Computer Networks

Unit:1

1. Introduction
2. Network Models
3. Introduction to Physical Layer
4. Digital andAnalog Transmission

Chapter1: Introduction

INTRODUCTION

Data Communication

- Data Communication is the exchange of 0s and 1s between devices using a transmission medium.
- It's local when devices are nearby and remote when further apart.
- Key components include data sources, Data sinks, and communication media.
- Data sources are devices or systems that originate and generate data.
- Data sinks, also known as data receivers, are devices or systems that receive and process the data sent by the data source.
- Communication media are the physical pathways or channels used to transport data from the source to sink, which can include cables, satellite circuits, or fiber optic lines.
- A device connected to a computer known as MODEMS (Converts digital to analog signals for transmission).

Communication Protocol

A set of rules that devices must agree upon for data exchange. It defines transmission rate, synchronization type (synchronous or asynchronous), and duplex mode (half duplex or full duplex). Protocols may also include error detection and data encoding techniques.

Characteristics of Data Communication

- **Delivery**
  - Ensure data reaches the correct destination and intended user without errors or misrouting.
- **Accuracy**
  - Transmit data free of errors or corruption, maintaining the integrity of the information.
- **Timeliness**
  - Real time delivery of data, especially for audio and video to prevent delays in transmission.
- **Jitter**
  - Manage variations in packet arrival times to ensure consistent and timely data delivery.

Data Communication Terminology

Data communication is the accurate transfer of data between machines to ensure both sender and receiver understand the data.

1. Data Channel

a. A data channel connects two computers or devices in communications.

b. It can be a physical medium, such as coaxial cable.

c. It can also be a specific carrier frequency within a larger channel, including wireless mediums.

2. Baud

a. It represents the number of signaling elements per second.

b. At slow speeds, one element corresponds to one bit.

c. Es- 300 baud = #00 bits

d. At higher speeds, multiple bits can be encoded within one element.

e. Data rates at high speeds are typically expressed in bps.

f. In practice, a 9600 bps modem can operate at 2400 baud.

3. Bandwidth

a. It is the data transmission capacity in a given time.

b. In digital devices, it's expressed in bps (bits/sec) or Bps (Bytes/second).

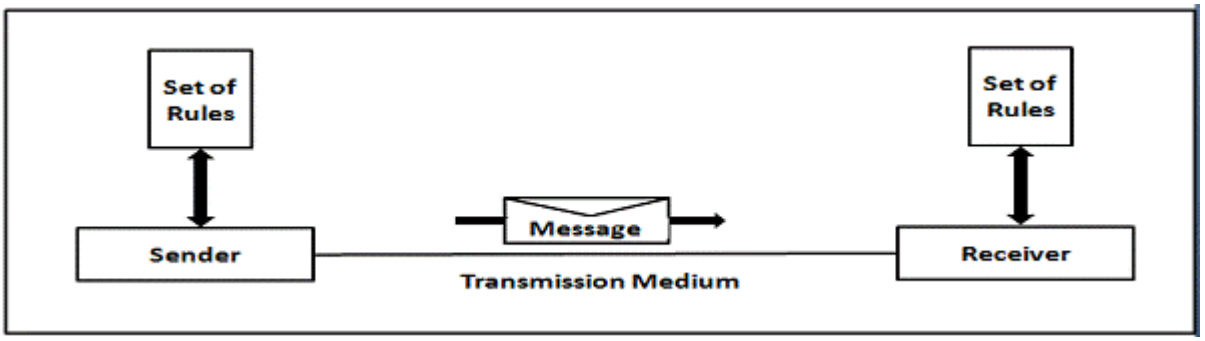
c. Analog devices use cycles/second or Hz to measure bandwidth.

d. Bandwidth is crucial for I/O devices; low bandwidth buses can hinder fast disk drives.

4. Data transfer rates

a. The amount of data transferred per second by a communication channel is known as data transfer rate. It is measured in bits per second.

Components of Data Communication



Message

Message is the information to be communicated by the sender to the receiver.

Sender

The sender is any device that is capable of sending the data (message).

Receiver

Receiver is a device that the sender wants to communicate the data.

Transmission medium

Path by which the data (message) travels from sender to receiver. Can be wired or wireless and many subtypes in both.

Protocol

It's an agreed upon set of rules used by sender and receiver to communicate data. It governs data communication.

Data Representation

Data is a collection of raw facts that, through processing, transforms into meaningful information. It can manifest in various forms and representations.

1. **Text**
    a. Combination of alphabets. Stored as a pattern of bits.
2. **Numbers**
    a. 0 to 9. Stored as a pattern of bits.
3. **Images**
    a. Images composed of pixels (pixels are represented as bits). And their number and type determines image size.

4. Audio

a. Data can also be in the form of sound. Audio data is continuous, not discrete.

5. Video

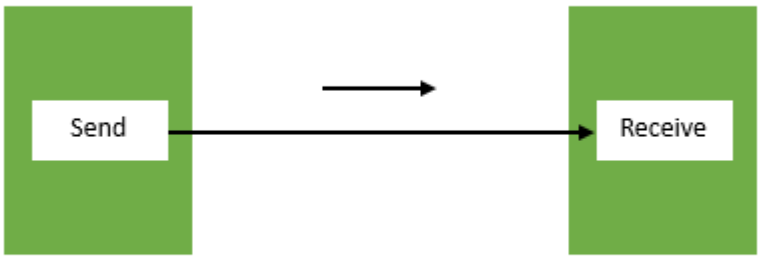
a. Video refers to the broadcasting of data in the form of a picture or movie.

Data Flow

Data can flow between the two devices in the following ways.

1. **Simplex**
2. **Half Duplex**
3. **Full Duplex**

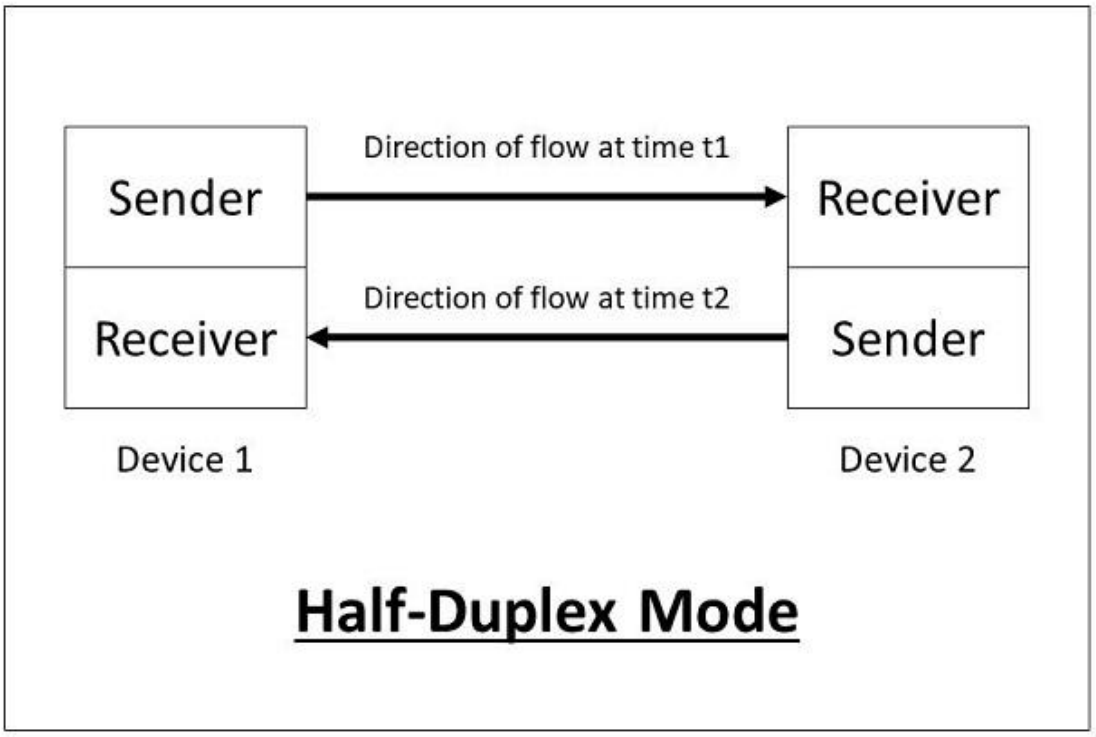
Simplex



Simplex

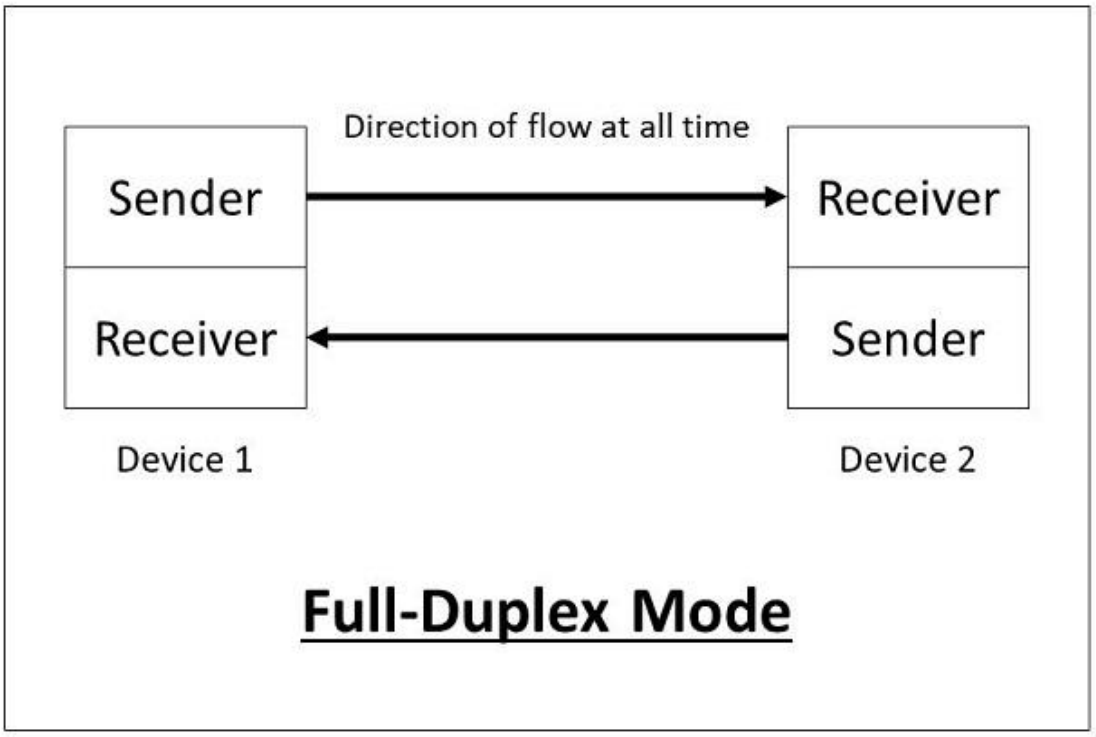
It is unidirectional. Only one of the devices sends the data while other receives

Half Duplex



In half duplex both stations can transmit as well as receive but not at the same time.

Full Duplex



Both stations can transmit and receive at the same time.

Networks

A computer network is a set of interconnected devices using common communication protocols. It enables resource sharing among nodes, including computers, servers, and networking hardware. Networks use various technologies and can support applications like web access, digital media, and communication tools.

Network Types

They mainly are of four types-

1. **LAN (Local Area Network)**
2. **PAN (Personal Area Network)**
3. **MAN (Metropolitan Area Network)**
4. **WAN (Wide Area Network)**

Local Area Network (LAN)

- **LAN** connects computers in a small area, like an office building.
- It links PCs via communication media (eg. twisted pair, coaxial cable).

- **LAN** is cost-effective, using inexpensive hardware like hubs and Ethernet cables.
- It offers high-speed data transfer.
- **LAN**s provide strong security.

Personal Area Network (PAN)

- **PAN** is for personal use within about 10 meter.
- **PAN** connects personal computer devices like laptops, phones, and media players.
- **PAN** typically covers a 30-foot area.

Metropolitan Area Network (MAN)

- **MAN** connects multiple **LAN**s in a larger geographic area.
- **MAN** is used by government agencies and private industries for citizen connectivity.
- **LAN** in **MAN** are linked through a telephone exchange line.
- Common **MAN** protocols include RS-232, Frame Relay, ATM, ISDN, OC-3, and ADSL.
- **MAN** has a broader range than **LAN.**

Wide Area Network (WAN)

- **WAN** covers vast areas, such as states or countries.
- **WAN** is larger than **LAN** and spans a broad geographic area using various connections.
- **Ex-** Internet.
- **WAN** finds applications in business, government, and education.

Internet

The Internet is a network of networks.

Definition of the Internet

The Internet is a global system of interconnected computer networks utilizing the Internet protocol suite (TCP/IP) to enable communication between devices. It comprises private, public, academic, business, and government networks linked through electronic, wireless, and optical technologies. This extensive network serves as a conduit for diverse information resources and services, such as the World Wide Web, electronic mail, telephony, and file sharing.

History of the Internet:

- ### Origins in the Late 1960s:
    - In the late 1960s, the concept took shape with the ARPANET, a collaborative effort aimed at connecting mainframe computers in research organizations.

  - By 1969, ARPANET was established, initially connecting four nodes.

- **Early Communication Protocols**
  - The Network Control Protocol (NCP) facilitated communication during the initial stages of ARPANET.
- **The Interknitting Project (1972):**
  - In 1972, Vint Cerf and Bob Kahn collaborated on the Interknitting Project, producing a pivotal paper outlining protocols for end-to-end packet delivery.
- **Development of TCP/IP:**
  - This collaboration led to the development of Transmission Control Protocol (TCP) to handle higher-level functions.
  - Internetworking Protocol (IP) was introduced for addressing and routing.
- **TCP/IP as the Foundation:**
  - TCP/IP emerged as the foundational protocol suite for the Internet, setting the stage for its exponential growth and evolution.
  - These protocols enabled the Internet to become a global phenomenon, connecting millions of users and facilitating various online services.

Internet Standards

An Internet standard is like a rulebook for the Internet. It's a well-tested set of rules that everyone working with the Internet needs to follow. Getting a rule into the standard involves a careful process.

How It Works

- **Internet Draft:**
  - It starts as a draft, a kind of early version that lasts for six months without any official status.
- **Request for Comment (RFC):**
  - If it's recommended, it gets published as an RFC. It's like a document with a number, and everyone interested can see it.

Levels of Development:

- **Proposed Standard:**
  - It's a stable and well-understood set of rules that many people have tested and used.

- **Draft Standard:**
  - If two independent groups successfully use it, it can become a standard.
- **Internet Standard:**
  - After proving it works well, it becomes a standard for everyone.

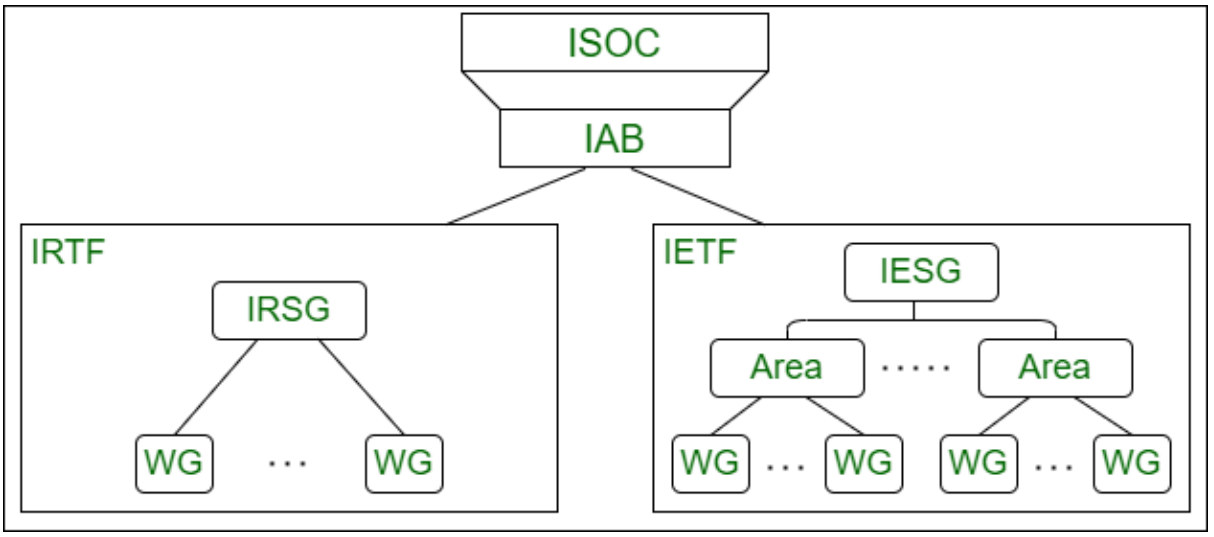
Other Categories:

- **Historic:**
  - Some rules are important historically but may not be used anymore.
- **Experimental:**
  - These rules describe experiments that don't affect the regular use of the Internet.
- **Informational:**
  - These documents share general or historical info about the Internet.

Levels of Importance:

- **Required:**
  - Everyone must follow these rules for the Internet to work, like basic protocols (e.g., IP and ICMP).
- **Recommended:**
  - They are not a must, but they are suggested because they're useful (e.g., FTP and TELNET).
- **Elective:**
  - Not needed or suggested, but some systems might use them.
- **Limited Use:**
  - Only use these rules in specific situations, often for experiments.
- **Not Recommended:**
  - These rules are not suitable for general use and may be old or outdated.

Internet Administration



The Internet, originating in research, has expanded into a widely used platform with significant commercial activity. Various groups coordinate Internet issues, guiding its growth. Key organizations in this landscape are detailed below:

Internet Society (ISOC):

- An international nonprofit organization formed in 1992.
- Supports the Internet standards process and maintains bodies such as IAB, IETF, IRTF, and IANA.
- Promotes research and scholarly activities related to the Internet.

Internet Architecture Board (IAB):

- The technical advisor to ISOC.
- Oversees the development of the TCP/IP Protocol Suite.
- Provides technical advisory support to the Internet community.
- Manages the Internet Engineering Task Force (IETF) and the Internet Research Task Force (IRTF).
- Acts as an external link between the Internet and other standards organizations.

Internet Engineering Task Force (IETF):

- A forum of working groups identifying operational problems and proposing solutions.
- Develops and reviews specifications intended as Internet standards.
- Organized into areas, addressing specific topics like applications, protocols, routing, and security.

Internet Research Task Force (IRTF):

- Focuses on long-term research topics related to Internet protocols, applications, architecture, and technology.

Network Models

Network Models

Protocol layering

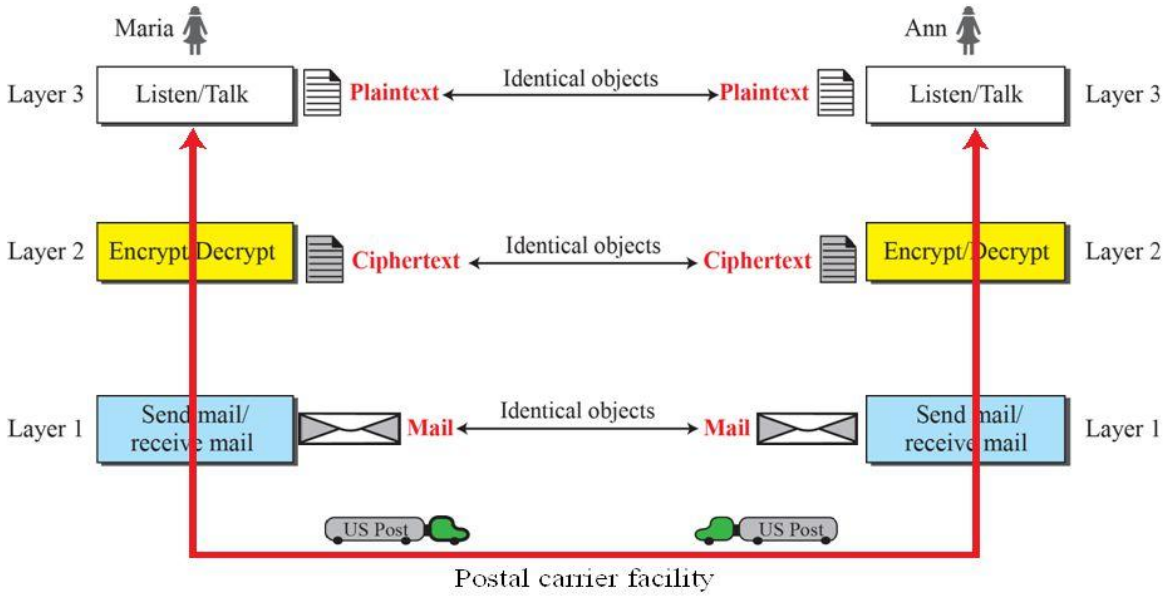
Protocol Layering in Communication Scenarios:

In the study of data communication and networking, protocols define the rules for effective communication among participants. As communication complexity varies, the concept of protocol layering arises. Two scenarios illustrate this concept:

1. Single-Layer Protocol

1.1. Communication Model: Simple, face-to-face interaction between Maria and Ann.
1.2. Protocol Rules: Greeting, using a friendship-level vocabulary, turn-taking, maintaining dialogue, and exchanging pleasantries.
1.3. Comparison: Contrasted with formal communication, like a lecture scenario, which is mostly monologue and formal.

2. Three-Layer Protocol



2.1. Communication Model: Maria and Ann, separated by distance, communicate through regular mail.

2.2. Three Layers: Sending, encrypting/decrypting, and receiving.
2.3. Security Measures: Encryption/decryption techniques employed to secure ideas.
2.4. Machines: Each party has three machines (or robots) corresponding to each layer.

Principles of Protocol Layering

1. **First Principle - Bidirectional Communication**
   1.1. Each layer is designed for bidirectional communication, performing two opposite tasks (e.g., listening and talking).
2. **Second Principle - Identical Objects**
   2.1. Objects under each layer at both communication sites must be identical (e.g., plaintext letter under layer 3).

Logical Connections

- Logical (imaginary) connections exist between corresponding layers at both communication sites.
- These connections facilitate the flow of information between layers in the protocol stack.

TCP/IP PROTOCOL SUITE

TCP/IP Protocol Suite

The TCP/IP protocol suite, foundational for the Internet, consists of four layers: Link, Internet, Transport, and Application. In a simple internet, logical connections between layers aid in understanding their duties.

Logical Connections

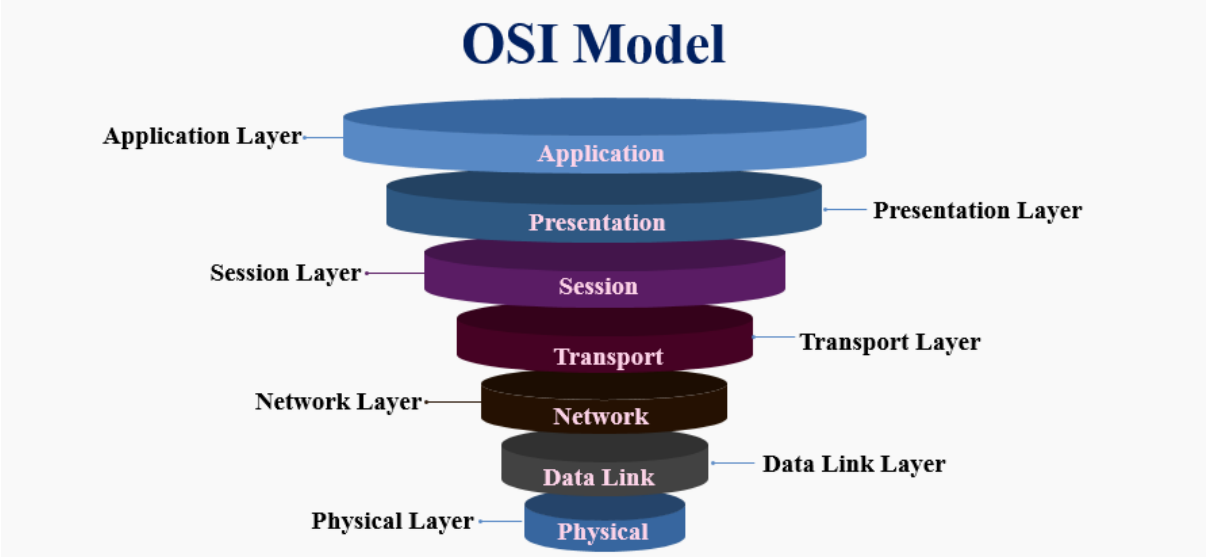
- **End-to-End vs. Hop-to-Hop:**
  - Application, transport, and network layers operate end-to-end.
  - Data-link and physical layers work hop-to-hop, where a hop is a host or router.
- **Data Units and Identical Objects:**
  - Top three layers maintain packet integrity across the internet.
  - Routers may alter packets at the network layer.
  - Identical objects exist between corresponding layers on different devices.
  - Logical connections and identical objects in TCP/IP

OSI Model

Introduction

- Established by the International Organization for Standardization (ISO) in the late 1970s.
- Consists of seven layers, each defining a part of the process of moving information across a network.
- Offers a layered framework for designing network systems.

Layers in OSI Model:



- **Physical Layer**
  - Concerned with the physical connection between devices.
- **Data Link Layer**
  - Handles framing, addressing, and error detection at the link level.
- **Network Layer**
  - Manages logical addressing, routing, and forwarding of data packets.
- **Transport Layer**
  - Ensures end-to-end communication, error detection, and recovery.
- **Session Layer**
  - Manages sessions between applications, including establishment, maintenance, and termination.
- **Presentation Layer**
  - Deals with data translation, encryption, and compression.
- **Application Layer**
  - Provides network services directly to end-users and applications.

Comparison with TCP/IP

- Conceptually guides the design of network architectures.

- Emphasizes the distinction between services, interfaces, and protocols.
- Initially faced challenges in timing, quality perception, and bureaucratic influence.

TCP/IP Model

Introduction

- Developed prior to the OSI model.
- Major design goals: connect multiple networks, survive partial subnet hardware failures, provide flexible architecture.
- Consists of four layers: Host-to-Network, Internet, Transport, and Application.

Layers in TCP/IP Model:

- Host-to-Network Layer
  - Connects hosts to the network using unspecified protocols.
- Internet Layer
  - Facilitates independent packet travel across different networks using the IP protocol.
- Transport Layer
  - Supports end-to-end communication with TCP (reliable, connection-oriented) and UDP (unreliable, connectionless) protocols.
- Application Layer
  - Houses higher-level protocols like TELNET, FTP, SMTP, DNS, NNTP, HTTP, etc.

Comparison with OSI:

- More tailored to the needs of connecting networks and offers a flexible architecture.
- Does not clearly distinguish between service, interface, and protocol.
- Gained widespread adoption due to practical implementation and connection-oriented focus.

Challenges and Criticisms:

OSI Model:

- Initial implementation challenges, leading to a perception of poor quality.
- Associated with bureaucratic influence, impacting its acceptance.

TCP/IP Model:

- Does not distinguish physical and data link layers clearly.
- Protocols, particularly in the early implementations, were ad hoc and not easily replaceable.

Comparison of Models:

Similarities:

- Both models are based on the concept of a stack of independent protocols.
- Functionalities of layers are roughly similar.

Differences:

- OSI model emphasizes the explicit distinction between services, interfaces, and protocols.
- TCP/IP model is less general, not well-suited for describing non-TCP/IP protocol stacks.

Challenges and Criticisms of OSI:

- **Timing**
  - Critical for success; standards written too early or too late may result in poor adoption.
- **Implementations**
  - Initial implementations were large, unwieldy, and slow.
- **Politics**
  - OSI is perceived as government-driven, impacting its image.
- **Technology**
  - OSI model and protocols criticized for complexity, inefficiency, and flawed layering.

INTRODUCTION TO PHYSICAL LAYER

- Data and signals
- Periodic analog signals
- Digital Signal
- Transmission Impairment
- Data rate limits
- Performance