R&D Document: Working & Functionality of the TCP/IP Model

Tushar Bhosale

June 2025

Contents

1 Introduction

The TCP/IP model (Transmission Control Protocol/Internet Protocol) is a foundational networking architecture developed by the U.S. Department of Defense in the 1970s. It provides a standardized set of rules and protocols that govern data transmission across interconnected networks, such as the internet. The TCP/IP model is widely adopted and serves as the backbone of modern digital communication.

2 Role of TCP/IP

TCP/IP allows interoperability between diverse systems over different physical media (like copper, fiber, or wireless). It ensures seamless communication across LANs, WANs, and the global internet. The model divides data into packets, enabling reliable and accurate delivery from sender to receiver.

3 Layers of the TCP/IP Model

The TCP/IP model comprises four layers:

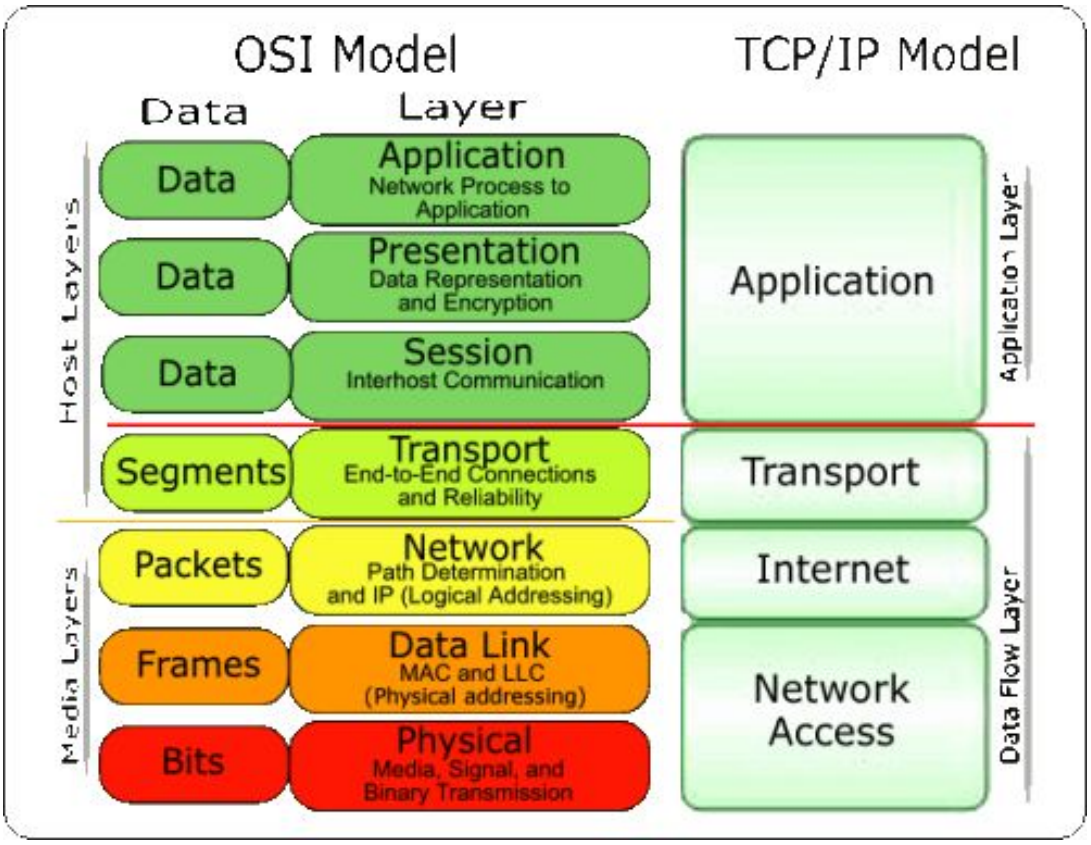

Figure 1: TCP/IP Model with OSI Comparison

3.1 Application Layer

Function: Interfaces with user-facing applications and services.

Responsibilities:

- Provides protocols like HTTP, FTP, SMTP, DNS, Telnet.
- Manages user authentication, data formatting, and encryption.
- Facilitates network services such as file transfer, email, and domain name resolution.

3.2 Transport Layer

Function: Ensures end-to-end communication and reliability of data.
Responsibilities:

- Segments and reassembles data streams.
- Provides flow control, error checking, and retransmission.
- Supports protocols like TCP (reliable, connection-oriented) and UDP (unreliable, connectionless).

3.3 Internet Layer

Function: Handles routing, addressing, and packet forwarding.
Responsibilities:

- Assigns logical addresses (IP addresses).
- Selects optimal paths using routing protocols.
- Supports protocols like IP, ICMP (error reporting), and ARP (MAC resolution).

3.4 Network Access Layer

Function: Manages physical transmission of data over network hardware.
Responsibilities:

- Converts IP packets into frames and transmits via physical media.
- Manages MAC addressing, framing, and error detection.
- Involves technologies such as Ethernet, Wi-Fi, and DSL.

4 Working of the TCP/IP Model

4.1 Sender Side

1. **Application Layer:** Prepares user data via protocols (e.g., HTTP).
2. **Transport Layer:** Segments data, adds headers with sequence numbers and ports.
3. **Internet Layer:** Adds source and destination IP addresses; handles routing.
4. **Network Access Layer:** Encapsulates data in frames and sends as bits over media.

4.2 Receiver Side

1. **Network Access Layer:** Receives bits and reconstructs frames.
2. **Internet Layer:** Verifies IP address and routes packet.
3. **Transport Layer:** Reassembles segments and checks for errors.
4. **Application Layer:** Delivers data to end-user applications.

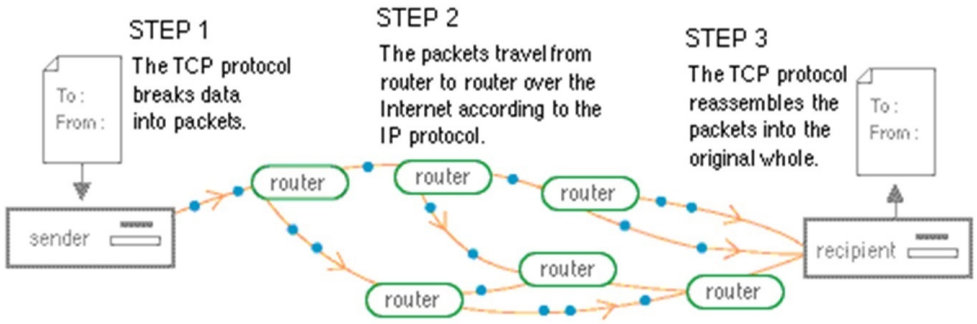

Figure 2: Data Transmission Process in TCP/IP Model

5 Advantages of TCP/IP

- **Interoperability:** Supports communication across various hardware and software.
- **Scalability:** Effective for both small and large-scale networks.
- **Open Standard:** Based on publicly available protocols, not controlled by a single entity.
- **Reliability:** Ensures data integrity with retransmission and error control.
- **Flexibility:** Adapts to different network types and data transmission needs.

6 Disadvantages of TCP/IP

- **Security Limitations:** Not originally designed with security in mind.
- **Complexity:** Might be overkill for small or isolated networks.
- **Overhead:** Adds protocol headers, increasing data size and processing.
- **IPv4 Limitations:** Address exhaustion, although mitigated by IPv6.

7 Why TCP/IP over OSI

- **Simplified Design:** 4-layer model is easier to implement than OSI's 7 layers.
- **Protocol-Driven:** TCP/IP was built around practical, existing protocols.
- **Real-World Usage:** TCP/IP is the actual model in use, while OSI is mostly educational.

8 Conclusion

The TCP/IP model remains the backbone of modern networking. With its streamlined architecture and robust design, it enables consistent, scalable, and interoperable communication across a diverse array of devices and infrastructures. Its simplicity, flexibility, and support for real-world protocols make it a practical standard for today's interconnected world.

9 References

1. Computer Networking: Principles, Protocols and Practice – Olivier Bonaventure
2. GeeksforGeeks: TCP/IP Model
3. Wikipedia: Internet Protocol Suite
4. RFC 1122: Requirements for Internet Hosts – Communication Layers
5. Cloudflare Learning: TCP