6 Application Layer

Having discussed all the types of layers, we have now reached the layer where all applications are found.

In this chapter, we will discuss some real network applications.

Application layer assumes that there is an imaginary direct connection through which they can communicate.
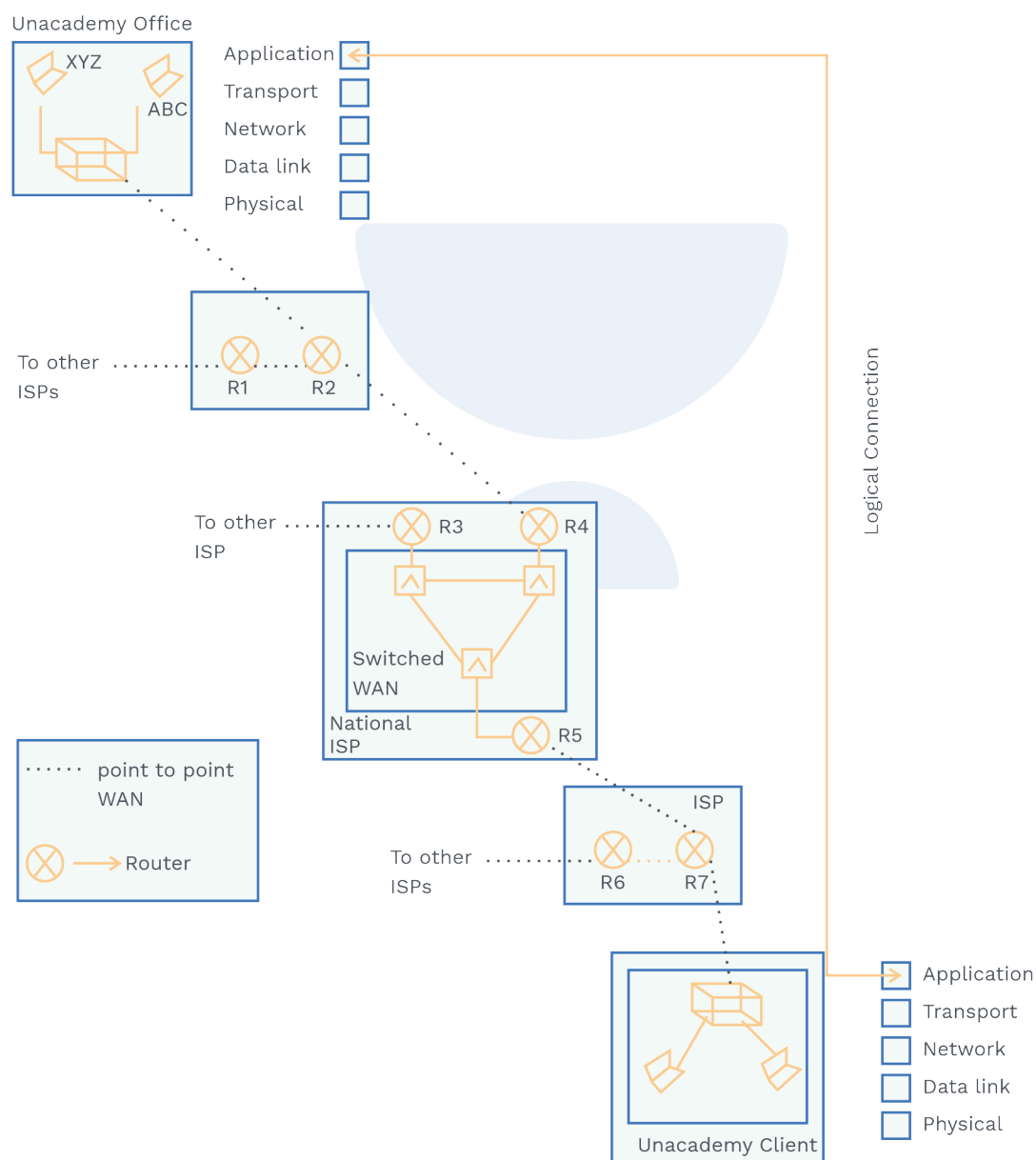

Fig 6.1 Shows The Idea Behind This Logical Connectivity.

6.1 DNS

Hey learners! Do you know which protocol handles naming within internet?
DNS.
Let's discuss about DNS.

The DNS name space:

- Managing a large set of names is really non–trivial.
- For the Internet, the top of the naming hierarchy is managed by an organization called ICANN (Internet Corporation for Assigned Names and Numbers).
- Internet is divided into many top–level domains where each domain covers many hosts.
- Each domain is divided into sub–domains, and these sub domains are further divided.
- All the domains can be represented in the form of a tree.
- The leaves of the tree indicate domains that have no sub–domains.
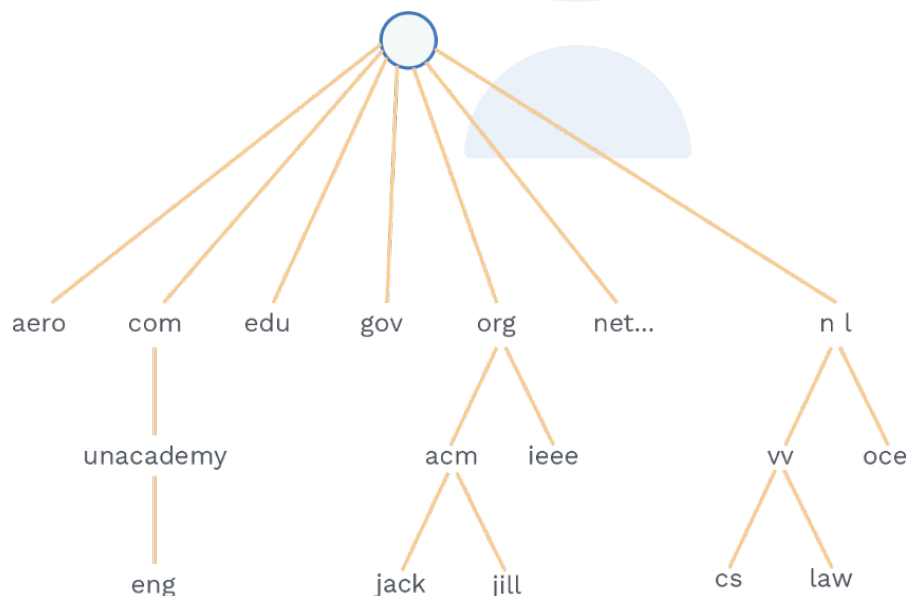- A leaf domain may contain a single host or it may represent a company that contains thousands of hosts.

Fig. 6.2 Portion Of The Internet Domain Name Space

Domain resource records:

- Every domain, whether it is a single host or a top-level domain, has a set of resource records. These records are present in the DNS database.
- A resource record has five-tuples:
  <Domain_name, Time_to_live, Class, Type, Value>

Name servers:

- The DNS name space is divided into non-overlapping zones.
- It distributes the information among many computers.
- Name server divides the whole space into many domains based on the first level.
- The root stands alone and creates as many domains (subtrees) as possible, these are first–level nodes.
- We have a hierarchy of servers in the same way that we have a hierarchy of names.
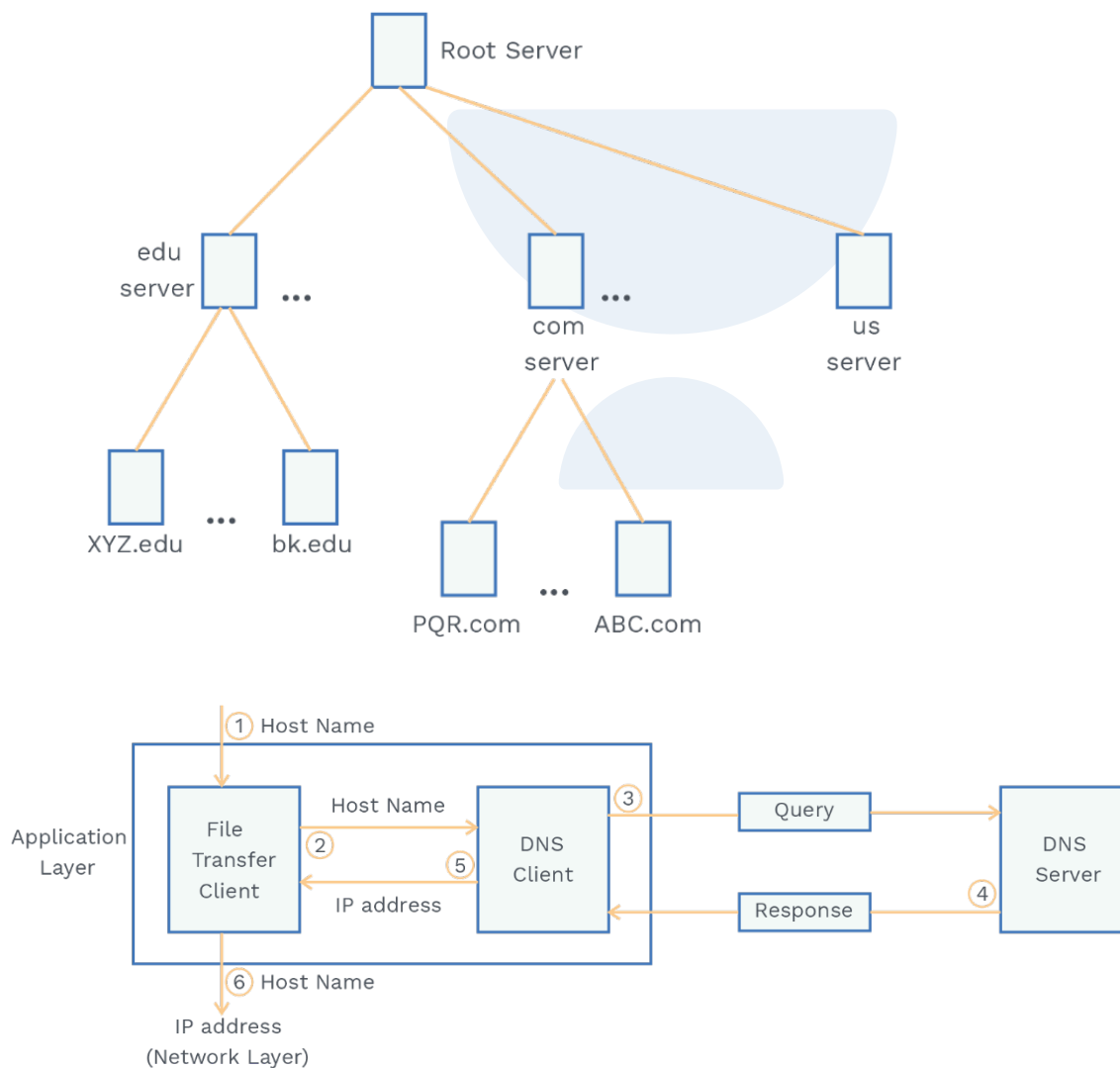
Fig. 6.3 Purpose Of DNS

- The TCP/IP suits require the IP address of the file transfer server to establish the connection.

The steps below are used to map the hostname to IP address:

1) The user sends the hostname to the file transfer client.
2) The file transfer client sends the hostname to the DNS client.
3) Each computer, after being booted knows the address of its DNS server. DNS client sends query message to a DNS server. DNS query includes file transfer server name and it is sent using known IP address of DNS server.
4) The DNS server responds with the IP address of the desired file transfer server.
5) DNS server sends the IP address to the file transfer client.
6) The received IP address is being used by file transfer client to access file transfer server.

Note:

- DNS uses port number 53.
- DNS is stateless protocol.

There are two ways in which DNS can contact the server:
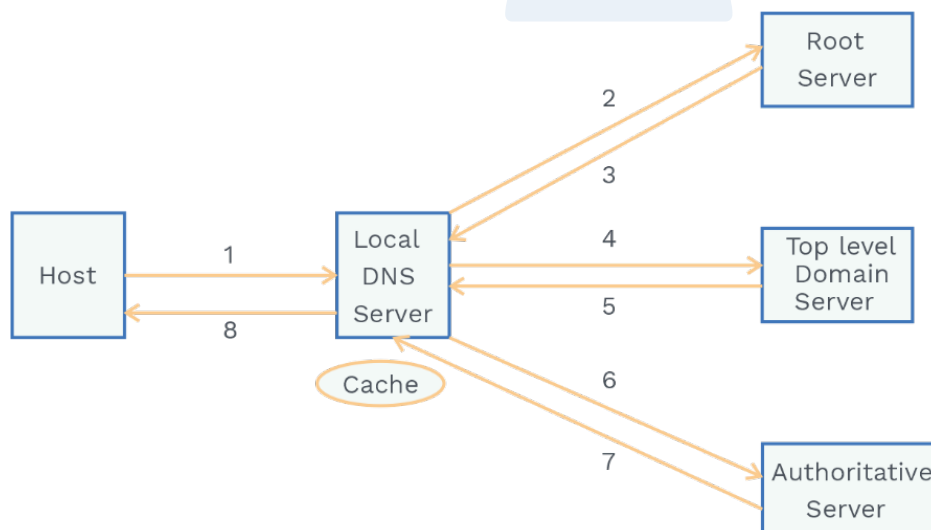**Method 1:** Iterative Approach

Fig. 6.4 Iterative Approach

Lets say www.unacademy.com needs to be find using DNS iterative approach
Step 1: Host will ask Local DNS server do you have www.unacademy.com address, If no Go to step 2, else send me

Step 2: Local DNS Server will ask Root Server do you have www.unacademy.com address,

    If (false) // i.e no information about address at Root Server
    Local DNS Server: Ask Top Domain Server
else
    Local DNS Server: Take address from Root Server // Step 3

Step 4: Local DNS Server will ask Top Level Domain Server do you have www.unacademy.com address,

    If (false) // i.e no information about address at Top Level Domain Server
    Local DNS Server: Ask Authoritative Server
    else
    Local DNS Server: Take address from Top Level Domain Server // Step 5

Step 6: Local DNS Server will ask Authoritative Server do you have www.unacademy.com address,

    If (true) // i.e information present about address at Authoritative Server
    Local DNS Server: Take address from Authoritative Server // Step 7

Step 8: Local DNS server will send the address of www.unacademy.com to host and also local DNS server maintains the address mapping in cache.
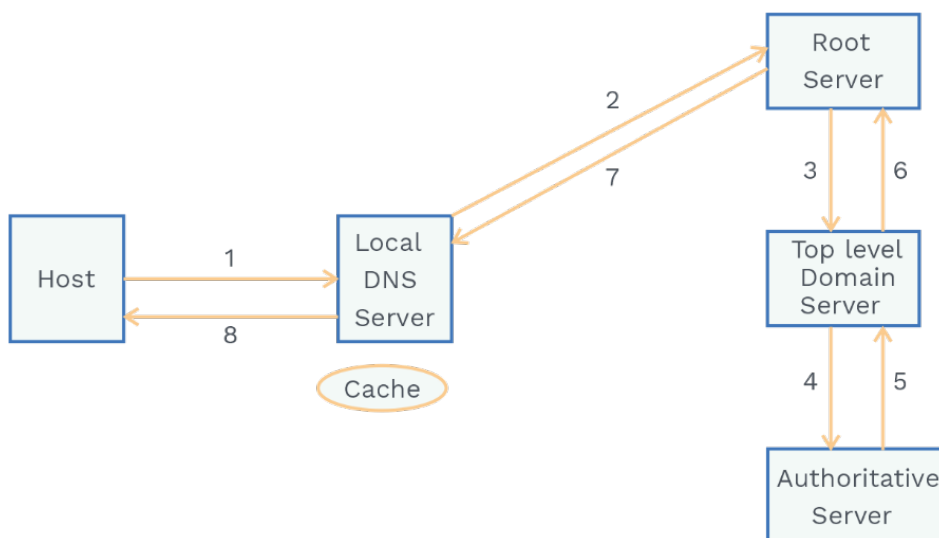
Method 2: Recursive Approach

Fig. 6.5 Recursive Approach

Step 1: Host will ask the Local DNS server do you have www.unacademy.com address, If not Go to Step2

Step 2: Local DNS Server will ask Root Server do you have www.unacademy.com address,

   If (false) // i.e no information about address at Root Server
   ask Top Level Domain Server

Step 3: Root Server will ask Top Level Domain Server do you have <u>www.unacademy.com</u> address,

   If (false) // i.e no information about address at Top Level Domain Server
   Ask Authoritative Server

Step 4: Top Level Domain Server will ask Authoritative Server do you have www.unacademy.com address,

   If (true) // i.e information present about address at Authoritative Server
   Give address back

Step 5: Give Information to Top Level Domain Server.
Step 6: Give information back to Root server.
Step 7: Give information back to Local DNS server.
Step 8: Give information back to Host and also DNS will maintain address mapping in its cache.

6.2 HYPERTEXT TRANSFER PROTOCOL (HTTP)

- HTTP defines how the client–server programs are written to retrieve web pages from the web.
- An HTTP client sends an HTTP request and an HTTP server returns a response.
- HTTP uses the services of TCP. A connection has to be established between client and server before any transaction that takes place between client and server.
- The clients and servers need not worry about erroneous/corrupted messages exchanged or loss of any message because the underlying transport layer protocol is TCP which is highly reliable.

Note:

HTTP prior to version 1.1 specified non–persistent connections, while persistent connections are default in version 1.1, but it can be changed by the user.
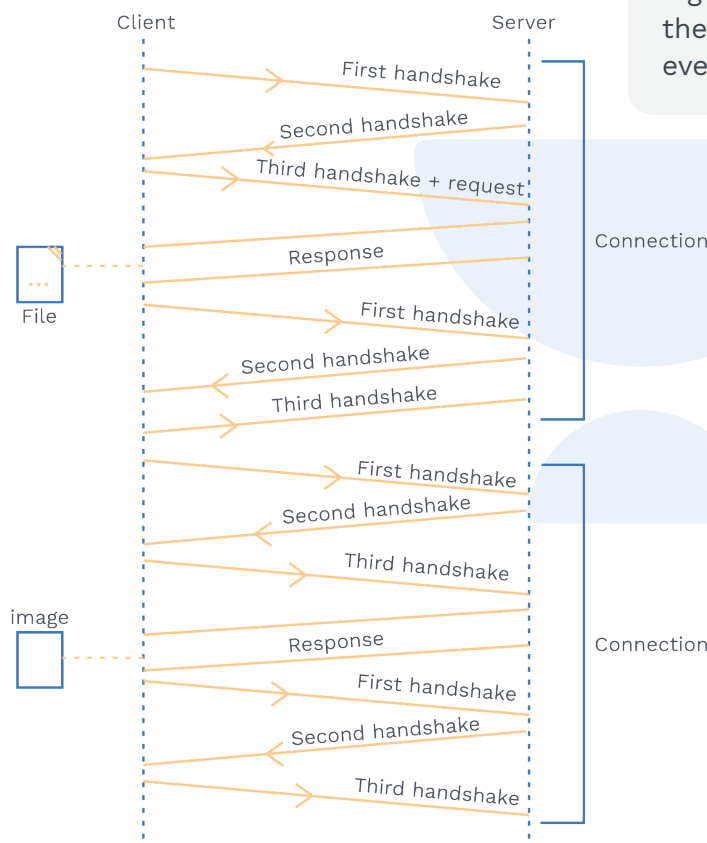
Nonpersistent connections:

- One TCP connection is established for each request/response in a non–persistent connection.

- Three steps are involved in this strategy:
  1) The client initiates a TCP connection and sends a request.
  2) The server sends the response and terminates the connection.
  3) The client reads the data until it encounters an end-of-file marks it then closes the connection.

**Fig. 6.6 Non–Persistent–Connection**

Persistent connection:
- By default HTTP 1.1 uses persistent connection.
- In persistent connection, the connection is left open for more requests.
- If the client requests or if the timer times out, server can close the connection.
- Resources and Time are saved using a persistent connection.

- The method field defines the HTTP request type.
  In HTTP 1.1, several methods are defined.

Method	Action
GET	Request a document from server
HEAD	Request information about a document but not the document itself
PUT	Sends a document from the client to the server.
POST	Sends some information from the client to server
TRACE	Echoes the incoming request
Delete	Removes the web page
Connection	Reserved
Options	Enquires about available options

Fig 6.7 Different Methods of HTTP
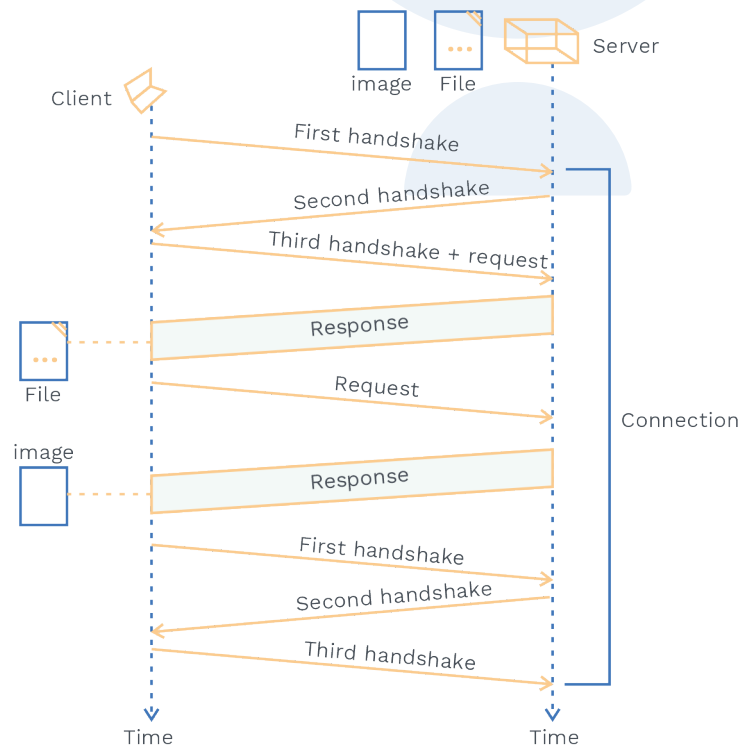
6.3 FILE TRANSFER PROTOCOL (FTP)

- FTP is a standard protocol provided by TCP/IP for copying a file from one host to another.
- Can we transfer files using HTTP?
  Yes, we can, but the FTP is the better choice to transfer bigger files.
- Basic model of FTP has three components – the user interface, the client control process and the client data transfer process.
- The server has a server control process and server data transfer process.
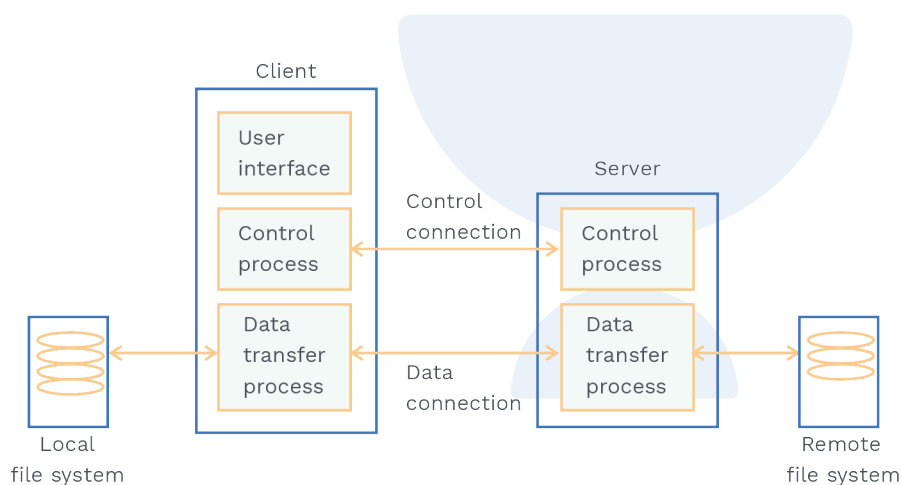
Fig. 6.8 Basic Model Of FTP

- There are two connection in FTP → Control Connection
  → Data Connection
- The control connection remains connected during the entire FTP session.
- The data connection is opened and closed for each file transfer activity.

Note:

FTP use two well-known TCP ports. It uses port 21 for the control connection and port 20 for data connection.

- Below are few FTP commands that can be performed on the remote host through local host after connecting to remote host.

Command	Description
• ABOR	Abort the previous command
• DELE	Delete a file
• LIST	List subdirectories
• MKD	Make new directory
• PORT	Client chooses a port
• PWD	Display name of current directory
• QUIT	Logout of the system
• MODE	Define transmission mode (S: Stream) (B: Block) (C: compressed)

Table 6.9 Commands

Note:
File transfer in FTP involves three steps:
- Retrieving a file (server to client)
- Storing a file (client to server)
- Directory listing (server to client)

6.4 ELECTRONIC MAIL (E–MAIL)
- It allows users to exchange messages.
- Unlike FTP or HTTP, in the case of E–mail the server program need not run all the time.
- Now we will discuss, how is it possible?

UA: User Agent
MTA: Message Transfer Agent
MAA: Message Access Agent

Previous Years' Question

Identify the correct order in which the following actions take place in an interaction between web browser and a web server.
1) The web browser requests a webpage using HTTP.
2) The web browser establishes a TCP connection with the web server.
3) The web server sends the requested webpage using HTTP.
4) The web transfer resolves the domain name using DNS.
   a) 4, 2, 1, 3   b) 1, 2, 3, 4
   c) 4, 1, 2, 3   d) 2, 4, 1, 3
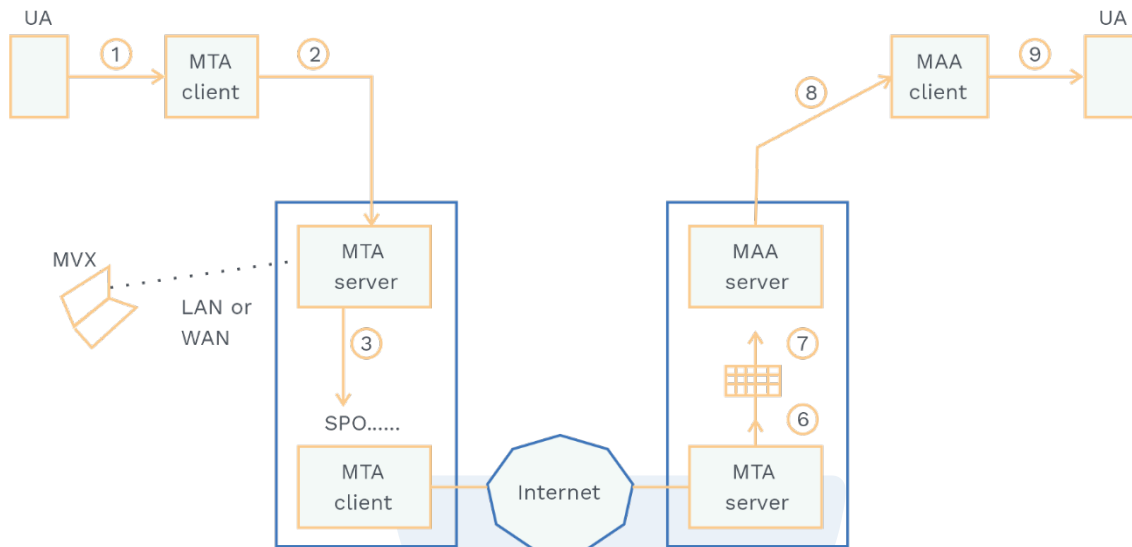**Sol: a)**   **(GATE-2014 (Set–1))**

Fig. 6.9 Basic Architecture Of E–mail

Message transfer agent:
- Simple Mail Transfer Protocol (SMTP) is used twice, between the sender and sender's mail server, and also between two mail servers.
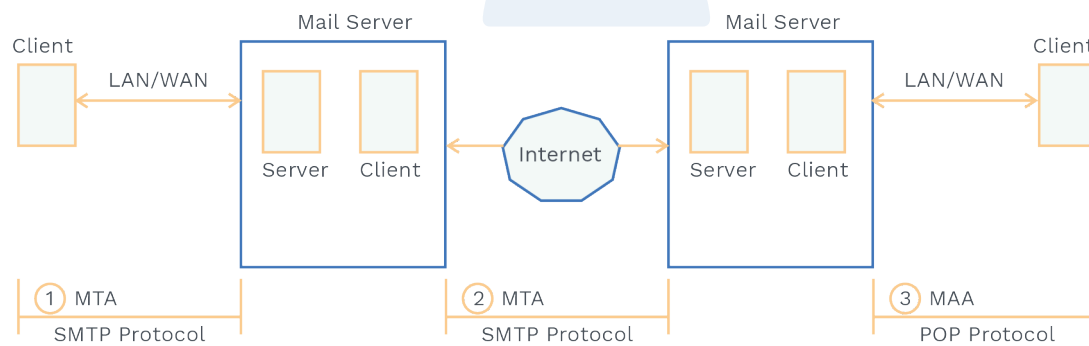

Fig. 6.10 Protocol Used In E–mail

- Command is sent from an MTA client to an MTA server.
- The format of a command is:
  Keyword: argument(s)
- SMTP defines 14 commands:
  i) HELO
  ii) MAIL FROM
  iii) RCPT TO
  iv) DATA

193

v) QUIT

vi) RSET

vii) VRFY

viii) NOOP

ix) TURN

x) EXPN

xi) HELP

xii) SEND FROM

xiii) SMOL FROM

xiv) SMAL FROM

Message Access Agent: POP

- It is used to retrieve mail from the mail server.
- The client POP3 software is installed on the recipient computer.
- The server POP3 software is installed on the mail server.
- POP3 has 2 modes: the delete mode and the keep mode.
- In keep mode, the mail remains in the mail box after retrieval. In Delete mode,the mail gets removed from the mailbox.
- POP3 is a stateful protocol.

IMAP4:

- It is another mail access protocol like POP3 but is more powerful and has more features than POP3.
- POP3 does not allow to check the mail contents partially before the user downloads.
- Advantages of IMAP4 over POP3:
  i) A user can check mail contents before downloading.
  ii) A user can search the contents of e (mail) for specific strings of characters prior to downloading.
  iii) A user can partially download email.
  iv) A user can create, delete or rename mailboxes on the mail server.

Previous Years' Question

Which of the following is/are example(s) of stateful application layer protocol?

i) HTTP **ii)** FTP

iii) TCP **iv)** POP3

a) i) and ii) only

b) ii) and iii) only

c) ii) and iv) only

d) iv) only

Sol: c) (GATE-2016 (Set–1))

Chapter summary

- DNS: Maps host name to IP address.
- HTTP: Retrieves web pages from the web.
- Non-persistent HTTP connection–One TCP connection is made for each request/response.
- Persistent HTTP connection: The server leaves the connection open for more requests after sending a response.
- FTP: Standard protocol provided by TCP/IP for copying a file from one host to another.
- Two components of FTP — Control Connection / Data Connection
- Email: • UA [User Agent]
  • MTA [Message Transfer Agent]
  → SMTP
  • MAA [Message Access Agent]
  → POP3
  → IMAP4