R&D Document: Working of All Layers in the OSI Model

Tushar Bhosale

June 2025

Contents

1 Introduction

The OSI (Open Systems Interconnection) Model is a conceptual framework used to understand and implement standard protocols in network communications. It divides the communication process into seven layers, where each layer serves a specific function and communicates with adjacent layers. This layered approach enables interoperability between different systems and technologies.

2 Overview of OSI Layers

Layer	Name	Function
7	Application	Interface for user applications and network services
6	Presentation	Data format translation, encryption, and compression
5	Session	Establishes, manages, and terminates sessions between applications
4	Transport	Provides reliable data transfer, flow control, and error recovery
3	Network	Routing, addressing, and packet forwarding
2	Data Link	Frame formation, MAC addressing, and error detection on physical links
1	Physical	Transmission and reception of raw bit streams over physical medium

Table 1: Summary of OSI Layers

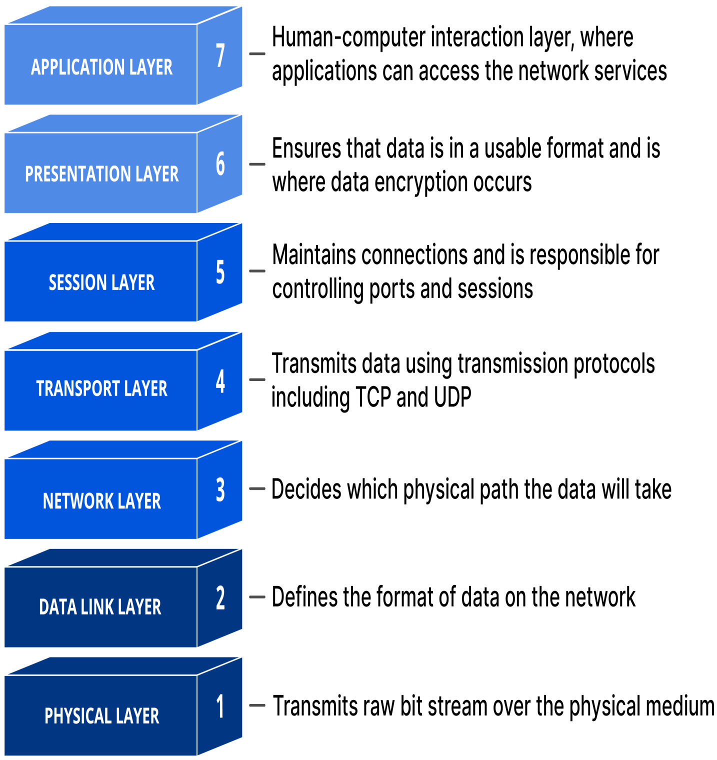

Figure 1: Overview of the OSI Model Layers

3 Detailed Layer-wise Explanation

3.1 Physical Layer (Layer 1)

Purpose and Functions: The Physical Layer is the lowest layer of the OSI model. It deals with the physical connection between devices, focusing on transmitting raw bits (0s and 1s) over the communication medium. It defines the hardware specifications, electrical signals, voltage levels, timing of voltage changes, physical data rates, maximum transmission distances, and physical connectors such as cables, switches, hubs, and network interface cards (NICs).

Key aspects include:

- Bit-level transmission: sending and receiving unstructured raw data.
- Media types: copper cables, fiber optics, wireless radio frequencies.
- Physical topology: bus, star, ring, mesh.
- Signal encoding: modulation and line coding.
- Synchronization of bits via clocks.

—

3.2 Data Link Layer (Layer 2)

Purpose and Functions: The Data Link Layer ensures reliable data transfer between two directly connected nodes by organizing bits into frames. It manages physical addressing through MAC (Media Access Control) addresses and performs error detection and correction to maintain data integrity over the physical medium.

Responsibilities include:

- Framing: encapsulating raw bits into structured frames.
- Physical addressing: assigning MAC addresses to devices.
- Error detection: using CRC (Cyclic Redundancy Check) and parity bits.
- Flow control: managing data rate between sender and receiver.
- Media access control: determining how devices share the physical medium (e.g., CSMA/CD in Ethernet).

The Data Link Layer is typically divided into two sublayers:

- Logical Link Control (LLC): manages frame synchronization, flow control, and error checking.
- Media Access Control (MAC): handles access to the physical transmission medium.

—

3.3 Network Layer (Layer 3)

Purpose and Functions: The Network Layer is responsible for packet forwarding including routing through intermediate routers. It assigns logical addresses (typically IP addresses) to devices and determines the best path for data to travel from source to destination across multiple networks.

Key functions include:

- Logical addressing (IP addressing).
- Routing: selecting optimal paths for data delivery.
- Packet forwarding and switching.
- Fragmentation and reassembly of packets.
- Handling congestion control and packet sequencing.

Protocols at this layer include IPv4, IPv6, ICMP, and routing protocols such as OSPF and BGP.

—

3.4 Transport Layer (Layer 4)

Purpose and Functions: The Transport Layer ensures reliable data transfer from end-to-end and controls data flow and error recovery. It segments data from the upper layers, manages retransmissions, and maintains logical connections between hosts.

Core functions:

- Segmentation and reassembly of data.
- Connection establishment, maintenance, and termination.
- Flow control to avoid congestion.
- Error detection and correction using acknowledgments and retransmissions.
- Multiplexing: supporting multiple communication sessions using port numbers.

Main protocols:

- TCP (Transmission Control Protocol) — reliable, connection-oriented.
- UDP (User Datagram Protocol) — connectionless, faster, no guaranteed delivery.

—

3.5 Session Layer (Layer 5)

Purpose and Functions: The Session Layer manages sessions or connections between applications. It establishes, maintains, and synchronizes communication sessions, handling dialog control (which side transmits when) and recovery from interruptions.

Functions include:

- Establishing sessions between communicating systems.
- Maintaining sessions during data exchange.
- Synchronization with checkpoints to allow recovery.
- Dialog control: managing half-duplex or full-duplex communication.

—

3.6 Presentation Layer (Layer 6)

Purpose and Functions: The Presentation Layer formats data to be presented to the Application Layer. It translates data formats, handles data compression to optimize bandwidth, and encrypts/decrypts data for security.

Key tasks:

- Data translation between different formats (e.g., ASCII to EBCDIC).
- Data encryption and decryption for confidentiality.
- Data compression and decompression.
- Syntax negotiation to ensure both ends interpret data properly.

—

3.7 Application Layer (Layer 7)

Purpose and Functions: The Application Layer provides the interface between network services and end-user applications. It facilitates services like file transfers, email, remote login, and network management. This is where protocols like HTTP, FTP, SMTP, and DNS operate.

Key features:

- User interface support.
- Resource sharing and remote file access.
- Network virtual terminals.
- Directory services and network management.

—

4 Data Flow and Encapsulation

Data flows top-down at the sender's side and bottom-up at the receiver's side. Each layer adds a header (and sometimes trailer) to the data as it moves down (encapsulation) and removes them as it moves up (decapsulation).

—

5 Conclusion

The OSI model remains a foundational tool for understanding networking. Each layer abstracts complex processes into manageable parts, allowing developers to design interoperable systems and protocols. While real-world implementations like TCP/IP differ slightly, OSI continues to guide network education and troubleshooting.

6 References

- Tanenbaum, Andrew S., and David J. Wetherall. *Computer Networks*, 5th ed., Pearson, 2010.
- Stallings, William. *Data and Computer Communications*, 10th ed., Pearson, 2013.
- Forouzan, Behrouz A. *Data Communications and Networking*, 5th ed., McGraw-Hill, 2012.
- Kurose, James F., and Keith W. Ross. *Computer Networking: A Top-Down Approach*, 7th ed., Pearson, 2017.
- `https://en.wikipedia.org/wiki/OSI_model`
- `https://learningnetwork.cisco.com/s/article/OSI-Model-Reference-Sheet`