# Computer Networks - Notes

**Unit 1: Introduction to Networks and Physical Layer**

**1. Computer Network**

**Detailed Definition:** A computer network is a collection of interconnected computers and devices that can communicate with each other and share resources. It allows computers to exchange data and share hardware/software resources.

**Basic Components:**

- **Nodes:** Computers, servers, smartphones, routers
- **Links:** Cables, wireless connections
- **Network Devices:** Switches, routers, modems

**2. Types of Networks**

**LAN (Local Area Network)**

- Covers small geographical area
- Example: Office, school, home network
- High speed, low cost
- Uses Ethernet or Wi-Fi

**WAN (Wide Area Network)**

- Covers large geographical area
- Example: Internet, corporate networks
- Connects multiple LANs
- Uses telephone lines, satellites

**MAN (Metropolitan Area Network)**

- Covers a city
- Larger than LAN, smaller than WAN
- Example: Cable TV network

**PAN (Personal Area Network)**

- Very small area (10 meters)
- Example: Bluetooth devices

**3. Network Models**

**OSI Model (Open Systems Interconnection)**

**Detailed Definition:** A 7-layer theoretical model that describes how data travels from one computer to another over a network.

**7 Layers:**

1. **Physical:** Raw bit transmission over physical medium
2. **Data Link:** Error detection, frame formatting

3. **Network:** Routing, IP addressing

4. **Transport:** End-to-end connection, reliability

5. **Session:** Connection establishment, maintenance

6. **Presentation:** Data translation, encryption

7. **Application:** User interfaces, network applications

**TCP/IP Model**

**Detailed Definition:** A 4-layer practical model used in real-world networks like the Internet.

**4 Layers:**

1. **Network Access:** Physical and data link functions

2. **Internet:** Routing and IP addressing

3. **Transport:** End-to-end communication

4. **Application:** User applications and services

**4. Transmission Media**

**Guided (Wired) Media**

- **Twisted Pair:** Telephone wires, Ethernet cables

- **Coaxial Cable:** Cable TV, older Ethernet

- **Fiber Optics:** High speed, long distance, expensive

**Unguided (Wireless) Media**

- **Radio Waves:** Wi-Fi, Bluetooth

- **Microwaves:** Satellite communication

- **Infrared:** Remote controls, short distance

**5. Encoding and Modulation**

**Encoding:** Converting digital data to digital signals
**Modulation:** Converting digital data to analog signals for transmission

**6. Switching Techniques**

**Circuit Switching**

- Dedicated path established before communication

- Example: Traditional telephone network

- Inefficient for data transmission

**Packet Switching**

- Data broken into packets

- Each packet travels independently

- Example: Internet

- Efficient for data transmission

**Message Switching**

- Store and forward entire message
- Used in email systems

**Video Links:**

- **English:** [Computer Networks Introduction](Computer Networks Introduction)
- **Hindi:** [Networks Basics in Hindi](Networks Basics in Hindi)

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**Unit 2: Data Link Layer**

**1. Data Link Layer**

**Detailed Definition:** The second layer in OSI model responsible for node-to-node data transfer. It takes packets from network layer and encapsulates them into frames.

**Functions:**

- Framing
- Error control
- Flow control
- Access control

**2. Framing**

**Detailed Definition:** The process of dividing the stream of bits received from network layer into manageable data units called frames.

**Methods:**

- **Character Count:** Number of characters in frame
- **Flag Bytes:** Special characters mark start/end
- **Bit Stuffing:** Special bit pattern marks boundaries

**3. Error Detection and Correction**

**Parity Check**

- Simple error detection
- Adds extra parity bit
- **Even Parity:** Total 1's even
- **Odd Parity:** Total 1's odd
- Detects single-bit errors

**CRC (Cyclic Redundancy Check)**

- Powerful error detection
- Uses polynomial division
- Adds checksum to data
- Detects burst errors

**Checksum**

- Sum of all data bits
- Used in TCP/IP protocols

## 4. Flow Control

**Detailed Definition:** Regulating the amount of data sent by sender to prevent overwhelming the receiver.

**Methods:**

- **Stop-and-Wait:** Send one frame, wait for ACK
- **Sliding Window:** Multiple frames in transit

## 5. Sliding Window Protocols

### Go-Back-N ARQ

- Sender can send N frames without ACK
- Receiver only accepts frames in order
- Lost frames cause retransmission of all subsequent frames

### Selective Repeat ARQ

- Receiver accepts out-of-order frames
- Only lost frames are retransmitted
- More efficient but complex

## 6. MAC (Media Access Control) Protocols

### ALOHA

- Simple random access protocol
- Stations transmit whenever they have data
- Low efficiency

### CSMA/CD (Carrier Sense Multiple Access/Collision Detection)

- Used in Ethernet
- Listen before transmit
- Detect collisions and retransmit

### CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance)

- Used in Wi-Fi
- Avoid collisions using RTS/CTS

## 7. IEEE Standards

### Ethernet (IEEE 802.3)

- Wired LAN standard
- Uses CSMA/CD

- Speeds: 10 Mbps to 100 Gbps

**Wi-Fi (IEEE 802.11)**

- Wireless LAN standard

- Uses CSMA/CA

- Versions: 802.11a/b/g/n/ac/ax

**Video Links:**

- **English:** Data Link Layer

- **Hindi:** Data Link Layer in Hindi

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**Unit 3: Network Layer**

**1. Network Layer**

**Detailed Definition:** The third layer in OSI model responsible for source-to-destination delivery of packets across multiple networks. It handles logical addressing and routing.

**Functions:**

- Logical addressing (IP addresses)

- Routing

- Packet forwarding

- Fragmentation

**2. IP Addressing**

**IPv4 (Internet Protocol Version 4)**

- 32-bit address

- Dotted decimal notation (e.g., 192.168.1.1)

- 4.3 billion possible addresses

- Classes: A, B, C, D, E

**IPv6 (Internet Protocol Version 6)**

- 128-bit address

- Hexadecimal notation

- Virtually unlimited addresses

- Example: 2001:0db8:85a3:0000:0000:8a2e:0370:7334

**3. Subnetting**

**Detailed Definition:** Dividing a large network into smaller, manageable sub-networks to improve performance and security.

**Benefits:**

- Reduced network traffic

- Improved security

- Simplified management

**Example:** Network 192.168.1.0/24 divided into four subnets:

- 192.168.1.0/26
- 192.168.1.64/26
- 192.168.1.128/26
- 192.168.1.192/26

## 4. Routing Algorithms

### Distance Vector Routing

- Each router shares its entire routing table
- Uses Bellman-Ford algorithm
- Example: RIP (Routing Information Protocol)
- Slow convergence

### Link State Routing

- Each router shares only its connected links
- Uses Dijkstra's algorithm
- Example: OSPF (Open Shortest Path First)
- Fast convergence

### BGP (Border Gateway Protocol)

- Used between different autonomous systems
- Policy-based routing
- Internet backbone routing

## 5. IP Datagram Structure

- **Version:** IPv4 or IPv6
- **Header Length:** Size of header
- **TOS:** Type of Service
- **Total Length:** Size of datagram
- **TTL:** Time to Live
- **Protocol:** TCP or UDP
- **Source/Destination IP**
- **Data:** Payload

## 6. Fragmentation

**Detailed Definition:** Breaking large IP packets into smaller pieces to fit the Maximum Transmission Unit (MTU) of the network.

**Reassembly:** Done at destination

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**Unit 4: Transport Layer**

**1. Transport Layer**

**Detailed Definition:** The fourth layer in OSI model responsible for end-to-end communication between applications on different hosts.

**Functions:**

- Process-to-process delivery

- Connection management

- Flow control

- Congestion control

- Error control

**2. Transport Protocols**

**UDP (User Datagram Protocol)**

- Connectionless

- Unreliable

- No flow control

- Fast, low overhead

- Uses: DNS, VoIP, streaming

**Header Fields:**

- Source Port, Destination Port

- Length, Checksum

**TCP (Transmission Control Protocol)**

- Connection-oriented

- Reliable

- Flow control

- Congestion control

- Uses: Web browsing, email, file transfer

**Header Fields:**

- Sequence Number, Acknowledgement Number

- Window Size

- Flags: SYN, ACK, FIN, RST

### 3. TCP Connection Management

**Three-Way Handshake (Connection Establishment)**

1. **SYN:** Client sends synchronization request
2. **SYN-ACK:** Server acknowledges and synchronizes
3. **ACK:** Client acknowledges

**Connection Termination**

1. **FIN:** One side requests termination
2. **ACK:** Other side acknowledges
3. **FIN:** Other side requests termination
4. **ACK:** First side acknowledges

### 4. Flow Control

**Sliding Window Protocol:**

- Receiver advertises window size
- Sender adjusts transmission rate
- Prevents receiver overflow

### 5. Congestion Control

**Algorithms:**

- **Slow Start:** Exponential growth initially
- **Congestion Avoidance:** Additive increase
- **Fast Retransmit:** Duplicate ACK detection
- **Fast Recovery:** After fast retransmit

### 6. Quality of Service (QoS)

**Detailed Definition:** The ability to provide different priority to different applications, users, or data flows.

**Techniques:**

- Traffic shaping
- Packet scheduling
- Admission control

**Video Links:**

- **English:** [Transport Layer Protocols](#)
- **Hindi:** [TCP/IP in Hindi](#)

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### Unit 5: Application Layer

### 1. Application Layer

**Detailed Definition:** The top layer in OSI model that provides interfaces and protocols needed by users. It enables applications to access network services.

**Protocols:**

- HTTP, FTP, SMTP, DNS
- Telnet, SSH
- DHCP, SNMP

## 2. DNS (Domain Name System)

**Detailed Definition:** The phonebook of the Internet that translates domain names to IP addresses.

**Process:**

1. Check local cache
2. Query local DNS server
3. Query root servers
4. Query TLD servers
5. Query authoritative servers

**Record Types:**

- **A:** IPv4 address
- **AAAA:** IPv6 address
- **CNAME:** Canonical name
- **MX:** Mail exchange

## 3. HTTP (Hypertext Transfer Protocol)

- Web page transfer
- Stateless protocol
- **HTTP Methods:** GET, POST, PUT, DELETE
- **Status Codes:** 200 OK, 404 Not Found, 500 Server Error

## 4. FTP (File Transfer Protocol)

- File transfer between computers
- Two connections: Control (21) and Data (20)
- **Modes:** Active and Passive

## 5. Email Protocols

### SMTP (Simple Mail Transfer Protocol)

- Sending email between servers
- Port 25

### POP3 (Post Office Protocol)

- Download email to local computer

- Port 110
- Deletes from server after download

**IMAP (Internet Message Access Protocol)**

- Access email on server
- Port 143
- Keeps mail on server

## 6. Network Management

**SNMP (Simple Network Management Protocol)**

- Network device management
- **Components:** Manager, Agent, MIB

## 7. P2P File Sharing

- Direct sharing between users
- No central server
- Examples: BitTorrent, Skype

## 8. Multimedia Streaming

- Real-time audio/video delivery
- Protocols: RTP, RTCP, RTSP

**Video Links:**

- **English:** Application Layer Protocols
- **Hindi:** Application Layer in Hindi

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## Unit 6: Network Security and Management

### 1. Network Security

**Detailed Definition:** Policies and practices adopted to prevent and monitor unauthorized access, misuse, modification, or denial of computer network resources.

### 2. Firewalls

**Detailed Definition:** A network security system that monitors and controls incoming and outgoing network traffic based on predetermined security rules.

**Types:**

- **Packet Filtering:** Examines each packet
- **Stateful Inspection:** Tracks connection state
- **Proxy Firewall:** Acts as intermediary
- **Next-Generation Firewall:** Deep packet inspection

### 3. Cryptography

**Symmetric Encryption**

- Same key for encryption and decryption

- Fast, efficient for large data

- Examples: AES, DES, 3DES

**Asymmetric Encryption**

- Public key and private key

- Secure key exchange

- Examples: RSA, Diffie-Hellman

**Digital Signatures**

- Verify authenticity and integrity

- Uses asymmetric cryptography

**Digital Certificates**

- Electronic documents proving ownership

- Issued by Certificate Authorities (CA)

## 4. VPN (Virtual Private Network)

**Detailed Definition:** Extends a private network across a public network, enabling users to send and receive data as if their devices were directly connected to the private network.

**Types:**

- **Remote Access VPN:** For individual users

- **Site-to-Site VPN:** Connects entire networks

## 5. Intrusion Detection Systems (IDS)

- Monitors network for malicious activities

- **Types:** Network-based, Host-based

- **Detection Methods:** Signature-based, Anomaly-based

## 6. Wireless Security

### WEP (Wired Equivalent Privacy)

- Weak security

- Easily cracked

### WPA (Wi-Fi Protected Access)

- Stronger than WEP

- **WPA2:** Current standard

- **WPA3:** Latest standard

## 7. Network Monitoring

- **SNMP:** Device monitoring

- **NetFlow:** Traffic analysis

- **Packet Sniffers:** Wireshark, tcpdump

**Video Links:**

- **English:** [Network Security](#)

- **Hindi:** [Network Security in Hindi](#)

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**Unit 7: Emerging Topics and Case Studies**

**1. Wireless Networks**

**Wi-Fi 6 (802.11ax)**

- Higher efficiency

- Better performance in crowded areas

- Lower latency

**5G Networks**

- High speed mobile broadband

- Low latency

- Massive device connectivity

**2. Mobile IP**

**Detailed Definition:** Allows mobile devices to move between networks while maintaining the same IP address.

**Components:**

- **Home Agent:** In home network

- **Foreign Agent:** In visited network

- **Mobile Node:** The mobile device

**3. IoT (Internet of Things) Networking**

**Detailed Definition:** Network of physical objects embedded with sensors, software, and connectivity to exchange data.

**Protocols:**

- **MQTT:** Lightweight messaging

- **CoAP:** Web transfer protocol

- **LoRaWAN:** Long range communication

**4. Network Virtualization**

**Detailed Definition:** Creating virtual versions of network resources like switches, routers, and firewalls.

**Benefits:**

- Resource optimization

- Faster deployment

- Cost reduction

## 5. Cloud Networking

**Detailed Definition:** Network capabilities and resources available as cloud services.

**Models:**

- **IaaS:** Infrastructure as a Service
- **PaaS:** Platform as a Service
- **SaaS:** Software as a Service

## 6. Software Defined Networking (SDN)

- Separates control plane from data plane
- Centralized network management
- Programmable networks

## 7. Case Studies

**Enterprise Network**

- Multiple departments
- Security zones
- Redundant connections

**Campus Network**

- Multiple buildings
- Wireless coverage
- High bandwidth

**Data Center Network**

- High availability
- Load balancing
- Security

**Video Links:**

- **English:** Emerging Network Technologies
- **Hindi:** New Network Technologies

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**Important Concepts Summary**

**Protocols and Port Numbers:**

| Protocol | Port | Purpose |
|----------|------|--------------|
| HTTP | 80 | Web browsing |

| Protocol | Port | Purpose |
|----------|------|---------|
| HTTPS | 443 | Secure web |
| FTP | 20,21 | File transfer |
| SSH | 22 | Secure remote access |
| Telnet | 23 | Remote access |
| SMTP | 25 | Email sending |
| DNS | 53 | Domain name resolution |
| DHCP | 67,68 | IP address assignment |
| SNMP | 161 | Network management |

**Network Devices:**

| Device | Function | OSI Layer |
|--------|----------|-----------|
| Hub | Connects devices | Physical |
| Switch | Connects devices intelligently | Data Link |
| Router | Connects networks | Network |
| Bridge | Connects network segments | Data Link |
| Gateway | Connects different protocols | All layers |

**IP Address Classes:**

| Class | Range | Purpose |
|-------|-------|---------|
| A | 1.0.0.0 - 126.255.255.255 | Large networks |
| B | 128.0.0.0 - 191.255.255.255 | Medium networks |
| C | 192.0.0.0 - 223.255.255.255 | Small networks |

| Class | Range | Purpose |
|-------|-------|---------|
| D | 224.0.0.0 - 239.255.255.255 | Multicast |
| E | 240.0.0.0 - 255.255.255.255 | Experimental |

**Career Opportunities:**

- Network Administrator
- Network Engineer
- Security Analyst
- Cloud Network Engineer
- Network Architect

**Final English Video:** Computer Networks Full Course
**Final Hindi Video:** Computer Networks Complete Course