TCP/IP Model

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The TCP/IP model is a fundamental framework for computer networking. It stands for Transmission Control Protocol/Internet Protocol, which are the core protocols of the Internet. This model defines how data is transmitted over networks, ensuring reliable communication between devices. It consists of four layers: the Link Layer, the Internet Layer, the Transport Layer, and the Application Layer. Each layer has specific functions that help manage different aspects of network communication, making it essential for understanding and working with modern networks.

TCP/IP was designed and developed by the Department of Defense (DoD) in the 1960s and is based on standard protocols. The TCP/IP model is a concise version of the OSI model. It contains four layers, unlike the seven layers in the OSI model. In this article, we are going to discuss the TCP/IP model in detail.

TCP/IP model was developed alongside the creation of the ARPANET, which later became the foundation of the modern internet. It was designed with a focus on the practical aspects of networking at the time. The lower-level hardware details and physical transmission medium were largely abstracted away in favor of higher-level networking protocols.

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What Does TCP/IP Do?

The main work of TCP/IP is to transfer the data of a computer from one device to another. The main condition of this process is to make data reliable and accurate so that the receiver will receive the same information which is sent by the sender. To ensure that, each message reaches its final destination accurately, the TCP/IP model divides its data into packets and combines them at the other end, which helps in maintaining the accuracy of the data while transferring from one end to another end. The TCP/IP model is used in the context of the real-world internet, where a wide range of physical media and network technologies are in use. Rather than specifying a particular Physical Layer, the TCP/IP model allows for flexibility in adapting to different physical implementations.

Difference Between TCP and IP

Feature	TCP (Transmission Control Protocol)	IP (Internet Protocol)
Purpose	Ensures reliable, ordered, and error-checked delivery of data between applications.	Provides addressing and routing of packets across networks.
Type	Connection-oriented	Connectionless

Feature	TCP (Transmission Control Protocol)	IP (Internet Protocol)
Function	Manages data transmission between devices, ensuring data integrity and order.	Routes packets of data from the source to the destination based on IP addresses.
Error Handling	Yes, includes error checking and recovery mechanisms.	No, IP itself does not handle errors; relies on upper-layer protocols like TCP.
Flow Control	Yes, includes flow control mechanisms.	No
Congestion Control	Yes, manages network congestion.	No
Data Segmentation	Breaks data into smaller packets and reassembles them at the destination.	Breaks data into packets but does not handle reassembly.
Header Size	Larger, 20-60 bytes	Smaller, typically 20 bytes
Reliability	Provides reliable data transfer	Does not guarantee delivery, reliability, or order.
Transmission Acknowledgment	Yes, acknowledges receipt of data packets.	No

How Does the TCP/IP Model Work?

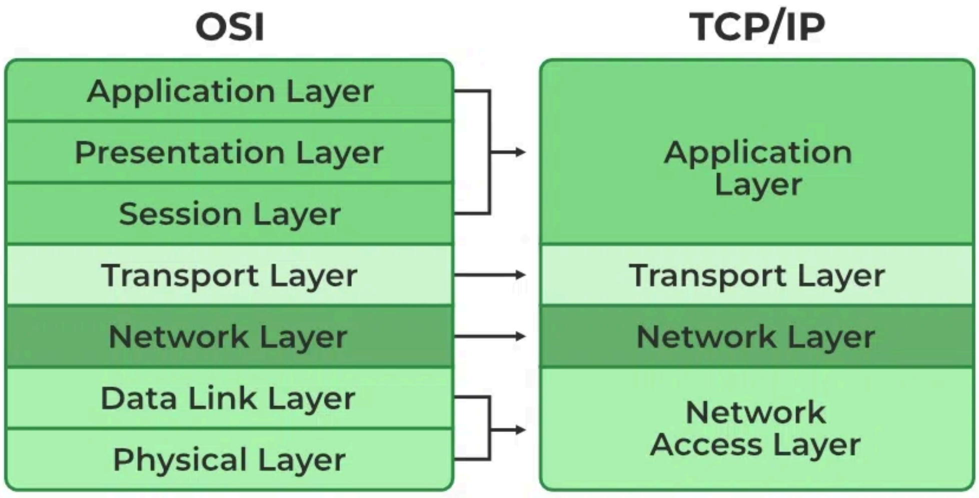
Whenever we want to send something over the internet using the TCP/IP Model, the TCP/IP Model divides the data into packets at the sender's end and the same packets have to be recombined at the receiver's end to form the same data, and this thing happens to maintain the accuracy of the data. TCP/IP model divides the data into a 4-layer procedure, where the data first go into this layer in one order and again in reverse order to get organized in the same way at the receiver's end.

For more, you can refer to TCP/IP in Computer Networking.

Layers of TCP/IP Model

- Application Layer
- Transport Layer(TCP/UDP)
- Network/Internet Layer(IP)
- Network Access Layer

The diagrammatic comparison of the **TCP/IP and OSI** model is as follows:



TCP/IP and OSI

1. Network Access Layer

It is a group of applications requiring network communications. This layer is responsible for generating the data and requesting connections. It acts on behalf of the sender and the Network Access layer on the behalf of the receiver. During this article, we will be talking on the behalf of the receiver.

The packet's network protocol type, in this case, TCP/IP, is identified by network access layer. Error prevention and "framing" are also provided by this layer. Point-to-Point Protocol (PPP) framing and Ethernet IEEE 802.2 framing are two examples of data-link layer protocols.

2. Internet or Network Layer

This layer parallels the functions of OSI's Network layer. It defines the protocols which are responsible for the logical transmission of data over the entire network. The main protocols residing at this layer are as follows:

- **IP:**IP stands for Internet Protocol and it is responsible for delivering packets from the source host to the destination host by looking at the IP addresses in the packet headers. IP has 2 versions: IPv4 and IPv6. IPv4 is the one that most websites are using currently. But IPv6 is growing as the number of IPv4 addresses is limited in number when compared to the number of users.

- **ICMP:**ICMP stands for Internet Control Message Protocol. It is encapsulated within IP datagrams and is responsible for providing hosts with information about network problems.
- **ARP:**ARP stands for Address Resolution Protocol. Its job is to find the hardware address of a host from a known IP address. ARP has several types: Reverse ARP, Proxy ARP, Gratuitous ARP, and Inverse ARP.

The Internet Layer is a layer in the Internet Protocol (IP) suite, which is the set of protocols that define the Internet. The Internet Layer is responsible for routing packets of data from one device to another across a network. It does this by assigning each device a unique IP address, which is used to identify the device and determine the route that packets should take to reach it.

Example: Imagine that you are using a computer to send an email to a friend. When you click "send," the email is broken down into smaller packets of data, which are then sent to the Internet Layer for routing. The Internet Layer assigns an IP address to each packet and uses routing tables to determine the best route for the packet to take to reach its destination. The packet is then forwarded to the next hop on its route until it reaches its destination. When all of the packets have been delivered, your friend's computer can reassemble them into the original email message.

In this example, the Internet Layer plays a crucial role in delivering the email from your computer to your friend's computer. It uses IP addresses and routing tables to determine the best route for the packets to take, and it ensures that the packets are delivered to the correct destination. Without the Internet Layer, it would not be possible to send data across the Internet.

3. Transport Layer

The TCP/IP transport layer protocols exchange data receipt acknowledgments and retransmit missing packets to ensure that packets arrive in order and without error. End-to-end communication is referred to as such. Transmission Control Protocol (TCP) and User Datagram Protocol are transport layer protocols at this level (UDP).

- **TCP:** Applications can interact with one another using TCP as though they were physically connected by a circuit. TCP transmits data in a way that resembles character-by-character transmission rather than separate packets. A starting point that establishes the connection, the whole transmission in byte order, and an ending point that closes the connection make up this transmission.
- **UDP:** The datagram delivery service is provided by UDP , the other transport layer protocol. Connections between receiving and sending hosts are not verified by UDP. Applications that transport little amounts of data use UDP rather than TCP because it eliminates the processes of establishing and validating connections.

4. Application Layer

This layer is analogous to the transport layer of the OSI model. It is responsible for end-to-end communication and error-free delivery of data. It shields the upper-layer applications from the complexities of data. The three main protocols present in this layer are:

- **HTTP and HTTPS:**HTTP stands for Hypertext transfer protocol. It is used by the World Wide Web to manage communications between web browsers and servers. HTTPS stands for HTTP-Secure. It is a combination of HTTP with SSL(Secure Socket Layer). It is efficient in cases where the browser needs to fill out forms, sign in, authenticate, and carry out bank transactions.
- **SSH:**SSH stands for Secure Shell. It is a terminal emulations software similar to Telnet. The reason SSH is preferred is because of its ability to maintain the encrypted connection. It sets up a secure session over a TCP/IP connection.
- **NTP:**NTP stands for Network Time Protocol. It is used to synchronize the clocks on our computer to one standard time source. It is very useful in situations like bank transactions. Assume the following situation

without the presence of NTP. Suppose you carry out a transaction, where your computer reads the time at 2:30 PM while the server records it at 2:28 PM. The server can crash very badly if it’s out of sync.

The host-to-host layer is a layer in the OSI (Open Systems Interconnection) model that is responsible for providing communication between hosts (computers or other devices) on a network. It is also known as the transport layer.

Some common use cases for the host-to-host layer include:

- **Reliable Data Transfer:** The host-to-host layer ensures that data is transferred reliably between hosts by using techniques like error correction and flow control. For example, if a packet of data is lost during transmission, the host-to-host layer can request that the packet be retransmitted to ensure that all data is received correctly.
- **Segmentation and Reassembly:** The host-to-host layer is responsible for breaking up large blocks of data into smaller segments that can be transmitted over the network, and then reassembling the data at the destination. This allows data to be transmitted more efficiently and helps to avoid overloading the network.
- **Multiplexing and Demultiplexing:** The host-to-host layer is responsible for multiplexing data from multiple sources onto a single network connection, and then demultiplexing the data at the destination. This allows multiple devices to share the same network connection and helps to improve the utilization of the network.
- **End-to-End Communication:** The host-to-host layer provides a connection-oriented service that allows hosts to communicate with each other end-to-end, without the need for intermediate devices to be involved in the communication.

Example: Consider a network with two hosts, A and B. Host A wants to send a file to host B. The host-to-host layer in host A will break the file into smaller segments, add error correction and flow control information, and then transmit the segments over the network to host B. The host-to-host layer in host B will receive the segments, check for errors, and reassemble the file. Once the file has been transferred successfully, the host-to-host layer in host B will acknowledge receipt of the file to host A.

In this example, the host-to-host layer is responsible for providing a reliable connection between host A and host B, breaking the file into smaller segments, and reassembling the segments at the destination. It is also responsible for multiplexing and demultiplexing the data and providing end-to-end communication between the two hosts.

Why TCP/IP Model Does Not Have Physical Layer

The physical layer is not covered by the TCP/IP model because the data link layer is considered the point at which the interface occurs between the TCP/IP stock and the underlying network hardware. Also, it is designed to be independent of the underlying physical media. This allows TCP/IP to be flexible and adaptable to different types of physical connections, such as Ethernet, Wi-Fi, fiber optics, or even older technologies like dial-up modems. The physical layer is typically handled by hardware components and standards specific to the physical medium being used, like Ethernet cables or radio waves for Wi-Fi.

Other Common Internet Protocols

TCP/IP Model covers many Internet Protocols. The main rule of these Internet Protocols is how the data is validated and sent over the Internet. Some Common Internet Protocols include:

- **HTTP (Hypertext Transfer Protocol):**HTTP takes care of Web Browsers and Websites.
- **FTP (File Transfer Protocol):**FTP takes care of how the file is to be sent over the Internet.
- **SMTP (Simple Mail Transfer Protocol):**SMTP is used to send and receive data.

Difference between TCP/IP and OSI Model

TCP/IP	OSI
TCP refers to Transmission Control Protocol.	OSI refers to Open Systems Interconnection.
TCP/IP uses both the session and presentation layer in the application layer itself.	OSI uses different session and presentation layers.
TCP/IP follows connectionless a horizontal approach.	OSI follows a vertical approach.
The Transport layer in TCP/IP does not provide assurance delivery of packets.	In the OSI model, the transport layer provides assurance delivery of packets.
Protocols cannot be replaced easily in TCP/IP model.	While in the OSI model, Protocols are better covered and are easy to replace with the technology change.
TCP/IP model network layer only provides connectionless (IP) services. The transport layer (TCP) provides connections.	Connectionless and connection-oriented services are provided by the network layer in the OSI model.

Advantages of TCP/IP Model

- **Interoperability** : The TCP/IP model allows different types of computers and networks to communicate with each other, promoting compatibility and cooperation among diverse systems.
- **Scalability** : TCP/IP is highly scalable, making it suitable for both small and large networks, from local area networks (LANs) to wide area networks (WANs) like the internet.
- **Standardization** : It is based on open standards and protocols, ensuring that different devices and software can work together without

compatibility issues.
- **Flexibility** : The model supports various routing protocols, data types, and communication methods, making it adaptable to different networking needs.
- **Reliability** : TCP/IP includes error-checking and retransmission features that ensure reliable data transfer, even over long distances and through various network conditions.

Disadvantages of TCP/IP Model

- **Complex Configuration** : Setting up and managing a TCP/IP network can be complex, especially for large networks with many devices. This complexity can lead to configuration errors.
- **Security Concerns** : TCP/IP was not originally designed with security in mind. While there are now many security protocols available (such as SSL/TLS), they have been added on top of the basic TCP/IP model, which can lead to vulnerabilities.
- **Inefficiency for Small Networks** : For very small networks, the overhead and complexity of the TCP/IP model may be unnecessary and inefficient compared to simpler networking protocols.
- **Limited by Address Space** : Although IPv6 addresses this issue, the older IPv4 system has a limited address space, which can lead to issues with address exhaustion in larger networks.
- **Data Overhead** : TCP, the transport protocol, includes a significant amount of overhead to ensure reliable transmission. This can reduce efficiency, especially for small data packets or in networks where speed is crucial.

Conclusion

In conclusion, the TCP/IP model is the backbone of modern internet communication, allowing different devices and networks to connect and share information reliably. Despite some complexity and security concerns, its flexibility, scalability, and widespread adoption make it essential for both small and large networks. Overall, the TCP/IP model is crucial for ensuring efficient and effective network communication.

Frequently Asked Questions on TCP/IP Model – FAQs

Which IP Addresses Do TCP/IP Work With?

> *TCP/IP generally works with both the IP that is, IPv4 and IPv6. If you are using IPv4 or IPv6, it seems that you are already working on TCP/IP Model.*

How many layers are in the TCP/IP Model?

> *The TCP/IP Model has four layers:*
>
> - *Network Interface Layer*
> - *Internet Layer*
> - *Transport Layer*
> - *Application Layer*

What does each layer do?

> - ***Network Interface Layer**: Handles the physical transmission of data over a network.*
> - ***Internet Layer**: Manages the routing of data packets across the network.*
> - ***Transport Layer**: Ensures reliable data transmission between devices.*