TG ACADEMIC RESOURCE SERIES

# COMPUTER NETWORKS

The OSI Reference Model
Seven Layers, Core Functions & Data Encapsulation

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| **SUBJECT** | Computer Networks / Data Communication |
| **LEVEL** | Class 11-12 / BTech / BCA / MCA / BSc / MSc |
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|---|---|---|
| **7** | **APPLICATION** | Network services used by applications<br>HTTP, DNS, SMTP (application protocols) |
| **6** | **PRESENTATION** | Data representation, translation, compression, encryption<br>Formatting / encryption functions |
| **5** | **SESSION** | Establishes, manages and terminates logical sessions<br>Dialog and session control |
| **4** | **TRANSPORT** | End-to-end transport, segmentation, reliability and ports<br>TCP, UDP |
| **3** | **NETWORK** | Logical addressing and routing between networks<br>IP; routers operate mainly here |
| **2** | **DATA LINK** | Framing, local link delivery and MAC addressing<br>Ethernet, Wi-Fi MAC; switches mainly here |
| **1** | **PHYSICAL** | Transmission of raw bits over a medium<br>Signals, cables, radio; hubs/repeaters |

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This sample is a concise introduction to the seven-layer conceptual model. It is designed for revision and as a preview of a structured teaching approach.

# 1. Learning Objectives

After studying this note, you should be able to:

- Name the seven OSI layers in the correct order.
- Describe the main responsibility of each layer.
- Identify common protocol examples and typical networking devices associated with layers.
- Explain encapsulation and decapsulation.
- Trace a simple web request through the layered model.

# 2. What Is the OSI Model?

The **Open Systems Interconnection (OSI) model** is a seven-layer reference model used to describe and organise the functions involved in network communication. It provides a common vocabulary for learning, design and troubleshooting.

> The model is conceptual: real network protocols do not always fit neatly into only one OSI layer. Protocol stacks used in practice are commonly described using the TCP/IP model.

# 3. The Seven Layers at a Glance

| Layer | Name | Primary responsibility | Examples / association |
|---|---|---|---|
| 7 | Application | Network services available to application processes | HTTP, DNS, SMTP |
| 6 | Presentation | Representation, syntax, encoding, compression and encryption functions | Data formats and transformations |
| 5 | Session | Establish, manage and end communication sessions | Dialog / session management |
| 4 | Transport | Process-to-process delivery; ports; segmentation; transport reliability where provided | TCP, UDP |
| 3 | Network | Logical addressing and routing across networks | IP; routers mainly |
| 2 | Data Link | Framing and delivery over a local link; link-layer addressing | Ethernet, Wi-Fi MAC; switches mainly |
| 1 | Physical | Transmission and reception of raw bits as signals | Copper, fibre, radio; repeaters |

> Layer numbers are shown from top to bottom. Data is handed downward for transmission and upward at the receiving endpoint.

# 4. Understanding the Layers

## Layers 7 to 5: Services and dialogue

**7. Application:** Closest to user-facing software. It provides network-related services to application processes. Examples of application-layer protocols include HTTP, DNS and SMTP. The layer itself is not the web browser or email app; it defines the network protocol service they use.

**6. Presentation:** Concerned with how data is represented between systems. It may involve character encoding, data-format translation, compression and encryption/decryption functions. In real Internet stacks, these functions may be implemented within libraries or application protocols rather than as a distinct layer.

**5. Session:** Describes the establishment, management and termination of logical communication sessions, including dialogue control and synchronisation concepts. Modern protocols may combine these functions with other layers.

## Layers 4 to 1: Delivery across the network

**4. Transport:** Supports communication between processes on end systems. Port numbers help identify application endpoints. TCP provides a reliable, ordered byte stream; UDP provides datagrams without TCP-style delivery guarantees.

**3. Network:** Provides logical addressing and routing so packets can move between different networks. IP is the central Internet Protocol example. Routers mainly make forwarding decisions at this layer, while also examining lower-layer framing.

**2. Data Link:** Handles framing and delivery over a single local link, with link-layer addressing and error detection mechanisms in common technologies. Ethernet and Wi-Fi define data-link functions. Layer-2 switches forward frames using MAC addresses.

**1. Physical:** Defines the transmission of bits as electrical, optical or radio signals, including signalling, connectors, frequencies and physical media. Repeaters and traditional hubs operate at this level.

Device-layer associations are useful learning guides, not absolute boundaries. For example, multilayer switches can also perform Layer-3 routing.

# 5. Encapsulation and Decapsulation

At the sending host, each lower layer receives data from the layer above and adds control information, commonly in the form of a header (and, at the data-link layer, a trailer). This process is called **encapsulation**.

At the receiving host, the corresponding layers inspect and remove their protocol information as the data moves upward. This is called **decapsulation**.

| OSI layer | Typical data unit (PDU) | Illustrative addition / function |
|---|---|---|
| Application / Presentation / Session | Data | Application content and representation/session functions |
| Transport | Segment (TCP) / Datagram (UDP) | Transport header, including source and destination ports |
| Network | Packet | IP header, including source and destination IP addresses |
| Data Link | Frame | Link-layer header and trailer; local link addressing |
| Physical | Bits | Signals sent through the medium |

PDU names are conventions used to explain the layers. The exact format and terminology depend on the protocol.

# 6. Example: Opening a Website

Suppose a user opens a website using a browser. A simplified explanation of the layered responsibilities is:

1. **Application:** The browser uses an application protocol such as HTTP or HTTPS; DNS may be used to resolve the host name.
2. **Presentation:** Data encoding and cryptographic protection are handled by suitable software/protocol functions. TLS is commonly implemented above TCP or integrated with transport in QUIC; it is not simply a universal OSI Layer-6 protocol.
3. **Session:** Logical communication state and dialogue-related functions are maintained by the relevant protocols and software.
4. **Transport:** TCP or QUIC/UDP carries application data between endpoints, using ports and transport mechanisms.
5. **Network:** IP packets are routed toward the destination network.
6. **Data Link:** Each local link carries frames to the next hop, such as the local router.
7. **Physical:** Bits are transmitted as signals over Wi-Fi, copper or fibre.

Important: this is a conceptual mapping. HTTPS, TLS, QUIC and modern networking implementations do not map one-to-one onto the OSI layers.

# 7. OSI Model as a Troubleshooting Guide

The model helps organise fault isolation. A network issue may be investigated from the physical connection upward, or from the application downward, depending on the symptoms.

| Layer | Example symptom / check |
|---|---|
| Physical | No link light, damaged cable, weak wireless signal, power issue. |
| Data Link | VLAN mismatch, frame errors, MAC-learning or local-link issue. |
| Network | Incorrect IP address, subnet, gateway, route or blocked IP path. |
| Transport | Port closed, connection refused, retransmissions or transport timeout. |
| Session | Session state or dialogue management problem in the relevant system. |
| Presentation | Encoding, certificate, encryption or incompatible data-format issue. |
| Application | Incorrect URL, DNS/application configuration, service error or HTTP response. |

This is a troubleshooting framework, not a strict diagnostic law. Many real problems span multiple layers.

# 8. Check Your Understanding

**Q1.** Which OSI layer is mainly responsible for routing packets between networks?

**Q2.** Which layer uses port numbers to help identify application processes?

**Q3.** What is the difference between encapsulation and decapsulation?

**Q4.** A Layer-2 switch mainly forwards which data unit using which address type?

**Q5.** Why should the OSI model be treated as a reference model rather than an exact description of every modern protocol?

## Suggested Answers (brief)

**A1.** Network layer (Layer 3).
**A2.** Transport layer (Layer 4).
**A3.** Encapsulation adds protocol control information as data moves down the sending stack; decapsulation processes and removes it as data moves up the receiving stack.
**A4.** Frames, using MAC addresses.
**A5.** Real protocol suites combine, distribute or implement functions differently; some protocols span multiple conceptual layers.

# Where to Go Next

A broader Computer Networks programme can continue with TCP/IP architecture, IPv4 addressing and subnetting, routing, switching, DNS, HTTP/HTTPS, TCP versus UDP, error detection and network security. These deserve separate worked notes and practice sessions.

**In guided classes:** students can practise layer mapping, packet-flow reasoning, subnetting, protocol analysis and structured troubleshooting using scenarios and diagrams.

**About this resource**
TG Academic Resource Series | CN-001 | Version 1.0
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