□ R&D Document: Understanding the OSI Model, TCP/IP Architecture, and Key Internet Protocols

🧑‍💻 **Submitted To:** Celebal Technologies, Summer Internship Program – Cloud Infra and Security

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📖 1. Introduction

In the modern era of networking and cloud computing, understanding network communication models and protocols is foundational. This R&D document explores the detailed architecture, functionality, and relevance of the OSI and TCP/IP models. Additionally, it analyzes key protocols—**TCP, UDP, HTTP, HTTPS, and ICMP**—used in every layer of internet-based communication.

🎯 2. Objectives

- To study the structure and operation of the OSI and TCP/IP models.
- To understand how data flows across a network using layered architecture.
- To analyze the working mechanisms of transport and application layer protocols.
- To explore the importance of secure and reliable communication.
- To document findings in a format suitable for internal learning and documentation within Celebal Technologies.

🧱 3. OSI Model – Layers and Working

The **OSI (Open Systems Interconnection)** model, developed by ISO, divides network communication into **7 abstraction layers**, each with defined roles.

Layer	Name	Function	Examples
7	**Application**	User interface and communication (e.g., browsers)	HTTP, FTP, SMTP
6	**Presentation**	Data translation, encryption/decryption	SSL, TLS, JPEG, ASCII
5	**Session**	Dialog control between systems	NetBIOS, RPC
4	**Transport**	Reliable/unreliable delivery; segmentation	TCP, UDP
3	**Network**	Logical addressing, routing, path determination	IP, ICMP
2	**Data Link**	MAC addressing, error detection (node-to-node)	Ethernet, PPP, Switches
1	**Physical**	Raw bit transmission through medium	Cables, Hubs, Voltages

🔄 Data Flow (Encapsulation)

Each layer **adds headers or trailers** to data before passing it to the next lower layer (encapsulation). The reverse occurs during reception (decapsulation).

🌐 4. TCP/IP Model – Architecture and Functionality

The **TCP/IP model**, also known as the **Internet Protocol Suite**, is a 4-layer protocol suite that underpins the modern internet.

TCP/IP Layer	OSI Equivalent	Responsibilities	Protocols
Application	Layer 7–5	Provides services to the user (email, web, file transfer)	HTTP, FTP, DNS
Transport	Layer 4	Reliable/unreliable data delivery	TCP, UDP
Internet	Layer 3	Routing, IP addressing	IP, ICMP, ARP
Network Access	Layer 2–1	Physical and data link level transmission	Ethernet, Wi-Fi, ARP

🔑 Key Design Goals

- Interoperability across diverse systems
- End-to-end communication

- Fault tolerance and congestion handling

📡 5. Protocols and Their Working

🔹 5.1 TCP (Transmission Control Protocol)

- **Connection-oriented**, **reliable**, **byte-stream protocol**
- Uses **3-way handshake** for connection establishment (SYN → SYN-ACK → ACK)
- Ensures **data sequencing**, **acknowledgment**, **error correction**
- Common Ports: 80 (HTTP), 443 (HTTPS), 25 (SMTP), 21 (FTP)

Use Case: Web pages, email, file transfers requiring data integrity.

🔸 5.2 UDP (User Datagram Protocol)

- **Connectionless**, **unreliable**, lightweight protocol
- No handshake, less overhead
- Suitable for real-time applications: **VoIP**, **DNS**, **video streaming**
- No flow or congestion control

Use Case: Gaming, live audio/video, DNS queries where speed is more important than reliability.

🌐 5.3 HTTP (Hypertext Transfer Protocol)

- **Application Layer**, **stateless** protocol
- Works over TCP (Port 80)
- Follows a request-response model
- Methods: GET, POST, PUT, DELETE

Use Case: Web communication (HTML documents, images, APIs)

🔐 5.4 HTTPS (HTTP Secure)

- **Secure version of HTTP**
- Adds **TLS/SSL encryption** over TCP
- Uses **Port 443**
- Protects against **man-in-the-middle attacks**, **data tampering**, and **eavesdropping**

Use Case: Secure online transactions, login systems, banking apps.

🛠️ 5.5 ICMP (Internet Control Message Protocol)

- Used for **error reporting** and **network diagnostics**
- Works at the **Network Layer**
- Does not transport user data
- Examples: **ping**, **traceroute**

Use Case: Verifying connectivity, diagnosing unreachable hosts, TTL expiry.

⚖️ 6. Comparative Analysis

Criteria	TCP	UDP	HTTP	HTTPS	ICMP
Reliability	✔	✘	✔	✔	N/A
Encryption	✘	✘	✘	✔	✘
Connection	Connection-oriented	Connectionless	Stateless	Stateless & Secure	Control Protocol
Speed	Moderate	Fast	Fast	Slightly slower than HTTP	Very Fast
Typical Use	Email, Web	VoIP, DNS	Browsing	Secure Browsing	Diagnostics

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🌐 7. Applications in Real-World Networking

Sector	Use Case	Related Protocols
Cloud Services	API requests, service authentication	HTTPS, TCP
Streaming Platforms	Real-time video/audio	UDP
Network Monitoring	Packet inspection, health check	ICMP
Web Development	REST APIs, client-server interaction	HTTP/HTTPS
IoT Devices	Lightweight messaging	UDP, MQTT

✅ 8. Conclusion

A deep understanding of network models and protocols enables professionals to build scalable, secure, and interoperable systems. While OSI serves as a theoretical reference, TCP/IP defines the backbone of real-world internet systems. Each protocol—TCP, UDP, HTTP, HTTPS, and ICMP—plays a

crucial role in enabling seamless digital communication, supporting the cloud infrastructure we rely on today.

🖧 9. References

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