

CS 4450, CS 5456

Computer Networks: Architecture and Protocols

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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”?

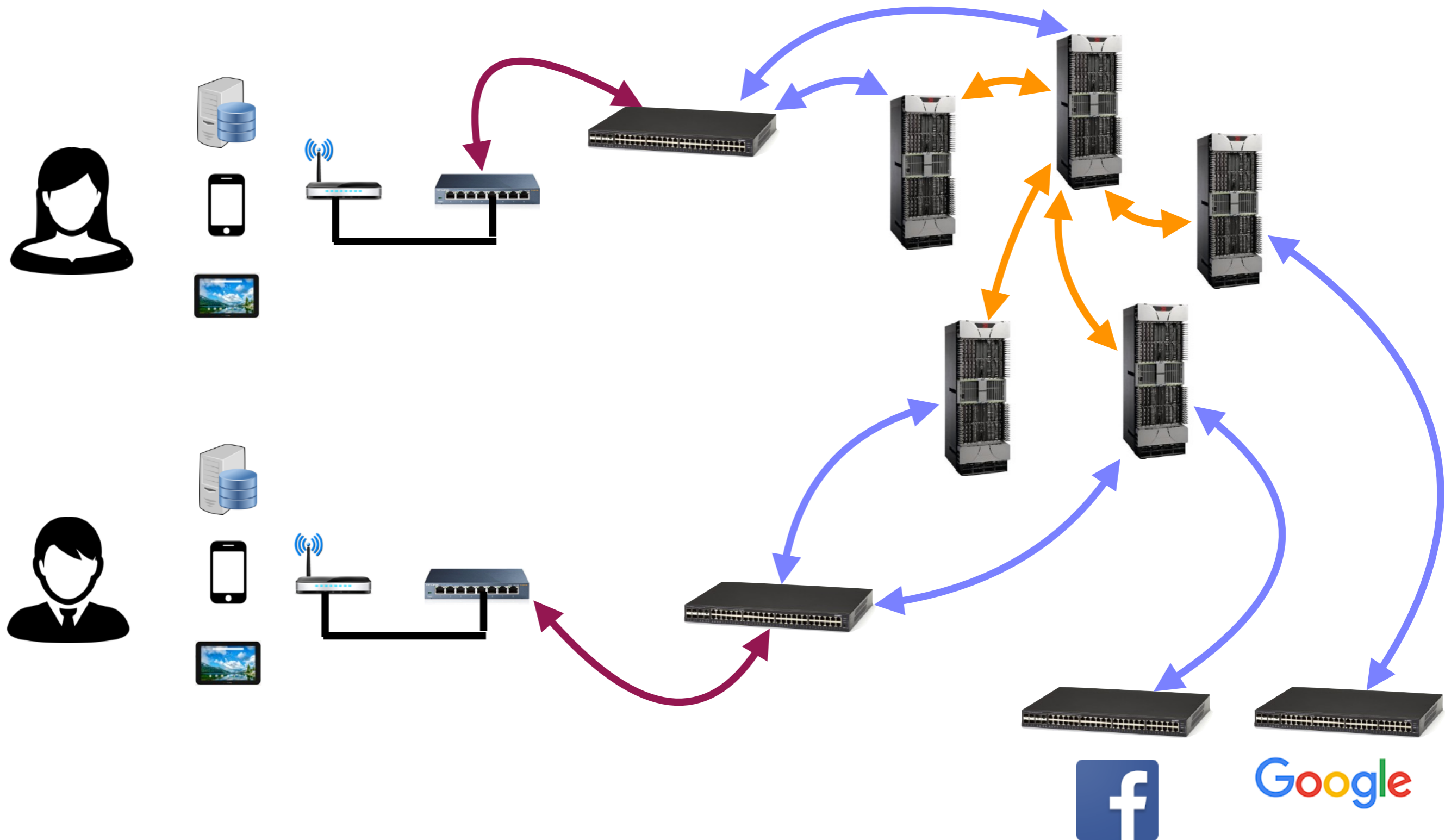
What is a computer network?

A set of network elements connected together that implement a set of protocols for the purpose of enabling (distributed) applications at end hosts

- **Three important components:**
 - **Set of network elements, connected together:**
 - Core “infrastructure”
 - **Protocols:**
 - Needed to use the network
 - **Purpose:**
 - Enabling (distributed) applications at end hosts

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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 50 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?

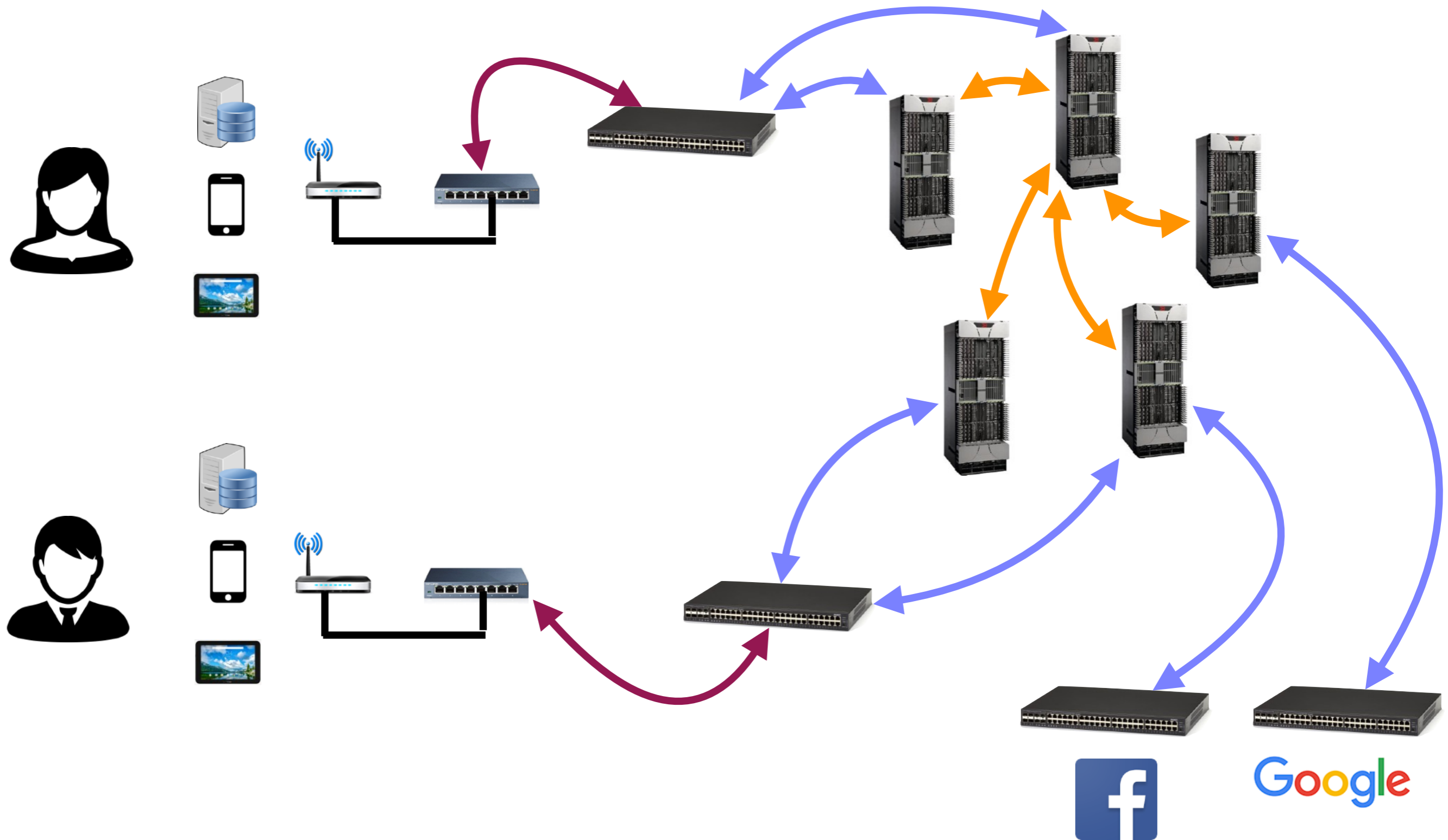
What do computer networks look like?

Core infrastructure includes:

- **End hosts:** they send/receive data
- **Switches/Routers:** they forward data (chopped into 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: enabled creation 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, Sports broadcast
- **Relationships**
 - Okcupid, Tinder, ...

Why study computer networks?

#2: To learn how to design for tussle!

- **Federated System**

- The Internet interconnects different networks
 - >18000 Internet Service Providers (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**

- > 67% of world population
- 1.24 trillion unique URLs (1.1 billion websites)
- Every **second**, approximately
 - > 3 million emails
 - > 99000 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 2030 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 50 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]

Why study computer networks?

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

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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, roughly one every two weeks**
 - For you to practice questions; solutions available after one week
 - Several programming assignments included
 - For people who are interested in gaining hands-on experience
- **In-class surprise quizzes**
 - There may be no quiz, or there may be a quiz per lecture
 - Pay attention, regularly read material, attend lectures
- **Three exams: two prelims, one final**
- **Class feedback**
- **CS5456: project/survey** (more details soon)

Course grade

- We will assign you 2 preliminary grades

	Grade1	Grade 2
Exam 1	20	20
Exam 2	25	30
Exam 3	40	45
Quizzes	10	0
Course eval	5	5

- Your **final grade** will be the **best out of the 2** preliminary grades
- I am perfectly happy to assign everybody an **A grade**

Course workload

- **My courses tend to be “heavy”**: require regular attention
 - You have been warned!
- **My exams tend to be hard**
 - You have been warned!
- **Quizzes usually draw questions from the problem sets**
 - 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, data structures
 - 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

- **Ed Discussions**

- Not a substitute for classes

- **Office hours**

- TBA soon

- **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: cs4450-prof@cornell.edu

If you decide to stay ...

Announcements

- The webpage is up
 - Your first stop for all questions
 - **Read the webpage for course policies, etc.**
- Login on Ed Discussions!

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?