Lecture-8

Network Interface

Layer 1: Physical Layer

Main Goal

- Reliable transmission of **raw bits (1s and 0s)** between devices

Key Functions

- **Reliable Bit Transmission**
- **Interfaces**
  - Mechanical
  - Electrical
  - Electromagnetic
  - Timing specifications
- **Digital → Analog Conversion**
  - Modulation techniques
- **Transmission Media Definition**
  - Wired or wireless

Transmission Media Types

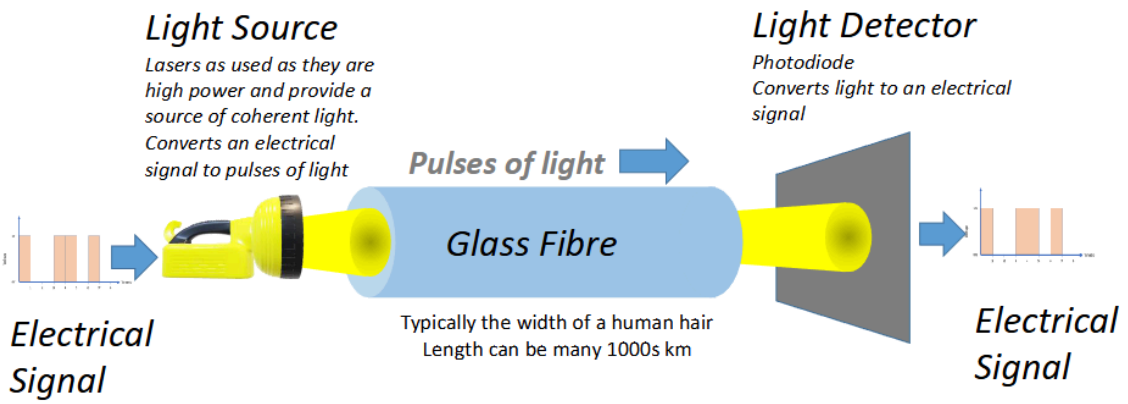
Wired Media

Type	Description
Copper (Electrical)	Uses voltage levels (e.g., 5V = ‘1’, 0V = ‘0’)
Fibre Optics	Uses pulses of light

Fibre facts:

- Uses high-power lasers
- Light detected by a **photodiode**

- A single fibre (hair-width) carries massive data



Wireless Media

- Radio waves,Lasers,Microwaves,Infrared

Radio Transmission

- Similar to sound waves (tone & loudness)
- Radio spectrum divided into bands:
  - VHF, UHF, L, S, C, Ku, K, Ka, X
- Used for:
  - FM radio
  - LTE/mobile phones
  - Wi-Fi
  - Satellite communication

Data Encoding & Clocks

Data Encoding

- Converts digital data into:
  - Electrical, Optical, Radio signals
- Decoding = reverse process

Encoding Techniques

- **NRZ (Non-Return-to-Zero)**

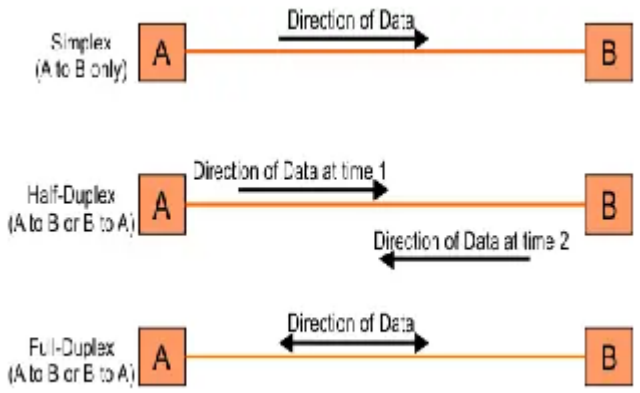
    - uses voltage for 0 and 1.
    - Sync problems with long i dentical bits (0s or 1s).
- **Manchester Encoding**
    - Transition in middle of each bit
    - 1 → High to Low
    - 0 → Low to High
    - Prevents clock desynchronisation ✅

Clocks

- Used to determine when to read bits
- Clock drift = data corruption

Transmission Modes

Mode	Description	Example
Simplex	One-way	Radio broadcasting
Half-Duplex	Two-way, not simultaneous	Walkie-talkie
Full-Duplex	Two-way simultaneous	Phone call (fastest)



Security

- Physical protection
    - Locks, cages
    - Access controls
    - Fire suppression

- Security alarms

Layer 2: Data Link Layer (DLL)

Purpose

- Reliable data transfer over an **unreliable physical medium**

Reliability Concerns

- Data loss or corruption
- Flow control (fast sender vs slow receiver)

Key Services of Data Link Layer

1. **Framing**
2. **Physical Addressing (MAC)**
3. **Error Detection & Control**
4. **Flow Control**

1️⃣ Framing

- Encapsulates **network-layer packets** into frames
- Sent bit-by-bit over hardware
- Receiver reassembles bits back into frames

Ethernet Frame Structure

- **Header**: Source & Destination MAC addresses
- **Payload**:
  - Actual data (IP packet), Size: **46 – 1500 bytes**
- **Trailer**:
  - Error detection bits (CRC)
- **Flags**:
  - Indicate start & end of frame

2️⃣ Physical Addressing (MAC Address)

MAC Address Basics

- 48-bit (6-byte) hexadecimal number
- Uniquely identifies a device on a LAN

Structure

Part	Description
First 3 bytes	Manufacturer ID (OUI)
Last 3 bytes	Unique device identifier

- Stored (“burned”) into the **NIC**
- Every device needs:
  - IP address (Layer 3)
  - MAC address (Layer 2)

Address Resolution Protocol (ARP)

- Maps **IP → MAC** within local network

Process:

1. ARP Request (Broadcast)
2. ARP Reply (Unicast)

3️⃣ Error Detection & Control

Absolute reliability is impossible, but DLL detects errors.

Parity Bit

- Single bit added to data
- **Even parity** → total 1s is even
- **Odd parity** → total 1s is odd

⚠️ Limitation:

- Detects only **single-bit errors**
- Fails with burst errors

Cyclic Redundancy Check (CRC)

- Standard in Ethernet
- Mathematical checksum added to frame
- Receiver re-calculates and compares

Match → Data OK

Mismatch → Frame dropped

Retransmission handled by **Transport Layer (TCP)**

Other Methods

- Checksums
- Hamming Code

4️⃣ Flow Control

Controls sender speed to match receiver capacity

Methods

- **Feedback-based**: Receiver signals sender
- **Rate-based**: Sender limits its own speed

Security

- Uses **MACsec**
- Encrypts frame contents
- Common in large/core networks