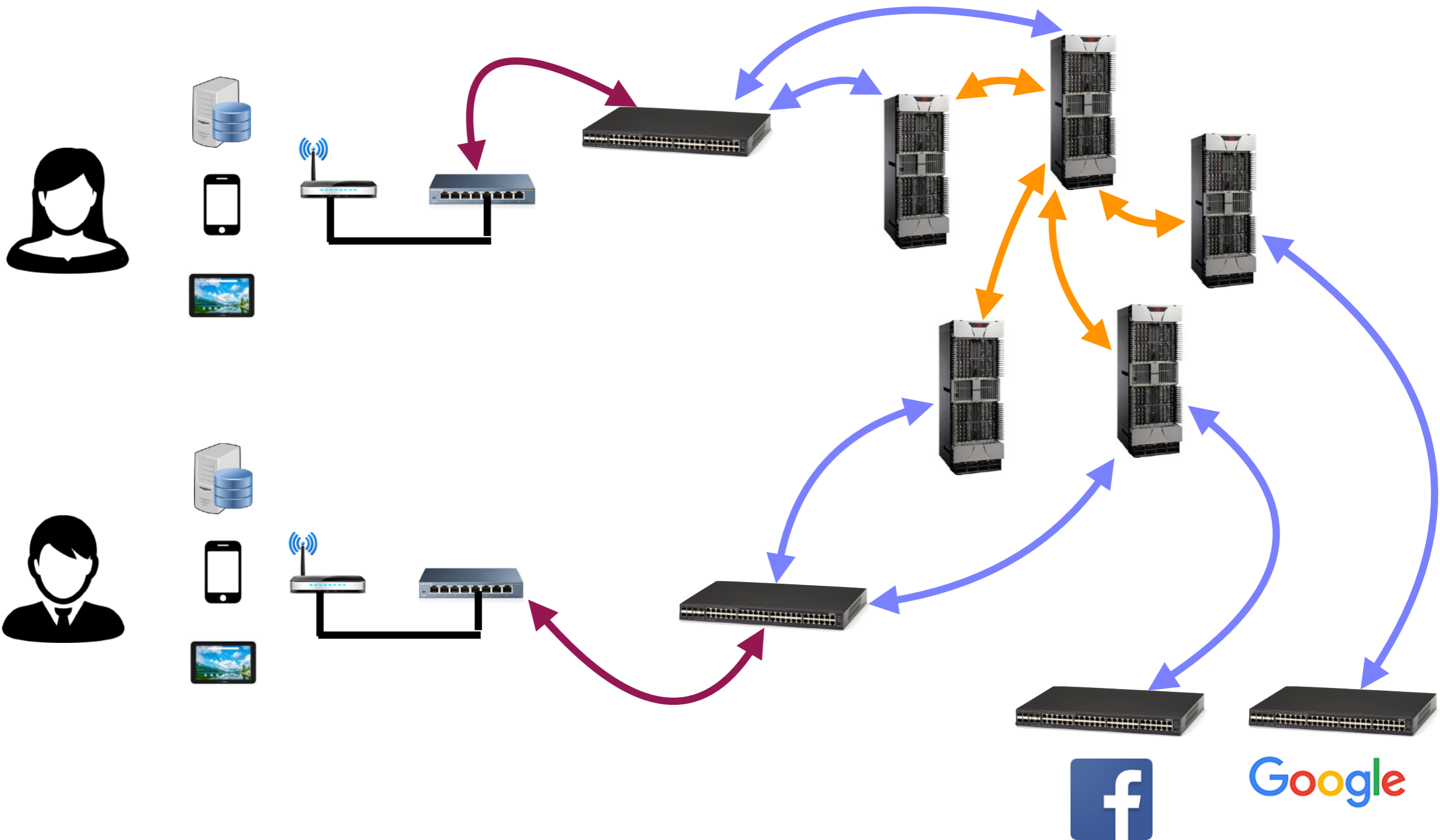
What do computer networks look like?

Three Basic components

- **End hosts:** they send/receive packets
- **Switches/Routers:** they forward packets
- **Links:** connect end hosts to switches, and switches to each other

What do computer networks look like?

End hosts, switches/routers, links



#4: Why study computer networks?

Why study computer networks?

What would the world look like without the Internet?

- Lets see

Why study computer networks?

#1: Has transformed and more importantly, is transforming everything!

- **Industry: core to and creator of many large and influential companies**
 - Google, Facebook, Apple, Cisco, Broadcom, AT&T, Verizon, Akamai
- **Communication**
 - Email, messenger, phones, VoIP, ...
- **Travel**
 - AirBnB, Uber, Maps, ...
- **Health**
 - Digital health, remote diagnostics,
- **Entertainment**
 - Netflix, news
- **Relationships**
 - Okcupid, Tinder, ...

Why study computer networks?

#2: To learn how to design for tussle!

- **Federated System**

- The Internet interconnects different networks (>18000 ISPs)
- How do you interconnect distrustful and competing entities?
- Constant tussle between business and technical factors!

Why study computer networks?

#3: To learn how to design for scale!

- **Tremendous scale**

- 51% of world population
- 1.24 trillion unique web pages
- Every **second**, approximately
 - > 2 million emails
 - > 40000 Google search queries
 - > 6000 Tweets
- **Introduced the phrase “Internet Scale”**

Why study computer networks?

#4: To learn how to design for diversity!

- **Communication latency:** Microseconds to seconds
- **Bandwidth:** 1Kilobits/second to 100Gigabits/second
- **Packet Loss:** 0-90%
- **Technology:** Wireless, satellite, optical, copper, ...
- **End hosts:** Sensors, cell phones, computers, servers, datacenters, ...
- **Applications:** **www**, voice, video, gaming, remote medicine
- **Trust models:** selfish (users), malicious (attackers), greedy (companies), ...

And yet, everything needs to work in tandem!

Why study computer networks?

#5: To learn how to design for evolution!

	1970	Today
Bandwidth	50 kbps	100+ Gbps
#End hosts	< 100 computers	8 billion +
Applications	Telnet and File transfer	!!

We have no clue what 2025 would be like!

Why study computer networks?

#6: To learn how to think “architecture rather than engineering”!

- **The early pioneers came up with a solution that has lasted for 40 years!**
 - Almost unchanged!!! A true success story of “thinking differently”!!
 - Brilliant in conception; sometimes weak in execution
 - Several **architectural principles** emerged
 - Decentralization [All lectures]
 - “Packets” [Lecture #2]
 - Statistical multiplexing [Lecture #2]
 - The end-to-end principle [Lecture #3, #6+]
 - Layering [Lecture #3, #6+]
 - Best effort service [Lecture #4, #6+]
 - Narrow waist interface [Lecture #6]

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Computer networks offer us a lesson on how to “reason” through the design of a complex, diverse, ever-evolving, failure-prone system

- What are our goals and constraints? How to prioritize them?
- How do we decompose a problem into smaller components?
- How to partition the functionality across multiple components?
- What are the design tradeoffs?

In short, how to **architect a system!**

#5: What is this course about?

What is this course not about?

- **There are many kinds of computer networks (and technologies)**
 - Telephone (landline) networks
 - Cellular networks
 - Wireless networks
 - Optical networks
 - Infiniband
 -
- **And many applications of these computer networks**
 - World Wide Web
 - Multimedia streaming
 - Social networks
 - Email/audio/video messaging
 - Search
 -

What is this course about?

Architectural principles, design goals and performance objectives in wired networks

- **What tasks get done?**

- What is delivered (packets, files, ...)?
- What are the semantics (reliability, ordering, ...)?

- **Where do tasks get done?**

- At the network elements? At the end-hosts?
- How do end hosts interface with network elements?
- How do different network elements interface with each other?

- **How tasks get done?**

- What protocols and algorithms do each of these use?
- How to achieve various performance objectives (latency, etc.)?

What is this course about?

Architectural principles, design goals and performance objectives in wired networks

- **Mostly drawing examples from the Internet**
 - Not a particular kind of network
 - Not just another technology on the list
 - **Ties different networks together**
- **Why Internet?**
 - Has similar goals as individual network technologies
 - Speed, Cost, Reliability, ...
 - Has an additional fundamental goal
 - **Ability to connect all computer networks (and technologies)**
 - **Leads to myriad of new challenges**

Questions?

#6: What is the course workload, grading policies, etc.?

Course workload

- **Problem set, one every two weeks (0%)**
 - For you to practice questions; solutions available after one week
- **Four projects (0%)**
 - To gain hands-on experience for people who are interested
- **In-class surprise quizzes (20%)**
 - There may be no quiz, or there may be a quiz per lecture
 - Pay attention, regularly read material, attend lectures
- **One prelim (30%), one final (45%)**
- **Class feedback (5%)**
- **New: Optional extra credit (some form of project; I will announce soon)**

Course workload

- **My courses tend to be “heavy”**: require regular attention
 - You have been warned!
- **My exams tend to be hard**
 - For those who miss lectures and do not care about problem sets!
 - But easy for people who attend lectures and solve problem sets.
 - You have been warned!
- **Quizzes will be simple**
 - Pay attention, regularly read material, attend lectures
 - Solve problem sets regularly

#7: How will this course be organized?

Course organization

- **Prerequisites**

- This is a senior-level course
- We expect knowledge of OS, algorithms, probability, algebra
 - Review your past courses as needed

- **Textbook**

- **Computer Networks: A systems approach**
 - 5th edition, but others are fine too (translate sections, etc.)
 - We will not follow its order of presentation
 - Instead, use it as a reference for individual topics
- e-version of the book available via Cornell library

- **Advanced readings**

- If you get curious about a topic and want to read more
- Anything not covered in the class will not be in exams/quizzes

Interaction with course staff

- **Piazza**

- Not a substitute for classes

- **Office hours**

- We want to choose timings that suit you; **fill the poll (check email)**
- We will announce office hours (time/location) in February
 - More hours by appointment

- **LOST sessions**

- We understand that students sometime lose track of the course
 - Spend the rest of the semester “catching up”
- Send us an email; we’ll help you catch up in 1-1 sessions
 - No need to give us a proof; we are here to help
 - But we will keep track to avoid abuse
- Secure, private email address: cs4450lost@gmail.com

5 minute break

#8: Who am I?

Instructor — Rachit Agarwal

- **Assistant Professor, starting Fall 2016**
- **Previously:** UC Berkeley, UIUC
- **Office:** 411c, Gates Hall
- **Proud of: my students**
 - Two PhD students (Saksham Agarwal, Qizhe Cai)
 - Graduated four undergraduate researchers so far
 - 3x now PhD students at MIT
 - Alana Marzoev, Akshay Narayan, Yannan Wu
 - 1x now PhD student at UC Berkeley (Zongheng Yang)
 - 2x current undergraduate researchers
 - Lloyd Brown (senior, applying for grad school)
 - Gautam Mekkat (junior, among you)

Instructor — Rachit Agarwal

- **Research interests: problems that excite me**
 - Publish in top conferences of several areas:
 - **Operating systems (OSDI)**
 - **Networking (NSDI, SIGCOMM)**
 - **Databases (SIGMOD)**
 - **Theory (SODA)**
 - **Information Theory (ISIT)**
 - **Diversity reflects my learning and teaching style!**
 - Competitive advantage: ignorance (and curiosity)!
- **Non-research interests:**
 - Food: Chocolate
 - Activity: Flying planes (still training; rarely get time)
 - Skill: Mixing cocktails (sorry, you'll never get to see, unless ...)
 - Sleep: 2-3 hours (so, expect Piazza answers at random hours)

#10: Is CS4450 the right course for you?

Ask yourself four questions...

- **Agree with the contract?**
 - No violation to the agreement
- **Want to understand the “concepts” and the “why” of networking?**
 - Not just looking for definitions, techniques and pseudo-codes
- **Willing to work regularly**
 - Attend lectures regularly
 - Work on problem sets regularly
- **Ready to have fun?**

If you decide to stay ...

Announcements

- I will send out an email when webpage is up
- Read the webpage for course policies, etc.
- If you enroll starting today, send us an email to add you to Piazza
- Fill out the office hour poll, so that we can decide on timings
- Find a partner to sit with in the class
 - Not necessary, but will help you!
 - You will solve a lot of questions with them
 - You will discuss a lot of design issues with them

If you decide to stay ...

Next lecture

- The beautiful concept of packets and flows
- Why packets and flows?
- What is statistical multiplexing?
- How long does it take for a packet to go from source S to destination D?

