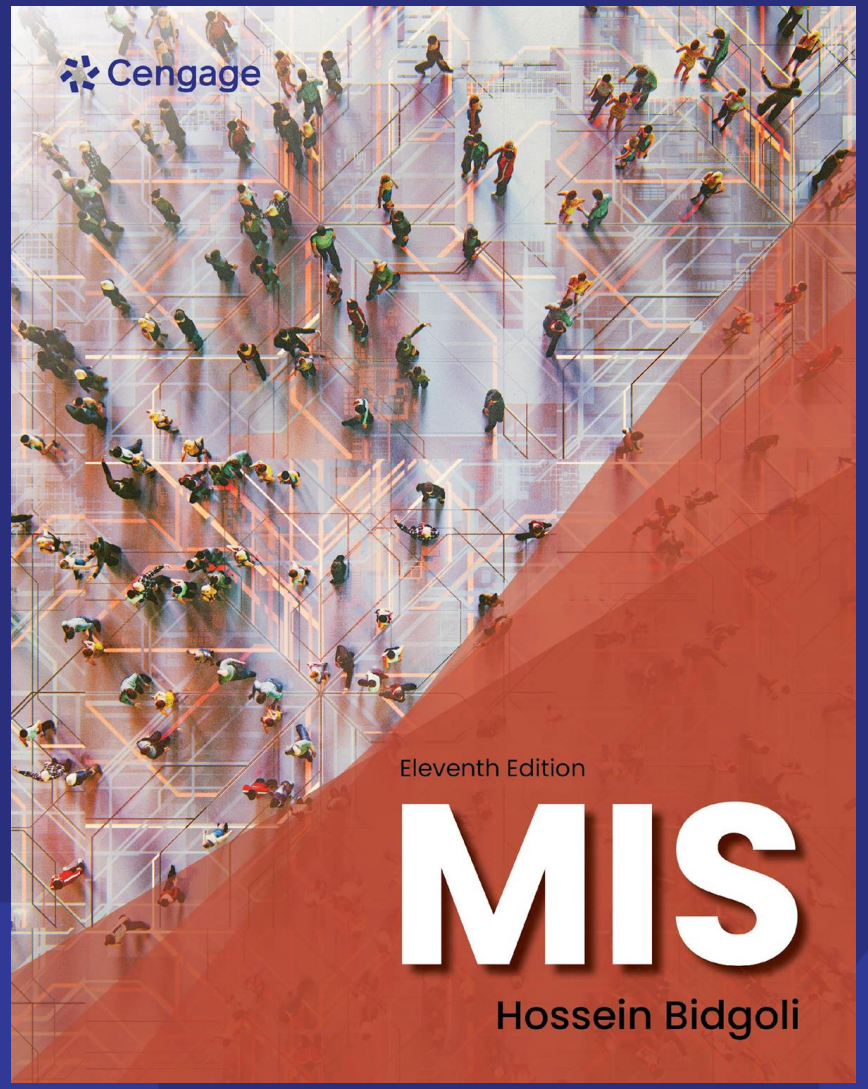


MIS, 11e

Module 6: Data Communication: Delivering Information Anywhere and Anytime

Cengage

Module Objectives

By the end of this module, you should be able to:

6.1 Describe the major applications of a data communication system.
6.2 Explain the three major components of a data communication system.
6.3 Describe the three major types of processing configurations.
6.4 Explain the three types of networks.
6.5 Describe the five main network topologies.
6.6 Explain important networking concepts, including protocols, TCP/IP, routing, routers, and the client/server model.
6.7 Examine wireless and mobile technologies and networks in a business setting.
6.8 Describe networking trends such as Wi-Fi, WiMAX, and Bluetooth
6.9 Discuss the importance of wireless security and the five techniques used.
6.10 Summarize the concept of convergence and its applications for business and personal use.
http://gaia.cs.umass.edu/kurose_ross/index.php

Data Communication System

- Electronic transfer of data from one location to another
- Critical for organizations
- Relied upon by virtual organizations and e-collaboration
- Support organization's efficiency and effectiveness

- **Watch**: https://www.youtube.com/watch?v=ewrBalT_eBM

Major Components of Data Communication System

- Components of a data communication system includes three different components
  - Sender and receiver devices
  - Modems or routers
  - A communication channel

- **Bandwidth** affects the amount of data that can be transferred from one point to another in 1 second
  - https://en.wikipedia.org/wiki/Bandwidth_(signal_processing)
  - https://www.youtube.com/watch?v=A_-L-kn9biw

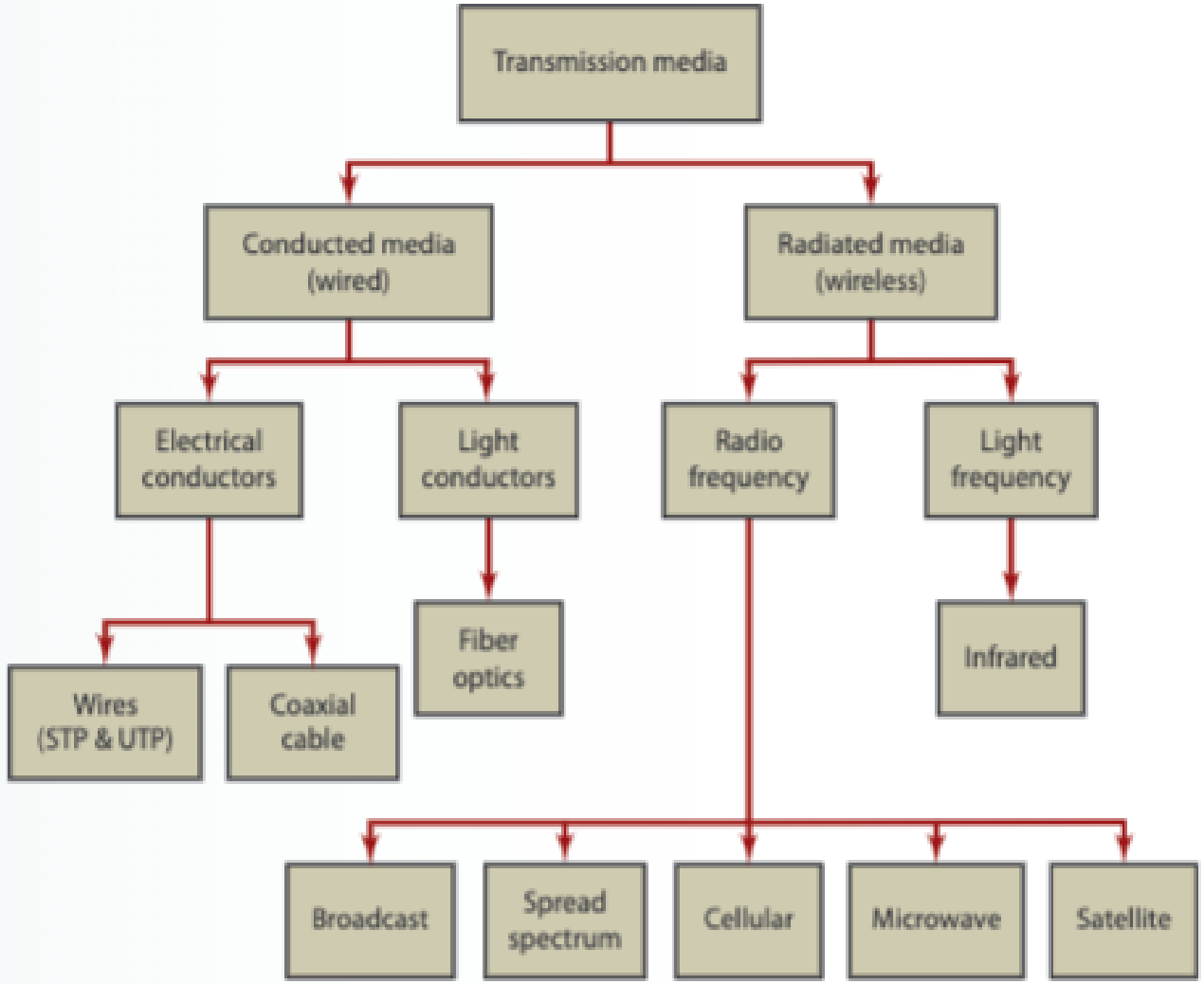
- **Attenuation** is the loss of power in a signal as it travels from the sending device to the receiving device

Major Components of Data Communication System

- **Communication media** connect sender and receiver devices and provides a physical path that signals are transmitted on

- Can be conducted or radiated
  - **Conducted media** provides a physical path (i.e. cable) that signals are transmitted on
  - **Radiated media** use an antenna for transmitting data

Exhibit 6.1
Types of communication media



Conducted Media

Major Components of Data Communication System

- Watch https://www.youtube.com/watch?v=A_-L-kn9biw
- Data transmission are divided into two types:
    1. Broadband: multiple pieces of data sent simultaneously
    2. Narrowband: voice-grade transmission that can transfer limited information in a specific period of time

- **Protocols** are rules that govern how data communicates

Major Components of Data Communication System: Sender and Receiver Devices

- Devices can have various formats
  - Input/output device (“thin client”)
  - Smart terminal
  - Personal computer
  - Netbook computer
  - Supercomputer
  - Smartphone

Major Components of Data Communication System: Modems or Routers

A **modem** is a device that connects the user to the Internet

- Required for dial-up, DSL and cable access to the Internet
- Not required for wireless and satellite connections to the Internet

  - https://www.youtube.com/watch?v=Mad4kQ5835Y
  - https://www.youtube.com/watch?v=1z0ULvg_pW8
  - https://www.youtube.com/watch?v=qQYiwmamq38

Types of Networks

- types of networks
  - Local Area Networks (LAN)
  - Wide Area Networks (WAN)
  - Metropolitan Area Networks (MAN)
- Connected using a hardware component that enables computers to communicate called a **Network Interface Card**

Watch: https://www.youtube.com/watch?v=4_zSIXb7tLQ

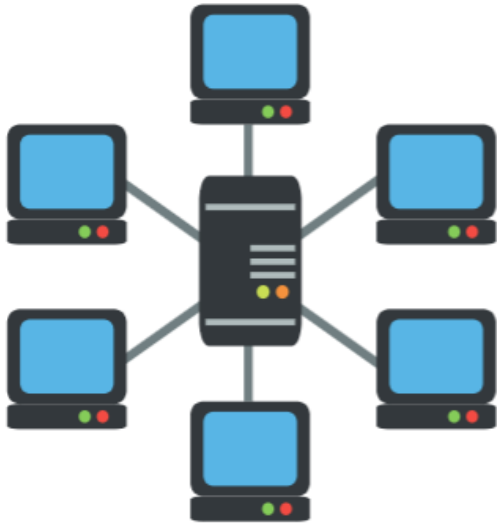
Table 6.1 Comparison of LANs, WANs, and MANs

Network Type	Ownership	Data Transfer Speed	Scope
LAN	Usually one party	100 Mbps to 10 Gbps	A building or a campus
WAN	More than one party	28.8 Kbps to 155 Mbps	Intercity to international
MAN	One to several parties	34 Mbps to 155 Mbps	One city to several contiguous cities

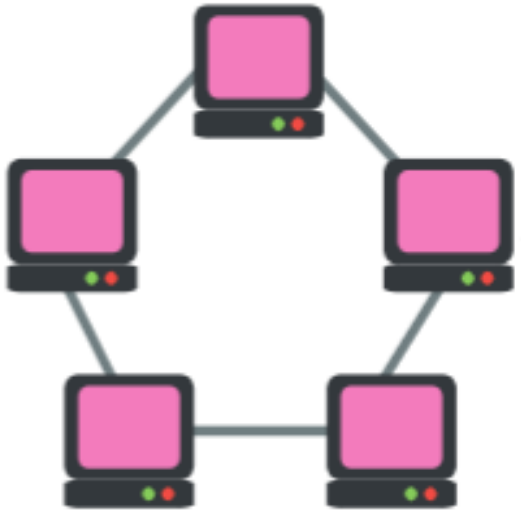
Network Topologies

- Represents a network's physical layout
- Five common topologies are
  - Star
  - Ring
  - Bus
  - Hierarchical
  - Mesh

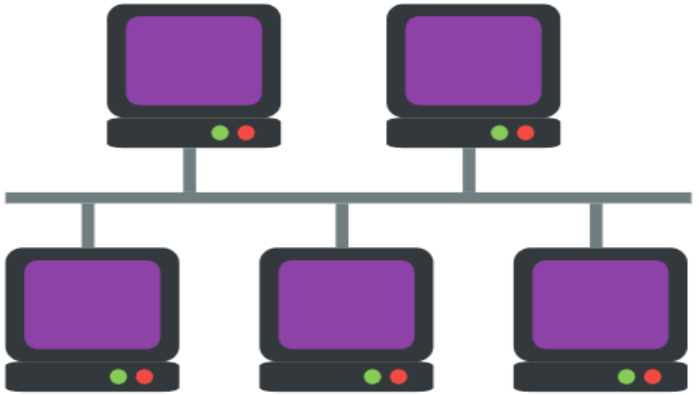
    Watch: https://www.youtube.com/watch?v=zbqrNg4C98U



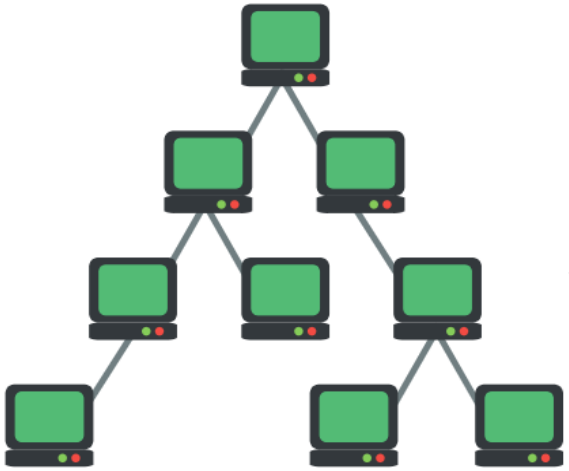
Star



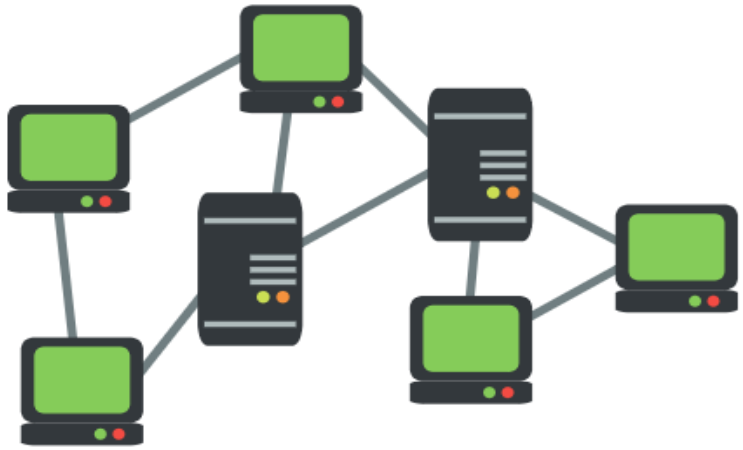
Ring



Bus



Tree



Mesh

Network Topologies

Star

- Consists of a central computer and nodes
- Host computer supplies the main processing power

Ring Topology

- No host computer is required
- Each computer manages its own connectivity
- Arranged in a circle
- Transmission is in one direction

Bus Topology

- Connects nodes along a network segment
- Ends of the cable are not connected
- A terminator is used at each end of the cable to absorb the signal

Hierarchical

- Combines computers with different processing strengths
- Failure of nodes at the bottom level may not have a negative impact on network performance
- Middle and top nodes are crucial for network operations

Mesh

- Every node is connected to every other node
- Highly reliable
- Costly and difficult to maintain

Network Topologies: Star Topology

Advantages of Star Topology

- Cable layouts are easy to modify
- Makes detecting problems easier
- Easily add nodes to a network
- More effective at handling heavy but short bursts of traffic

Disadvantages of Star Topology

- The entire network becomes inoperable if the central host fails
- Increased costs

Network Topologies: Ring Topology

Advantages of Ring Topology

- Requires less cable than Star topology
- Better for handling short bursts of traffic

Disadvantages of Ring Topology

- Difficult to diagnose problems
- Difficult to modify the network

Network Topologies: Hierarchical Topology

Advantages of Hierarchical Topology

- Provides network control
- Has lower costs than a star topology

Disadvantages of Hierarchical Topology

- Can be difficult to expand the network
- Traffic congestion can result at the root and higher-level nodes

Network Topologies: Bus Topology

Advantages of Bus Topology

- Easy to extend
- Reliable
- Wiring layout is simple
- Uses the least amount of cable of any topology
- Handles steady traffic well

Disadvantages of Bus Topology

- Fault diagnosis is difficult
- Can create a bottleneck when network traffic is heavy

Network Topologies: Mesh Topology

Advantages of Mesh Topology

- Highly reliable

Disadvantages of Mesh Topology

- Costly
- Difficult to maintain

Network Concepts

Protocols

- Agreed-upon methods and rules to exchange information
- Applied to hardware connections, data transmission, and file transfers
- Specify the format of message packets
- Multiple protocol support is becoming more important

TCP/IP

- **Transmission Control Protocol/Internet Protocol**
- Industry-standard suite of communication protocols

Routers

- Network connection device
- Contains software that connects network systems and controls traffic flow
- Forwards packets using static routes or dynamic routes

Routing

- Determining the route that data packet is transferred
- Uses a **routing table** to determine the best route for the packet
- **Centralized routing** is where one node is in charge of selecting the path for all packets

TCP/IP Model

Must-watch Video:

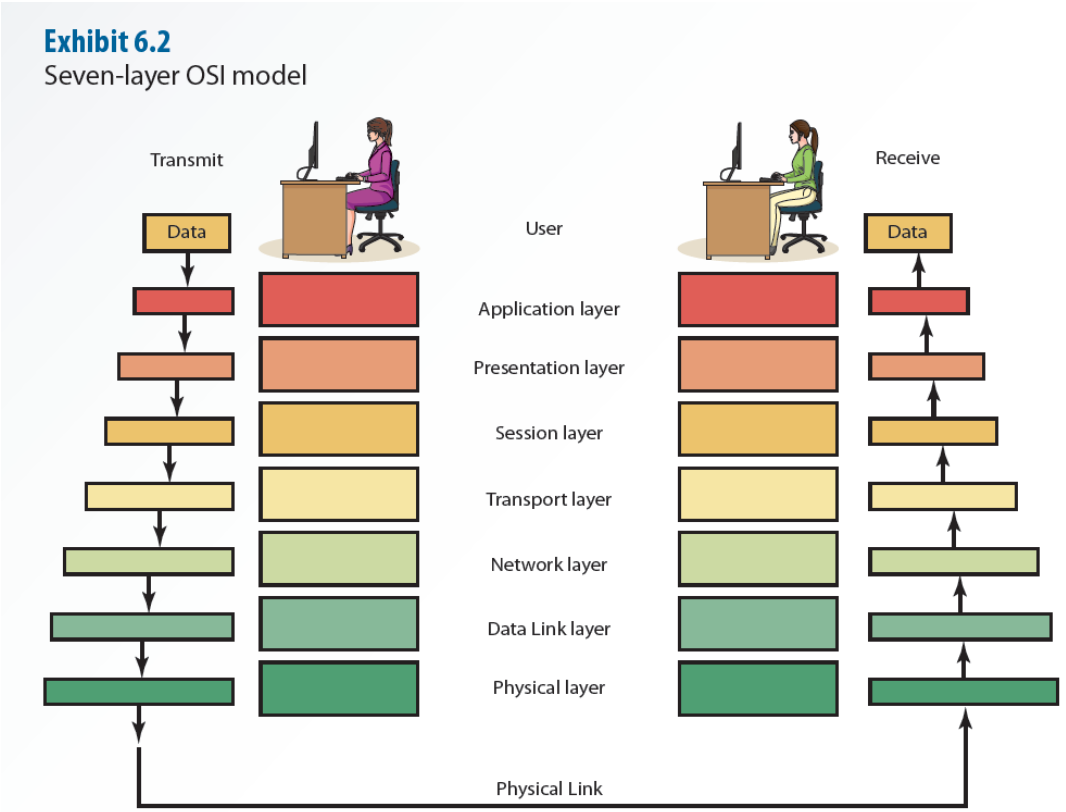
- TCP/IP 5-Layer Model: https://www.youtube.com/watch?v=2QGgEk20RXM
- TCP vs UDP: https://www.youtube.com/watch?v=uwoD5YsGACg

Open Systems Interconnection (OSI) Model

- Open Systems Interconnection Model
- **Seven-layer architecture**
- Defines how data is transmitted from computer to computer
- Standardizes interactions between network computers exchanging information
- Each layer performs a specific task

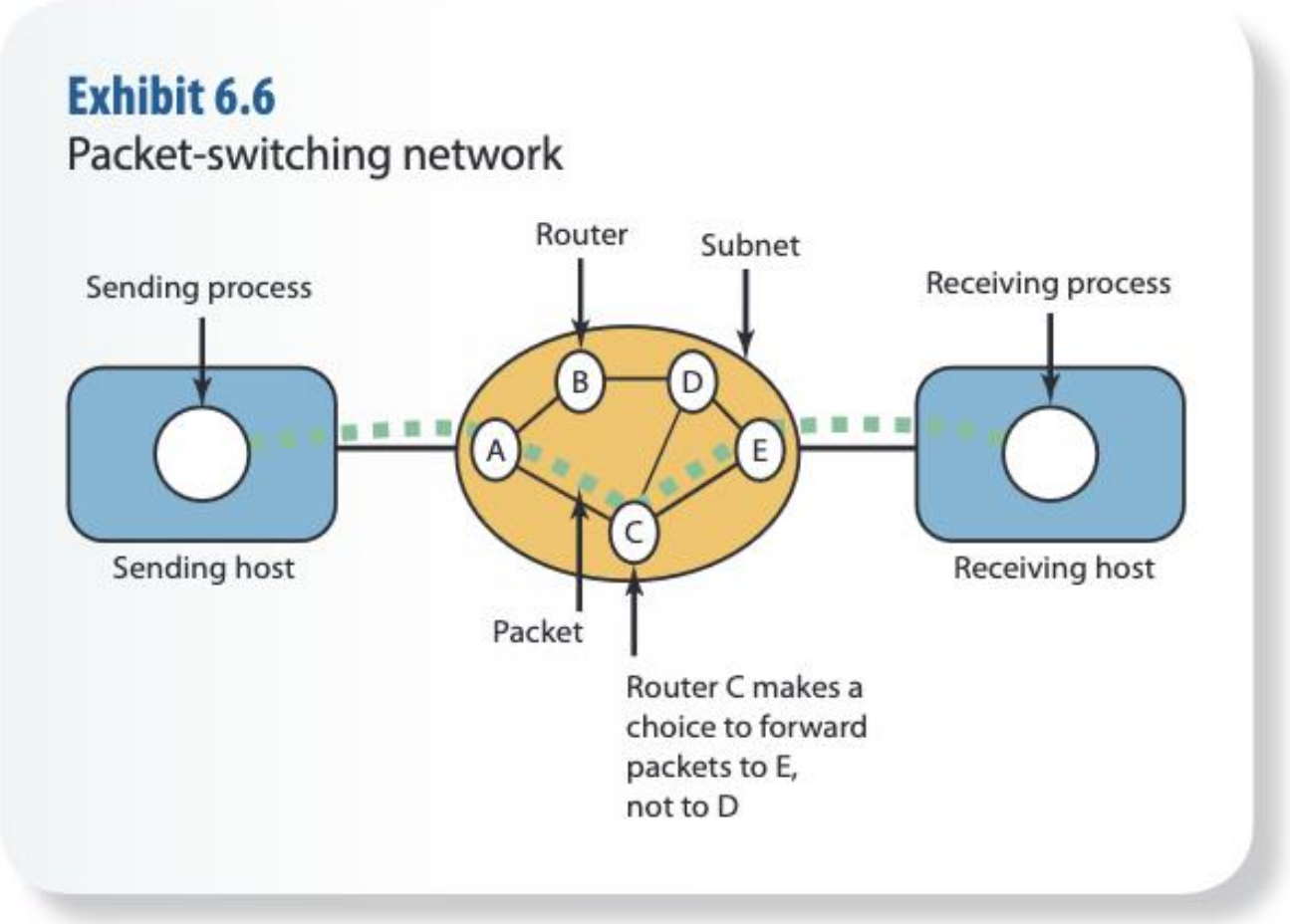
OSI Model

- Application layer
- Presentation layer
- Session layer
- Transport layer
- Network layer
- Data Link layer
- Physical layer



Short Tutorial: https://www.youtube.com/watch?v=0y6FtKsg6J4
More detailed Tutorial: https://www.youtube.com/watch?v=vv4y_uOneC0

Packet Switching Network



Packet switching vs circuit switching: https://www.youtube.com/watch?v=oUN-s6aFMTk

Network Concepts

Client/Server Model

- Software runs on the local computer (the **client**)
- The client communicates with the remote server to request information or services
- Three levels of logic
  - **Presentation logic**: focuses on how data is returned to the client
  - **Application logic**: focuses on software processing requests for users
  - **Data management**: focuses on data management and storage operations

Presentation tier

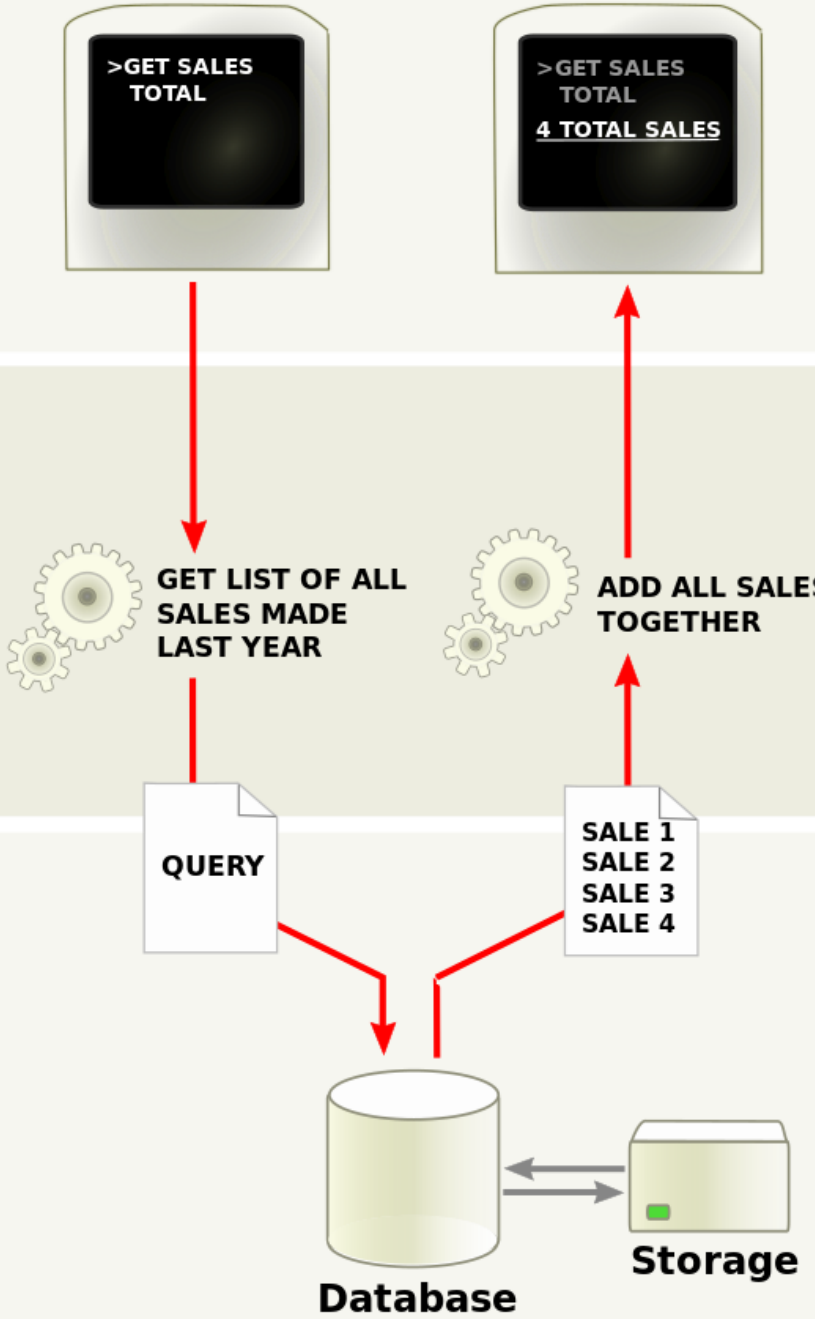
The top-most level of the application is the user interface. The main function of the interface is to translate tasks and results to something the user can understand.

Logic tier

This layer coordinates the application, processes commands, makes logical decisions and evaluations, and performs calculations. It also moves and processes data between the two surrounding layers.

Data tier

Here information is stored and retrieved from a database or file system. The information is then passed back to the logic tier for processing, and then eventually back to the user.



Refer to:

https://www.ibm.com/topics/three-tier-architecture

https://en.wikipedia.org/wiki/Multitier_architecture

Two-Tier Architecture

- Client (tier one) communicates directly with the server (tier two)
- Effective in small workgroups

N-Tier Architectures

- Works to balance the workload between the client and server
- Removes the application logic from the client and server and places it on a middle-tier server
- Three-tier architecture is the most common

Network Concepts

Wireless and Mobile Networks

- A **wireless network** uses wireless instead of wired technology
- A **mobile network** operates on a radio frequency

Wireless and Mobile Networks

Advantages

- Mobility
- Flexibility
- Easy of installation
- Low cost
- Provide access when no infrastructure is in place

Disadvantages

- Limited throughput
- Limited range
- In-building penetration problems
- Vulnerability to frequency noise
- Security

Wireless Technologies

Portable computers use small antennas to communicate with radio towers

- Fall into two groups
  - Wireless LANs (WLANs)
  - Wireless WANs (WWANs)
- Rely on the RF spectrum

Wi-Fi (IEEE 802.11, Watch: https://www.youtube.com/watch?v=Y7OWUg_kmK4)

- Broadband wireless technology
- Allows computers to communicate over a wireless signal
- Easy to set up
- Fast data transfer rates
- Security concerns due to susceptibility to interference

WiMAX (IEEE 802.16 protocol)

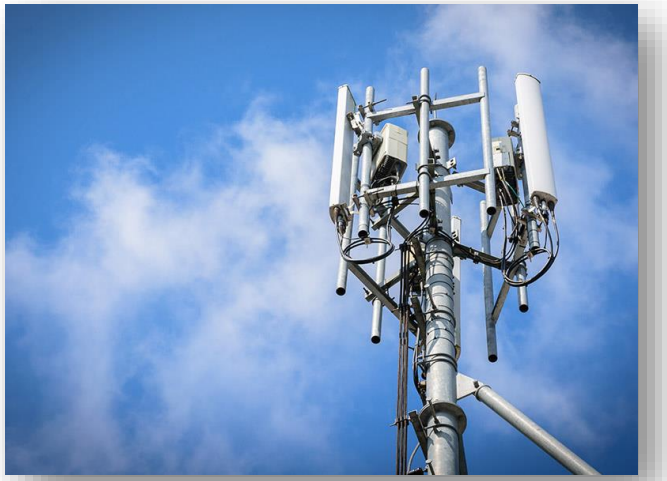
- Worldwide Interoperability for Microwave Access
- Broadband wireless technology
- Designed for wireless MANs

Wireless Technologies

Bluetooth (IEEE 802.15.1)

- Allows fixed and mobile devices to transfer data over short distances
- Can create a personal area network (PAN) for computerized devices

Mobile Networks



- Have a three-part architecture
  - Base stations
  - Mobile telephone switching offices
  - Mobile communication devices

- **Roaming** is using a cellular phone outside of the carrier's limited service area

- Two technologies have been developed to improve quality of digital communication
  - Time Division Multiple Access (TDMA)
  - Code Division Multiple Access (CDMA)

- 5G offers highest speeds

Wireless Security

- Additional security vulnerabilities for wireless security from ability to get in range of an access point (AP)

- Techniques to improve security (https://www.youtube.com/watch?v=WZaIfyvERcA)

  - Include a Service Set Identifier (SSID)
  - Use a Wired Equivalent Privacy (WEP)
  - Use an Extensible Authentication Protocol (EAP)
  - Use Wi-Fi Protected Access (WPA)
  - Use WPA2

More in-depth intro to Multiple Access technologies in Mobile Networks

- Spectrum is a scarce resource, and one that cannot be easily extended.
- A wireless system must make provisions to allow the simultaneous communication of as many users as possible within that band.
- If there is only a *single Base Station* (BS), how can it communicate with many Mobile Stations (MSs) simultaneously?

Multiple access technique

- Multiple access technique solves the problem.
- Multiple access techniques include:
  - Frequency Division Multiple Access (FDMA)
  - Time Division Multiple Access (TDMA)
  - Code Division Multiple Access (CDMA)
  - Space Division Multiple Access (SDMA)

Duplex vs Multiple access

Distinguish:

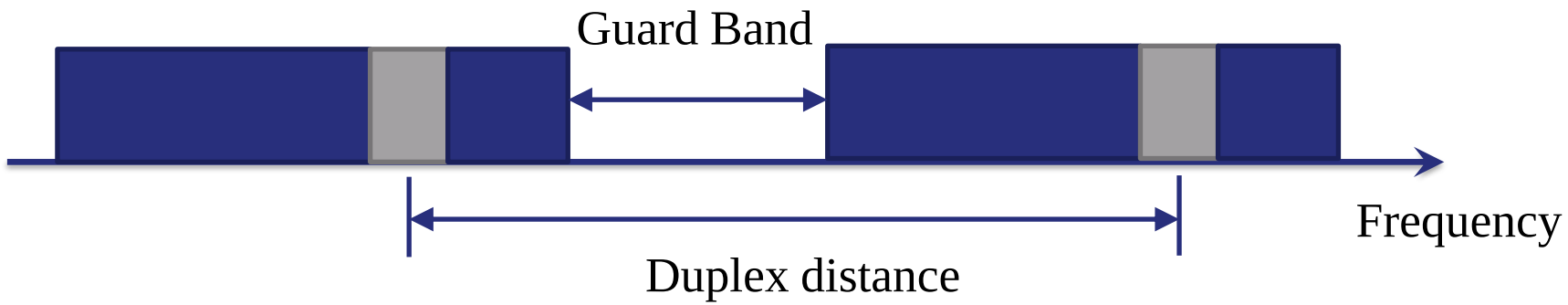
- Separation of two communication directions
  - Duplexing
    - Frequency division duplexing (FDD)
    - Time division duplexing (TDD)
- Separation of communication in one direction
  - Multiple Access

Duplexing Principles

- Communication directions:
- Base to mobile station:
  - Forward link or downlink or downstream
- Mobile to base station:
  - Reverse link or uplink or upstream

Duplexing Principles (CONT'D)

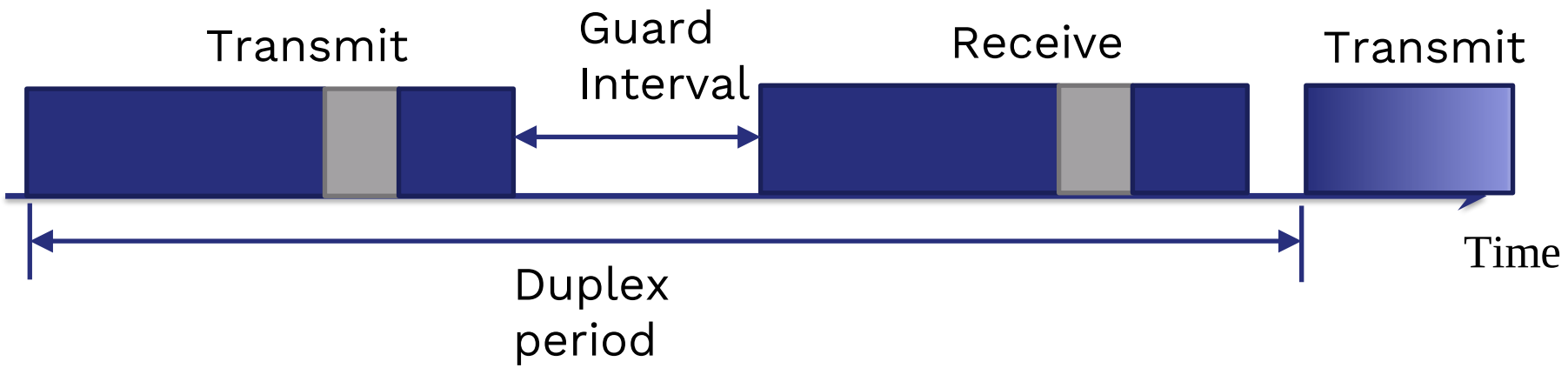
- Frequency division duplex (FDD):
- Separate frequency bands for traffic from/to base station
- Frequency separation is constant throughout the system



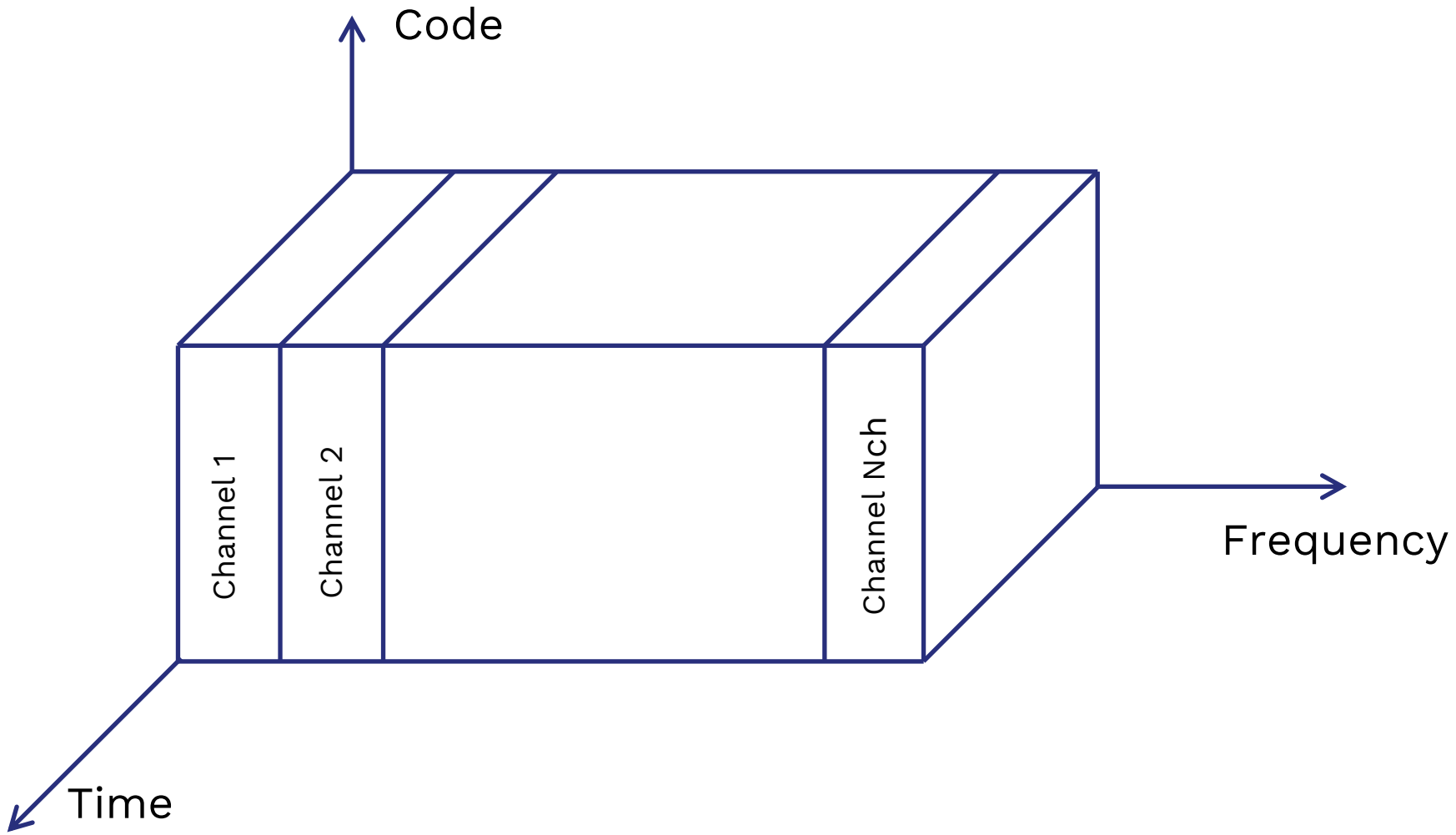
Common Practice: Allocate lower band to uplink and upper band to downlink (since propagation loss increases with frequency)

Duplexing Principles (CONT'D)

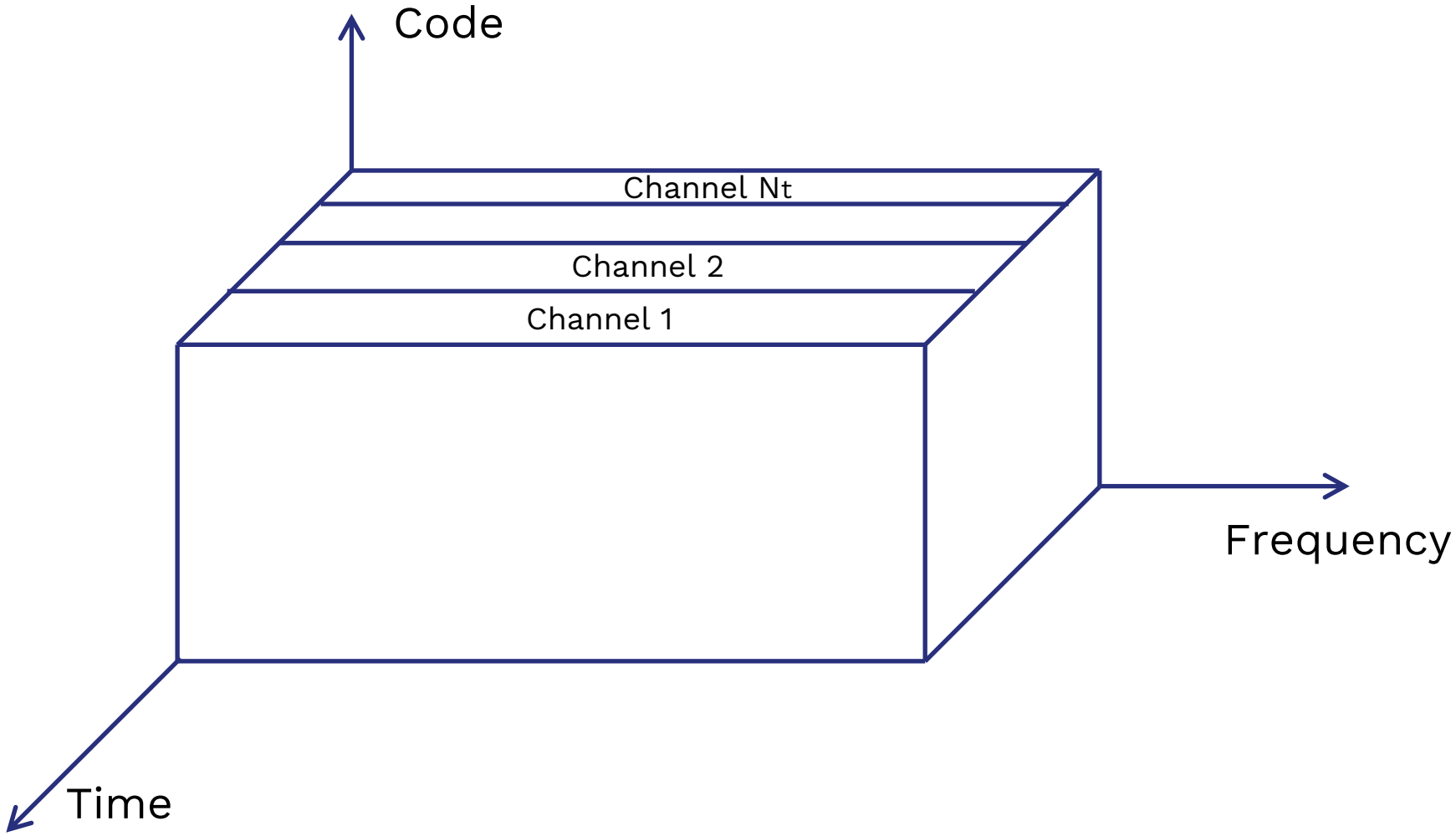
- Time division duplex (TDD):
- Separate time slots
- for traffic from/to base station
- Frequency separation is constant throughout the system



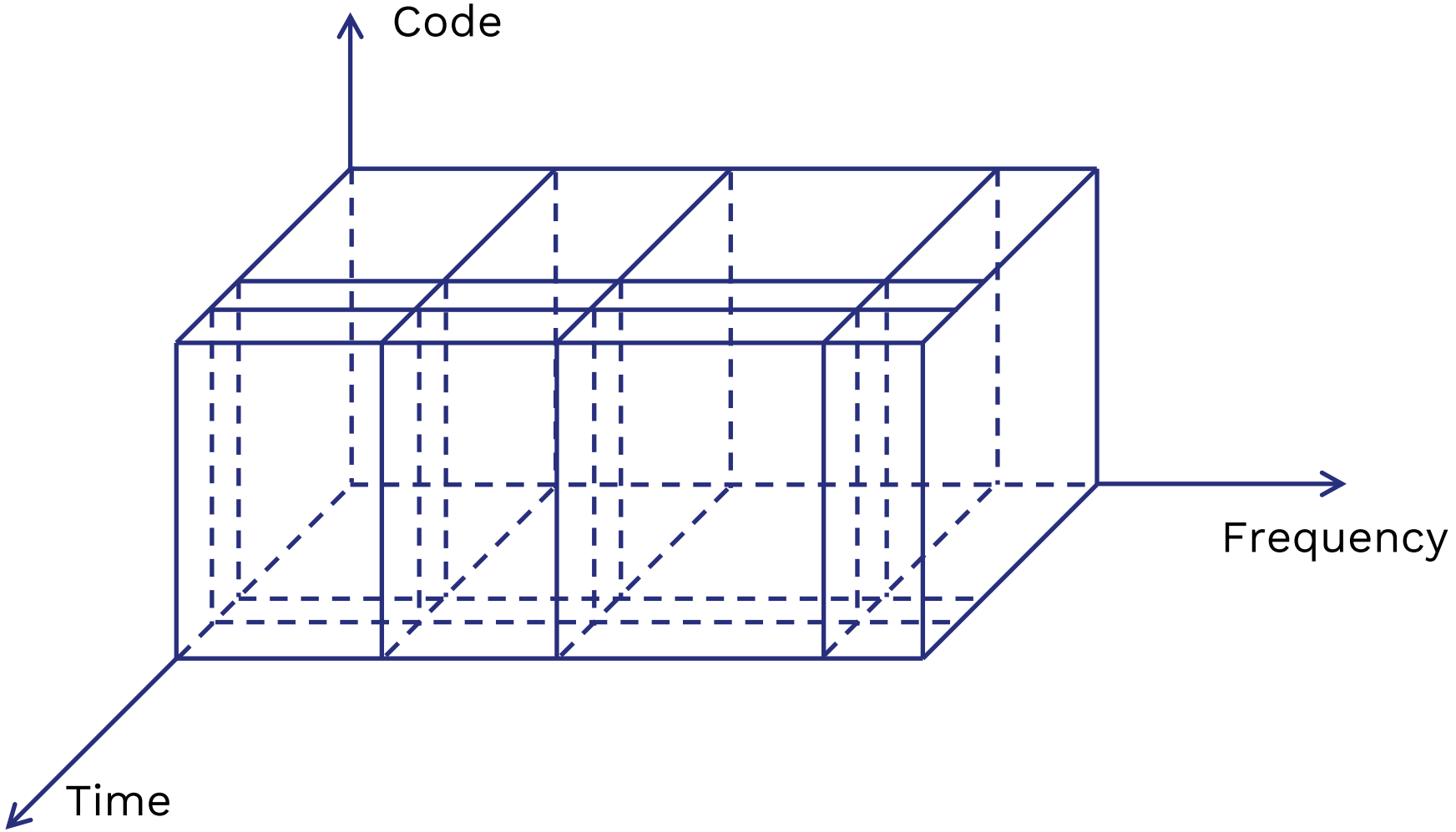
FDMA



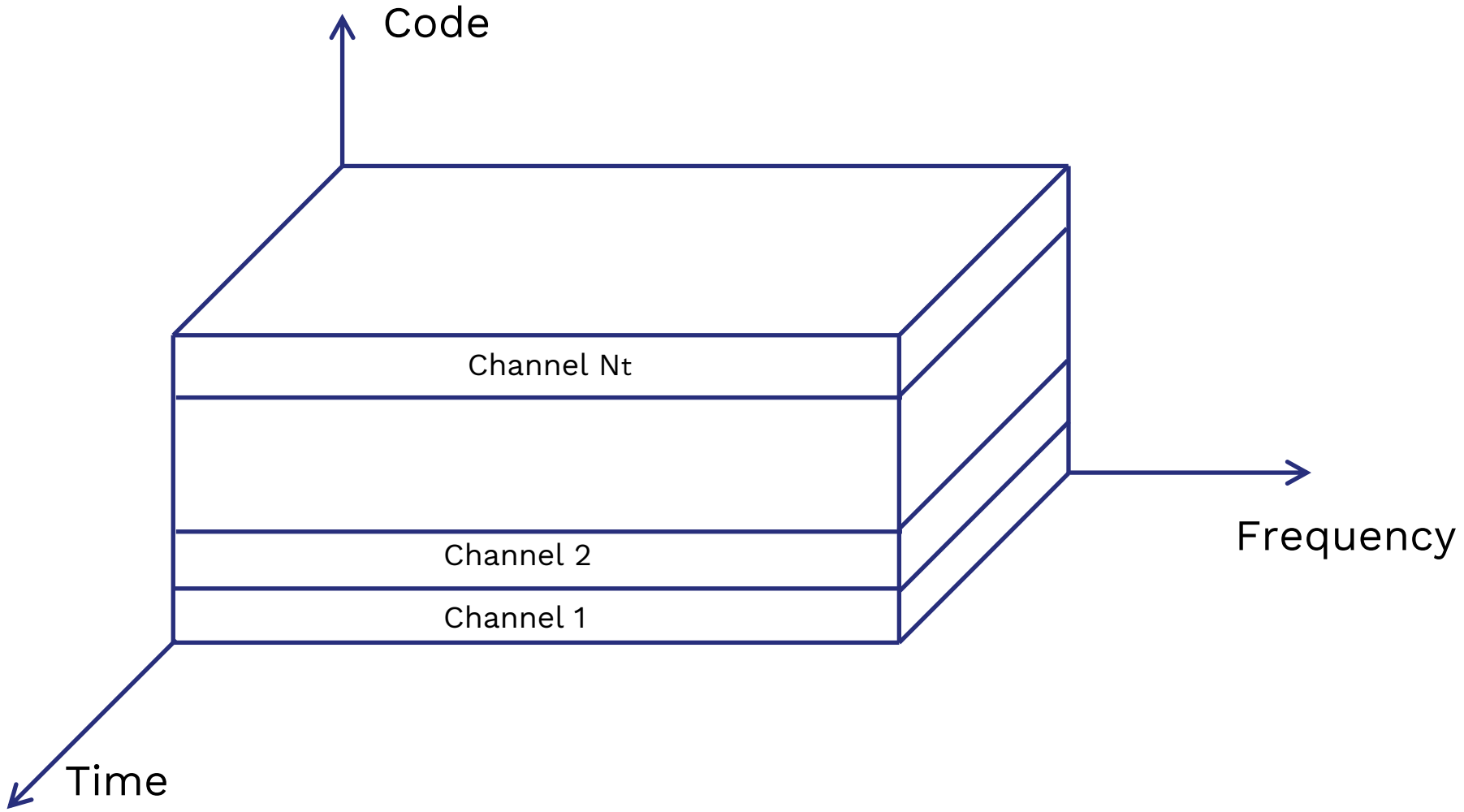
TDMA



TDMA + FDMA



CDMA



CDMA

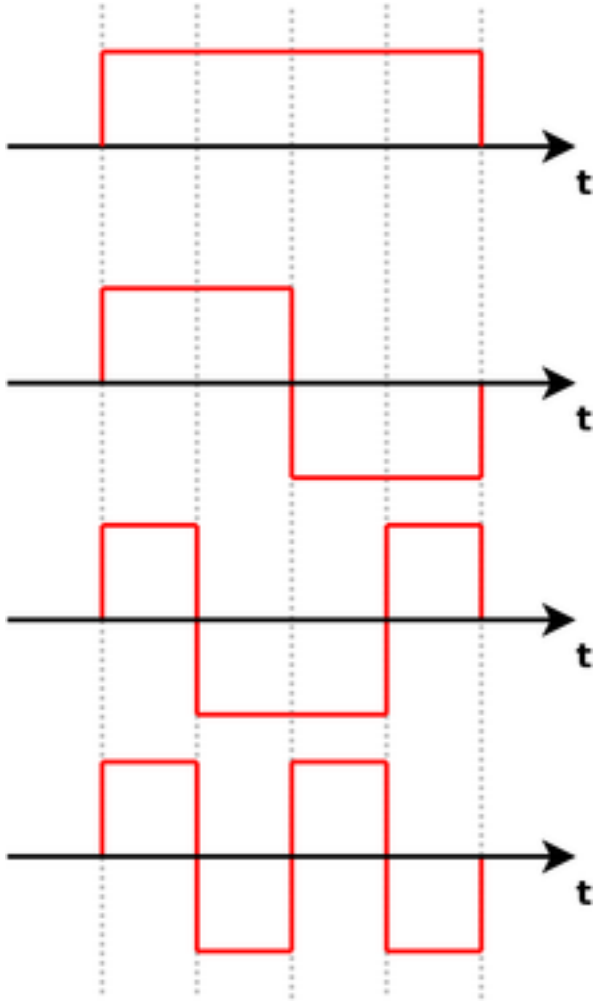
- All channels simultaneously occupy same frequency band and time period.
- Users are distinguished by individual codes.
- CDMA is a spread-spectrum multiple access technique.

Analogy:

- In a crowed room where people wish to talk to each other simultaneously:
  - TDMA: take turns to speak
  - FDMA: speak at different pitches
  - CDMA: speak in different languages

CDMA (CONT'D)

orthogonal codes



An example of four mutually orthogonal codes.

CDMA (CONT'D): EXAMPLE

Each user is associated with a different code, say **v**.

- A 1 bit is represented by transmitting a positive code, **v**
- A 0 bit is represented by a negative code, **–v**.

For example, if **v** = (v_0, v_1) = (1, –1) and the data that the user wishes to transmit is (1, 0, 1, 1), then the transmitted symbols would be

(**v**, **–v**, **v**, **v**) = (v_0, v_1, $-v_0$, $-v_1$, v_0, v_1, v_0, v_1) = (1, –1, –1, 1, 1, –1, 1, –1).

There are two senders that are transmitting to BS simultaneously

- sender0 has code0 (1, –1) and data0 (1, 0, 1, 1)
- sender1 has code1 (1, 1) and data1 (0, 0, 1, 1)
- signal0 = (1, –1, –1, 1, 1, –1, 1, –1)
- signal1= (–1, –1, –1, –1, 1, 1, 1, 1)

CDMA (CONT'D): EXAMPLE

Because signal0 and signal1 are transmitted at the same time into the air, they add to produce the raw signal:
(1, −1, −1, 1, 1, −1, 1, −1) + (−1, −1, −1, −1, 1, 1, 1, 1) = (0, −2, −2, 0, 2, 0, 2, 0)

Decode data0:
(0, −2, −2, 0, 2, 0, 2, 0) => ((0, −2), (−2, 0), (2, 0), (2, 0))
Since code0 is (1, − 1). We calculate the dot product of the code0 and each element of ((0, −2), (−2, 0), (2, 0), (2, 0)) , and we get (2, − 2, 2, 2). If we interpret all positive value as 1 and negative value as 0, we get the data0.

SDMA

Spatial separation of different communication links

- Using smart antennas
- Using precoding

Convergence of Voice, Video and Data

- **Convergence** is the integration of voice, video, and data to that multimedia information can be used for decision making
- May require network upgrades to support media that requires additional bandwidth (i.e. video)
- Newer available technologies such as ATM, Gigabit Ethernet, 5G networks have made convergence more accessible
- Result of combination of technological innovation, changes in the market structure, and regulatory reform
- Applications that use convergence include e-commerce, video on demand, video conferencing, virtual reality and more.

Knowledge Check Activity 1-1

Which statement describes the OSI model?

a. It is a seven layer architecture that defines how data is transmitted from computer to computer.

b. It is a five layer architecture that defines how data is transmitted from computer to computer.

c. It is a communication protocol used by the Internet.

d. It is a communication protocol used by wireless technologies.

Knowledge Check Activity 1-1: Answer

Which statement describes the OSI model?

Answer: It is a seven layer architecture that defines how data is transmitted from computer to computer.

The OSI models has seven layers that are used. Starting at the top, they are as follows: Application layer, Presentation layer, Session layer, Transport layer, Network layer, Data link layer, Physical layer

Polling Activity 1-1

It’s time to take a poll! Get your devices ready and open your [Kahoot] app. You can join the poll using this link/PIN: [enter link or PIN]

The Internet is the largest network of computers. What type of network is it?

a. LAN
b. WAN
c. MAN
d. NET

Polling Activity 1-1: Answer

The Internet is the largest network of computers. What type of network is it?

Answer: WAN

Wide Area Networks can span cities, states and countries. The Internet is an example of a WAN.

Discussion Activity 1-1

What are the layers of the Open Systems Interconnection? What is the advantage of using this standard?

Discuss possible correct answers with your classmates.

Discussion Activity 1-1: Answer

What are the layers of the Open Systems Interconnection? What is the advantage of using this standard?

Answer: Seven layers are used to define how data is transmitted from computer to computer in a network. It standardizes interaction between network computers exchanging information.

Explanation: The OSI model distinctly separates services, interfaces, and protocols which allows it to be flexible with different network configurations and underlying hardware and software used.

Summary

Now that the lesson has ended, you should be able to:

- Describe the major applications of a data communication system.
- Explain the three major components of a data communication system.
- Describe the three major types of processing configurations
- Explain the three types of networks.
- Describe the five main network topologies.
- Explain important networking concepts.