Fundamentals of Computer Networks and Data Communication

Computer networks and data communication form the backbone of modern information sharing. A **computer network** is a system of interconnected devices that communicate and share resources, while **data communication** focuses on the transfer of information between devices.

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1. What is a Computer Network?

A **computer network** is a collection of computers, servers, or other devices connected to share resources like data, software, and hardware.

Examples of Networks:

- The Internet (global network).
- A company's intranet (private network).

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2. What is Data Communication?

Data communication refers to the process of transferring data between devices through a medium (wired or wireless). It ensures that the transmitted data is accurate and efficient.

Key Components of Data Communication:

1. **Sender:** The device that sends the data (e.g., a computer or smartphone).
2. **Receiver:** The device that receives the data (e.g., a server or printer).
3. **Message:** The information being transmitted.

4. **Transmission Medium:** The physical path (e.g., cables or air) over which data is transmitted.
5. **Protocol:** A set of rules governing data transmission (e.g., TCP/IP).

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3. Types of Computer Networks

1. **Local Area Network (LAN):**
    - Covers a small geographical area like an office or home.
    - Example: A network in a school computer lab.
2. **Wide Area Network (WAN):**
    - Spans a large geographical area, often connecting multiple LANs.
    - Example: The Internet.
3. **Metropolitan Area Network (MAN):**
    - Covers a city or a large campus.
    - Example: City-wide Wi-Fi networks.
4. **Personal Area Network (PAN):**
    - A network for personal devices, like Bluetooth or a mobile hotspot.

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4. Data Transmission Modes

1. **Simplex:** Data flows in one direction only.
    - Example: Television broadcast.

2. **Half-Duplex:** Data flows in both directions, but only one direction at a time.
    - Example: Walkie-talkies.
3. **Full-Duplex:** Data flows in both directions simultaneously.
    - Example: Phone calls.

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5. Types of Transmission Media

1. **Wired (Guided) Media:**
    - **Twisted Pair Cable:** Common in LANs; cheap but limited speed.
    - **Coaxial Cable:** Used in cable TV; offers higher bandwidth.
    - **Fiber Optic Cable:** Transmits data as light; high speed and long distances.
2. **Wireless (Unguided) Media:**
    - **Radio Waves:** Used in Wi-Fi and mobile communication.
    - **Microwaves:** Used in satellite communication.
    - **Infrared:** Used in remote controls.

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6. Network Topologies

Network topology refers to the arrangement of devices in a network.

1. **Bus Topology:**
    - All devices share a single communication line.
    - Advantage: Easy to install.

- Disadvantage: If the main cable fails, the network goes down.

2. **Star Topology:**
   - Devices are connected to a central hub.
   - Advantage: Easy to troubleshoot.
   - Disadvantage: If the hub fails, the network is affected.
3. **Ring Topology:**
   - Devices are connected in a circular manner.
   - Advantage: Equal access for all devices.
   - Disadvantage: A single failure disrupts the network.
4. **Mesh Topology:**
   - Every device is connected to every other device.
   - Advantage: Reliable and fault-tolerant.
   - Disadvantage: Expensive to implement.

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7. Network Protocols

Protocols are sets of rules that enable communication between devices.

1. **Transmission Control Protocol/Internet Protocol (TCP/IP):**
   - Ensures reliable data transfer over the Internet.
2. **HyperText Transfer Protocol (HTTP/HTTPS):**
   - Used for accessing web pages.
3. **File Transfer Protocol (FTP):**

- Transfers files between computers.

4. **Simple Mail Transfer Protocol (SMTP):**
    - Sends emails.
5. **Dynamic Host Configuration Protocol (DHCP):**
    - Assigns IP addresses to devices automatically.

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8. Switching Techniques

1. **Circuit Switching:**
    - Establishes a dedicated path between sender and receiver.
    - Example: Traditional telephone systems.
2. **Packet Switching:**
    - Data is divided into packets and sent independently.
    - Example: Internet communication.
3. **Message Switching:**
    - Entire messages are stored and forwarded.
    - Example: Email.

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9. OSI Model (Open Systems Interconnection)

The OSI model explains how data travels through a network in 7 layers:

1. **Physical Layer:** Transmits raw data over the medium (e.g., cables).
2. **Data Link Layer:** Ensures error-free data transfer.
3. **Network Layer:** Handles routing and addressing (e.g., IP).

4. **Transport Layer:** Ensures reliable data transfer (e.g., TCP).
5. **Session Layer:** Manages connections between applications.
6. **Presentation Layer:** Translates data formats (e.g., encryption).
7. **Application Layer:** Provides network services to applications (e.g., HTTP).

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10. Data Communication Devices

1. **Router:** Connects different networks and directs data packets.
2. **Switch:** Connects devices in a LAN, forwarding data intelligently.
3. **Modem:** Converts digital signals to analog for Internet access.
4. **Access Point:** Enables wireless devices to connect to a network.

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11. Common Applications of Networks and Data Communication

1. **Email and Messaging:** Sending and receiving instant messages.
2. **Video Conferencing:** Zoom, Microsoft Teams, etc.
3. **File Sharing:** Cloud storage platforms like Google Drive.
4. **E-Commerce:** Online shopping websites.