Lecture 1: Course overview and Introduction to computer networks

CS356: Computer Networks, Fall 2025

Instructor: Venkat Arun

(Adapted from Daehyeok Kim’s slides)

Course staff

Instructor: Venkat Arun

- Assistant professor in UT computer science
- Research areas: Networked systems and formal methods
- Website: https://www.cs.utexas.edu/~venkatar/

TA: Jeongyoon Moon

- PhD student in the UTNS group
- Research Areas: Systems for ML

Communication channels

Course webpage: https://www.cs.utexas.edu/~venkatar/f25/

- Syllabus, programming assignments, lecture slides, …

Canvas: https://utexas.instructure.com/courses/1421734

- Assignment submission, grade book, and attendance

Ed discussion: https://edstem.org/us/courses/84822/discussion

- Announcements, Q&A, and discussion

Let me know if you don't have access to any of them

Office hours

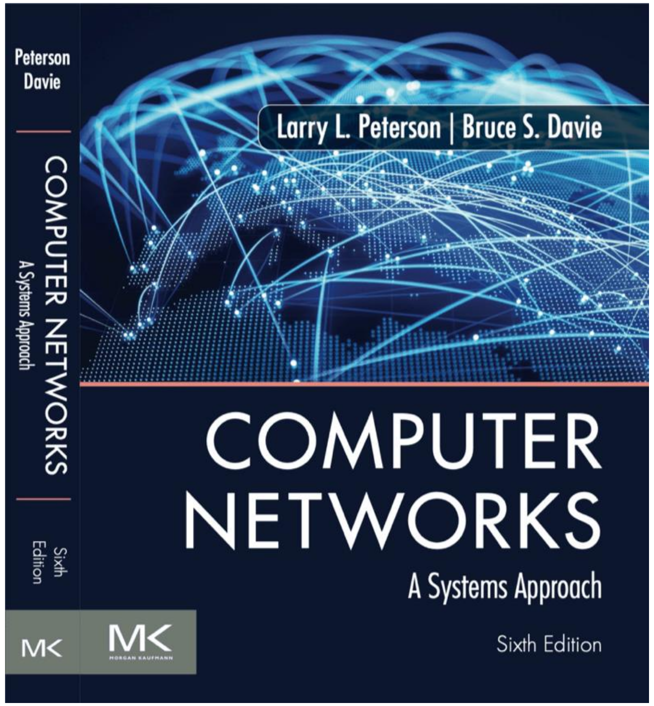
Instructor: Venkat Arun

- After class either outside class or in GDC 6.726

TA: Jeongyoon Moon

- 11:30 AM -12:30 PM, Tuesdays and Thursdays at GDC 1.302 (Desk 1)

Textbook



Computer Networks: Systems Approach, 6th edition by Larry Peterson and Bruce Davie

Available online: https://book.systemsapproach.org/

Lectures may not exactly follow the book

- Please attend lectures!

The internet is an impressive feat of engineering

- Can send data between almost any two locations in the world
- Through equipment operated by tens of thousands of different organizations
- Supporting almost any application
- The same basic concepts have survived over decades
- Yet it evolves rapidly, adapting to technological and societal changes and getting completely new abilities every 5-10 years

- Arguably, the largest human-built machine

The three parts of computer science

- Theory
  - Focuses on the fundamental limits of computation and knowledge. What problems can computers solve in principle, and how efficiently? How can information be communicated securely, even with untrusted parties? What does it mean to *prove* something, and how do proofs give us certainty?
- Artificial intelligence
  - Asks how we can make computers perceive, reason, and act in the real world. It teaches you to think in terms of uncertainty and approximation—reasoning in “fuzzy” ways—while grounding ideas in rigorous models and experimental evidence.
- Computer Systems (this course)
  - Examines how to build real-world computer systems that actually work. How do hardware and software interact? What are the tradeoffs in performance, reliability, and scalability when designing systems people rely on every day?

About this course

Introductory course in computer networks

Objectives

- To learn what computer networks are and how they work today
- To understand why they are designed the way they are and how they are likely to evolve
- To learn how to write networked applications and services and program software routers through programming assignments

Ed discussion

We will be using Ed discussion for all discussions

Please post class-related questions on Ed instead of emailing the instructor or TA

- You will get answers quicker, and it will benefit the whole class

If you have a more personal question, please send private message through Ed Discussion

Please use common sense when posting questions:

- Hints/ideas ok, but cannot post full solutions ☺

Grading

3 Quizzes (60%): in class quizzes

No Final exam

Programming assignments (40%): five programming assignments

Grades will be uploaded to Canvas

Grading bonuses

- Class participation (4 + 1 = 5% bonus)
  - 4%: 4 * (fraction of classes attended as measured by instapoll)
  - 1%: In-class participation

- Assignments will often have a bonus component

Quizzes

Give the instructor at least two weeks notice with reasons if you cannot make the quizzes

You are allowed to bring 3 pages of notes to the quizzes.

You can ask us questions: The course staff will be available during the quiz. You may ask us specific and factual questions during the quiz. If we decide that the question is regarding nitty-gritty details about network protocols, we will answer it (e.g. how a particular routing algorithm works or what port number is used for what protocol).

Programming assignments

Five programming assignments in groups of two. Group of 1 or 3 needs special permission from instructor.

Form a group as soon as possible

- Use Ed's "Finding Partners" category to find your partner

Submission: "Assignments" menu in Canvas

Late submission: 5 "free" late days, after that you will be penalized 20% of the total points of the assignment per day

Please do not post solutions online (e.g. in StackOverflow or public git repositories). They take time to develop and this will make next year's course difficult.

CloudLab and AWS

You can use CloudLab or AWS for the programming assignments. We will provide AWS credits upon request

CloudLab: Compute platform for experiments

Assignment 1 will guide you how to use them!

Alternately, if you have a Linux machine, you can use that. Most assignments will work on OSX and WSL2 as well, but could be extra work to get things working. The assignments will be more fun if you have >= 2 machines

System log collection in CloudLab nodes

System logs are collected for research purposes in CloudLab

- Kernel events: Process / thread start, disk IO, TCP communication and process kill/OOM events)
- Node & process info: CPU/memory/network/disk statistics

Collected logs are periodically sent to a storage

Three TCP ports (2021, 2022, and 5170) are in use for log collection

No personally identifiable information is collected!

Assignment policy

All code and results you submit must be the original work of your group

Cheating and plagiarism will not be tolerated and will be dealt with in accordance with the University of Texas policies and procedures

If you fail to adhere to the policy, your case will be sent to the Dean of Students and placed on your file

Use of LLMs (e.g. ChatGPT)

They are an exciting new tool, and we encourage you to use them. Using them effectively will be a useful skill. The assignments explicitly point to situations where they may be handy.

However, use your common sense. The assignment must be your original work. Just copy-pasting their output is not ok.

Golden rule: Ultimately, you are responsible for understanding everything you write. We may quiz you at our discretion.

UT students have free access to UT Spark (ChatGPT 4o)

Class participation

Everyone is expected to attend lectures and participate

- Your attendance will be recorded on Canvas
- Lectures will be recorded on a “best effort” basis (i.e. if the recording equipment works) for later review.

Please ask questions!

- Will make class more fun for everyone
- Others may also benefit from your question

Feedback

- This course is for you and you can help shape it. Please let me know what does and does not work for you during the course.
- Channels of communication:
  - Private (or non-private) messages on Ed Discussion
  - Email
  - Speak up after/during class

Let’s get started!

What are the applications on the internet?

WWW, media streaming, real-time communication, gaming, …

What's the common requirement of these applications?

- Connectivity – In principle, the network just needs to transport bytes. In practice, there are differences in what the apps need, and the internet is flexible enough to support that.

App example1: World Wide Web (WWW)

The most basic application accessed using a web browser

Interface: Uniform Resource Locator (URL)

- E.g., https://cs.utexas.edu/~venkatar/f25

https → Hypertext Transfer Protocol Secure (HTTPS) should be used to download the file

utcs356.github.io → machine name that serves the file (host)

f25/index.html → identifier of the particular page

It is called "the web" because this universal naming convention allows us to create a *web* of inter-connected pages.

Retrieving a page via HTTP(S)

1. Retrieve an address for the host (cs.utexas.edu)
    1. E.g., 185.199.109.153
2. Set up a connection to the host
3. Request object(s) – many messages, possibly
4. Receive object – many messages, possibly

Key performance metric: Page load time (PLT)

- Time to load the entire page (including images, scripts, etc)
- Or time to display just the visible part of the page

App example 2: Media streaming

A widespread application class of the Internet

- E.g., Netflix is responsible for 15% of Internet traffic[1]
- More broadly, video is responsible for ~70% of the bytes

Unlike web page loading, it demands a continuous data flow

Users want good "quality of experience" (QoE)

- Delivery start can be delayed but not too much
- Low rebuffering events, high bandwidth/quality

App example 3: Real-time communications

Popular application types that have grown rapidly in recent years

- E.g., Zoom, Teams, Skype, …

Tight timing constraints

- When you speak, you want to be heard at the other end near simultaneously

It must provide consistent views across multiple participants

App example 4: Next generation real-time communication

Augmented/Virtual reality applications, networked robots

Much shorter timing constraints (~50ms instead of 200-300ms)

Sensitive to violations at the tail

- Even if 99% of frames are displayed on time, user experiences a disruption once every 3 seconds at 30 frames/second

App example 5: Massively distributed computation in supercomputers/datacenters

- Massive scientific computations
- Web search! We take it for granted
- Massive neural networks (Large Language Models, computer vision…)

All these applications need a very large number of computers to coordinate very closely with each other

Particularly important since individual processors have stopped getting faster

Network design requirements

Network operators

- Scalable connectivity and cost-efficient resource sharing
- Manageability (for configuration, troubleshooting, accounting, …)

World at large

- Flexible connectivity that can be extended by anyone and adapt to new technology

Application developers

- Support for common services via well-defined abstractions

Requirement 1: Scalable connectivity

A network must provide connectivity among a set of computers

- From small, private networks with limited connections to large-scale networks (e.g., Internet)

"Scalable" connectivity

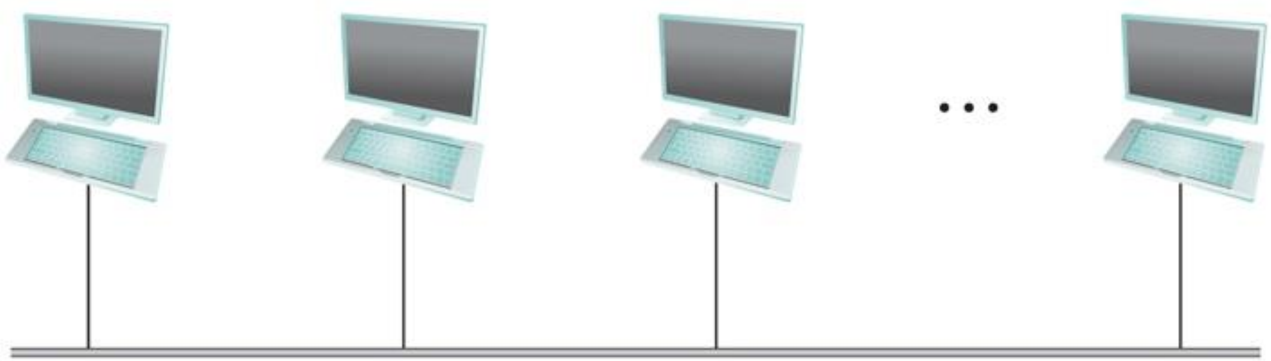
- The network must provide connectivity that support an arbitrarily large number of computers
- We call such connectivity "scalable connectivity"

Two Key Principles

- Switched Networks
- Packet switching

Direct links

Point-to-point

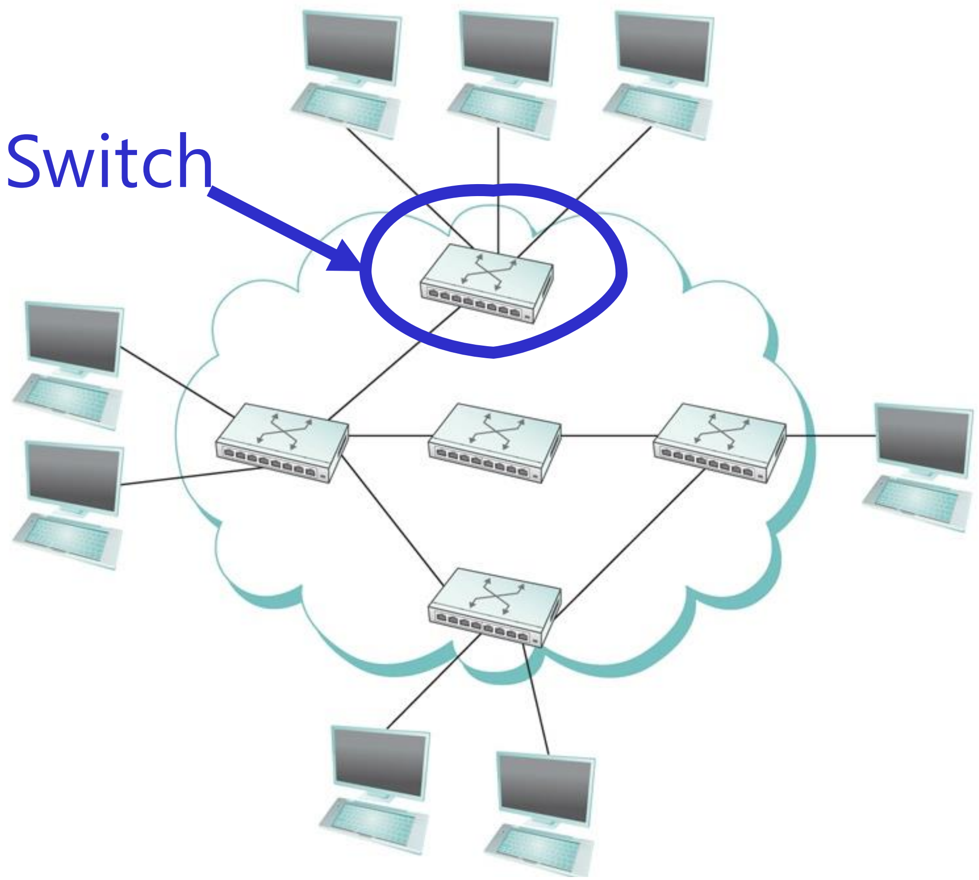


Multiple-access
(e.g., Wi-Fi or cellular networks)

What limits the size of networks only with direct links?

- Number of nodes they can connect
- Geographical distance they can cover (e.g., WiFi coverage)

Switched networks



Allowing a collection of computers can be "indirectly" connected

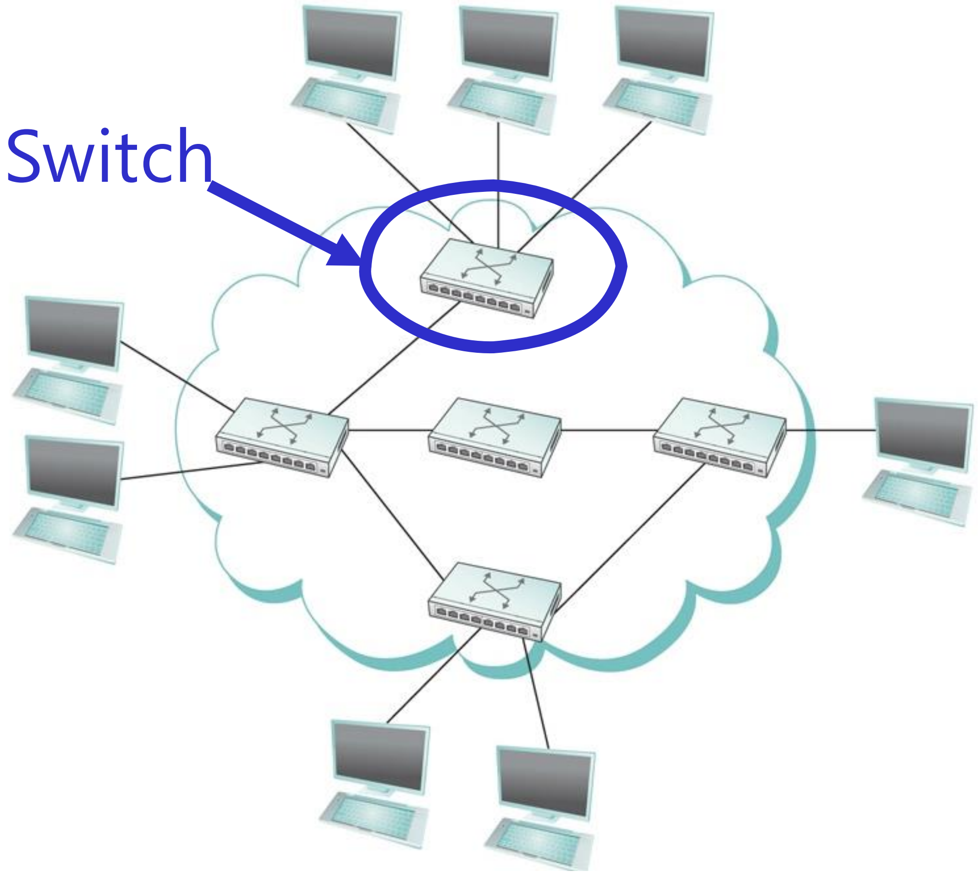
Circuit-switched

- Used in telephone networks
- Recently used in optical networks

Packet-switched

- Used in majority of computer networks
- Focus of this course

Packet-switched networks



Switches: forwarding messages from one node to another

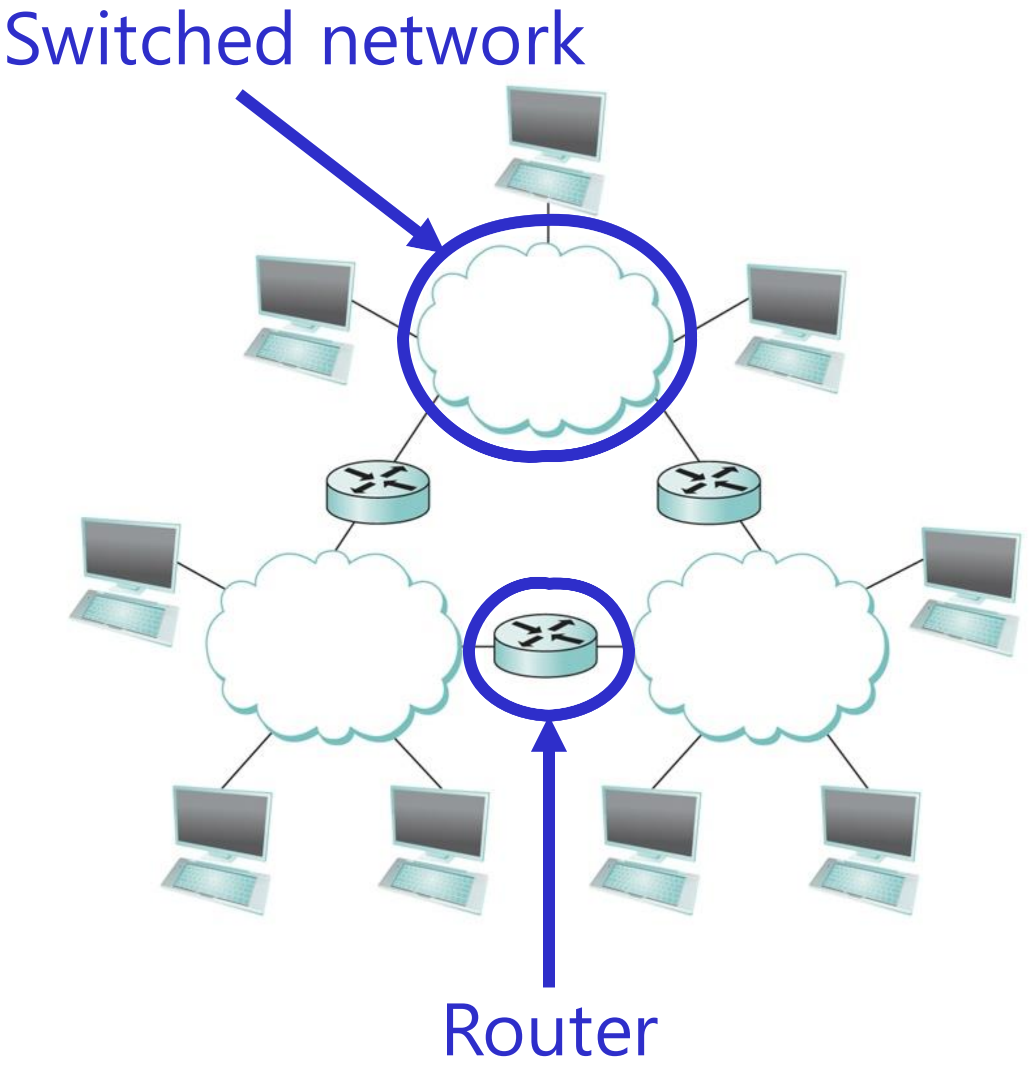
- Every node has a unique address

Forwarding table

Node address	Switch port number
Node 1's address	0
Node 2's address	1
…	…

- If a message destined for node 1 arrives, then send it out on port 0
- We will discuss the details later

Internetwork of switched networks



Stitching switched networks to scale networks to larger size

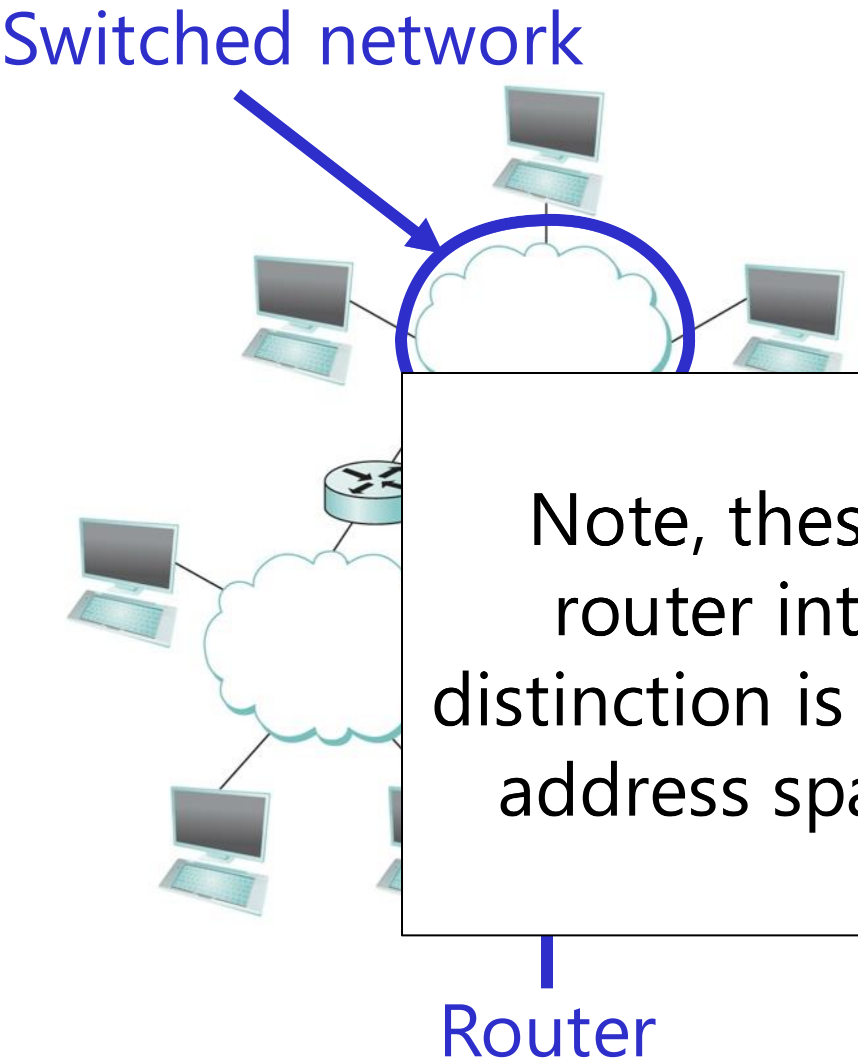
Routers: forwarding messages between networks

- Using a different type of address type called IP address, so every router does not need every node's address
- We will discuss the details later

An internetwork is managed by a single administrative entity

- UT Austin, AT&T, Google, …

Internetwork of switched networks



Stitching switched networks to scale networks to larger size

Routers: forwarding messages between networks

type called IP

t need every

Note, these days people use switch and router interchangeably. The important distinction is whether there is hierarchy in the address space (we will discuss more later)

single

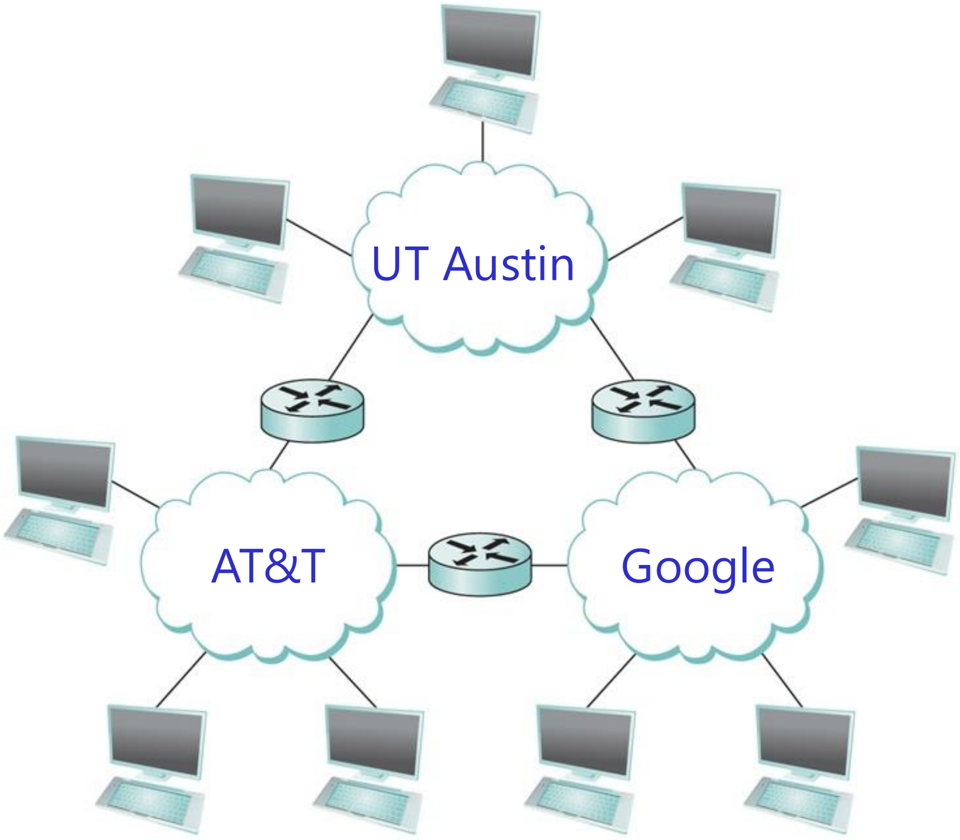
administrative entity

- UT Austin, AT&T, Google, …

The "Internet"

Recursively grouped interconnection of internetworks

- The interconnections are again made via routers



Summary

Computer networks are an essential infrastructure for modern apps

- Must be general to support diverse applications' needs
- Must adapt to changing technology and societal needs

Scalable connectivity: support for an ever-increasing number of computers on a network

- Packet-switched networks via switches
- Internetwork of switched networks via routers
- The "Internet": recursively grouped interconnection of internetworks

Next up: other requirements and network architecture