A R&D report
on

TCP/IP Model & Its Layers

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By

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Objective

The purpose of this document is to help demystify the TCP/IP Model and its 4 layers by focusing on the inconsequential and significant concepts of networking. This is because the goal is to take complex networking concepts and put them into an easy-to-follow document for those who are new to networking or just want to enhance their base knowledge, even a little bit.

This document will:

- Explain the 4 Layers of the TCP/IP Model: This will cover the 4 Layers of the TCP/IP model. The goal is to break the layers out in a way that is understandable, while still focusing on how each layer relates to the data transmission and the network in an easily digestible way. Avoiding jargon unless necessary.
- Provide Real-World Scenarios: This will describe how each layer would function when we use the TCP/IP model; this could be relevant with every 'normal' computer usage today, e.g., web browsing, file transferring or online communications, etc.
- Provide Protocols and Flow: This will cover relevant protocols (IP, TCP, UDP) and their operation within the TCP/IP model.
- Task List at the TCP/IP Model Perspective: Determining how to use the TCP/IP model is very helpful, or beneficial, for the task of troubleshooting networks, etc., by allowing individuals to classify their troubleshooting, distinguish layer functionality, and determine how to successfully complete a task.
- Basic Framework for Future Learning: This document can help your organisational thinking process develop if you are trying to learn and expand your knowledge on the concepts of networking.

Introduction

The TCP/IP Model (Transmission Control Protocol/Internet Protocol) is a set of communications protocols used by the Internet and other computer networks. The TCP/IP model's lineage dates back to the 1970s when it was developed by the **U.S. Department of Defence** for the **ARPANET**, which was the forerunner to the current era of the internet. The initial TCP/IP protocols were developed for communicating between computers over a wide area, in the spirit of creating communication that was flexible and fault-tolerant.

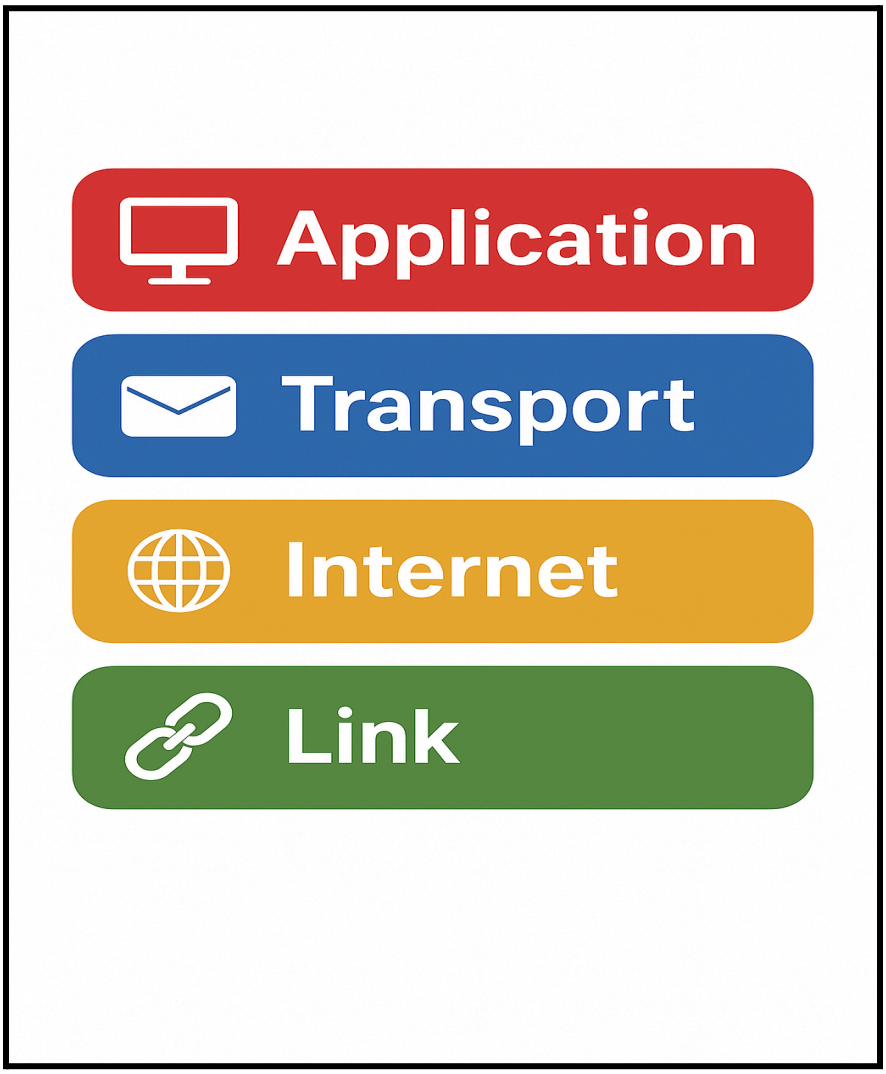
Some Benefits of the TCP/IP Models are:

- Standardisation ensures standard communications from one device to another through different devices, technologies, and networks.
- Simplicity, whereas the OSI (Open Systems Interconnection) model has 7 layers, the TCP/IP model will generally have 4. Simplicity of keeping to a smaller number of protocols simplifies the network communication to the applicable networking protocols, with most institutional use.
- Scalability and Flexibility are designed to work for different networks to work together as a smaller local network to an internet-scale/global network.
- End-to-End - reliable end-to-end communication and ensuring that data is delivered correctly to the destination, even if it traverses many different networks and devices.

The TCP/IP model is important to facilitate our understanding of how data flows across networks and from one device to another to support a variety of internet services such as web browsing, email, and file transfer. The model defines the rules and standards for how data is transmitted across networks, enabling the interconnection of various devices globally.

The 7 Layers Breakdown

The TCP/IP model, a layered communication model, is comprised of 4 layers of specific functionality. Each layer has a role to play in the process of communication. The layers each perform the communication role, and each is configured to work in conjunction with the other to ensure data is sent properly from its originating device to the device that is receiving the data. Below is a description of each layer.



1. Application Layer (Layer 1)

The Application Layer is the top layer of the TCP/IP Model. The Application Layer is where you find applications and network services for the Application Layer being able to communicate physically to the user applications. The Application Layer is where applications like web browsers, email, and file sharing applications (such as sharing your photos with friends) use the existing applications to send and receive data through the network.

Key Functions:

- Provides Network services to Applications (e.g. web browser, email client, etc.)
- Defines protocols for communication between Software Applications
- Allows Applications to exchange data with other applications over a network

Protocols:

- HTTP (Hyper Text Transfer Protocol): Used for web browsing (HTTP/HTTPS)
- FTP (File Transfer Protocol): Used for moving files across a network
- SMTP (Simple Mail Transfer Protocol): Used to send email
- DNS (Domain Name System): resolves domain names (such as www.example.com) to IP addresses

Example Use: When you open a web browser and type in the name of a website, the Application Layer uses the HTTP or HTTPS protocol to send a request to the server. The server then sends back the requested web page, which gets displayed in the browser client.

2. Transport Layer (Layer 2)

The Transport Layer provides reliable data transmission between two network nodes. The Transport Layer guarantees that the sequence of data is correct, controls flow and detects and recovers any errors encountered in transmission. The Transport Layer supports end-to-end communication between systems and provides the necessary control for reliable data transmission.

Functions:

- Segmentation/Reassembly - Contains the ability to break the transferred "data" into smaller contained parts or segments and then ensures those segments will be reconstructed in the correct sequence at the receiving side.
- Flow Control - Controls the speed of transmission so the sending will not overwhelm the receiving.
- Error Control - Detects and corrects errors when transmitting data.
- Connection Opening/Termination - Assures to open, keep open and close necessary synchronous channels of communication.

Protocols:

- TCP (Transmission Control Protocol): Reliable, connection-based communication with retransmission of lost packets and in-order delivery.
- UDP (User Datagram Protocol): Faster, connectionless communication that does not guarantee delivery, only speed (more applicable to use-cases which expect to lose data).

Example Use:

- TCP: In the case of receiving a file, TCP would be responsible for making sure that all pieces of a file are received in the correct order. If a packet is lost or corrupted, TCP will attempt to retransmit the information.
- UDP: In the case of a video call, UDP would be used so that a missed frame would not hinder communication more than latency would.

3. Network Layer (Layer 3)

The Internet Layer is responsible for logical addressing, routing and delivery of data through one or more networks. Logical addressing allows the devices on different networks to communicate with each other by finding the best path for the data to travel between devices across a network (routing).

Key Functions:

- Logical Addressing (IP Addressing): The Internet Layer assigns IP addresses to devices, providing them with unique identifiers for location on a network.
- Routing: The Internet Layer chooses a path for the data to travel from source to destination across many different networks.
- Packetisation: The Internet Layer divides data into packets for transmission across the network.

Protocols

- IP (Internet protocol): Handles the addressing in routing packets across the networks. You can think of IP as defining the format for IP packets and taking care of delivering data based on the use of an address, specifically using IP addresses.
- IPv4 (Internet Protocol version 4): The most widely used version of IP, which uses 32-bit addresses.
- IPv6 (Internet Protocol version 6): The latest version of IP, which uses 128-bit addresses, has been developed due to the increasing number of devices connected to the internet.
- ICMP (Internet Control Message Protocol): This is used for diagnostic purposes (like ping) and to report errors when communicating over the network.

Example Usage:

When you send an email or visit a website, when your data is broken down into little IP packets, each packet is addressed with an IP address so that routers can steer your packet across many different networks until it arrives at its destination.

4. Network Interface Layer (Link Layer)

The Network Interface Layer is the lowest layer in the TCP/IP model. It addresses the physical transmission of data across a physical network medium, whether it is wired (Ethernet) or wireless (Wi-Fi). In addition, it specifies the format within which data will be transmitted and assures that the data can and will be delivered to the correct destination on the local network.

The following outlines the primary functions of the Network Interface Layer:

- Physical Addressing: The Network Interface Layer assigns a MAC (Media Access Control) address to each network interface card (NIC) on a device. Devices must identify themselves to each other on a local network so that they can communicate correctly.
- Framing: The Network Interface Layer organises the data into frames for transmission across the physical medium.
- Access to the Physical Medium: The Network Interface Layer determines how devices access the shared medium (Ethernet or Wi-Fi) and ensures proper timing.
- Error Detection: The Network Interface Layer checks for transmission errors and makes adjustments if needed.

Protocols:

- Ethernet: A widely popular protocol used for wired networks that defines how devices on the same network communicate over cables.
- Wi-Fi: A wireless protocol for how devices can communicate over radio frequencies in a local area network (LAN).
- ARP (Address Resolution Protocol): Used to map the MAC address of a device based on the IP address of the device on a local network.

Example Usage:
When sending framed data packets from your computer to another on the same wired Ethernet connection, or to a connected device on Wi-Fi, the Network Interface Layer provides the frame that transports the data to the target MAC address. If there are routers involved, in the case of communicating with a remote server, ARP will map the router's IP address to the router's MAC address.

Real-Life Analogy

TCP/IP Layer	Postal Concept
4 **Application**	Writing a letter
3 **Transport**	Putting in an envelope
2 **Internet**	Addressing
1 **Link**	Delivery truck

References

1. Study-CCNA – "OSI and TCP/IP Models Explained": https://study-ccna.com/osi-tcp-ip-models/

2. GeeksforGeeks – Difference Between OSI Model and TCP/IP Model https://www.geeksforgeeks.org/difference-between-osi-model-and-tcp-ip-model/