China Communications

Zhe Zhang

Course Outline

Course Objectives

- Students will learn basic concepts about communications. By investing the cases in China communications, students will develop a systematic understanding of communication systems and get to know China better.

Course Outline

Lists of Topics

- Basic concepts of communications
- Communication network structure
- Computer networks
- Cellular networks
- Internet of things (IoT)
- Satellite communications
- Future communication technologies

Course Outline

Class Philosophy

- We want you to learn and to be successful
- Attend class and recitations regularly to discuss material
- In summary, be proactive. Interact with us and with your fellow students and support each other

Course Outline

Late policy

- Don’t be late
- If you must be late, inform me in advance
- If you cannot inform me in advance (e.g., medical), provide a doctor’s note or other allowable documentation
- Unexcused late will lose a significant fraction of points

Course Outline

Grading

- Final grades = group discussions (attendance) + class presentations + project report
- group discussions (attendance): 20%
- class presentations: 30%
- project report: 50%

Course Outline

Contact Info

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  - We’ll make every effort to accommodate reasonable requests that support your learning better (you can reach me through the above email)
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- Slides can be downloaded here: https://petrelli.github.io/zhe/download/

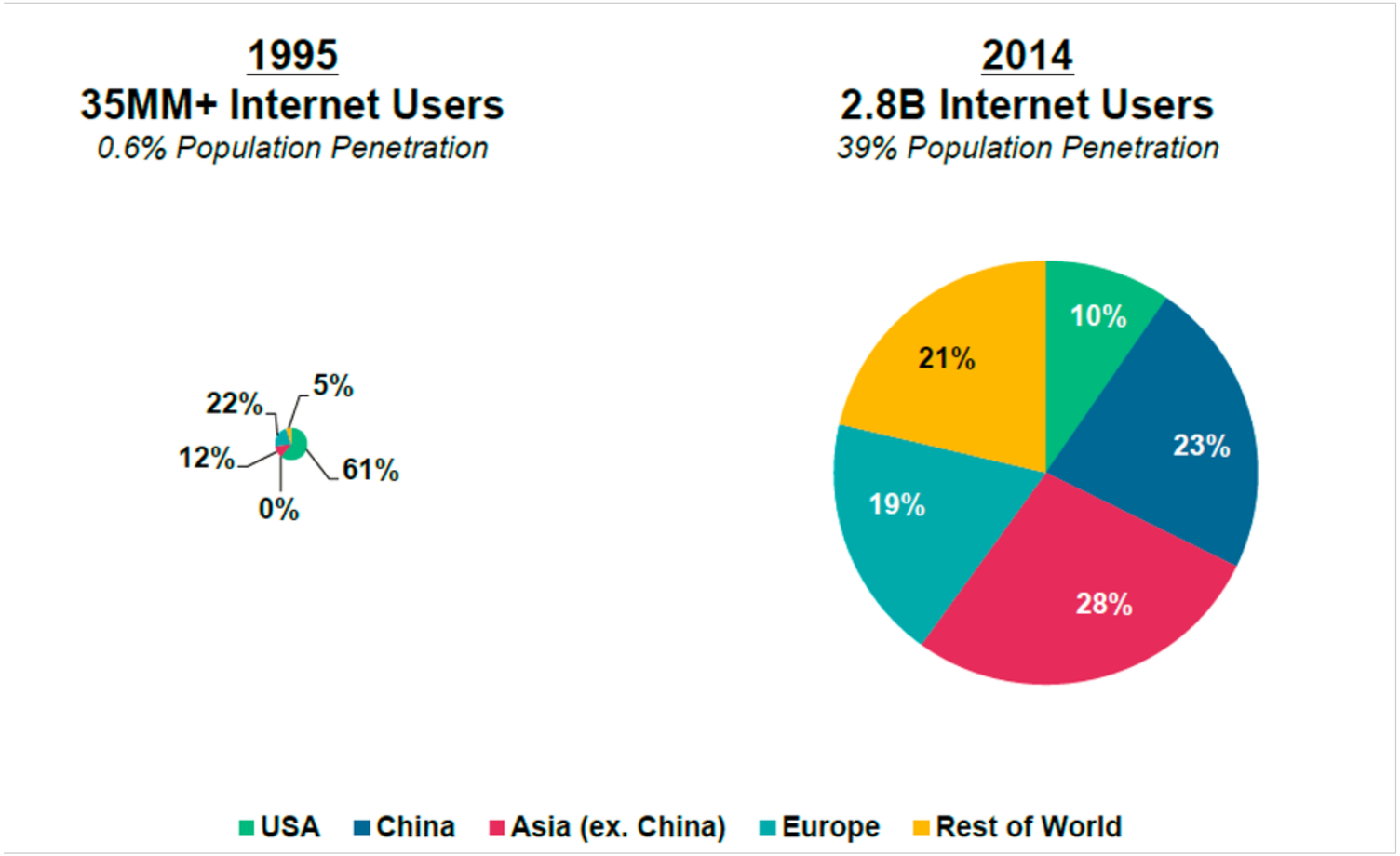
Chapter 1: Basic concepts of communications

The Internet has transformed everything

- How we communicate with other humans
- How we learn what's going on in the world
- How we learn and acquire knowledge
- How we transact and do business
- How we entertain ourselves
- How espionage and war is conducted

- In short how we live, especially through a pandemic.

Internet growth



2020

4.8B users

(61% of the world's population)

https://www.broadbandsearch.net/blog/internet-statistics

Overview

from left to right

Group Discussion

What communication apps do you use in current life?

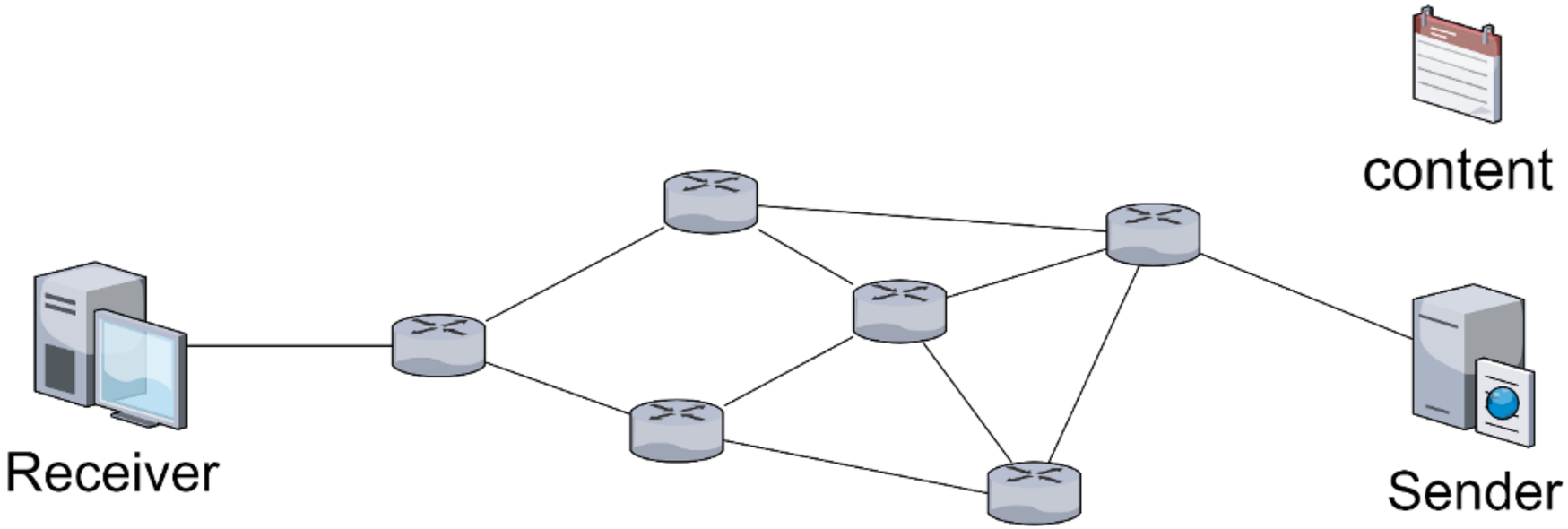
- Group size: 3-5 person
- Discussion time: 5 mins
- Each group needs one representative to present your group’s discussion conclusions, e.g., most popular app, how do you like it, or why you use it instead of others, etc.

Technology is cool.

Learn fundamental principles that underlie Internet technology.

So that you can use and build technology for fun, altruism, and profit.

How is the content transmitted?



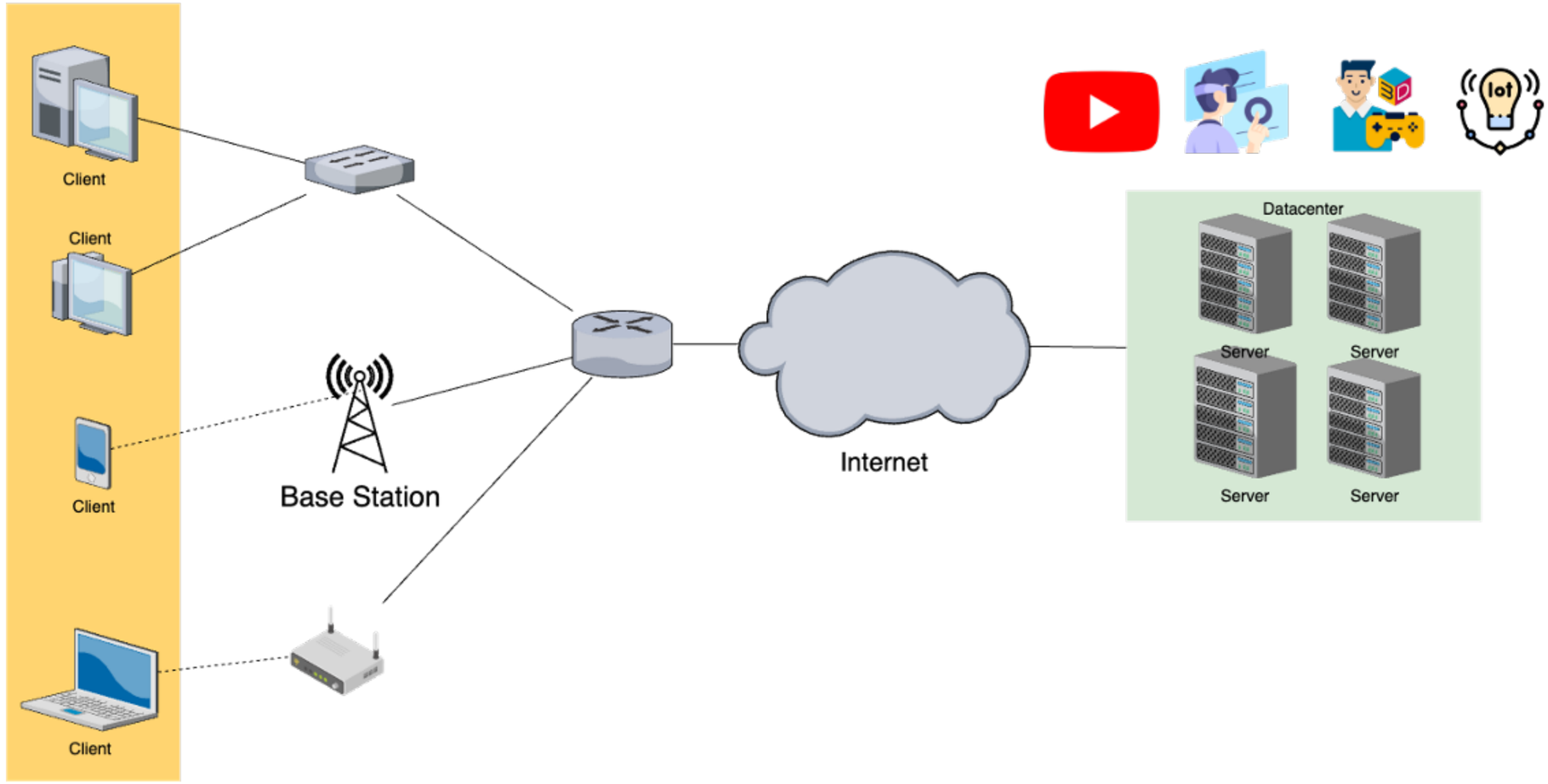
Definition of Communication

- The process of exchanging information between a sender and a receiver.
- key aspect:
  - sender
  - message (data)
  - medium
  - receiver
  - feedback

Definition of Communication

A case study

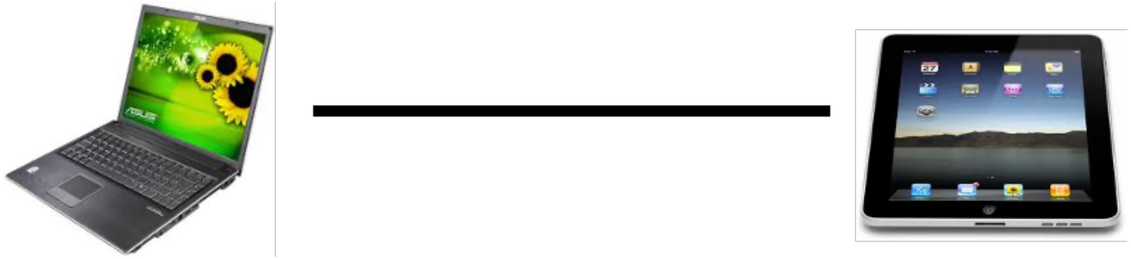
- Figure out the key aspects that are mentioned before



The Communication Process

Sending

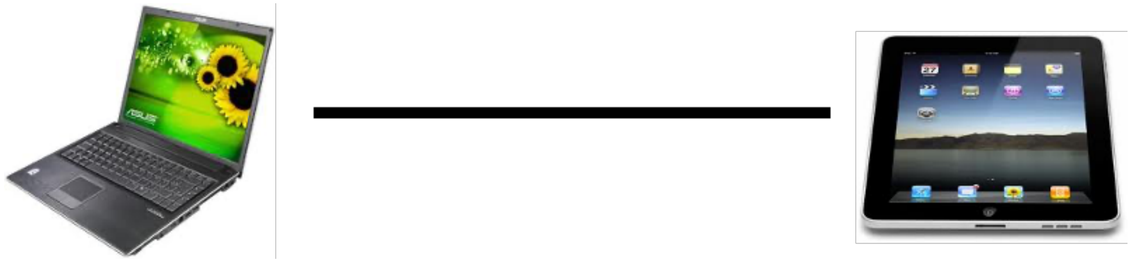
- With 1s and 0s
  - Computers only deal with 1s and 0s
  - So do networks
- How do we transmit 1s and 0s in a network?



The Communication Process

Sending

- Converting information into a form suitable for transmission.
  - Physical signaling (light, AC voltages, etc.) are often analog
  - Convert bits to signals through modulation of the physical characteristics of signals: encoding



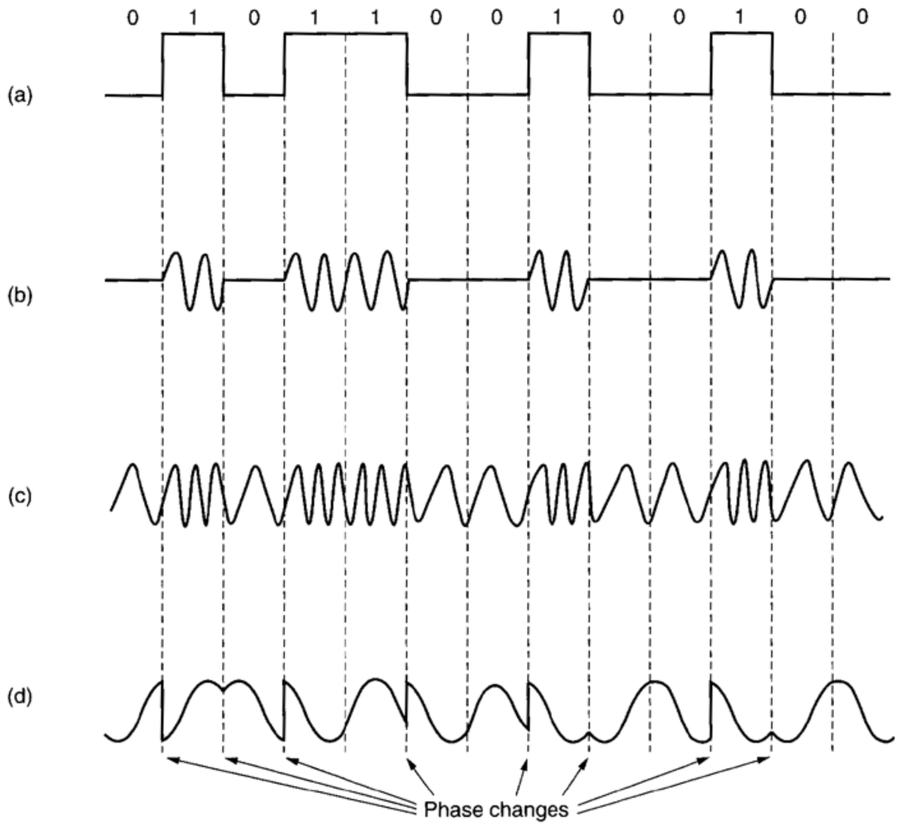


Fig. 2-18. (a) A binary signal. (b) Amplitude modulation. (c) Frequency modulation. (d) Phase modulation.

The Communication Process

Transmission

- Sending the encoded message through a medium,
  - Examples:
    - Wired Links: cooper wire, lasers over optic fiber, coax cables
    - Wireless Links: cellular 4G/5G, Wi-Fi, bluetooth, satellite

The Communication Process

Receiving

- Decoding: Convert signals back to digital by decoding physical signals
- Question: Why we need decoding?

Types of Communication

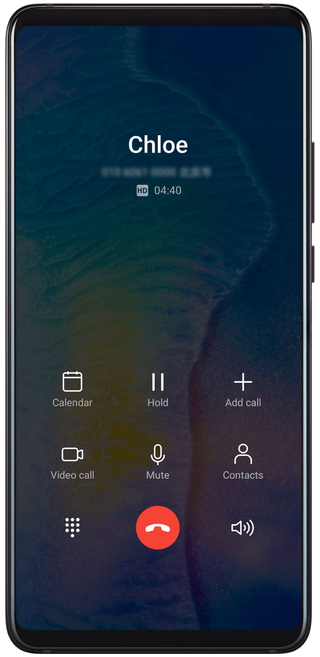
Ancient

- Fire Signals and Smoke

- Carrier Pigeon

Types of Communication

Modern Society (Information era)



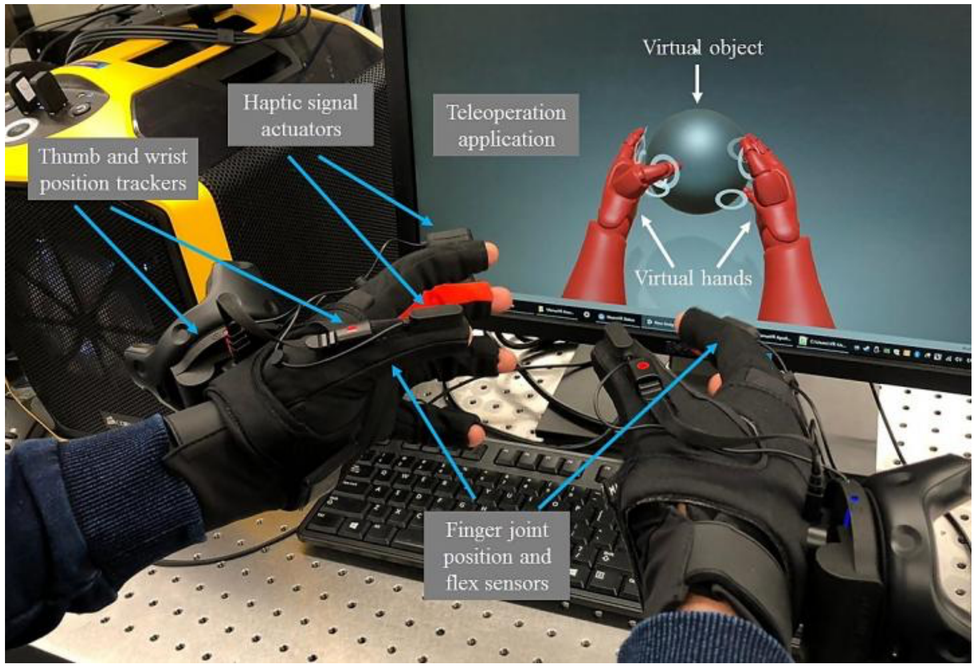
- Voice Communication

- Data Communication

- Video Communication

Types of Communication

The Next Era



- Haptic Communication

- Metaverse

Group Discussion

What type of communication dominates current network?

- Group size: 3-5 person
- Discussion time: 5 mins
- Each group needs one representative to present your group’s discussion conclusions, why do you guys believe it is dominating the current network.

Communication Systems

System Perspective

- A communication system transfers information from one point to another
- It can be categorized as:
  - Computer Communication System
  - Cellular Communication System

Communication Systems

Computer Networks

- Systems enabling communication between computers over a network.
- Current computer networks mainly use IP.
- What is a network?
  - Carrier of information between two or more entities
  - Entities may be hosts/endpoints, devices in the middle of the network
    - your laptop, router, etc.

Communication Systems

Cellular Networks

- Wireless communication enabling mobile device connectivity
- Based on radio frequency signals divided into cells
- Key features:
  - Wireless links
  - Different network structure compared to computer networks
    - However, it keeps evolving to mitigate this difference (also uses IP now)

Basic Concepts

Information, Data, and Signals

- What is the information?
  - The content or message being communicated
- What is the data?
  - Data is the raw representation of information, usually is digital (binary form, 0s and 1s)
- What are signals?
  - The physical representation of data (e.g., electromagnetic waves, AC voltages)

Basic Concepts

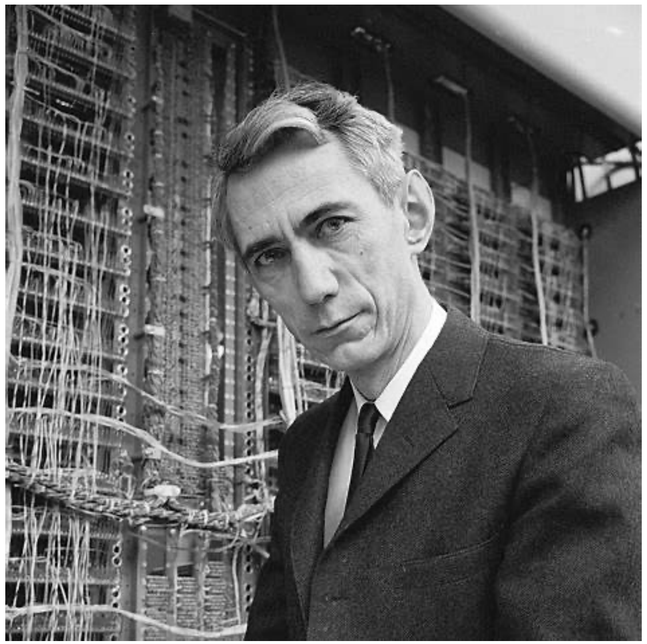
Bandwidth

- Definition:
  - In computer networks: The maximum amount of data that can be transmitted over a network or communication channel in a given period of time, is usually measured by bit per second (bps)
  - In cellular networks: The range of frequencies that a channel can carry, is usually measured in Hertz (Hz)

Claude Shannon

Father of the Information Age

- Claude Elwood Shannon (1916–2001) was an American mathematician, electrical engineer, and cryptographer, widely regarded as the "father of information theory.”
- Shannon is one of the organizers of Dartmouth workshop.
  - The term “artificial intelligence” was introduced in the project.
  - Shannon is also considered as one of the fathers of AI.



Basic Concepts

Channel Capacity (Shannon's Theory)

- Maximum amount of information that can be transmitted over a channel without error.
- Formula: $C = B * \log_2(1 + S/N)$
  - C: Channel capacity (bits per second)
  - B: Bandwidth of the channel (hertz)
  - S/N: Signal-to-noise ratio (dimensionless)
- Influenced by:
  - Bandwidth
  - Signal-to-noise ratio (SNR)

Basic Concepts

Latency

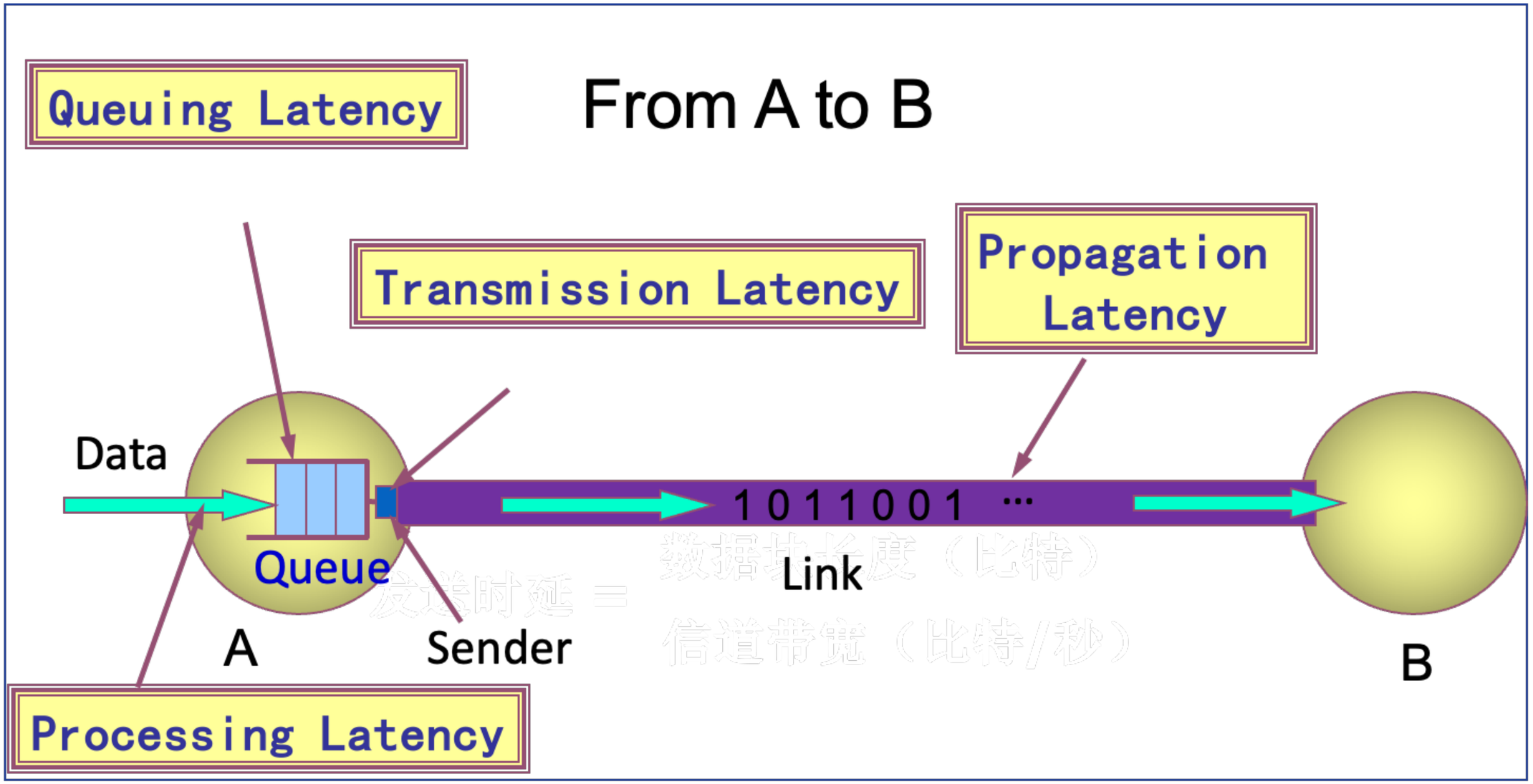
- Delay in communication, measured as the time between sending and receiving.
- Types:
  - Transmission latency
  - Propagation latency
  - Processing latency
  - Queuing latency

An Analogy: Conveyor Belt

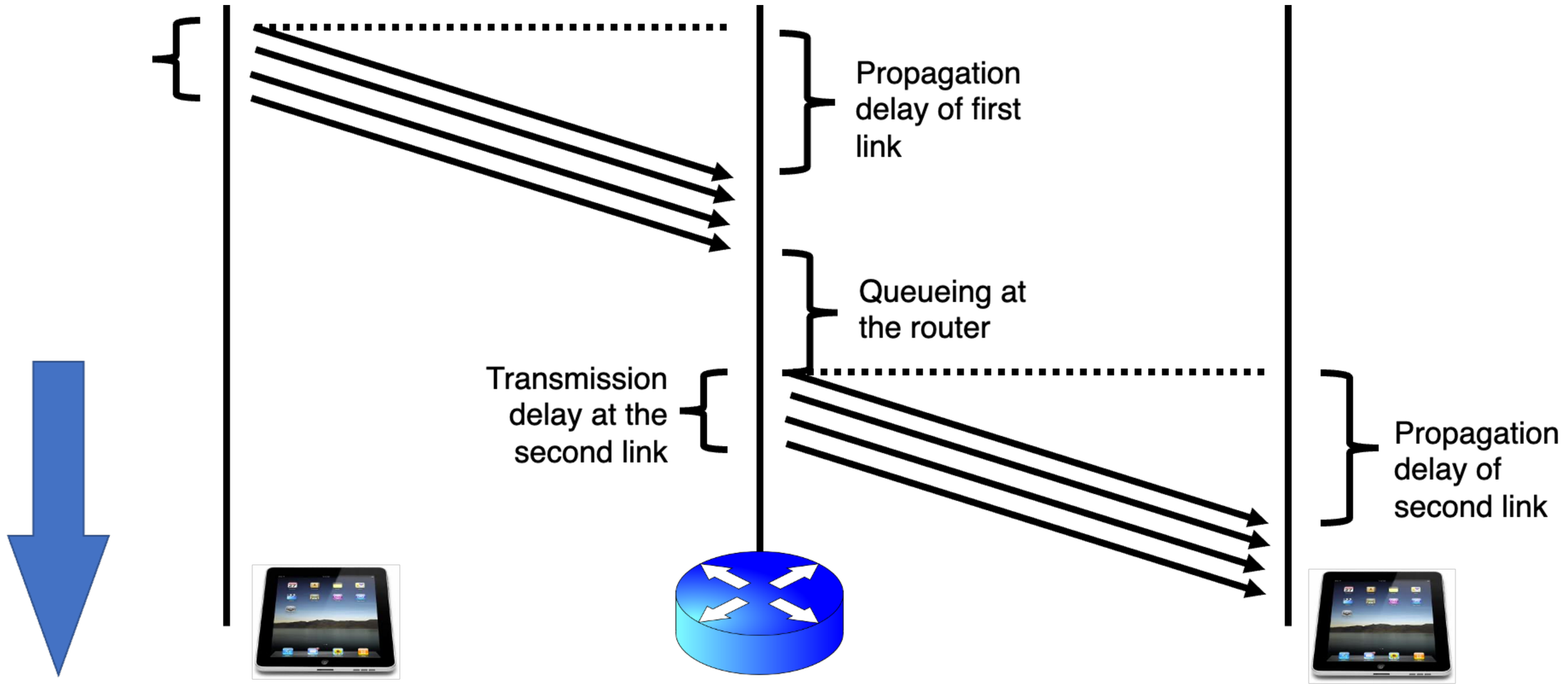
- Propagation delay = time for first box to travel the length of the belt
- Bandwidth = the number of boxes put on the belt per minute ("rate")
- Suppose we have N boxes in one shipment
- Shipment transmission time = N / rate
- The next box is put on the belt (1/rate) minutes after the last
- Total transfer time = transmission time + propagation delay

Basic Concepts

Latency



Visualizing the delays



Basic Concepts

Protocols

- Definition: Rules that govern communication between devices.
- Examples:
  - TCP/IP for Internet
  - RRC (Radio Resource Control) for radio resource control

Protocols: The “rules” of networking

Protocols consist of two things

Message format
structure of messages exchanged with an endpoint

Actions
operations upon receiving, or not receiving, messages

Example of a Zoom conversation:
Message format: English words and sentences
Actions: when a word is heard, say “yes”; when nothing is heard for more than 3 seconds, say “can you hear me?”

Thank You