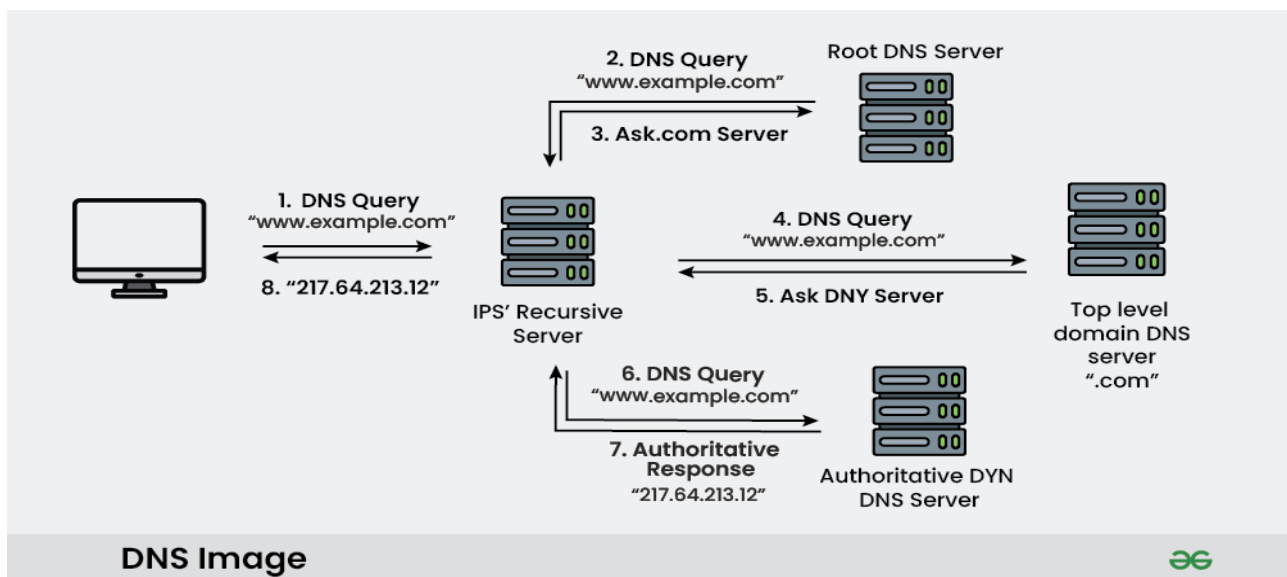


Module_5

Application Layer: Standard Client-Server Protocols:World Wide Web, HTTP, FTP, Electronic Mail, Domain Name System (DNS), SNMP.

1.What is Domain Name System(DNS)

A Domain Name System (DNS) is a critical component of the Internet infrastructure that plays a fundamental role in connecting users to websites, services, and resources across the World Wide Web. It is essentially the “phone book” of the internet, translating user-friendly domain names (like www.example.com) into numerical IP addresses (such as 192.0.2.1) that computers and network devices use to locate one another on the internet.



Explanation of the entire process presented in the above diagram

1. From user computer do a DNS query to ISP's recursive DNS server:

When a user enters a domain name (e.g., `www.example.com`) into a web browser, their computer sends a DNS query to their Internet Service Provider's (ISP) recursive DNS server. The recursive DNS server is responsible for handling DNS queries on behalf of the user and tries to resolve the domain name.

2. Do a DNS query to Root DNS server:

If the recursive DNS server doesn't have the IP address for the requested domain in its cache, it starts the resolution process by querying the root DNS server. The root DNS server is the top-level server in the DNS hierarchy, and it contains information about the authoritative DNS servers for top-level domains (TLDs), such as ".com," ".org," ".net," etc.

3. Ask .com server to ISP's recursive DNS server:

The root DNS server responds to the recursive DNS server's query with a referral to the authoritative DNS server for the ".com" TLD. The recursive DNS server then queries the ".com" TLD DNS server for the IP address of the domain in question.

4. DNS query to Top Level domain DNS server ".com":

The ".com" TLD DNS server, in response to the query from the recursive DNS server, provides a referral to the authoritative DNS server responsible for the specific domain, in this case, "example.com."

5. Ask DYN server to ISP's recursive DNS server:

The recursive DNS server queries the authoritative DNS server for "example.com." The authoritative DNS server for "example.com" is often a Dynamic DNS (DYN) server that contains the specific DNS records for the domain, such as A records (for IP addresses), MX records (for mail servers), etc.

6. DNS query to Authoritative DYN DNS Server:

The authoritative DYN DNS server receives the query and looks up the requested DNS record, such as the A record for “www.example.com.”

7. Authoritative response to ISP’s recursive DNS server:

The authoritative DYN DNS server responds to the recursive DNS server with the requested DNS record, which includes the IP address associated with “www.example.com.”

8. Response to user computer:

Finally, the recursive DNS server sends the IP address it received from the authoritative DYN DNS server back to the user’s computer. The user’s computer can then use this IP address to establish a connection to the web server hosting “www.example.com.”

Client-Server Model

The Client-server model is a distributed application structure that partitions tasks or workloads between the providers of a resource or service, called servers, and service requesters called clients. In the client-server architecture, when the client computer sends a request for data to the server through the internet, the server accepts the requested process and delivers the data packets requested back to the client. Clients do not share any of their resources. Examples of the Client-Server Model are Email, World Wide Web, etc.

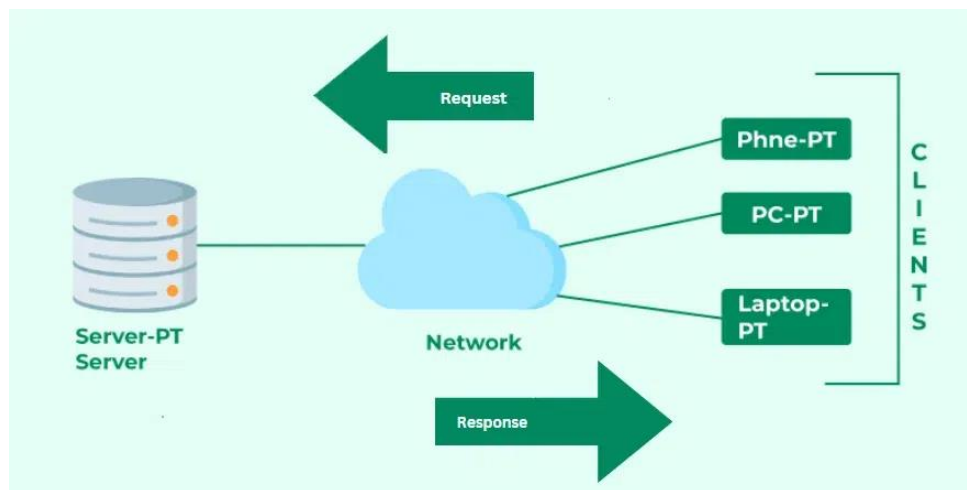
How Does the Client-Server Model Work?

In this article, we are going to take a dive into the **Client-Server** model and have a look at how the **Internet** works via, web browsers. This article will help us have a solid WEB foundation and help us easily work with WEB technologies.

- **Client:** When we say the word **Client**, it means to talk of a person or an organization using a particular service. Similarly in the digital world, a **Client** is a computer (**Host**) i.e. capable of receiving information or using a particular service from the service providers (**Servers**).

- **Servers:** Similarly, when we talk about the word **Servers**, It means a person or medium that serves something. Similarly in this digital world, a **Server** is a remote computer that provides information (data) or access to particular services.

So, it is the **Client** requesting something and the **Server** serving it as long as it is in the database.

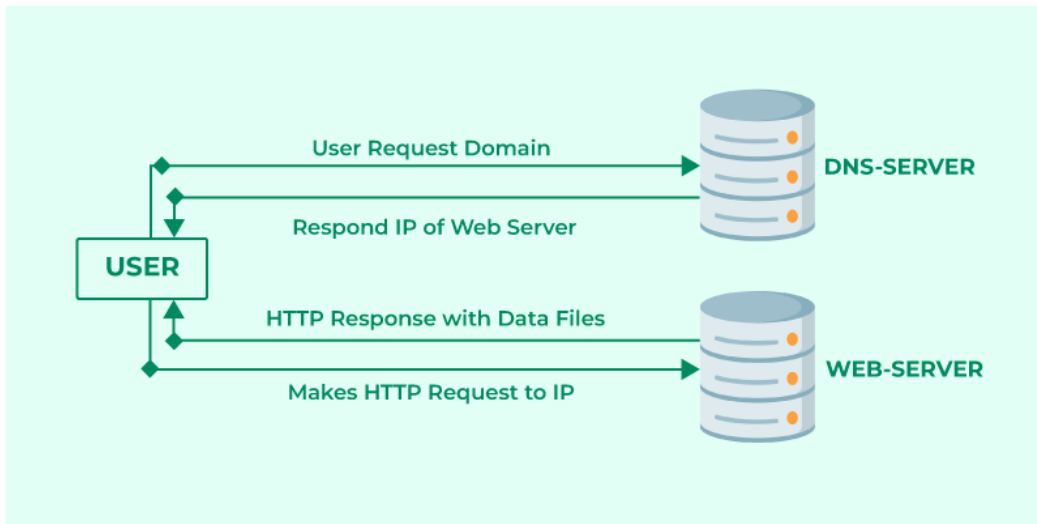


How the Browser Interacts With the Servers?

There are a few steps to follow to interact with the servers of a client.

- User enters the **URL**(Uniform Resource Locator) of the website or file.
The Browser then requests the [DNS\(DOMAIN NAME SYSTEM\)](#) Server.
- **DNS Server** lookup for the address of the **WEB Server**.
- The **DNS Server** responds with the **IP address** of the **WEB Server**.
- The Browser sends over an **HTTP/HTTPS** request to the **WEB Server's IP** (provided by the **DNS server**).
- The Server sends over the necessary files for the website.

- The Browser then renders the files and the website is displayed. This rendering is done with the help of **DOM** (Document Object Model) interpreter, **CSS** interpreter, and **JS Engine** collectively known as the **JIT** or (Just in Time) Compilers.



Client Server Request and Response

Advantages of Client-Server Model

- Centralized system with all data in a single place.
- Cost efficient requires less maintenance cost and Data recovery is possible.
- The capacity of the Client and Servers can be changed separately.

Disadvantages of Client-Server Model

- Clients are prone to viruses, Trojans, and worms if present in the Server or uploaded into the Server.
- Servers are prone to [Denial of Service \(DOS\)](#) attacks.
- Data packets may be spoofed or modified during transmission.

- Phishing or capturing login credentials or other useful information of the user are common and [MITM\(Man in the Middle\)](#) attacks are common.

The client-server architecture consolidates resources on servers for greater control and security, allows for flexible client options, and relies on a robust network for scalability and efficiency. While there are cost implications, the client-server model remains fundamental and has been shaped by trends such as cloud computing.

World Wide Web (WWW)

WWW stands for World Wide Web and is commonly known as the Web.

WWW is defined as the collection of different websites around the world, containing different information shared via local servers(or computers).

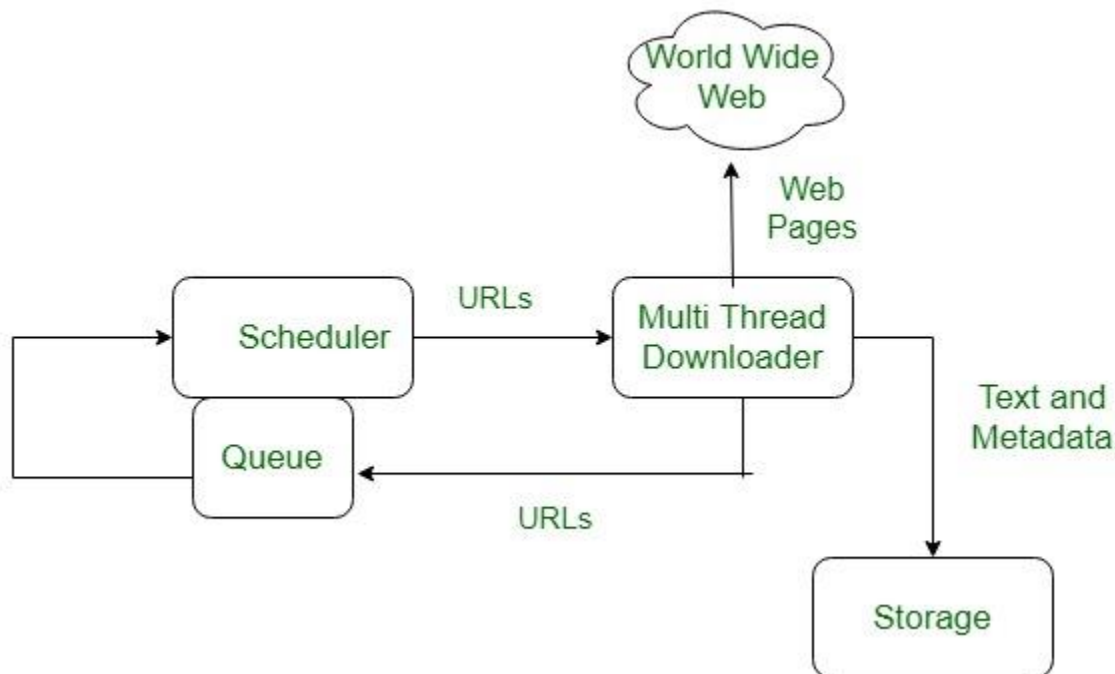
Web pages are linked together using hyperlinks which are HTML-formatted and, also referred to as hypertext, these are the fundamental units of the Internet and are accessed through [Hypertext Transfer Protocol\(HTTP\)](#). Such digital connections, or links, allow users to easily access desired information by connecting relevant pieces of information. The benefit of hypertext is it allows you to pick a word or phrase from the text and click on other sites that have more information about it. This data may be presented in text, picture, audio, or video formats on the internet.

System Architecture

From the user's point of view, the web consists of a vast, worldwide connection of documents or web pages. Each page may contain links to other pages anywhere in the world. The pages can be retrieved and viewed by using browsers of which internet explorer, Netscape Navigator, Google Chrome, etc are the popular ones. The browser fetches the page requested interprets the text and formatting commands on it, and displays the page, properly formatted, on the screen.

The basic model of how the web works are shown in the figure below. Here the browser is displaying a web page on the client machine. When the user clicks on a

line of text that is linked to a page on the abd.com server, the browser follows the hyperlink by sending a message to the abd.com server asking it for the page.

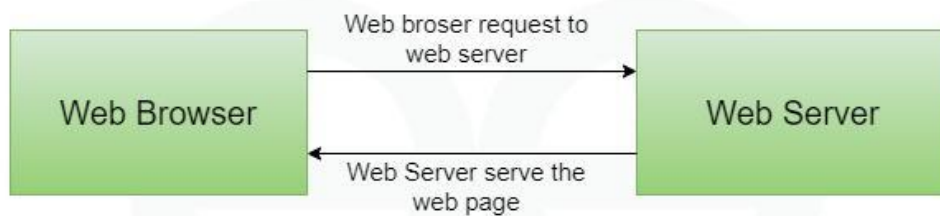


Here the browser displays a web page on the client machine when the user clicks on a line of text that is linked to a page on abd.com, the browser follows the hyperlink by sending a message to the abd.com server asking for the page.

Working of WWW

A Web browser is used to access web pages. Web browsers can be defined as programs which display text, data, pictures, animation and video on the Internet. Hyperlinked resources on the World Wide Web can be accessed using software interfaces provided by Web browsers. Initially, Web browsers were used only for surfing the Web but now they have become more universal.

The below diagram indicates how the Web operates just like [client-server architecture](#) of the internet. When users request web pages or other information, then the web browser of your system request to the server for the information and then the [web server](#) provide requested services to web browser back and finally the requested service is utilized by the user who made the request.



Web browsers can be used for several tasks including conducting searches, mailing, transferring files, and much more. Some of the commonly used browsers are Internet Explorer, Opera Mini, and Google Chrome.

Features of WWW

- WWW is open source.
- It is a distributed system spread across various websites.
- It is a Hypertext Information System.
- It is Cross-Platform.
- Uses Web Browsers to provide a single interface for many services.
- Dynamic, Interactive and Evolving.

Components of the Web

There are 3 components of the web:

- **Uniform Resource Locator (URL):** [URL](#) serves as a system for resources on the web.
- **Hyper Text Transfer Protocol (HTTP):** [HTTP](#) specifies communication of browser and server.

- **Hyper Text Markup Language (HTML):** [HTML](#) defines the structure, organisation and content of a web page.

Difference Between WWW and Internet

WWW	Internet
It is originated in 1989.	It is originated in 1960.
WWW is an interconnected network of websites and documents that can be accessed via the Internet.	Internet is used to connect a computer with other computer .
WWW used protocols such as HTTP	Internet used protocols such as TCP/IP
It is based on software.	It is based on hardware.
It is a service contained inside an infrastructure.	There is a entire infrastructure in internet.

What is HTTP ?

HTTP (Hypertext Transfer Protocol) is a fundamental protocol of the Internet, enabling the transfer of data between a client and a server. It is the foundation of data communication for the World Wide Web.

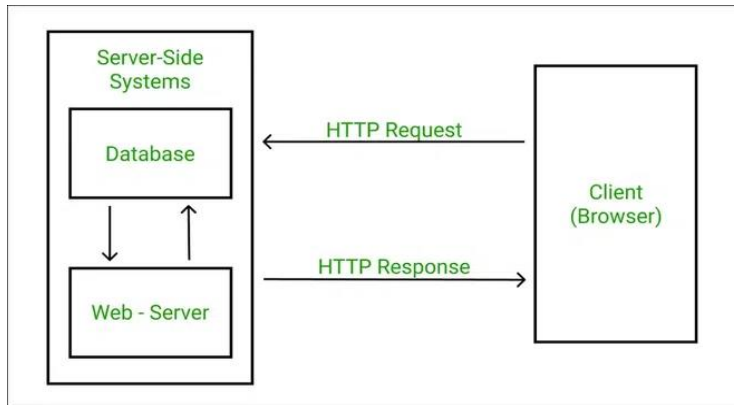
HTTP provides a standard between a web browser and a web server to establish communication. It is a set of rules for transferring data from one computer to another. Data such as text, images, and other multimedia files are shared on the World Wide Web. Whenever a web user opens their web browser, the user indirectly uses HTTP. It is an application protocol that is used for distributed, collaborative, hypermedia information systems.



HTTP Request/Response:

HTTP is a request-response protocol, which means that for every request sent by a client (typically a web browser), the server responds with a corresponding response. The basic flow of an HTTP request-response cycle is as follows:

- **Client sends an HTTP request:** The client (usually a web browser) initiates the process by sending an HTTP request to the server. This request includes a request method (GET, POST, PUT, DELETE, etc.), the target URI (Uniform Resource Identifier, e.g., a URL), headers, and an optional request body.
- **Server processes the request:** The server receives the request and processes it based on the requested method and resource. This may involve retrieving data from a database, executing server-side scripts, or performing other operations.
- **Server sends an HTTP response:** After processing the request, the server sends an HTTP response back to the client. The response includes a status code (e.g., 200 OK, 404 Not Found), response headers, and an optional response body containing the requested data or content.
- **Client processes the response:** The client receives the server's response and processes it accordingly. For example, if the response contains an HTML page, the browser will render and display it. If it's an image or other media file, the browser will display or handle it appropriately.



Features

- **Stateless:** Each request is independent, and the server doesn't retain previous interactions' information.
- **Text-Based:** Messages are in plain text, making them readable and debuggable.
- **Client-Server Model:** Follows a client-server architecture for requesting and serving resources.
- **Request-Response:** Operates on a request-response cycle between clients and servers.
- **Request Methods:** Supports various methods like GET, POST, PUT, DELETE for different actions on resources.

Advantages

- **Platform independence:** Works on any operating system
- **Compatibility:** Compatible with various protocols and technologies
- **Efficiency:** Optimized for performance
- **Security:** Supports encryption for secure data transfer

File Transfer Protocol (FTP)

File transfer protocol (FTP) is an Internet tool provided by TCP/IP. The first feature of FTP was developed by Abhay Bhushan in 1971. It helps to transfer files from one computer to another by providing access to directories or folders on remote computers and allows software, data, and text files to be transferred between different kinds of computers. The end-user in the connection is known as localhost and the server which provides data is known as the remote host.

The goals of FTP are:

- It encourages the direct use of remote computers.
- It shields users from system variations (operating system, directory structures, file structures, etc.)
- It promotes the sharing of files and other types of data.

Why FTP?

FTP is a standard communication protocol. There are various other protocols like HTTP which are used to transfer files between computers, but they lack clarity and focus as compared to FTP. Moreover, the systems involved in connection are heterogeneous systems, i.e. they differ in operating systems, directories, structures, character sets, etc the FTP shields the user from these differences and transfers data efficiently and reliably.

FTP can transfer ASCII, EBCDIC, or image files. The ASCII is the default file share format, in this, each character is encoded by NVT ASCII. In ASCII or EBCDIC the destination must be ready to accept files in this mode. The image file format is the default format for transforming binary files.

FTP Clients

FTP works on a client-server model. The FTP client is a program that runs on the user's computer to enable the user to talk to and get files from remote computers. It is a set of commands that establishes the connection between two hosts, helps to transfer the files, and then closes the connection.

Some of the commands are: *get the filename(retrieve the file from the directories get server)*, *mget filename(retrieve multiple files from the server)*, *ls(lists files available in the current directory of the server)*. There are also built-in FTP programs, which makes it easier to transfer files and it does not require remembering the commands.

Type of FTP Connections

FTP connections are of two types:

1. Active FTP connection: In an Active FTP connection, the client establishes the command channel and the server establishes the data channel. When the client requests the data over the connection the server initiates the transfer of the data to the client. It is not the default connection because it may cause problems if there is a firewall in between the client and the server.

2. Passive FTP connection: In a Passive FTP connection, the client establishes both the data channel as well as the command channel. When the client requests the data over the connection, the server sends a random port number to the client, as soon as the client receives this port number it establishes the data channel. It is the default connection, as it works better even if the client is protected by the firewall.

Anonymous FTP

Some sites can enable anonymous FTP whose files are available for public access. So, the user can access those files without any username or password. Instead, the username is set to anonymous and the password to the guest by default. Here, the access of the user is very limited. For example, the user can copy the files but not allowed to navigate through directories.

FTP

The FTP connection is established between two systems and they communicate with each other using a network. So, for the connection, the user can get permission by providing the credentials to the FTP server or can use anonymous FTP.

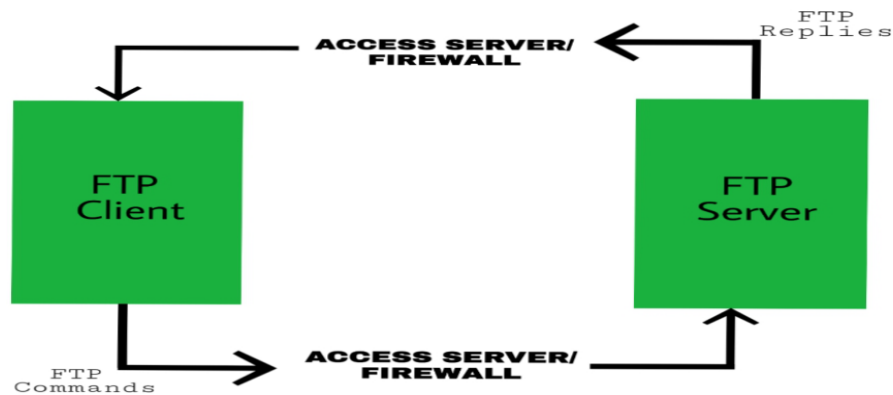
When an FTP connection is established, there are two types of communication channels are also established and they are known as command channel and data channel. The command channel is used to transfer the commands and responses

from client to server and server to client. FTP uses the same approach as TELNET or SMTP to communicate across the control connection. It uses the NVT ASCII character set for communication. It uses port number 21. Whereas the data channel is used to actually transfer the data between client and server. It uses port number 20.

The FTP client using the URL gives the FTP command along with the FTP server address. As soon as the server and the client get connected to the network, the user logs in using User ID and password. If the user is not registered with the server, then also he/she can access the files by using the anonymous login where the password is the client's email address. The server verifies the user login and allows the client to access the files. The client transfers the desired files and exits the connection. The figure below shows the working of FTP.

Detail Steps of FTP

- FTP client contacts FTP server at port 21 specifying TCP as transport protocol.
- Client obtain authorization over control connection.
- Client browse remote directory by sending commands over control connection.
- When server receives a command for a file transfer, the server open a TCP data connection to client.
- after transferring one file, server closes connection.
- server opens a second TCP data connection to transfer another file.
- FTP server maintains state i.e. current directory, earlier authentication.



Transmission Mode

FTP transfer files using any of the following modes:

- **Stream Mode:** It is the default mode. In stream mode, the data is transferred from FTP to TCP in stream bytes. Here TCP is the cause for fragmenting data into small segments. The connection is automatically closed if the transferring data is in the stream bytes. Otherwise, the sender will close the connection.
- **Block Mode:** In block mode, the data is transferred from FTP to TCP in the form of blocks, and each block followed by a 3-byte header. The first byte of the block contains the information about the block so it is known as the description block and the other two bytes contain the size of the block.
- **Compressed Mode:** This mode is used to transfer big files. As we know that, due to the size limit we can not transfer big files on the internet, so the compressed mode is used to decrease the size of the file into small and send it on the internet.

FTP Commands

Sr. no.	Command	Meaning
1.	cd	Changes the working directory on the remote host
2.	close	Closes the FTP connection
3.	quit	Quits FTP
4.	pwd	displays the current working Directory on the remote host
5.	dir or ls	Provides a Directory Listing of the current working directory
6.	help	Displays a list of all client FTP commands
7.	remotehelp	Displays a list of all server FTP commands
8.	type	Allows the user to specify the file type
9.	struct	specifies the files structure

Applications of FTP

The following are the applications of FTP:

- FTP connection is used by different big business organizations for transferring files in between them, like sharing files to other employees working at different locations or different branches of the organization.
- FTP connection is used by IT companies to provide backup files at disaster recovery sites.
- Financial services use FTP connections to securely transfer financial documents to the respective company, organization, or government.
- Employees use FTP connections to share any data with their co-workers.

Advantages of FTP

- **Multiple transfers:** FTP helps to transfer multiple large files in between the systems.
- **Efficiency:** FTP helps to organize files in an efficient manner and transfer them efficiently over the network.
- **Security:** FTP provides access to any user only through user ID and password. Moreover, the server can create multiple levels of access.
- **Continuous transfer:** If the transfer of the file is interrupted by any means, then the user can resume the file transfer whenever the connection is established.
- **Simple:** FTP is very simple to implement and use, thus it is a widely used connection.
- **Speed:** It is the fastest way to transfer files from one computer to another.

Disadvantages of FTP

- **Less security:** FTP does not provide an encryption facility when transferring files. Moreover, the username and passwords are in plain text and not a combination of symbols, digits, and alphabets, which makes it easier to be attacked by hackers.
- **Old technology:** FTP is one of the oldest protocols and thus it uses multiple TCP/IP connections to transfer files. These connections are hindered by firewalls.
- **Virus:** The FTP connection is difficult to be scanned for viruses, which again increases the risk of vulnerability.
- **Limited:** The FTP provides very limited user permission and mobile device access.
- **Memory and programming:** FTP requires more memory and programming efforts, as it is very difficult to find errors without the commands.

Electronic Mail

Electronic mail, commonly known as email, is a method of exchanging messages over the internet. Here are the basics of email:

1. An email address: This is a unique identifier for each user, typically in the format of name@domain.com.
2. An email client: This is a software program used to send, receive and manage emails, such as Gmail, Outlook, or Apple Mail.
3. An email server: This is a computer system responsible for storing and forwarding emails to their intended recipients.

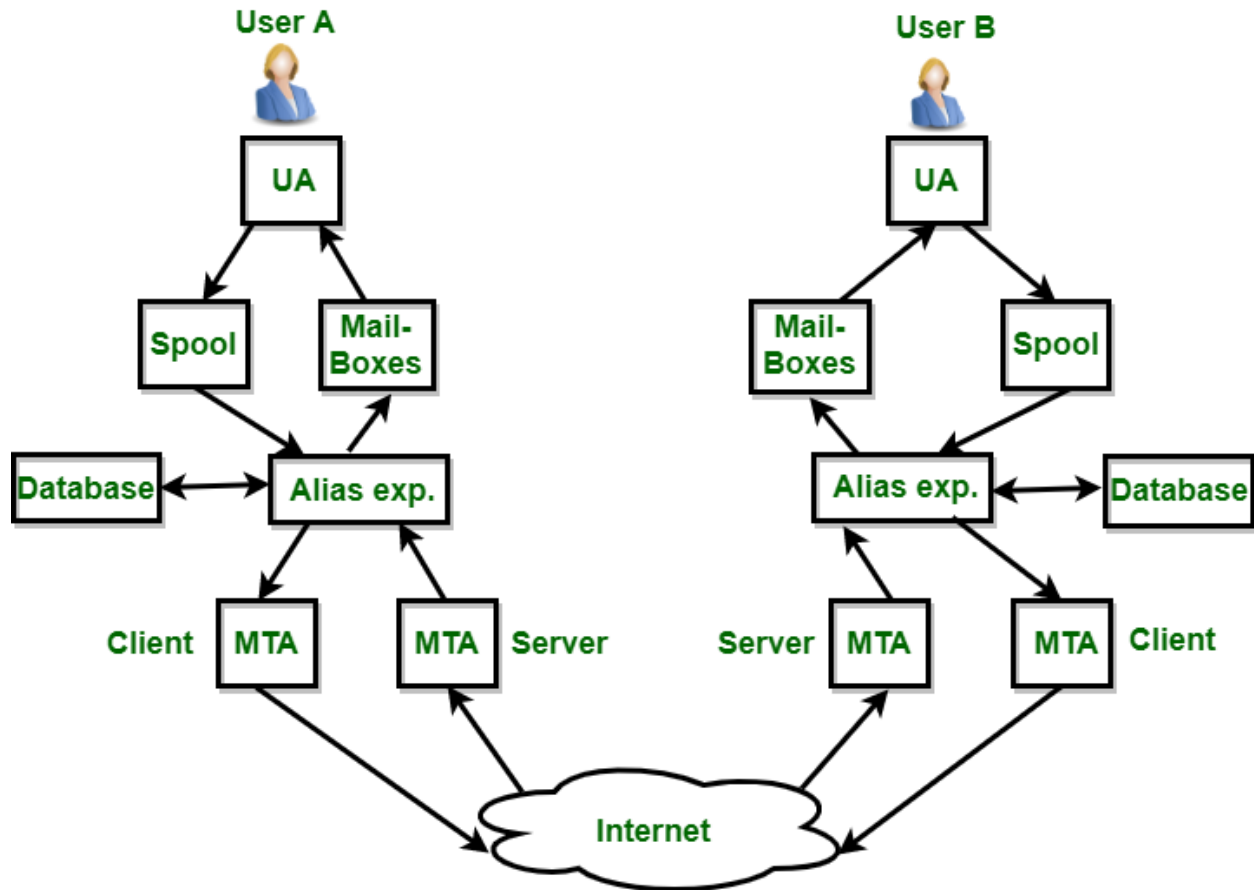
To send an email:

1. Compose a new message in your email client.
2. Enter the recipient's email address in the "To" field.
3. Add a subject line to summarize the content of the message.
4. Write the body of the message.
5. Attach any relevant files if needed.
6. Click "Send" to deliver the message to the recipient's email server.
7. Emails can also include features such as cc (carbon copy) and bcc (blind carbon copy) to send copies of the message to multiple recipients, and reply, reply all, and forward options to manage the conversation.

Electronic Mail (e-mail) is one of most widely used services of [Internet](#). This service allows an Internet user to send a **message in formatted manner (mail)** to the other Internet user in any part of world. Message in mail not only contain text, but it also contains images, audio and videos data. The person who is sending mail is called **sender** and person who receives mail is called **recipient**. It is just like postal mail service. **Components of E-Mail System** : The basic components of an email system are : User Agent (UA), Message Transfer Agent (MTA), Mail Box, and Spool file. These are explained as following below.

1. **User Agent (UA)** : The UA is normally a program which is used to send and receive mail. Sometimes, it is called as mail reader. It accepts variety of commands for composing, receiving and replying to messages as well as for manipulation of the mailboxes.
2. **Message Transfer Agent (MTA)** : MTA is actually responsible for transfer of mail from one system to another. To send a mail, a system must have client MTA and system MTA. It transfer mail to mailboxes of recipients if they are connected in the same machine. It delivers mail to

peer MTA if destination mailbox is in another machine. The delivery from one MTA to another MTA is done by [Simple Mail Transfer Protocol](#).



1. **Mailbox :** It is a file on local hard drive to collect mails. Delivered mails are present in this file. The user can read it delete it according to his/her requirement. To use e-mail system each user must have a mailbox . Access to mailbox is only to owner of mailbox.
2. **Spool file :** This file contains mails that are to be sent. User agent appends outgoing mails in this file using SMTP. MTA extracts pending mail from spool file for their delivery. E-mail allows one name, an **alias**, to represent several different e-mail addresses. It is known as **mailing**

list, Whenever user have to sent a message, system checks recipient's name against alias database. If mailing list is present for defined alias, separate messages, one for each entry in the list, must be prepared and handed to MTA. If for defined alias, there is no such mailing list is present, name itself becomes naming address and a single message is delivered to mail transfer entity.

Services provided by E-mail system :

- **Composition** – The composition refer to process that creates messages and answers. For composition any kind of text editor can be used.
- **Transfer** – Transfer means sending procedure of mail i.e. from the sender to recipient.
- **Reporting** – Reporting refers to confirmation for delivery of mail. It help user to check whether their mail is delivered, lost or rejected.
- **Displaying** – It refers to present mail in form that is understand by the user.
- **Disposition** – This step concern with recipient that what will recipient do after receiving mail i.e save mail, delete before reading or delete after reading.