Unit 1: Introduction to Data Communications

Lecture Hours: 3

1. Introduction to Data Communications

Definition:
Data communication involves the transfer of digital or analog data between devices through a transmission medium, such as wired or wireless channels.

Key Characteristics of Effective Data Communication:

1. **Delivery** – Ensures data reaches the intended destination.
2. **Accuracy** – Guarantees error-free transmission.
3. **Timeliness** – Provides data within an acceptable time frame (e.g., real-time applications require low latency).
4. **Jitter** – Refers to inconsistent delays in packet arrival, critical for real-time applications like VoIP.

Practical Example:

- **Email Transmission:** A user composes an email and sends it. The email travels through multiple network devices (routers, switches) before reaching the recipient’s inbox.

---

2. Data Communication Networks

A. Components of a Network

1. **Sender/Transmitter** – Initiates data transmission (e.g., a computer, smartphone).
2. **Receiver** – Accepts the transmitted data (e.g., a server, another computer).
3. **Message/Data** – The information being transmitted (e.g., text, video, audio).
4. **Transmission Medium** – The physical or wireless path (e.g., fiber optic cable, Wi-Fi).
5. **Protocols** – Rules governing data exchange (e.g., TCP/IP, HTTP).

Question:
Q: List and briefly explain the five key components of a data communication network.

B. Types of Networks

1. **Local Area Network (LAN)**
    - Covers a small geographic area (e.g., office, home).
    - High data transfer rates.
    - Example: A university’s computer lab network.
2. **Wide Area Network (WAN)**
    - Spans large distances (e.g., cities, countries).
    - Uses leased lines or satellites.
    - Example: The Internet.

3. **Metropolitan Area Network (MAN)**
    - Covers a city or campus.
    - Example: A city-wide broadband network.
4. **Personal Area Network (PAN)**
    - Short-range (e.g., Bluetooth, USB).
    - Example: Connecting a smartphone to a wireless headset.

Question:
Q: Differentiate between LAN and WAN with examples.

---

3. Network Models

A. Open Systems Interconnection (OSI) Reference Model

Introduction to OSI Model
The **OSI (Open Systems Interconnection) model** is a **7-layer conceptual framework** that standardizes network communication. It ensures interoperability between different vendors' devices by defining how data moves from one system to another.

Key Features:

- Developed by **ISO (International Organization for Standardization)** in 1984.
- Provides a **layered approach** to network communication.
- Each layer has **specific functions** and interacts with adjacent layers.

OSI Model Layers (Top to Bottom)

Layer No.	Layer Name	Function	Protocols & Devices
7	**Application Layer**	Provides user interface and network services (e.g., email, file transfer).	HTTP, FTP, SMTP, DNS
6	**Presentation Layer**	Translates, encrypts, and compresses data for secure transmission.	SSL/TLS, JPEG, MPEG
5	**Session Layer**	Establishes, manages, and terminates connections between applications.	NetBIOS, RPC, SIP
4	**Transport Layer**	Ensures reliable end-to-end data delivery (error recovery, flow control).	TCP, UDP, SCTP
3	**Network Layer**	Routes data packets between different networks using logical addressing.	IP, ICMP, OSPF, Router
2	**Data Link Layer**	Provides error-free node-to-node communication (MAC addressing).	Ethernet, PPP, Switch, NIC
1	**Physical Layer**	Transmits raw bitstream over a physical medium (cables, signals).	RJ45, Wi-Fi, Hub, Repeater

OSI Model Diagram

```
+-------------------------+
|     Application (7)     | → HTTP, FTP, SMTP
+-------------------------+
|    Presentation (6)     | → SSL, JPEG, MPEG
+-------------------------+
|       Session (5)       | → NetBIOS, SIP
+-------------------------+
|      Transport (4)      | → TCP, UDP
+-------------------------+
|       Network (3)       | → IP, Router
+-------------------------+
|    Data Link (2)        | → Ethernet, Switch
+-------------------------+
|      Physical (1)       | → RJ45, Hub
+-------------------------+
```

Key Functions of Each Layer

A. Application Layer (Layer 7)

- Provides **user applications** (web browsers, email).
- Protocols: **HTTP (Web), SMTP (Email), FTP (File Transfer), DNS (Domain Name System).**

B. Presentation Layer (Layer 6)

- **Encryption (SSL/TLS), Compression (ZIP), Encoding (ASCII, Unicode).**

C. Session Layer (Layer 5)

- **Manages sessions** (e.g., login/logout).
- Protocols: **NetBIOS (Windows), SIP (VoIP).**

D. Transport Layer (Layer 4)

- **Ensures reliable delivery** (TCP = connection-oriented, UDP = connectionless).
- **Flow control & error checking.**

E. Network Layer (Layer 3)

- **Logical addressing (IP addresses).**
- **Routing (Routers use OSPF, BGP).**

F. Data Link Layer (Layer 2)

- **MAC addressing (Ethernet).**
- **Switches operate here.**

G. Physical Layer (Layer 1)

- **Transmits raw bits (electrical/optical signals).**
- Devices: **Hubs, Repeaters, Cables (Fiber, Copper).**

Optional for Exam OSI Model Explained with Example (Email Sending Process)

Step-by-Step Data Flow:

1. **Application Layer (User sends email via SMTP)**
    - Email client (e.g., Outlook) formats the message.
    - Uses **SMTP** protocol.
2. **Presentation Layer (Encryption & Compression)**
    - Email is encrypted (**SSL/TLS**) for security.
3. **Session Layer (Establishes Connection)**
    - Maintains the session between sender and mail server.
4. **Transport Layer (Breaks Data into Segments)**
    - **TCP** ensures reliable delivery.
5. **Network Layer (Adds IP Address for Routing)**
    - **IP** adds source & destination addresses.
6. **Data Link Layer (Frames Data with MAC Addresses)**
    - **Ethernet** adds MAC addresses.
7. **Physical Layer (Transmits as Electrical Signals)**
    - Data sent via **cable or Wi-Fi**.

At the receiver's end, the process reverses (**decapsulation**).

B. Internet Model (TCP/IP Model – 4 Layers)

1. **Network Interface Layer** – Combines OSI's Physical and Data Link layers.
2. **Internet Layer** – Handles routing (e.g., IP).
3. **Transport Layer** – Manages data flow (e.g., TCP, UDP).
4. **Application Layer** – Combines OSI's Session, Presentation, and Application layers.

C. Message Transmission Using Layers

- **Encapsulation:** Data moves down the layers, with each layer adding a header.
- **Decapsulation:** At the receiver's end, headers are removed as data moves up.

OSI Model vs. TCP/IP Model

OSI Model (7 Layers)	TCP/IP Model (4 Layers)
More detailed, theoretical	Practical, used in the Internet
Session, Presentation separate	Combined into Application
Network Layer = Routing	Internet Layer = IP
Transport Layer = TCP/UDP	Same as OSI
Data Link + Physical = Network Interface	Same as OSI

Questions (10 Marks)

Explain the OSI model with a diagram and protocols used at each layer.

- **Answer:**
  - Define OSI model (7 layers).
  - Draw the diagram.
  - List functions & protocols for each layer.

---

4. Network Standards

A. Importance of Standards

- Ensures compatibility between devices.
- Promotes interoperability (e.g., Wi-Fi standards allow different devices to connect).

B. Standards-Making Process

1. **Proposal** – A need is identified.
2. **Drafting** – Experts develop specifications.
3. **Review & Approval** – Organizations like IEEE, ITU-T finalize standards.

C. Common Standards

1. **IEEE 802.11** – Wi-Fi standards.
2. **Ethernet (IEEE 802.3)** – Wired LAN standard.
3. **TCP/IP** – Internet protocol suite.

Question:
Q: Why are network standards important? Name two key networking standards.

---

5. Future Trends

A. Wireless LAN and BYOD (Bring Your Own Device)

- Employees use personal devices (laptops, smartphones) for work.
- Security challenges (e.g., unauthorized access).

B. Internet of Things (IoT)

- Smart devices communicate over the internet (e.g., smart homes, wearables).
- Example: A smart thermostat adjusts temperature based on user behavior.

C. Massively Online (Cloud Computing, Big Data)

- Cloud services (AWS, Azure) enable remote data storage and processing.
- Big data analytics improves decision-making.

Question:
Q: Explain how IoT is transforming modern businesses with an example.

Summary & Key Takeaways

- **Data communication** requires delivery, accuracy, timeliness, and minimal jitter.
- **Network types** include LAN, WAN, MAN, and PAN.
- **OSI (7 layers)** and **TCP/IP (4 layers)** models define structured communication.
- **Standards** (e.g., IEEE 802.11, TCP/IP) ensure interoperability.
- **Future trends:** BYOD, IoT, and cloud computing are shaping networking.