

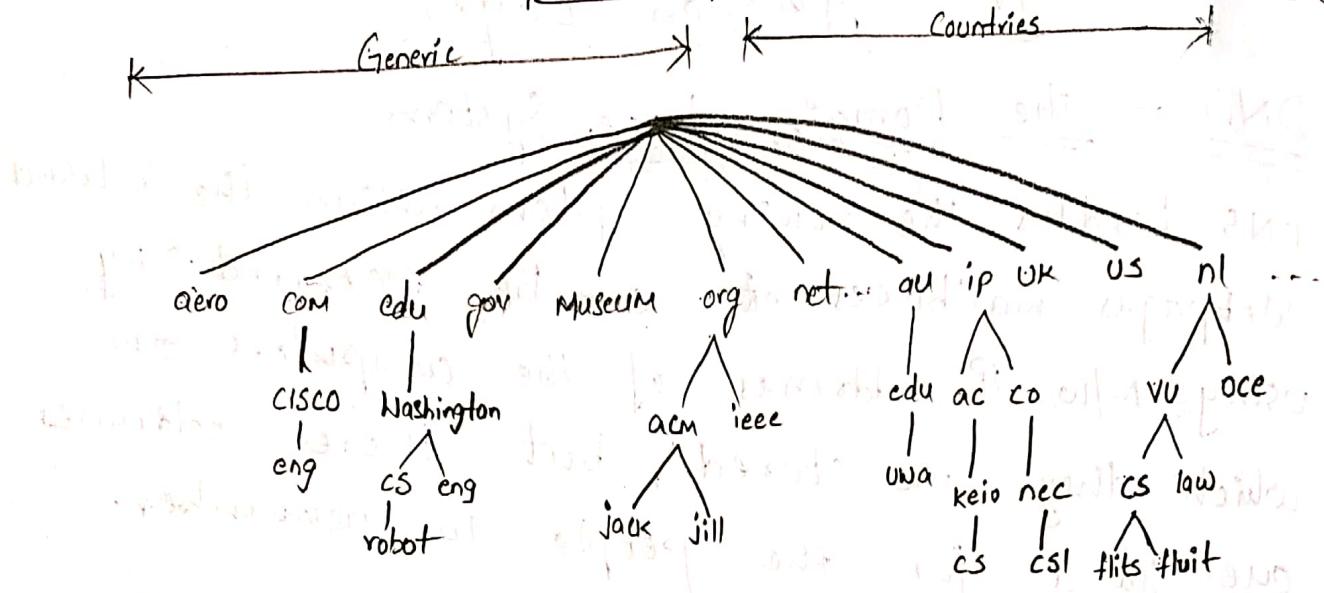
The Application Layer

DNS - The Domain Name System

- DNS handles the naming system within the internet.
- Webpages, mailboxes etc can be referred by using n/w IP addresses of the computers on which they are stored, but these addresses are hard for the people to remember.
- If we are browsing a company's web pages from 128.111.24.41, but if the company moves the web server to a different company moves machine with a different IP address, everyone needs to be told the new IP address.
- Hence, a web server might be known as www.gmail.com regardless of its IP address.
- Since n/w can understand only numerical addresses, some mechanism is required to convert the names to n/w addresses.
- Such a mechanism is DNS.
- It is used for mapping host names to IP addrs
- To map a name onto an IP address, an application program called a library procedure called the resolver.

DNS Name Space

A portion of Internet domain Name Space



- For the Internet, the top of the naming hierarchy is managed by an organization called ICANN (Internet Corporation for Assigned Names & Numbers).
- Internet is divided into 250 top-level domains.
- Each domain is partitioned into subdomains & these are further partitioned & so on.
- All these domains can be represented by a tree as shown in the above diagram.
- The top-level domains are divided into two categories : generic and countries.
- The generic domains include original domain. The country domains include one entry for every country.

The top-level domains are run by ¹⁷ registrars appointed by ICANN.

- If the top-level domain name is required, we should go to the corresponding registrars to check if the desired name is available & not used by somebody else.
- If there are no problems, the requester pays the registrar a small annual fee and gets the name.

Domain	<u>Intended Use</u>	<u>Start date</u>	<u>Restricted?</u>
com	commercial	1985	No
edu	Educational institutions	1985	Yes
gov	Government	1985	Yes
int	International Organizations	1988	Yes
mil	military	1985	Yes
net	Network providers	1985	No
org	Non-Profit organizations	1985	No
coop	Cooperatives	2001	Yes
info	Informational	2002	No
pro	Professionals	2002	Yes
jobs	Employment	2005	Yes

mobi	Mobile devices	2005	Yes
tel	Contact details	2005	Yes
travel	Travel Industry	2005	Yes

- Each domain is named by its path (www.google.com)
- The components are separated by "dot."
- Domain names are case-insensitive, so edu, Edu, EDU mean the same thing.
- Each component name can be up to 63 characters long & full path names must not exceed 255 characters.
- To create a new domain, permission is required of the domain in which it will be included.
- Eg :- If a university jntuk needs to start a website under the domain edu, it must ask the manager of the edu domain to assign it for jntuk.edu.

In this way, name conflicts are avoided & each domain can keep track of all its sub-domains.

Domain Resource Records

- Every domain whether it is a single host or top-level domain, can have a set of resource records.
- For a top-level domain, these records are DNS database.
- For a single host, the most common resource record is just its IP address, but many other kinds of resource records also exist.
- When a resolver gives a domain name to DNS, it gets the resource records associated with that name.
The function of DNS is to map domain names onto resource records.

The format of resource record is :-

Domain-name Time-to-live Class Type Value

Domain-name: It tells the domain to which the record applies.

Time-to-live: This field gives an indication of how stable the record is. When information is highly stable, it is assigned a large value.

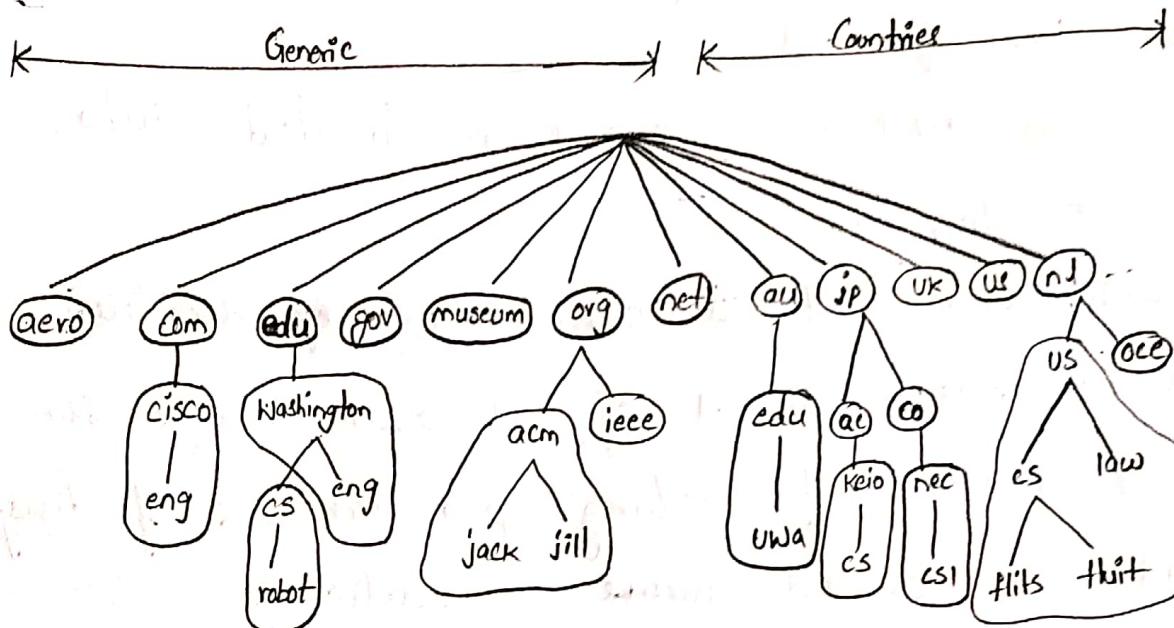
Such as 86,400 (no of sec in 1 day). When information is highly volatile, it is assigned a small value, such as 60 (1 minute).

- Class: For Internet information, it is always IN.
- Type: It tells the kind of the record.
There are many kinds of DNS records. They are:

<u>Type</u>	<u>Meaning</u>	<u>Value</u>
SOA	Start of authority	parameters for the zone
A	IPV ₄ add of a host	32-bit Integer
AAAA	IPV ₆ add of a host	128-bit Integer
MX	Mail Exchange	willing to accept mail
NS	Name Server	name of the server for the domain
CNAME	Canonical name	alias domain name pointer to
PTR	Pointer	IP add
SPF	Sender Policy Framework	Text encoding of mail sending policy.
SRV	Service	Host that provides it
TXT	Text	Descriptive ASCII text

DNS resource record types

Name Servers:



Part of DNS name space divided into zones

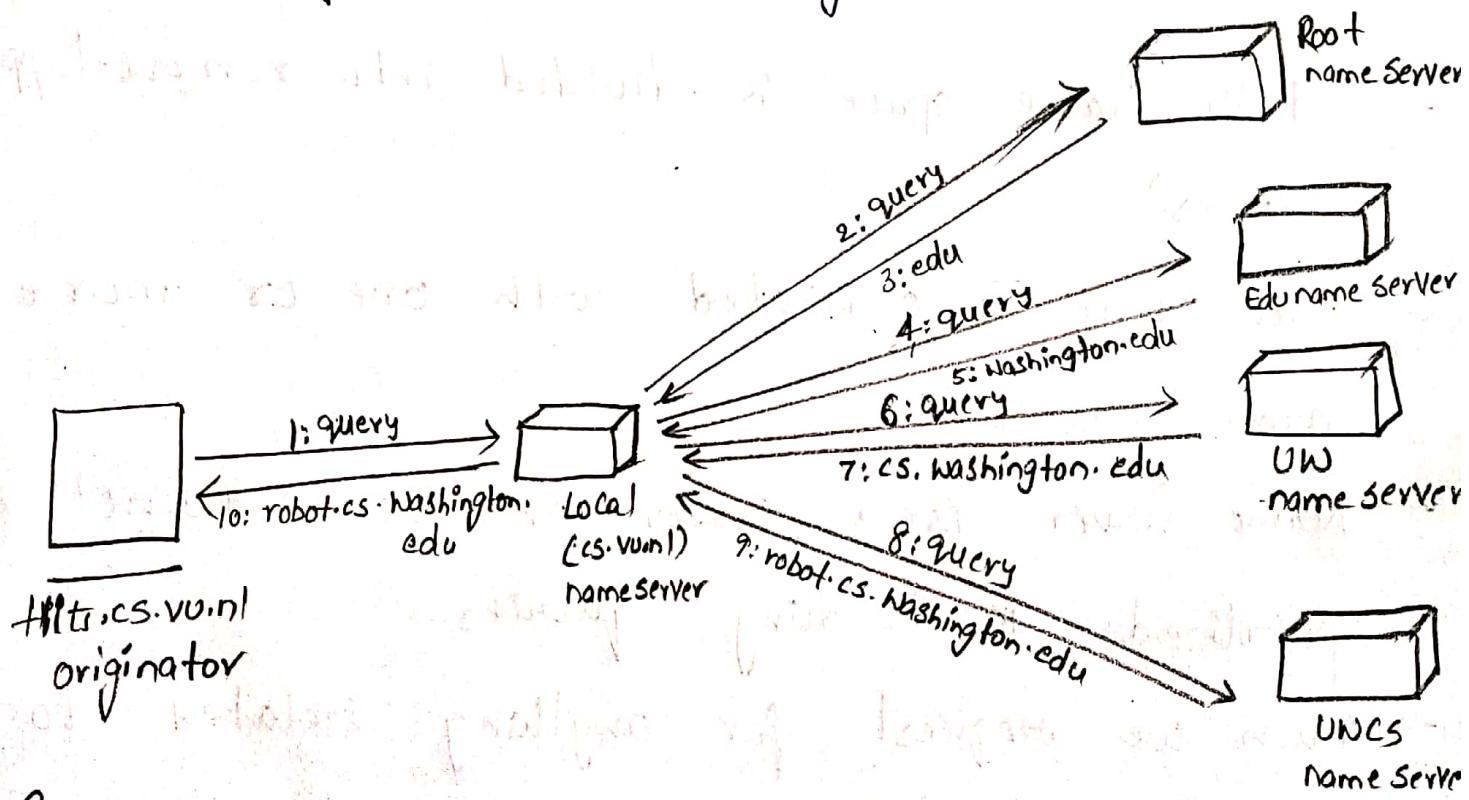
→ DNS Name space is divided into non overlapping zones.

- Each zone is associated with one or more name servers
- Name Server is a server on the Internet specialized in handling queries.
- When we request for anything related to domain name, it forwards it to one of the name servers
- In response, the DNS Server sends back the IP add

If a single name server is used for the entire

DNS db, it is very difficult to respond for all the queries.

- So, the DNS name space is divided into non overlapping zones.
- Each zone contains some part of the tree.
- Every zone consists of its own name servers.
- The process of looking up a name & finding an add is called name resolution.
- Consider that flits.cs.vu.nl wants to find the IP address of robot.cs.washington.edu.



Example of resolver looking up a remote name in 10 steps.

Step 1 :- Query is sent to the local name server.²³

Step 2 :- Local name server forwards the query to the root name server. These name servers have information about each top-level domain. It returns the IP add of edu domain which cs.washington.edu is located.

Step 3 :- Local name server forwards the query to edu name server. It returns the IP add of UW name server.

Step 4 :- Now the local name server forwards the query to UW name server. It returns the IP add of UWCS name server.

Step 5 :- Local name server forwards the query to UWCS name server. It returns the final answer, which the local name server forwards as a response to flits.cs.vu.nl.

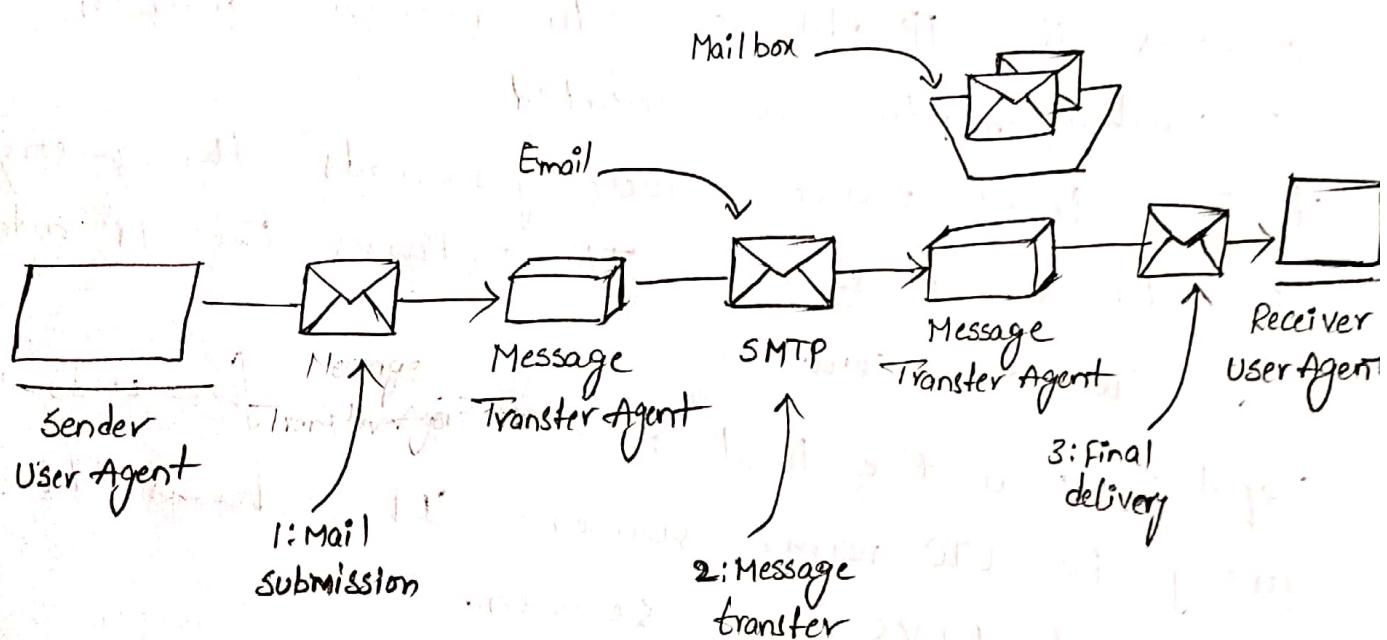
Hence the name has been resolved.

Electronic Mail.

The architecture of email system consists of two kinds of subsystems : the User Agent and the Message Transfer Agent.

User Agent :- It allows people to read & send emails.

Message transfer Agents: It moves the messages from source to destination. They run in the background on mail server machines.



Architecture of email system

(a) Mail Submission: The user agent is a program that provides an interface that allows the user to interact with the email system.

Here the user can compose messages, replies to messages & organize messages.

The act of sending new messages into the mail system for delivery is called mail submission.

Message transfer: The message transfer agent at the sender side forwards the email to the message transfer agent at the receiver side by using SMTP (Simple Mail Transfer Protocol). This is the message Transfer step.

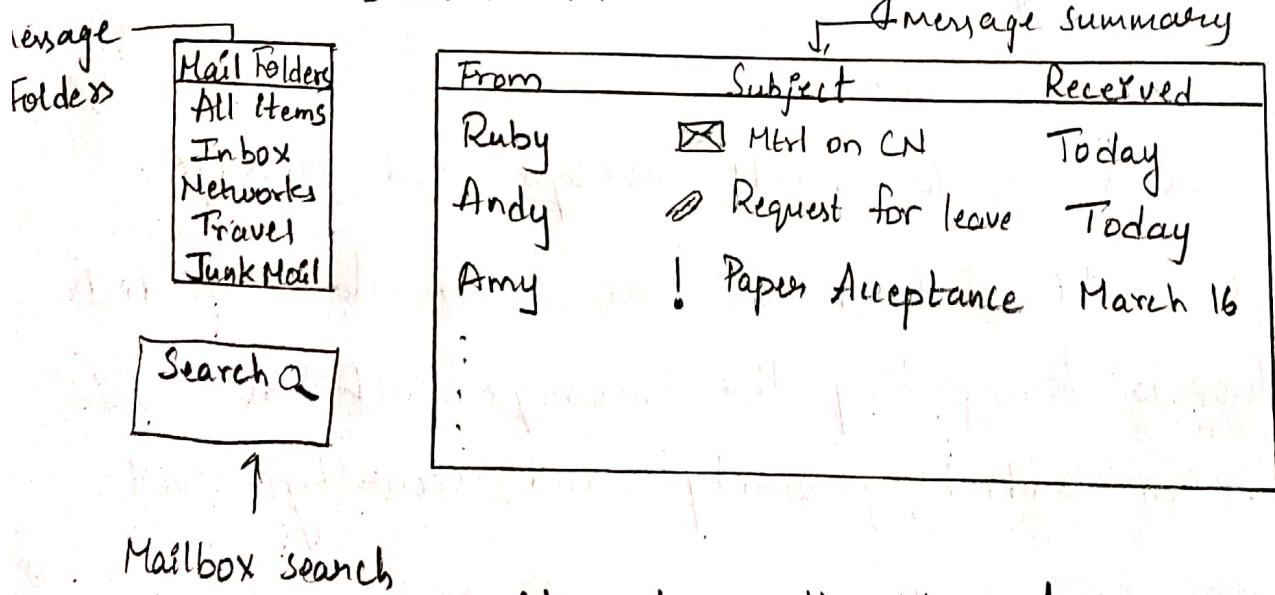
- (c) Final delivery: At the receiver side, the user agent and the message transfer agent are linked using mailboxes. They store email that is received for a user. They are maintained by mail servers.
- The retrieval of mail from the mailboxes is the final delivery.

Email message format,

- It consists of two parts envelope and message.
- i) envelope: It contains all the information needed for transporting the message such as destination address, priority and security level.
- ii) Message: It consists of two separate parts:
the header and the body.
- header: It contains the control information for user agent.
 - Message body: It contains the original message for the receiver.

The User Agent :

- A user agent is a program that accepts a variety of commands for composing, receiving & replying to messages.
- There are many popular user agents including Google Gmail, Mozilla Thunderbird & Apple Mail.
- Most user agents have a menu or icon-driven graphical interface that requires a mouse or a touch interface on smaller mobile devices.
- The typical elements of a user agent interface are as shown in the diagram.



Elements of the User Agent Interface

When a user agent is started, it will usually present a summary of the messages in the user's mailbox. The user agent presents the summary as follows:

it uses From, Subject and Received fields to display ²⁷ who sent the message, what it is about and when it was received.

- People who fail to include a subject field often discover that responses to their emails tend not to get the highest priority.
- The icons present near the subject might indicate unread mail (the envelope), attached mail (the paperclip) & important mail (the exclamation point).
- Many sorting orders are possible. The most common is to order messages based on the time that they were received, most recent displayed first.
- User agents provide a short preview of a message to help users decide when to read further.
- After a message has been read, the user can decide what to do with it. This is called message disposition.
It includes deleting the message, sending a reply, forwarding the message to another user & keeping the message for later reference.

Message Formats:

RFC 5322 - The Internet Message Format:

Header	Meaning
To:	Email address of primary recipient
Cc:	Email address of Secondary recipient
Bcc:	Email address for Blind Carbon copies
From:	Person or people who created the message
Sender:	Email address of the actual sender.
Received:	Line added by each transfer agent

- To: Email add of primary recipient.
- Cc: Email add of secondary recipient
Cc stands for Carbon Copy
 - Email addresses listed here will receive a copy of email that we sent to the people listed in the To: field.
 - Everyone listed under the Cc field will see everyone's email addresses that are under the To and Cc field.
- Bcc: Bcc stands for Blind Carbon Copy.
 - Email addresses listed here will receive a copy of email that you sent to the people listed in the To: field.

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- Everyone listed under the Cc field will see everyone's email address that are listed under the To & Cc field but will not see the addresses listed in Bcc field.
 - Each person listed on the Bcc field will not see the email address of other recipients.
 - From: It tells who wrote the message.
 - Sender:- It tells who sent the message
 - Received : It is added by each message transfer agent. It contains the agent's identity, the date & time message was received & other information that can be used for debugging the routing system.
 - Return-path : It is added by the final message transfer agent and was intended to tell how to get back to the sender.

In addition to the fields mentioned above, RFC 5322 messages also contain a variety of header fields used by the user agents or human recipients. The most common ones are listed below.

Header	Meaning
Date :	the date & time the message was sent
Reply - To :	Email add to which replies should be sent.
Message - Id :	Unique number for referencing the msg later
In - Reply - To :	Message - Id of the message which this is a reply.
References :	Other relevant message - Ids.
Keywords :	User chosen keywords.
Subject :	Short summary of the message for the one-line display

MIME (Multipurpose Internet Mail Extensions)

Header	Meaning
MIME - Version	Identifies the MIME Version.
Content - Description	Human - readable string telling what is in the message.
Content - Id	Unique Identifier
Content - Transfer encoding	How the body is wrapped for transmission.
Content - Type	Type & format of the content.

- MIME Version : It tells the user agent that the received message is a MIME message & which version of MIME it is using.

Content - Description : It briefly tells what is in the message so that the receiver can decide whether to read the message or not.

- Content - Id : It is used to identify the content. It is a unique number for referencing this message later.
- Content - Transfer - encoding : It tells how the body is wrapped for transmission through the N/w.
- Content - type : It specifies the nature of the message body. The content type should be mentioned so that the browser will know how to present it.

MIME Content types

Type	Example subtypes	Description
text	plain, html, xml, css	Text in various formats
image	gif, jpeg	pictures
audio	basic, mpeg, mp4	Sound
video	mpeg, mp4	Movies
model	vrm1	3D model
application	pdf, js, zip	Data produced by application
message	http	Encapsulated message
multipart	mixed, alternative, parallel	Combination of multiple types

Message Transfer :-

SMTP and Extension :-

- SMTP is a simple ASCII protocol. Using ASCII text makes protocols easy to develop, test & debug.
- Email is delivered by establishing a TCP connection with port number = 25 b/w the sending machine and receiving machine.
- After establishing the TCP connection to port 25, the sending machine operates as client & the receiving machine operates as server.
- Before sending email, the client announces whom the email is coming from & whom it is going to.
- If such a recipient exists at the destination, the server gives the client the go-ahead to send the message.
- Then the client sends the message & the server acknowledges it.
- No checksums are needed bcz TCP provide a reliable connection.
- When all the email has been exchanged in both directions, the connection is released.

Disadv of SMTP :-

- It doesn't include authentication.

It doesn't include encryption.

- To overcome the problems, SMTP was revised to have an extension mechanism.
- The use of SMTP with extensions is called ESMTP (Extended SMTP).

Some SMTP Extensions

Header	Description
AUTH	Client authentication
BINARYMIME	Server accepts binary messages
CHUNKING	Server accepts large messages in chunks
SIZE	Check message size before trying to send.

Message Transfer:

Once the sending mail transfer agent receives a message from the user agent, it will deliver it to the receiving mail transfer agent using SMTP.

To do this, the sender uses the destination address.

The Message transfer agents run on the mail server machines.

So, we should determine the correct mail server to contact, for this purpose DNS is used.

- DNS contains multiple types of records. Includes the MX or mail exchanger record.
- So, a DNS query is sent to get the MX records of the receiver domain.
- This query returns an ordered list of IP addresses of one or more mail servers.

Final Delivery:

IMAP (Internet Message Access Protocol).

- One of the main protocols that is used for final delivery is IMAP.
- To use IMAP, the mail server runs on IMAP server that listens to port 143.
- The user agent runs on IMAP client.
- The client connects to the server & begins to issue commands.

The client will start a secure transport in order to keep the messages & commands confidential.

To have a secure transport, authentication is performed (login).

Once logged in, different commands are used to

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deal with the messages - They are:-

Command	Description
CAPABILITY	List Server Capabilities
LOGIN	Logon to server
AUTHENTILATE	Logon with other method
SELECT	Select a folder
EXAMINE	Select a read-only folder
CREATE	Create a folder
DELETE	Delete a folder
RENAME	Rename a folder
LIST	List the available folders
STATUS	Get the status of folder
APPEND	Add a message to a folder
FETCH	Get messages from a folder
SEARCH	Find messages in a folder
COPY	Make a copy of message in a folder.
SUBSCRIBE	Add folder to active set
UNSUBSCRIBE	Remove folder from active set
LSub	List the active folders
LOGOUT	Logout & close connections