CS4450, CS5456
Introduction to Computer Networks

Lecture 1

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https://www.racheesingh.com/computernetworks-fa24/

Outline of today's lecture

1. What are computer networks?
2. Why should you care about computer networks?
3. Administrivia
    1. Course staff
    2. Course modules
    3. Course policies
4. What does it take to be successful in this class?

What is this class about?

Computer Networks

A general computer like desktops, laptops, servers, phones etc.

Software and hardware infrastructure that connects these computers

1. How do computers interconnect and exchange information?
2. Which architectural principles inform our design of these networks?
3. How have computer networks evolved to enable new applications?

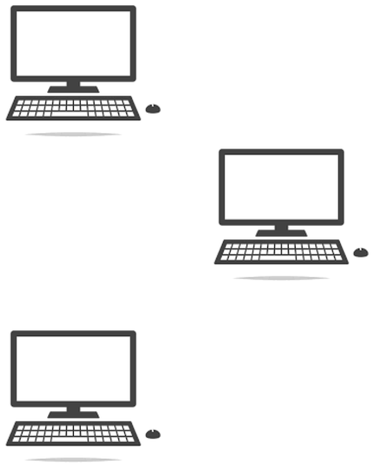
We will focus on the "Internet"

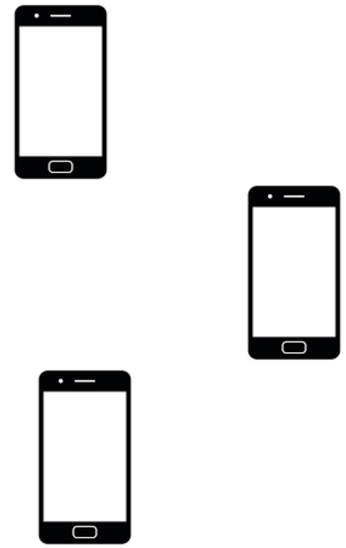
Computer Networks

Internet

1. There are many types of computer networks
    1. Example: telephone networks, cellular networks etc
2. The Internet ties these different types of networks together
3. We will mainly study the Internet in this course

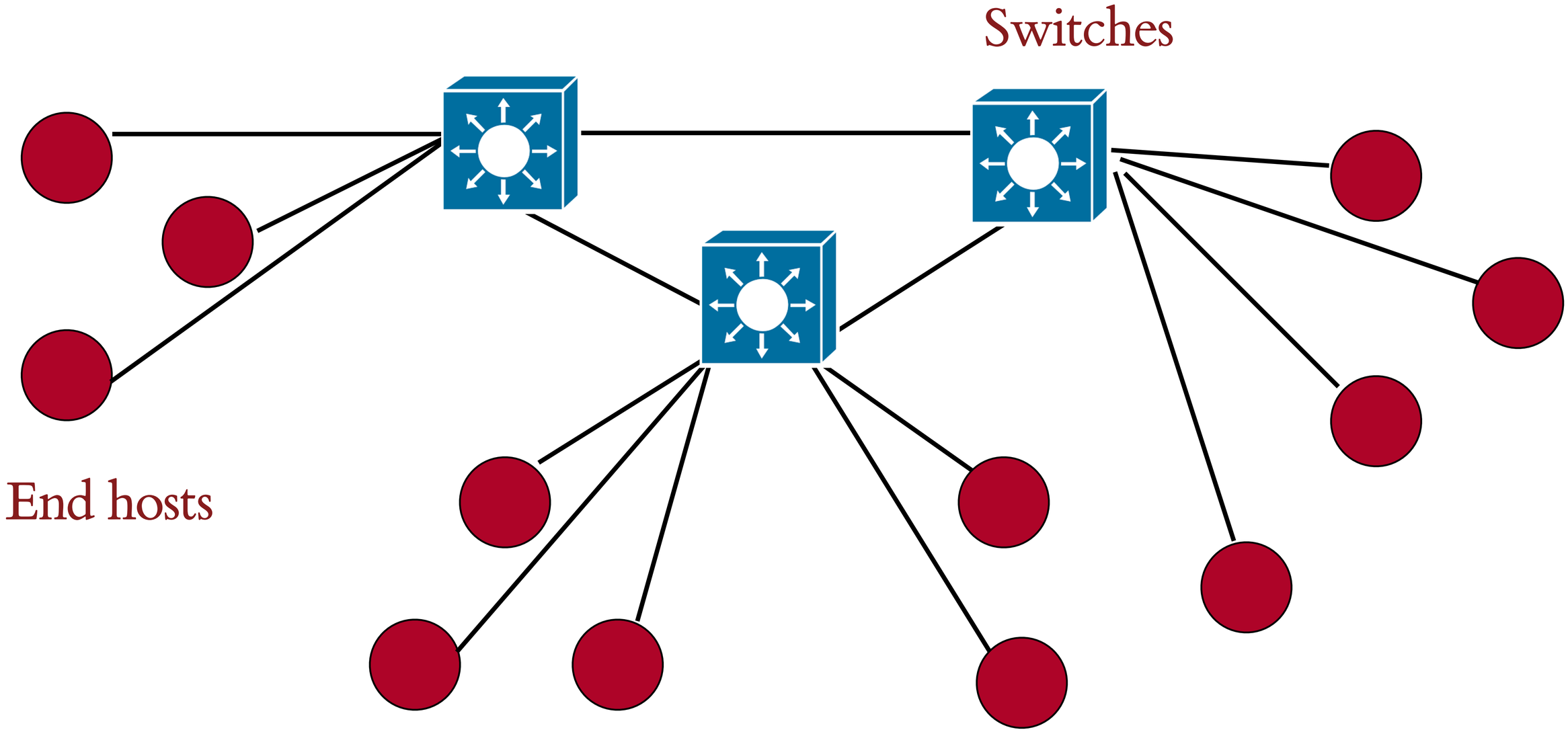
What does the Internet consist of?



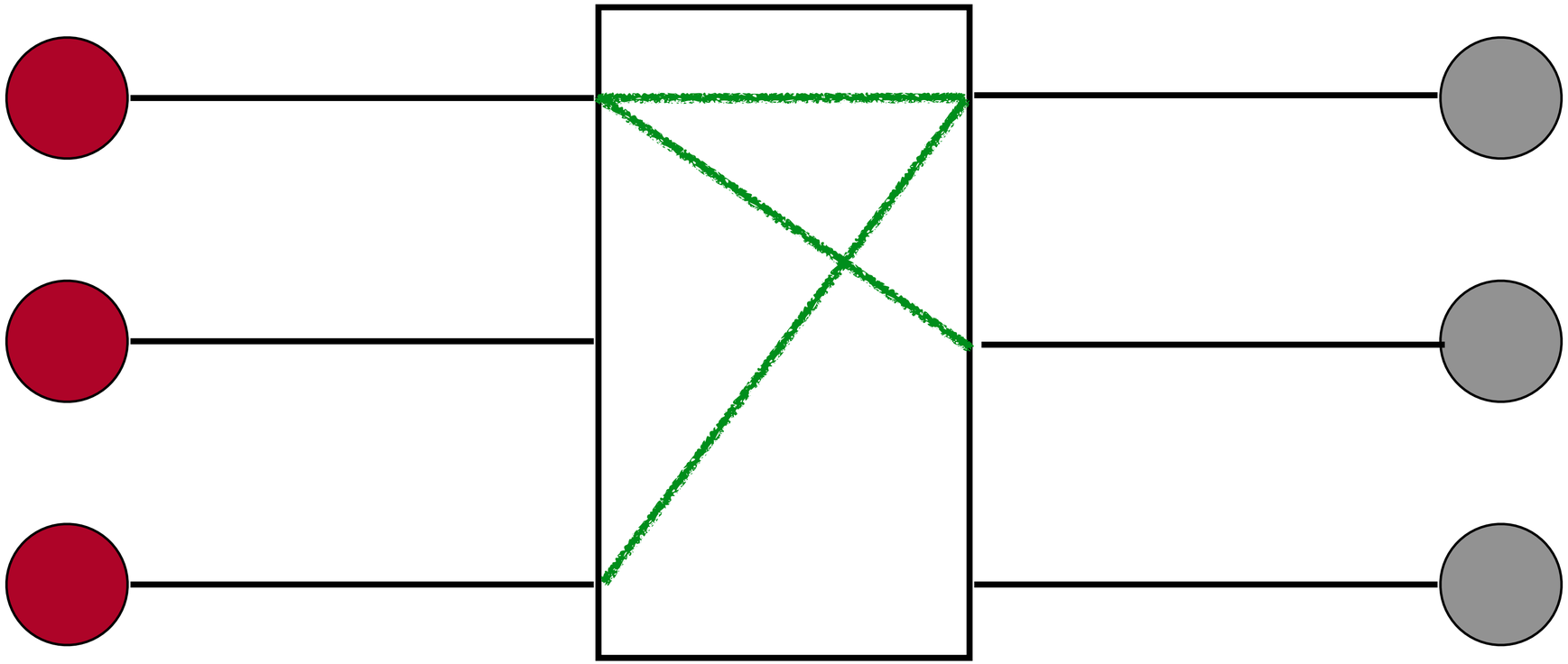


End hosts

What does the Internet consist of?



What is a switch?



Source Endpoint

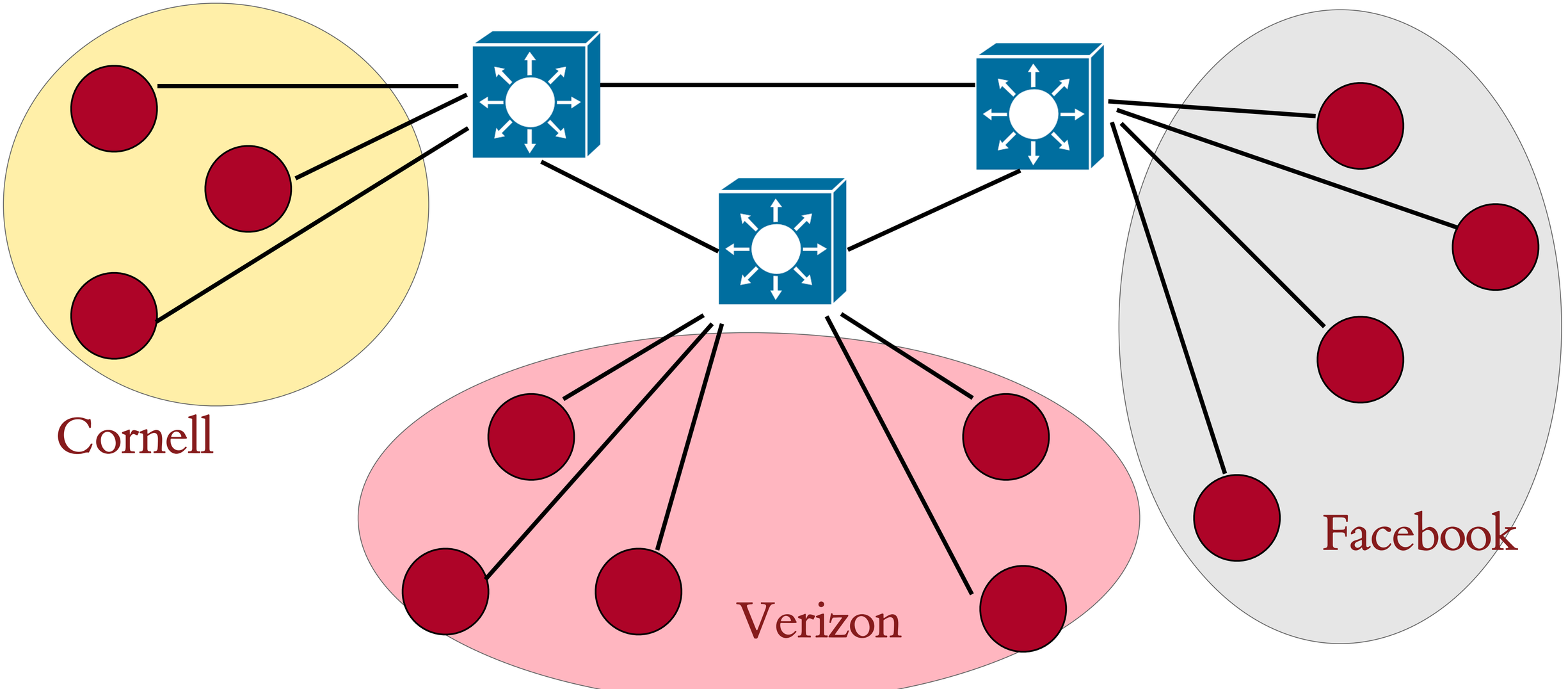
Switch

Dest. Endpoint

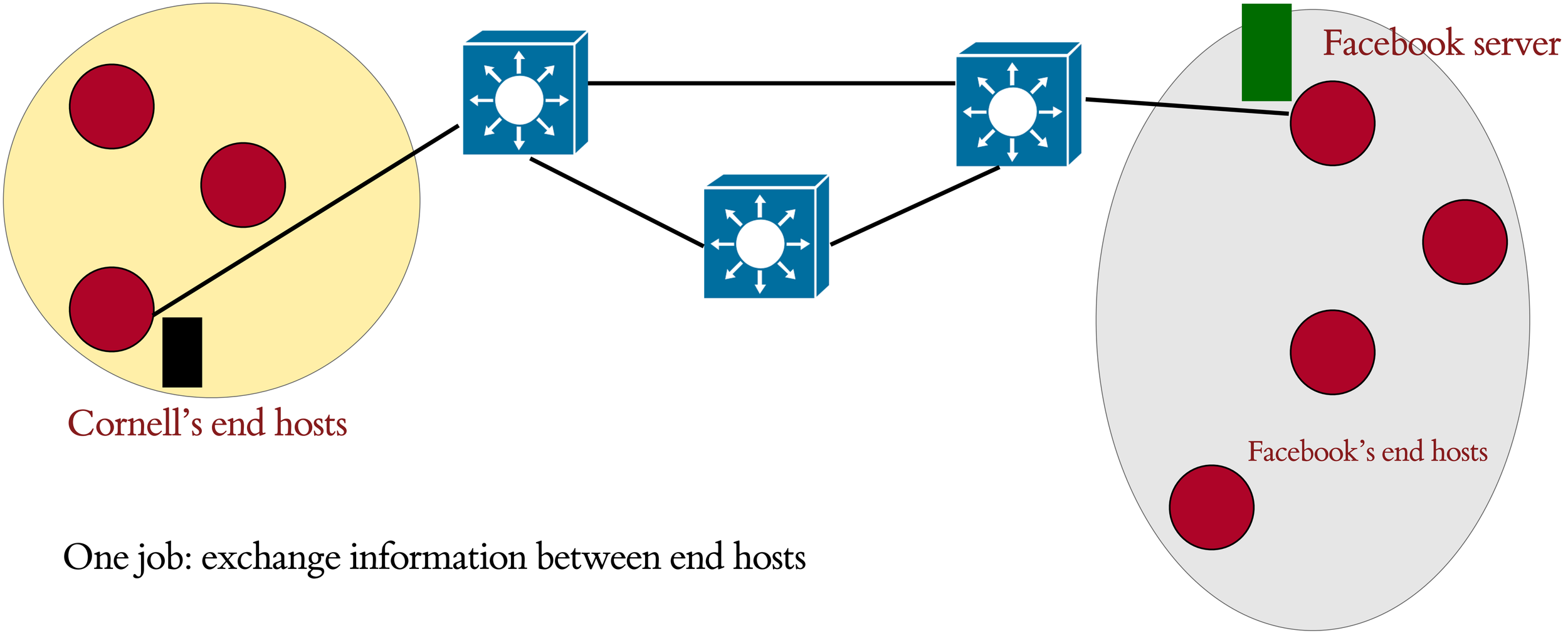
Switching in the 60s

"Where may I direct your call?

What does the Internet consist of?



What does the Internet do?



One job: exchange information between end hosts

Why should you learn about the Internet?

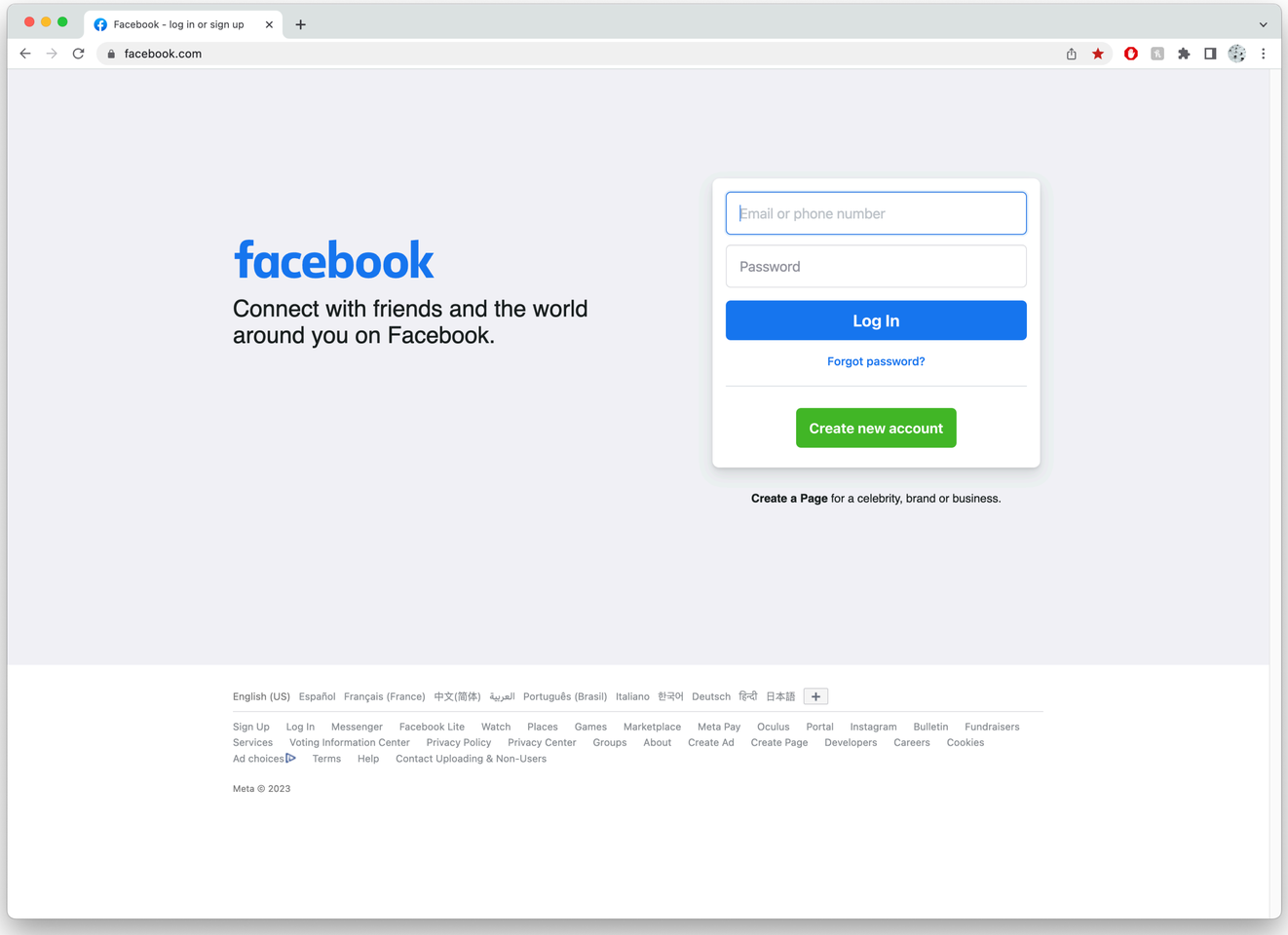
1. You and I rely on a functioning Internet connection every day
2. Things you do:
    1. For study (email, canvas)
    2. For fun (VR, Snapchat, Tiktok)
    3. For socializing (Facebook, Instagram)
3. Lets try an exercise!

What happens when you visit Facebook?

I went to my browser and typed www.facebook.com

The browser loaded the Facebook homepage

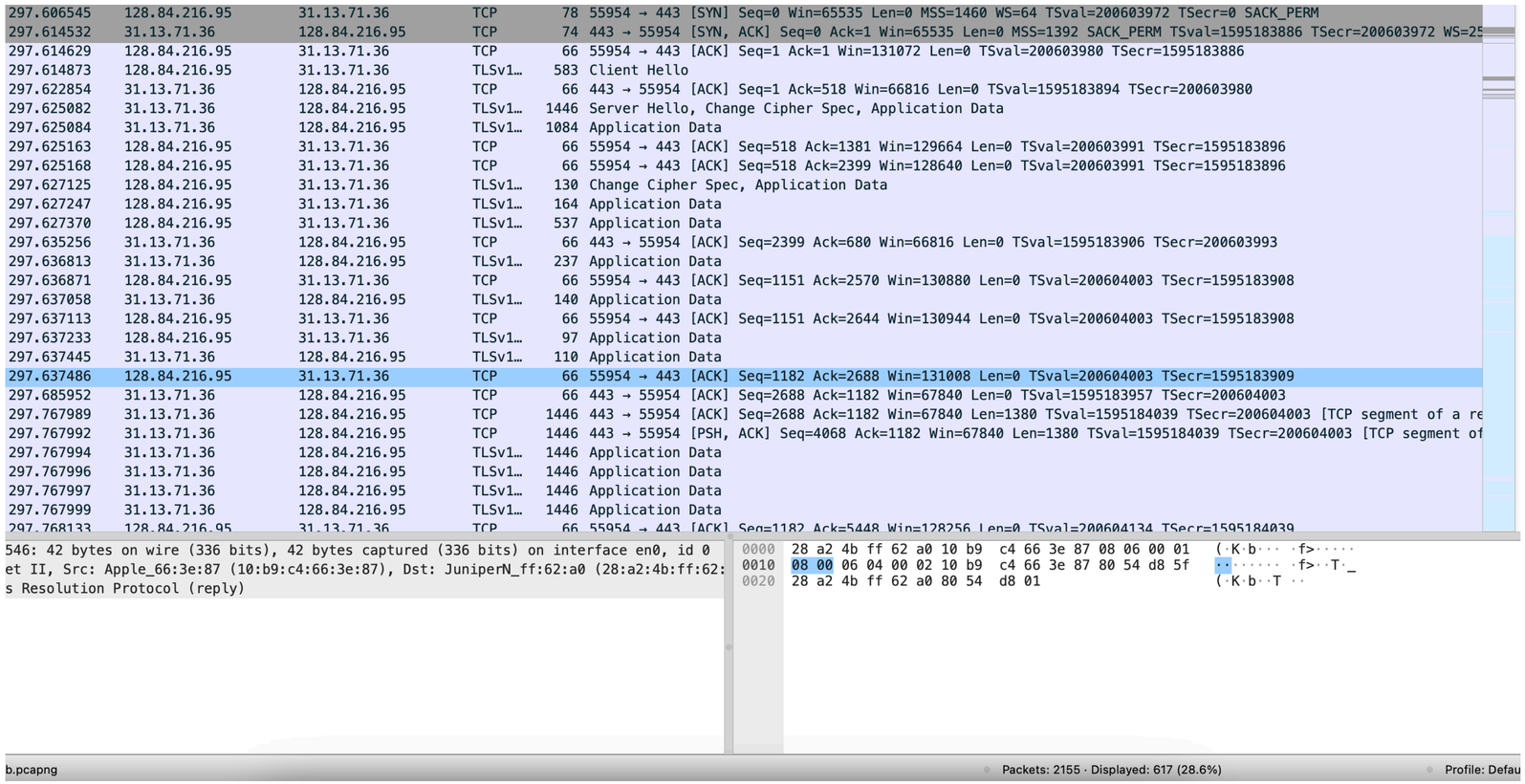
What goes on behind the scenes to load this webpage?



What happens when you visit Facebook?

I used a tool to capture all traffic exchanged in the background to load Facebook on my machine

To load this simple page, my computer exchanged over 2,000 “messages” on the Internet!

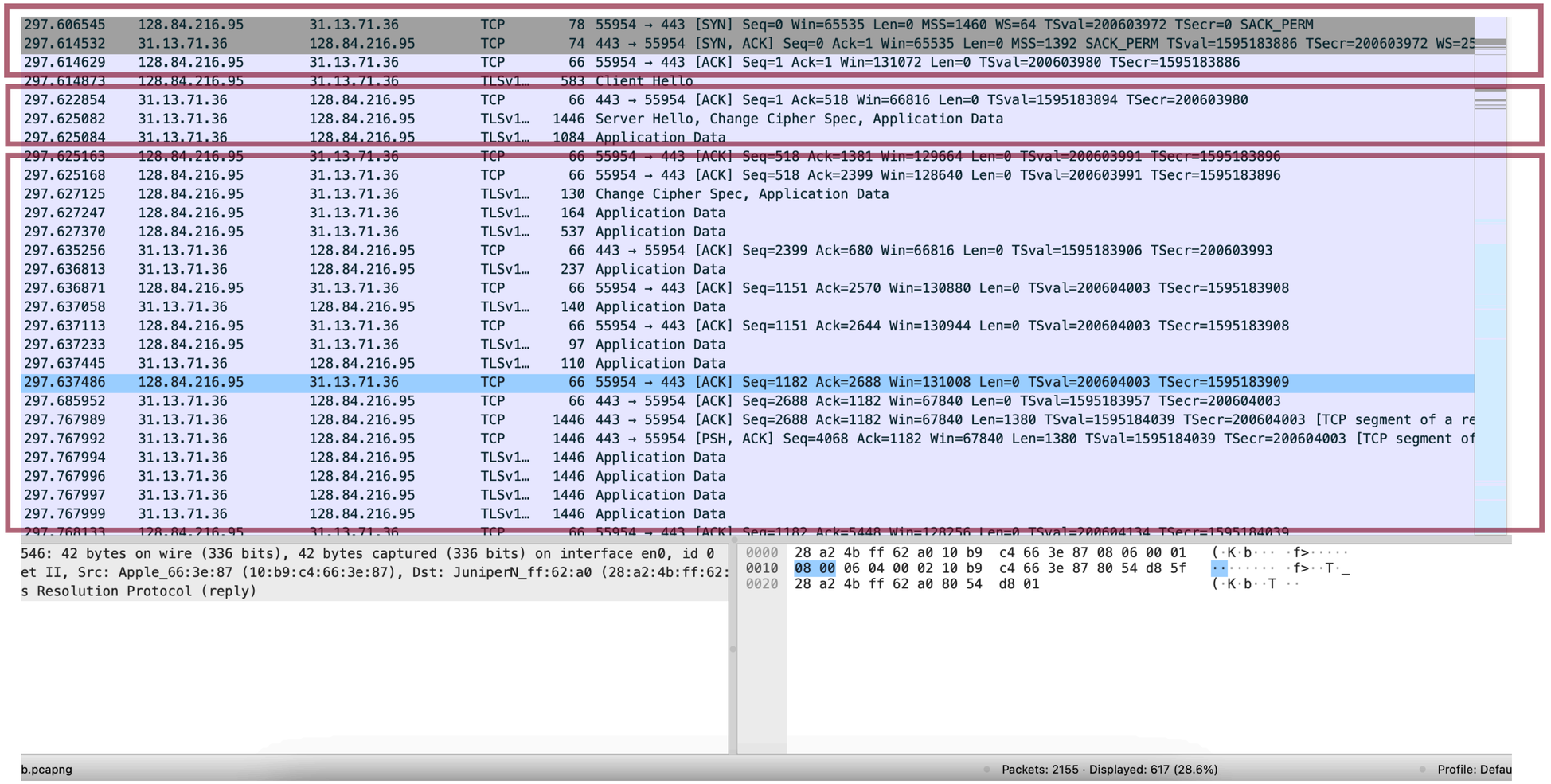


What is in these messages?

My browser sets up a TCP connection

Sets up a TLS session (security)

Facebook server sends data to my browser



Why should you learn about the Internet?

1. Internet consists of 60,000 + networks
    1. Each network is operated and controlled by a different organization
2. There is no centralized control on the Internet
    1. A federated system
3. Massive scale
    1. Users keep growing
    2. Applications keep evolving
4. Translates to very interesting design goals and challenges!

What are the goals for the Internet?

1. Connect different types of users (smartphones, laptops, cars)
2. Support an evolving variety of applications (live video, gaming, AR/VR)
3. Scale to the whole world
4. Resilient to failures
5. …

Five minute break

Course Staff: Instructor

Name: Rachee Singh

Research area: Computer networking

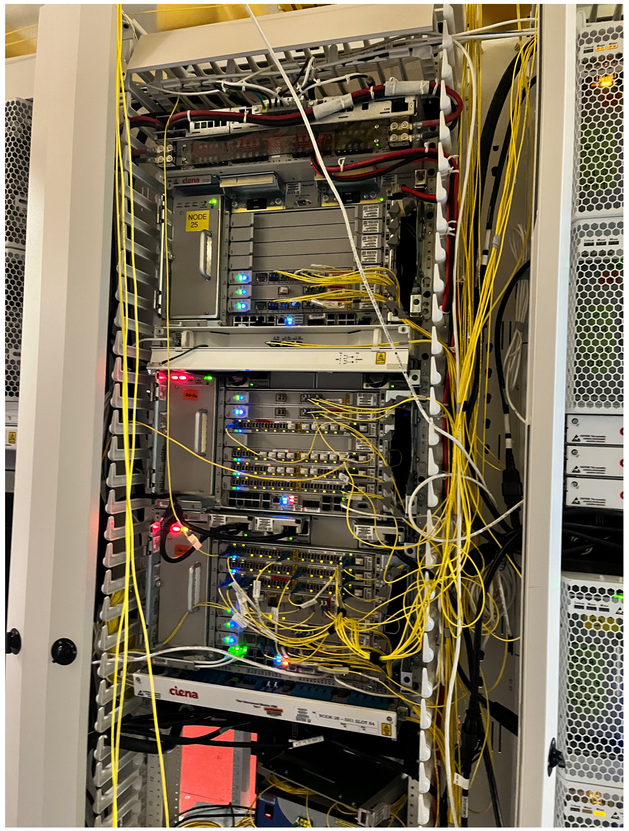
Previous job: Microsoft Research

Hobbies: Biking, running, baking bread

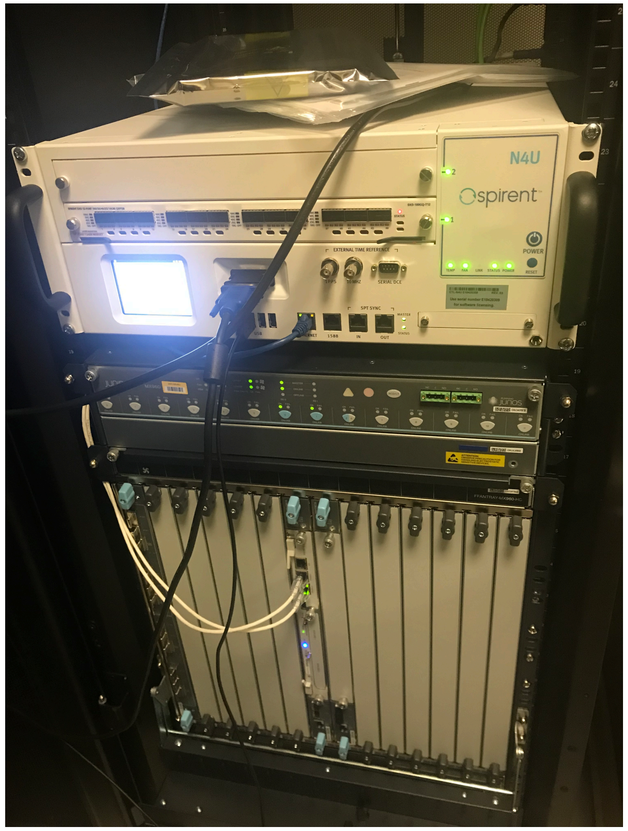
Professional Website: www.racheesingh.com

Rachee Singh

Research in optical networking



Connecting network nodes across
hundreds of kilometers with optical fiber



Testing with 400Gbps traffic

Course Modules

1. Module 0: Overview
2. Module 1: Architecture and design principles
3. Module 2,3, : Functionality in the "core" of the Internet (routing, forwarding)
4. Module 4: Functionality at the "endpoints" of the Internet (reliable transport)
5. Module 5 (tentative): recent topics in computer networking

Developing Intuition vs. Memorizing Concepts

1. There is a steep learning curve to computer networking
2. Networking is an old sub-field of computer science
3. Many acronyms (OSPF, BGP, STP), protocol specifications
4. This class is NOT about memorizing things!
5. My goal is to teach
    1. Architectural and design principles of networking
    2. Intuition for why networks are designed a certain way
    3. Reason about how to improve the state-of-the-art

I want you to actively think in this class

1. How do I motivate you to think?
    1. I'll ask questions that will force you to think
    2. I'll wait for you to ask questions
    3. I have a good tolerance for awkward silence when no one answers
2. We will do in-class exercises
    1. Each of you will be a router, an end host etc
3. Class participation will count towards your grade (more on this later)

Ask questions often

1. You are not expected to ask only “smart” questions
    1. Ask silly questions
    2. Ask questions if you are lost
    3. Ask questions if you missed something
2. Asking questions will help us keep a good pace
3. Asking questions will help others understand things better

Grading Policy

1. Class participation in the form of in-class quizzes (5%)
2. Prelim 1 (20%)
3. Prelim 2 (20%)
4. Final (20%)
5. Homeworks (30%)
6. Filling final course evaluations (5%)

How is class participation measured?

1. We will do unannounced in-class quizzes
    1. A quiz will have a single multiple choice question
    2. Based on something that we covered in class
    3. It will be trivial to answer this if you pay attention in class
2. You won't be graded on the correctness of your answer
    1. You will be graded only on "being present" for the quiz

Things you should know upfront

1. The exams and the homework are **short answer** questions only
2. Each question will test a small and self-contained concept
3. Why is this important to know?
    1. There will rarely be an opportunity to get partial points
    2. We can't grade you for "thinking" that went into the answer
4. Why do we design exams and homework this way?
    1. many reasons..

Important Course Policies

1. Academic integrity policy
    1. Don't cheat on exams, in-class quizzes, homework (on any course deliverable)
    2. All students involved in a cheating incident get an F on the course

2. Both prelim exams are in class so there should be no scheduling conflicts
3. Final exam is during the finals period (details TBA)

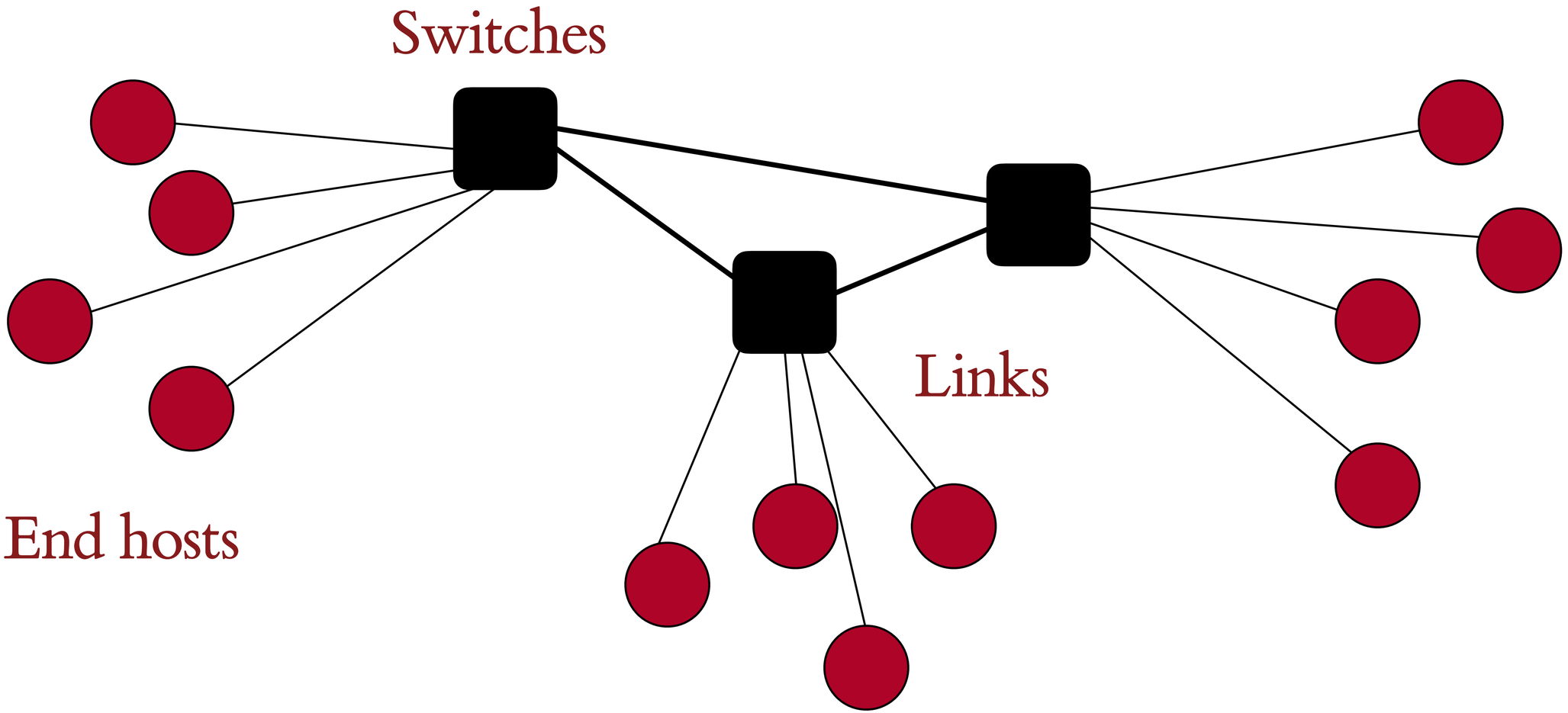
How to succeed in this class?

1. Attend lectures
2. Actively ask questions and participate in the class
3. Take a break from phones and laptops
4. Be willing to think actively and abstractly
5. If you fall behind, get in touch with TA staff for their help

Summary

1. This will be an exciting course
2. The course will teach you how the Internet works
    1. You need the Internet every day!
    2. Internet has transformed the world and continues to do so
3. Check out the Canvas course page for more information
4. Contact the course staff with any questions
    1. Use Ed Discussions
    2. Sensitive questions can be sent via private posts

What does a network consist of?


Switches
Links
End hosts

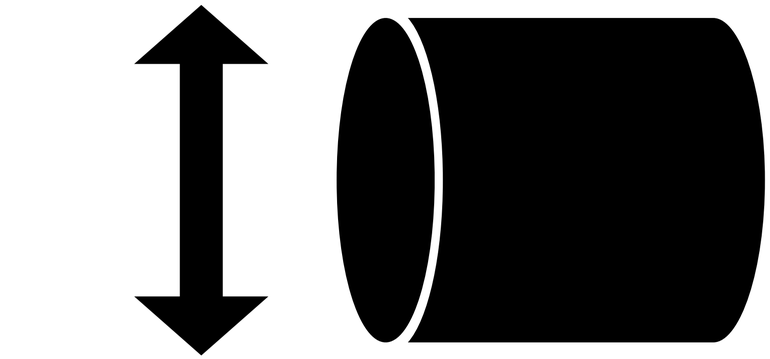
How do we evaluate the “performance” of a network?

Network performance metrics

1. Throughput
2. Delay
3. Loss, resilience to failure etc.
    1. (will discuss this later)

Bandwidth

1. Number of bits sent per second (bits per second, or bps)
2. Depends on
    1. Hardware
    2. Network traffic conditions
    3. ….

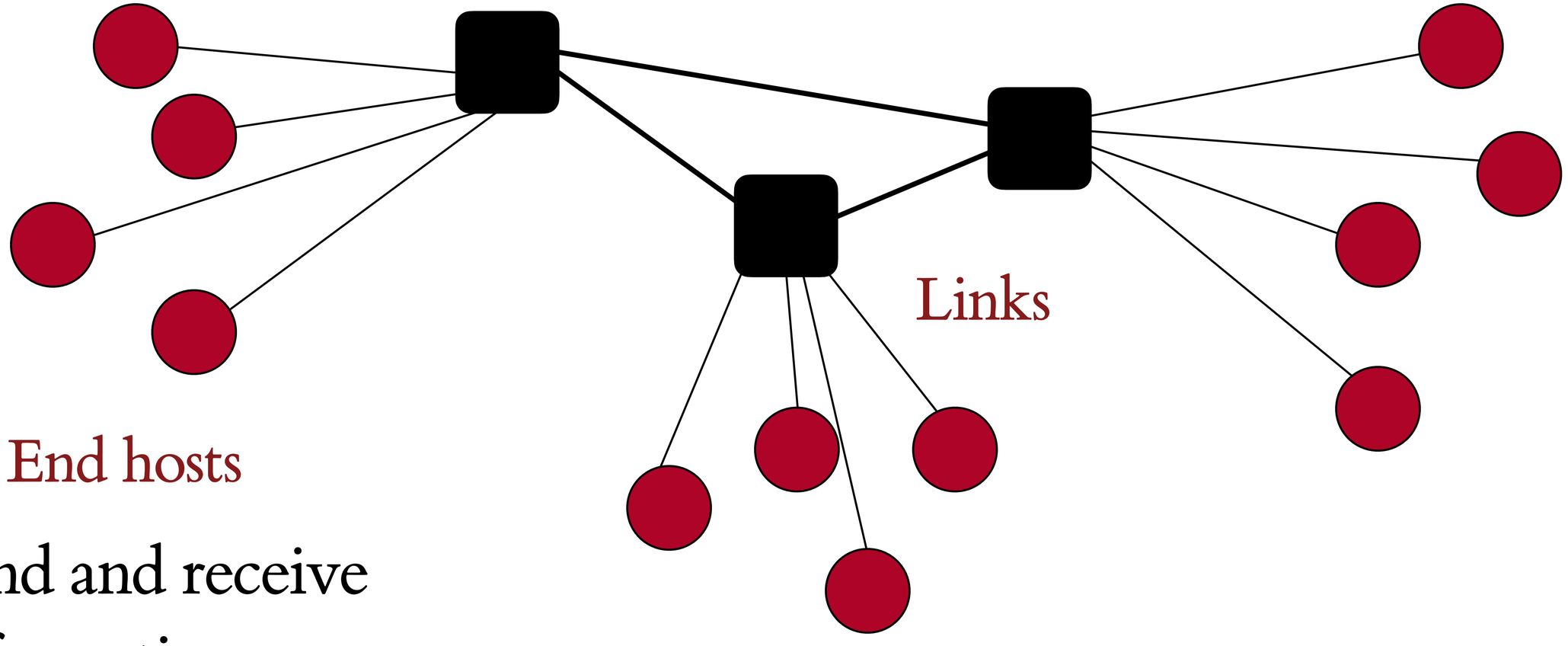


Delay

1. Time for all bits to go from source to destination (seconds)
2. Depends on
    1. Hardware
    2. Distance
    3. Traffic from other sources
    4. ….

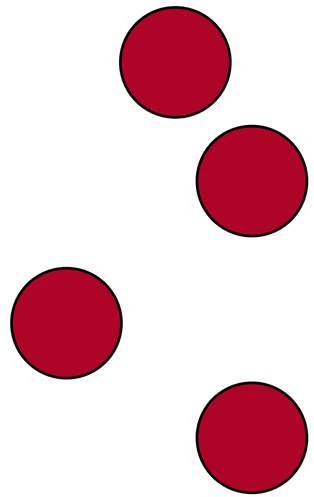
Why do we need switches in a network?

Why do we need switches?

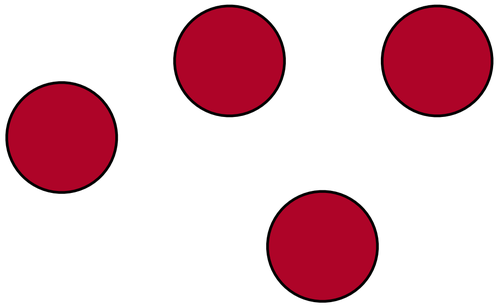


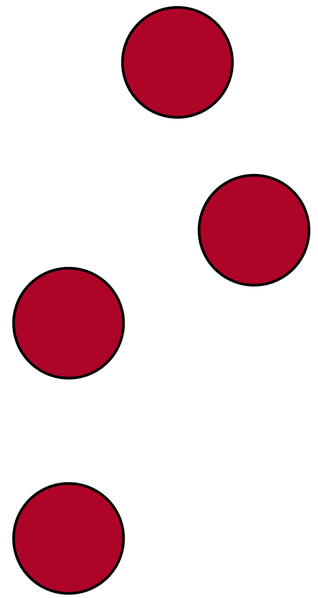
Send and receive information

Imagine if we did not have switches..



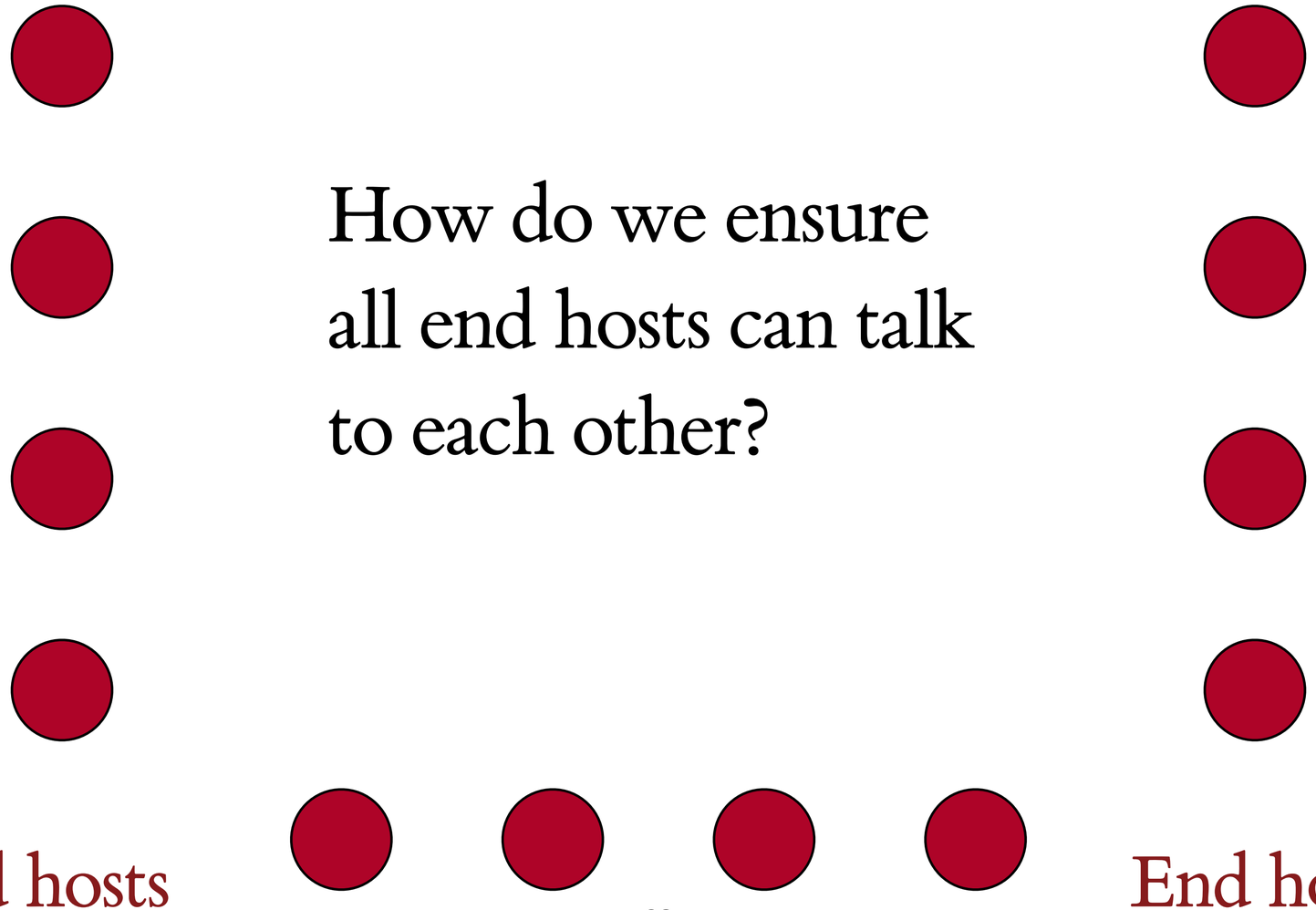
End hosts





End hosts

Imagine if we did not have switches..



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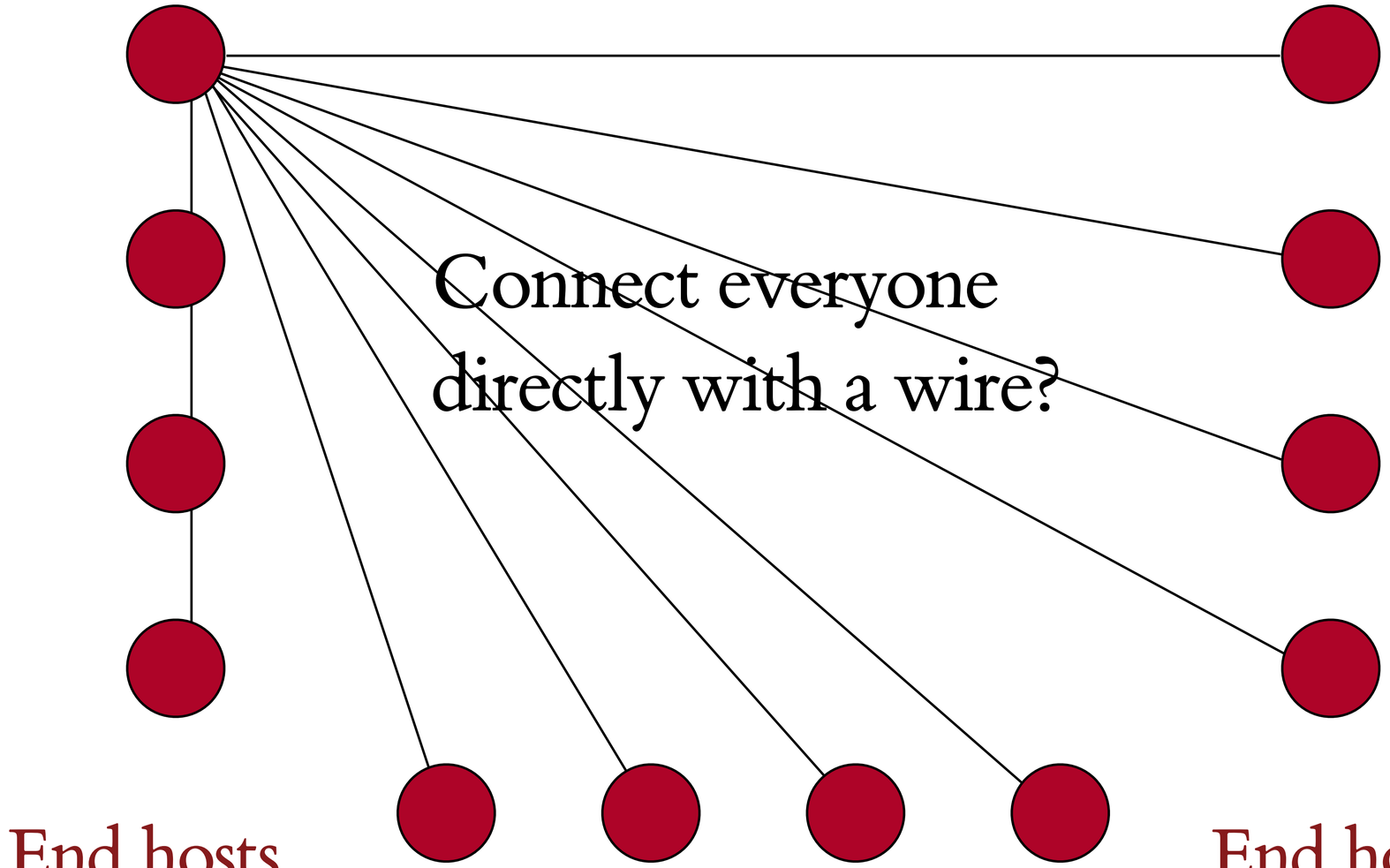
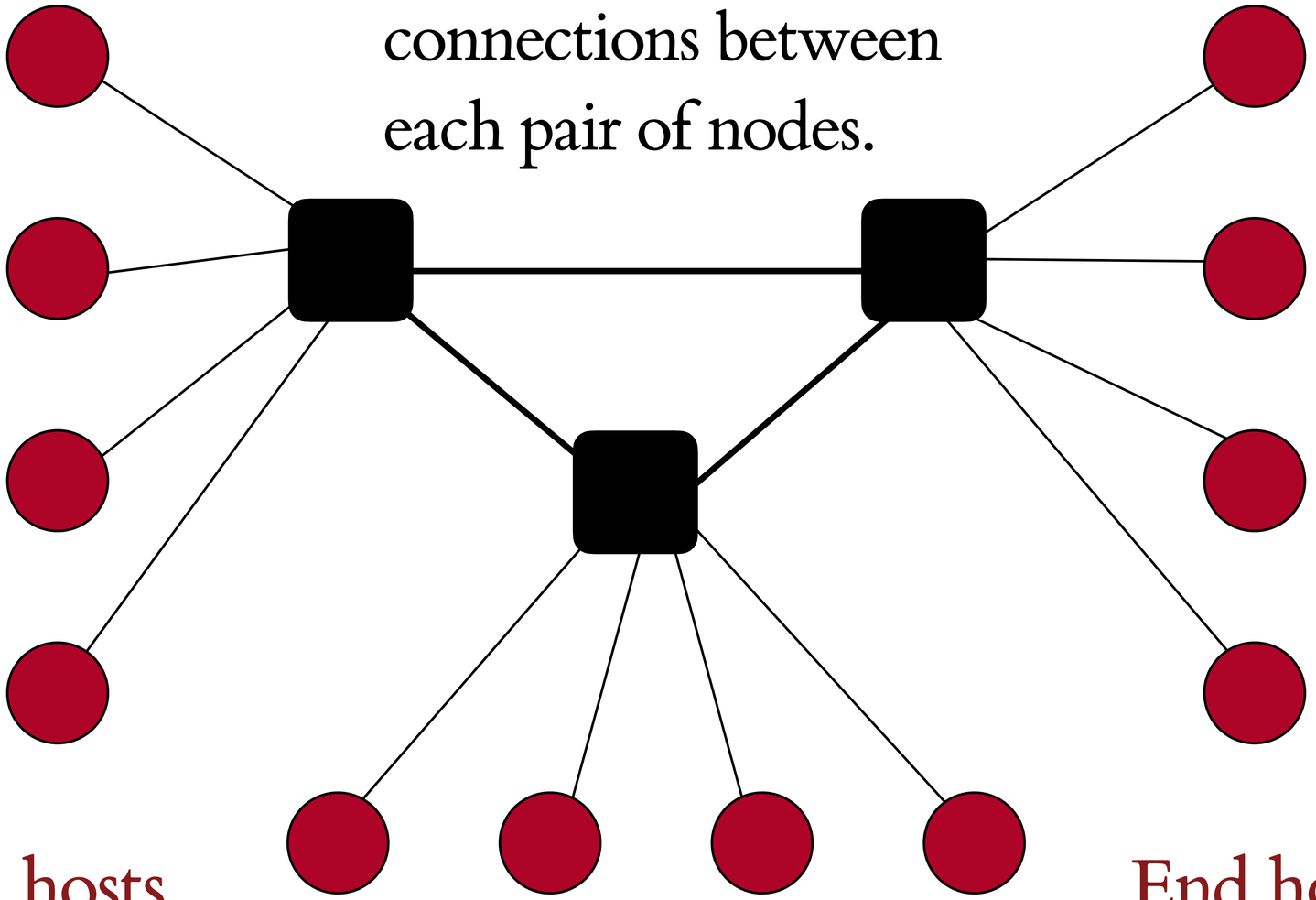


Switches provide a scalable way to connect nodes

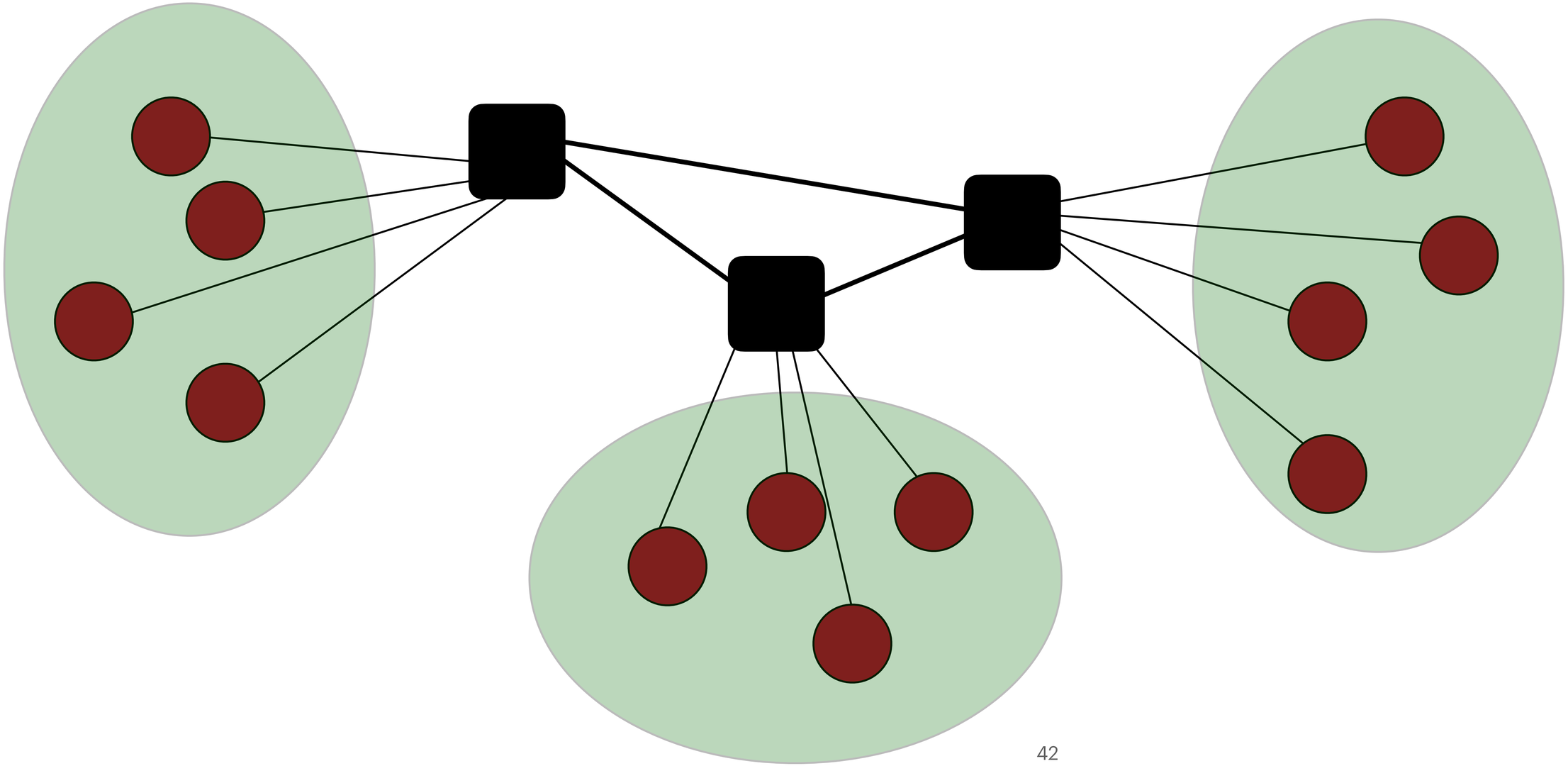
Without needing all connections between each pair of nodes.



End hosts

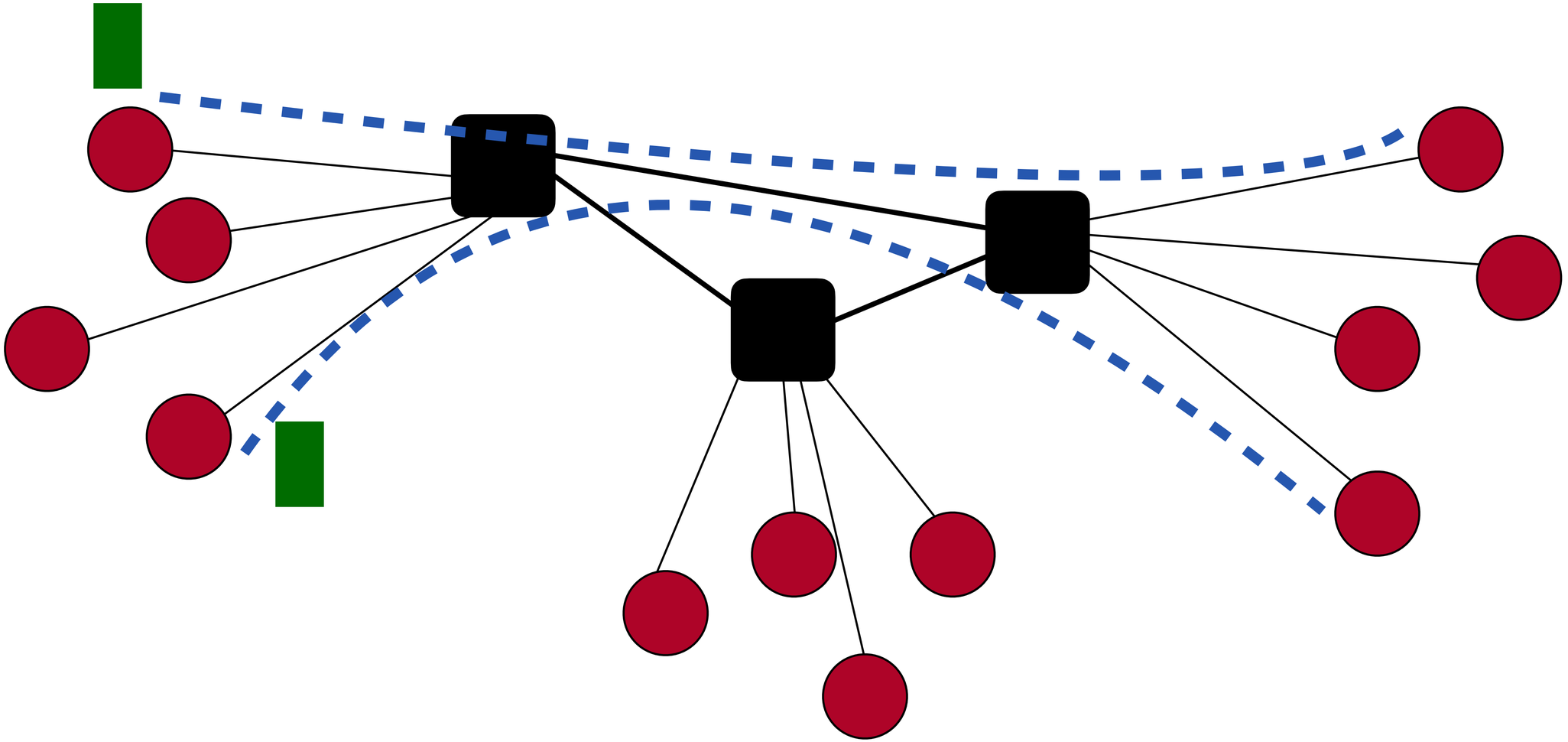
End hosts

Switches provide a scalable way to connect nodes

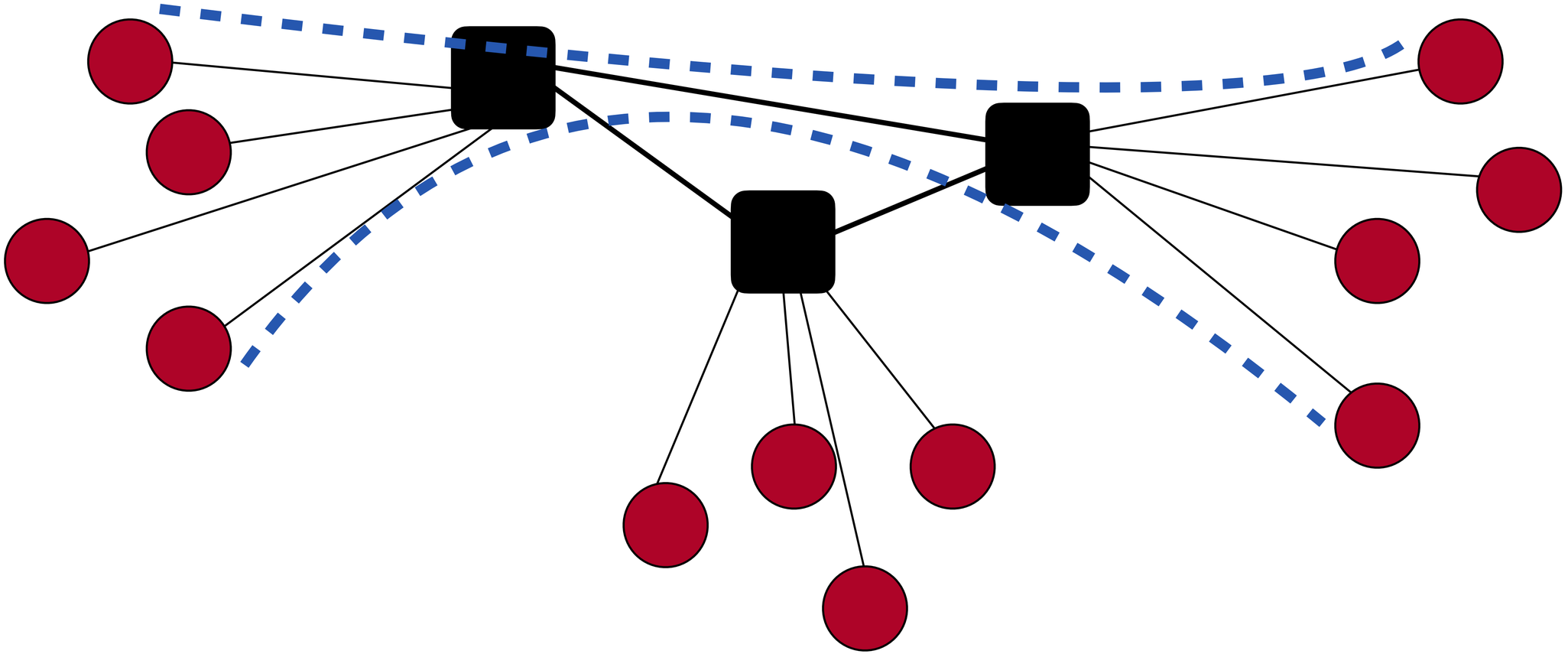


Why should we learn to share the network?

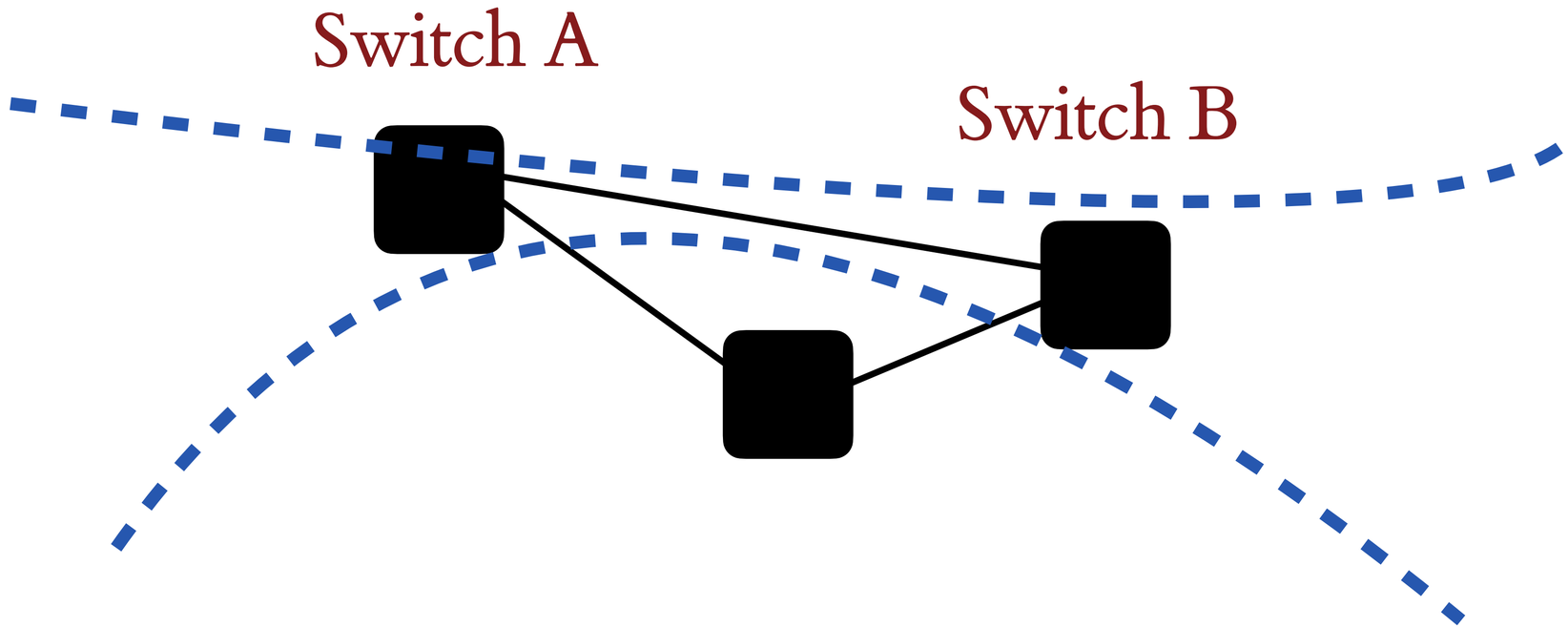
Sharing the network



Sharing the network

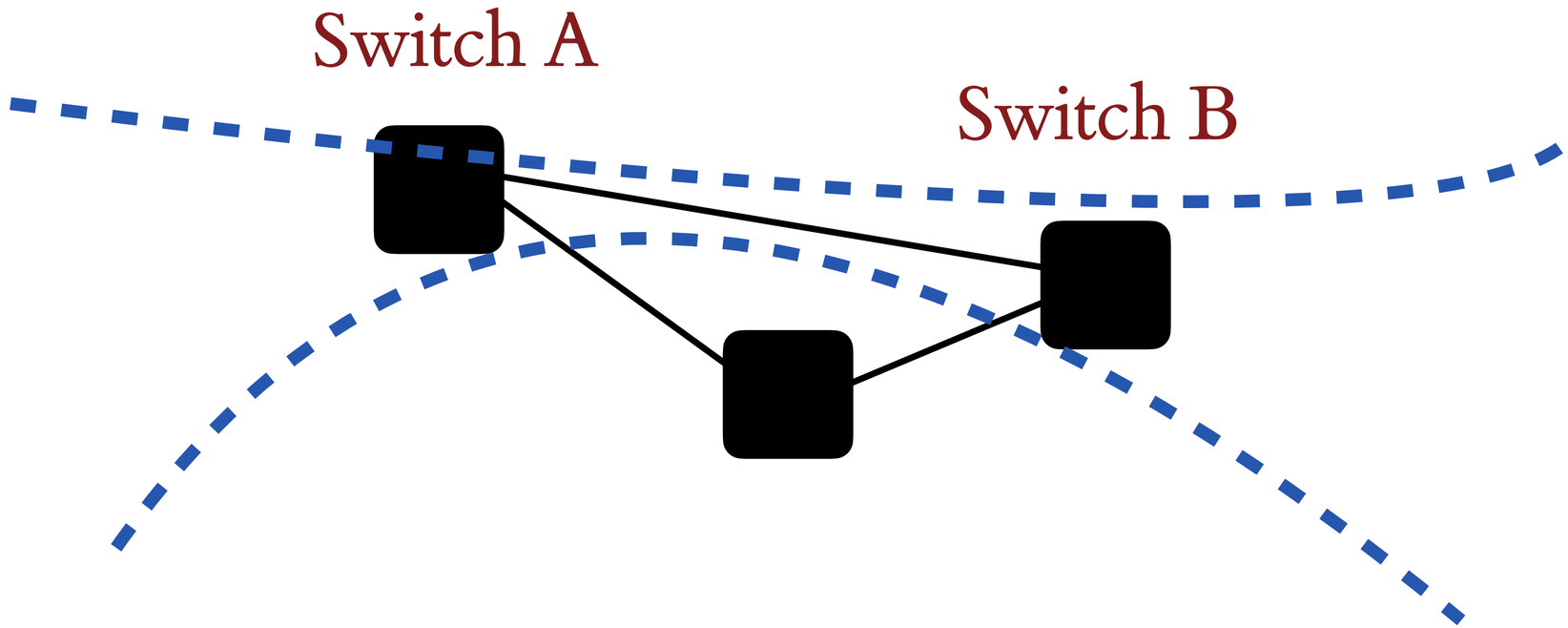


Sharing the network



Many network “paths” going through the same pair of switches and links.

Sharing the network



How should these different paths share the resources on the switches and links?

The problem of sharing the network

- Must support many “users” and “applications” at the same time
- Each user/application wants to use the network
  - To send and receive data
- Limited resources
    - We will learn, over the semester, that network has different types of resources
- Fundamental question:
    - How does the network decide which resource to allocate to which user/application at any given point of time?

Group Exercise 1:

How would you design a sharing mechanism?

Hint:

Think about sharing any resource (say, a computer)

Two approaches to sharing the network

1. Reservations
2. On-demand