National Institute of Technology Karnataka Surathkal
Department of Information Technology

IT 200 **Computer Communication and Networking**

Application Layer (2)

Dr. Geetha V

Assistant Professor

Dept of Information Technology

NITK Surathkal

Syllabus

- **Evolution of Data Communication and Networks,**
- **Transmission Fundamentals: Signaling Schemes, Encoding and Modulation,**
- Data Transmission over Networks – Switching Techniques, Layered Architecture of Computer Networks,
- OSI & TCP/IP Architectures and Layers with protocols,
- Data Link Control and Protocols, Error Detection and Correction,
- Internetworking & Routing,
- Transport Layer Protocols,
- Applications: DNS, **E-Mail, HTTP, WWW, Multimedia;**
- Implementation of Signaling and Modulation, Bit, Byte & Character Stuffing and Error Detection/Correction Coding Techniques, TCP/IP Level Programming, Routing Algorithms, Exercises comprising simulation of various protocols.

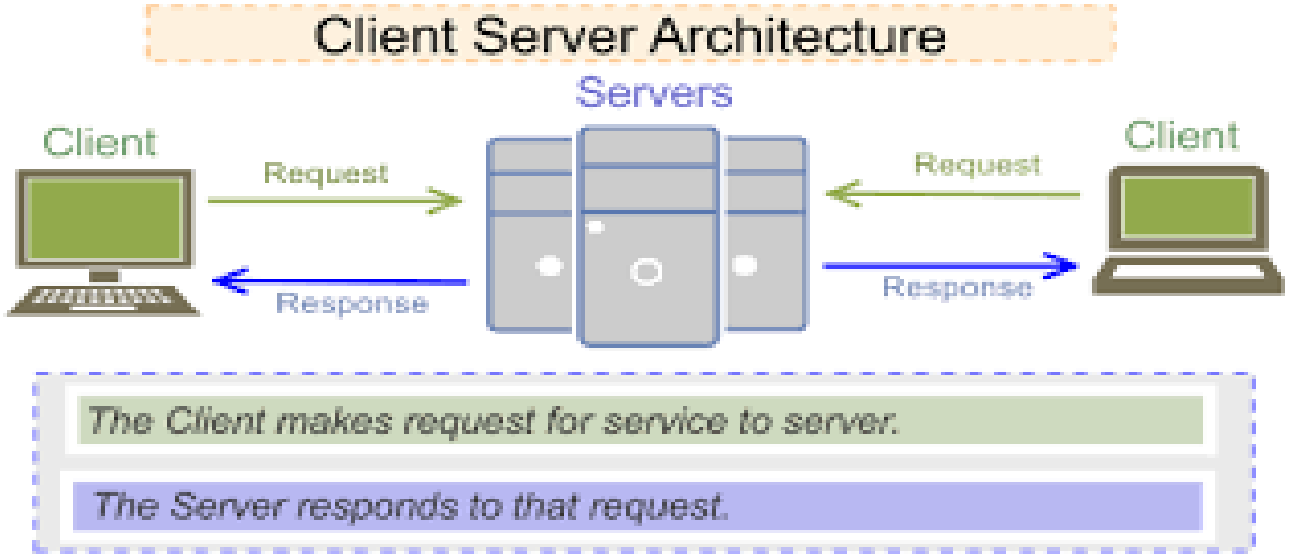
Index

Application Layer

- DNS : Domain Name System
- **Client Server Architecture**
- **Email**
- HTTP
- WWW
- Multimedia

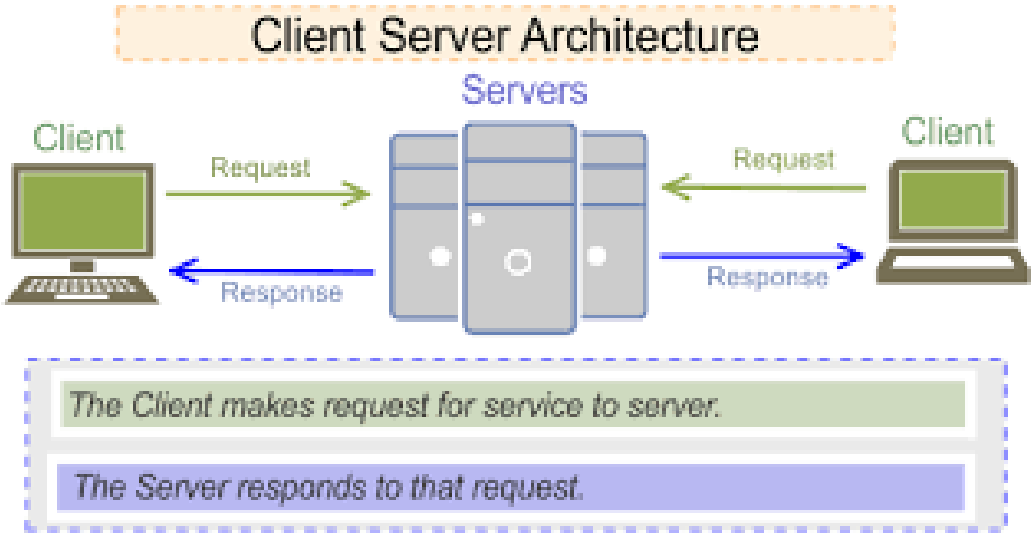
2.1 Client Server Architecture

- Client Server model for Internet Applications: A server is the one who provides requested services. Clients are the ones who request services.



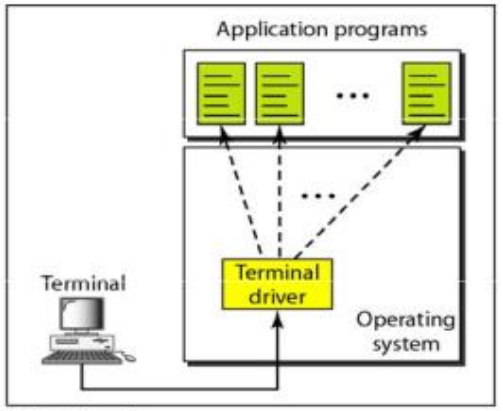
2.1 Client Server Architecture

- Client Server model for Internet Applications: Client server architecture is a computing model in which the server hosts, delivers, and manages most of the resources and services requested by the client. It is also known as the networking computing model or client server network as all requests and services are delivered over a network.

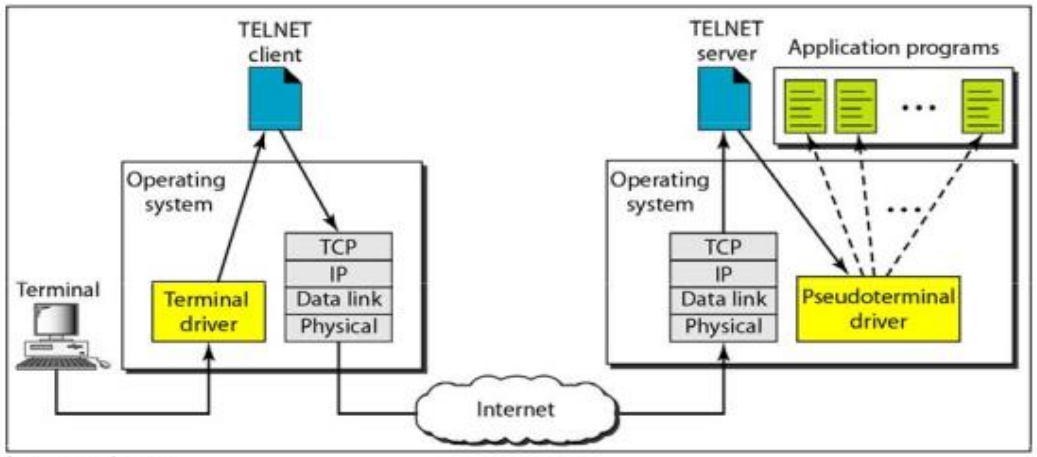


2.1 Client Server Architecture

- TELNET: It is a general-purpose client server application program.
- Local and remote login



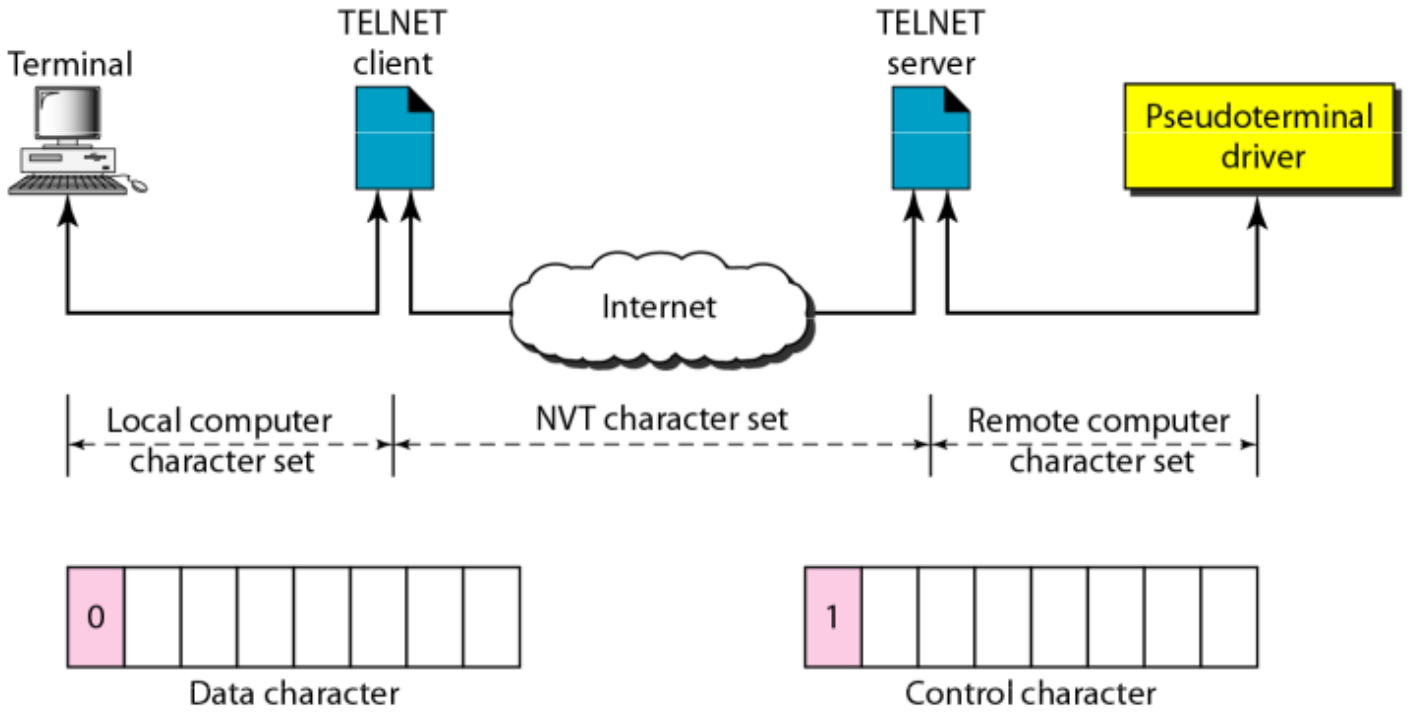
a. Local log-in



b. Remote log-in

2.1 Client Server Architecture

- TELNET: It is a general-purpose client server application program.
- NVT for communication
- NVT : Network Virtual Terminal
- The NVT uses 7 bit codes for characters



2.1 Client Server Architecture

- TELNET: It is a general-purpose client server application program.
- NVT for communication
- NVT : Network Virtual Terminal
- The NVT uses 7 bit codes for characters

Some NVT Characters

Character	*Decimal*	*Binary*	*Meaning*
EOF	236	11101100	End of file
EOR	239	11101111	End of record
SE	240	11110000	Suboption end
NOP	241	11110001	No operation
DM	242	11110010	Data mark
BRK	243	11110011	Break
IP	244	11110100	Interrupt process
AO	245	11110101	Abort output
AYT	246	11110110	Are you there?
EC	247	11110111	Erase character
EL	248	11111000	Erase line
GA	249	11111001	Go ahead
SB	250	11111010	Suboption begin
WILL	251	11111011	Agreement to enable option
WONT	252	11111100	Refusal to enable option
DO	253	11111101	Approval to option request
DONT	254	11111110	Denial of option request
IAC	255	11111111	Interpret (the next character) as control

2.1 Client Server Architecture

- TELNET: It is a general-purpose client server application program.
- NVT for communication
- NVT : Network Virtual Terminal
- The NVT uses 7 bit codes for characters

Table 26.2 *Options*

Code	*Option*	*Meaning*
0	Binary	Interpret as 8-bit binary transmission.
1	Echo	Echo the data received on one side to the other.
3	Suppress go ahead	Suppress go-ahead signals after data.
5	Status	Request the status of TELNET.
6	Timing mark	Define the timing marks.
24	Terminal type	Set the terminal type.
32	Terminal speed	Set the terminal speed.
34	Line mode	Change to line mode.

Table 26.3 *NVT character set for option negotiation*

Character	*Decimal*	*Binary*	*Meaning*
WILL	251	11111011	1. Offering to enable 2. Accepting a request to enable
WONT	252	11111100	1. Rejecting a request to enable 2. Offering to disable 3. Accepting a request to disable
DO	253	11111101	1. Approving an offer to enable 2. Requesting to enable
DONT	254	11111110	1. Disapproving an offer to enable 2. Approving an offer to disable 3. Requesting to disable

2.1 Client Server Architecture

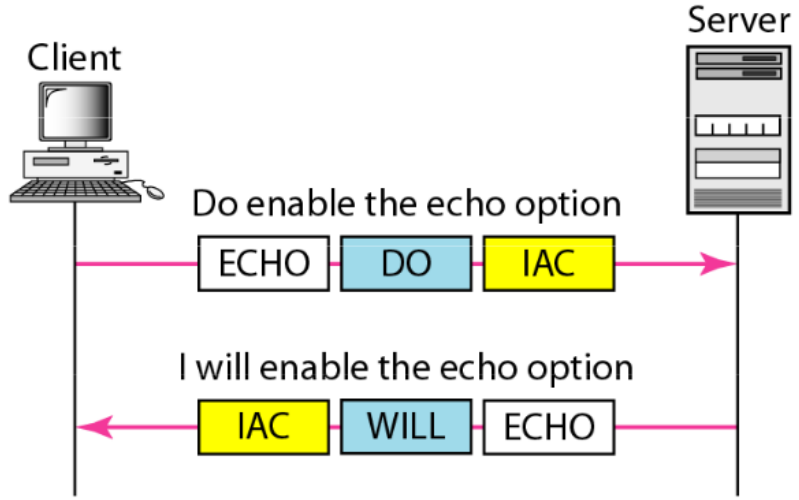
- TELNET: It is a general-purpose client server application program.
- NVT for communication
- NVT : Network Virtual Terminal
- The NVT uses 7 bit codes for characters

Table 26.2 *Options*

Code	*Option*	*Meaning*
0	Binary	Interpret as 8-bit binary transmission.
1	Echo	Echo the data received on one side to the other.
3	Suppress go ahead	Suppress go-ahead signals after data.
5	Status	Request the status of TELNET.
6	Timing mark	Define the timing marks.
24	Terminal type	Set the terminal type.
32	Terminal speed	Set the terminal speed.
34	Line mode	Change to line mode.

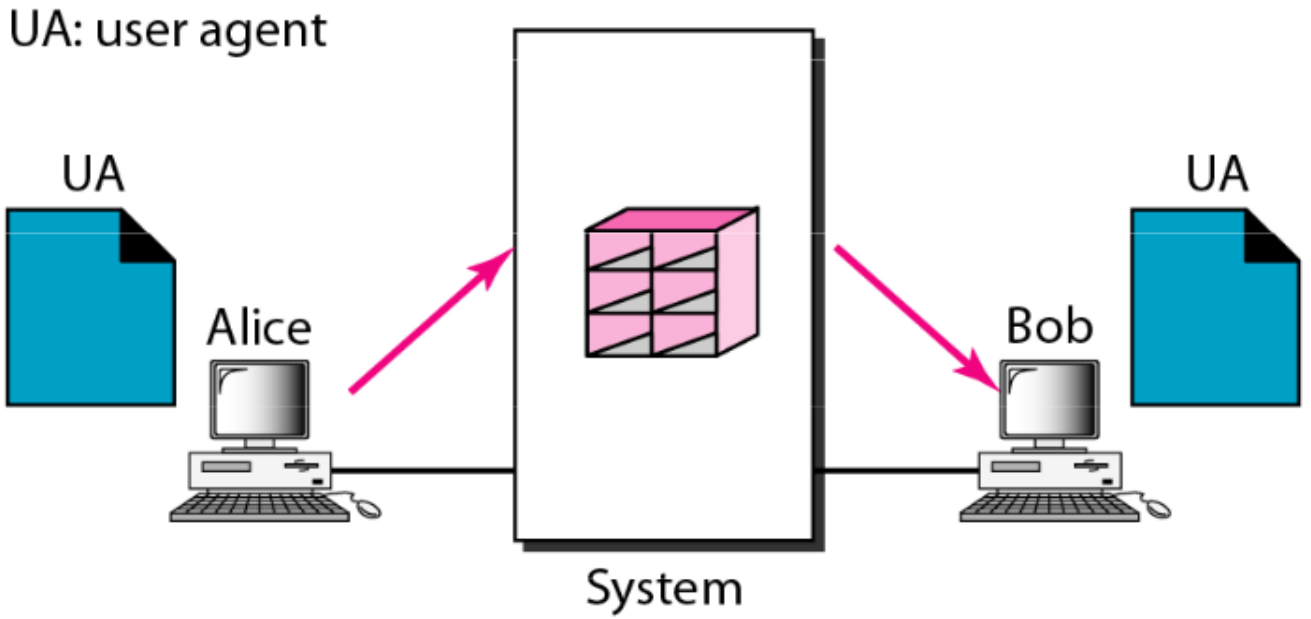
Table 26.3 *NVT character set for option negotiation*

Character	*Decimal*	*Binary*	*Meaning*
WILL	251	11111011	1. Offering to enable 2. Accepting a request to enable
WONT	252	11111100	1. Rejecting a request to enable 2. Offering to disable 3. Accepting a request to disable
DO	253	11111101	1. Approving an offer to enable 2. Requesting to enable
DONT	254	11111110	1. Disapproving an offer to enable 2. Approving an offer to disable 3. Requesting to disable



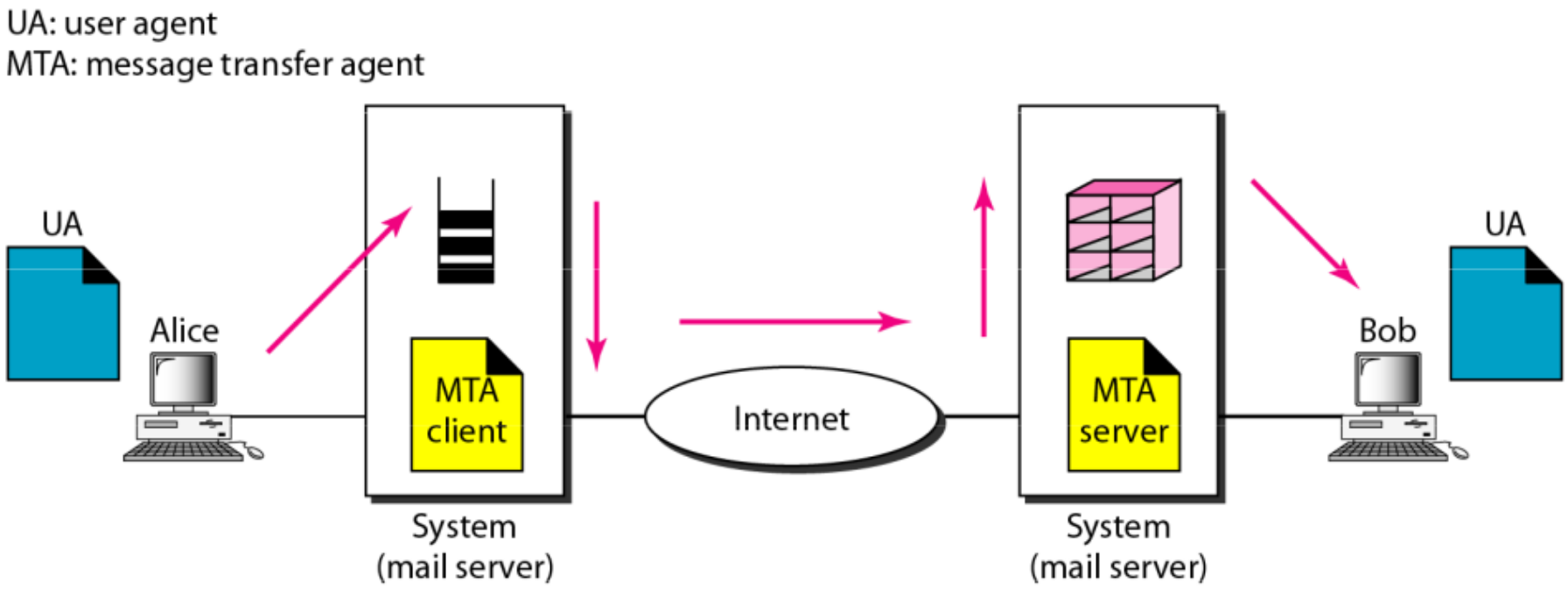
2.2 Electronic Mail

- First Scenario in Electronic mail: When the sender and the receiver of an email are on the same system, we need only two user agents.



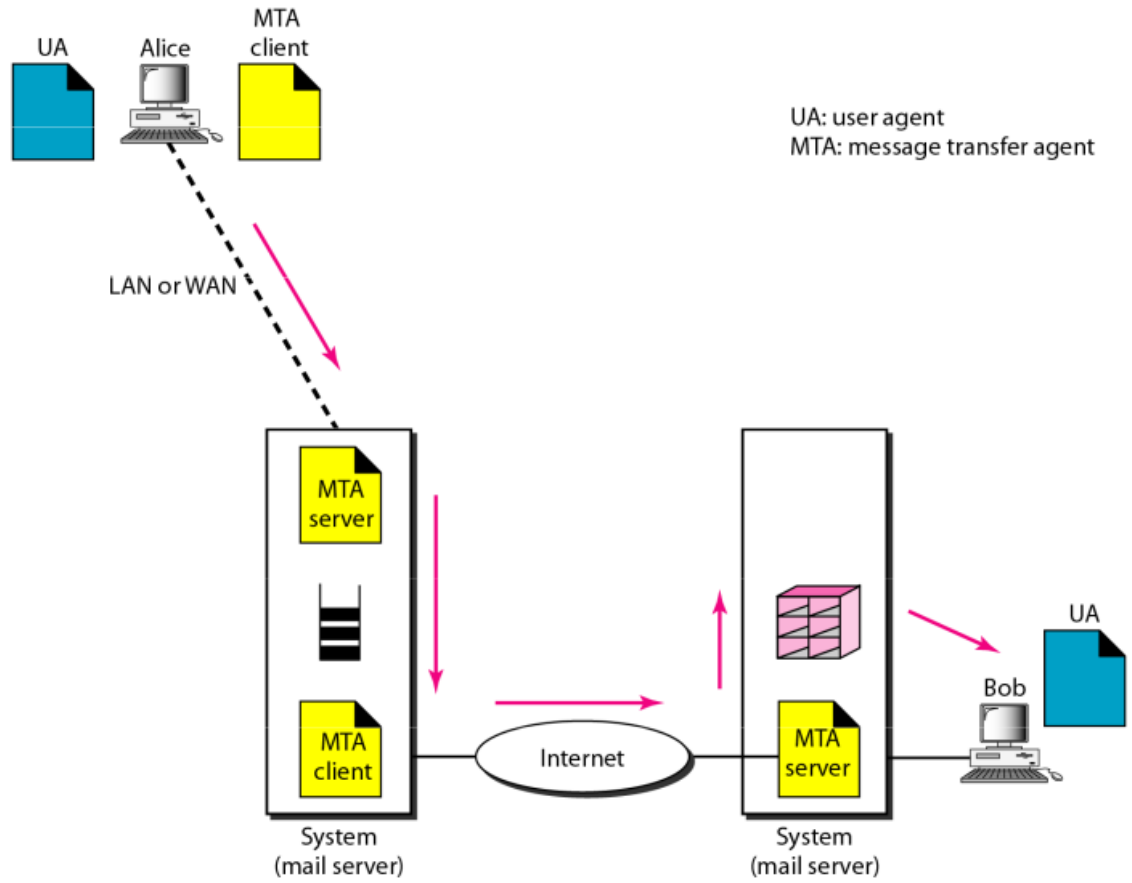
2.2 Electronic Mail

- Second Scenario in Electronic mail: When the sender and the receiver of an email are on the **different** system, we need only two user agents and a pair of client server communication or Message transfer agents (MTA).



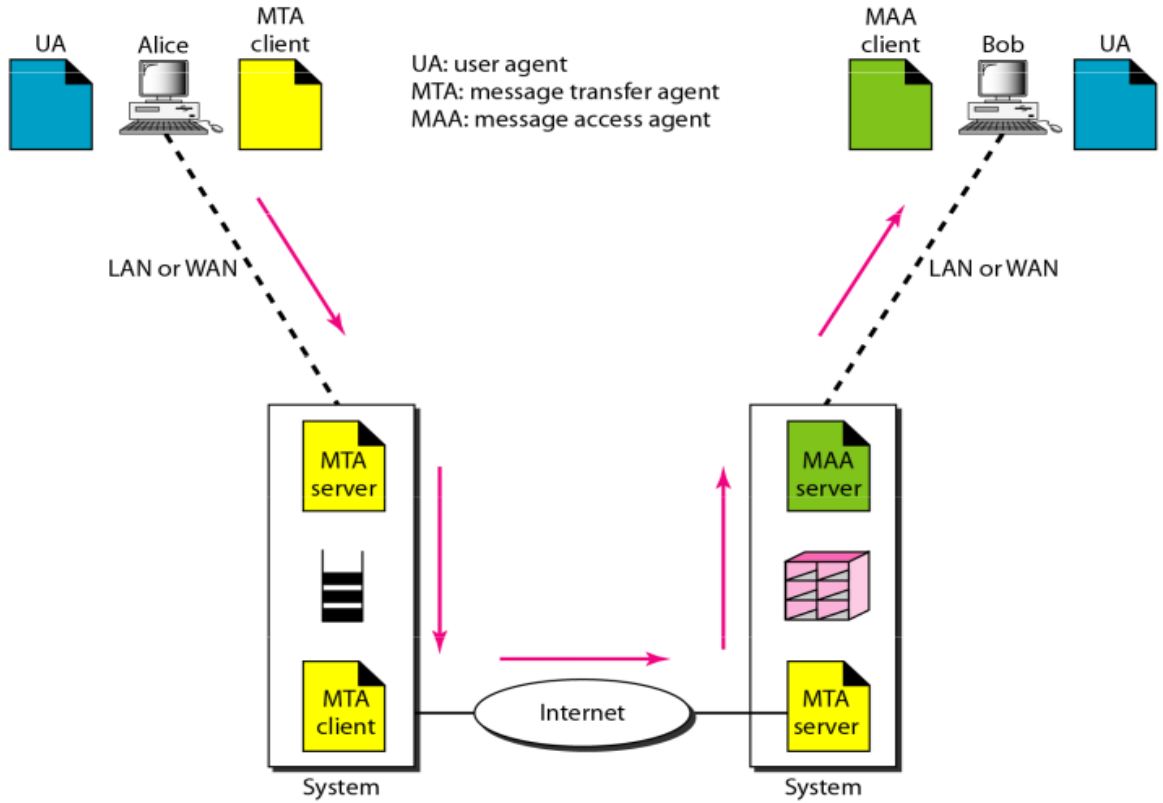
2.2 Electronic Mail

- Third Scenario in Electronic mail: When the sender is connected to the mail server via a LAN or a WAN, we need two UAs and two pair of MTAs.



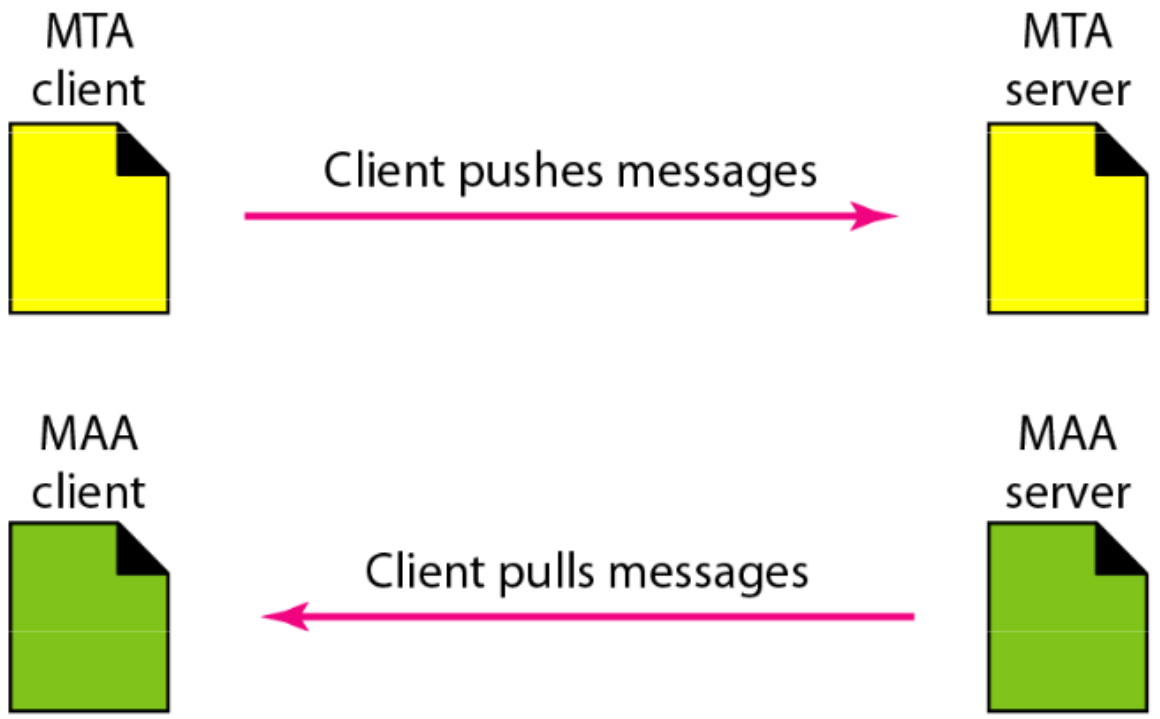
2.2 Electronic Mail

- Fourth Scenario in Electronic mail: When the sender is connected to the mail server via a LAN or a WAN, and receiver is also connected via LAN or WAN , we need two UAs, two pairs of MTAs and a pair of MAAs . This is most common type of email communication today.



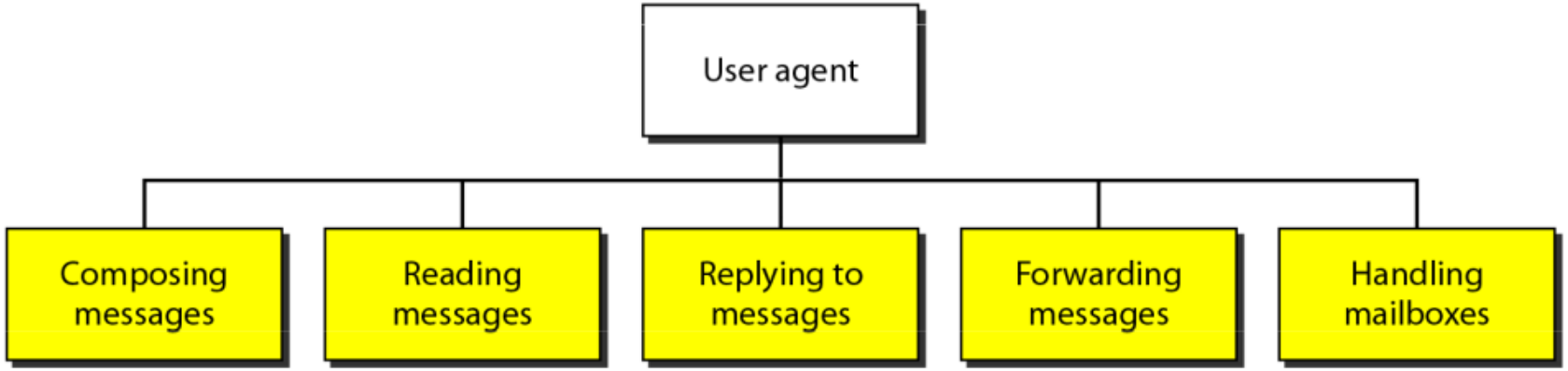
2.2 Electronic Mail

- Message Transfer Agent : Client to Server: Client pushes messages to Server
- Message Access Agent: Server to Client: Client pulls messages from Server



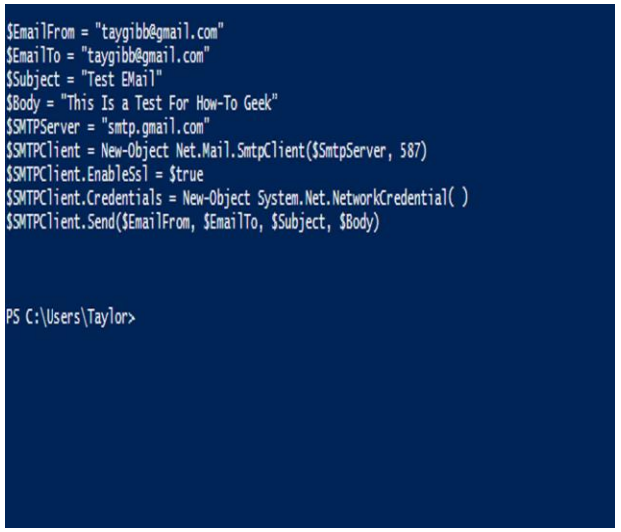
2.2 Electronic Mail

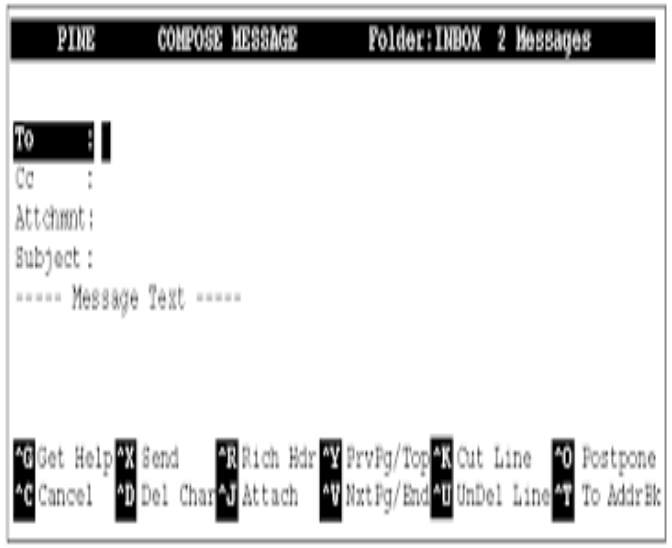
- Services of User Agents:
- Command driven user agents: mail, pine, elm
- GUI based user agents: Eudora, Outlook and Netscape,



2.2 Electronic Mail

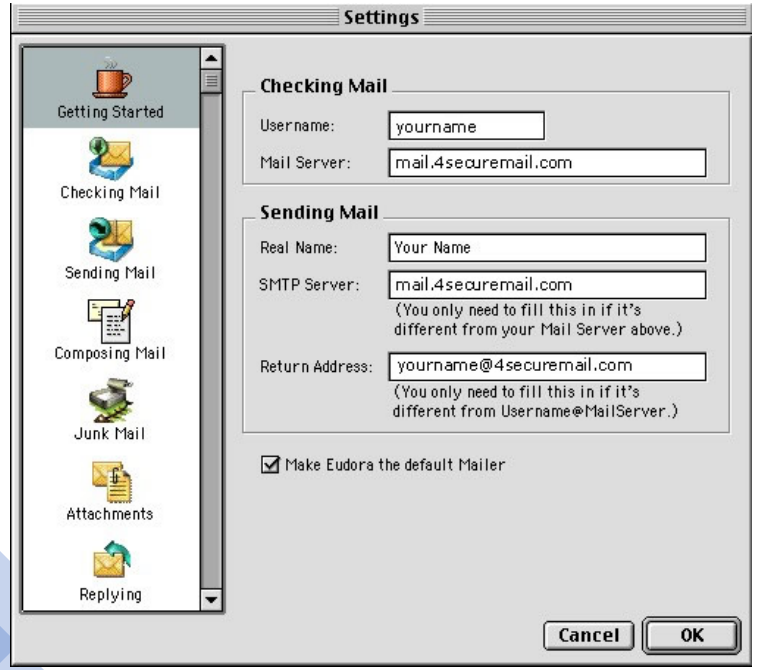
- Services of User Agents:
- **Command driven user agents: mail, pine, elm**
- GUI based user agents: Eudora, Outlook and Netscape,

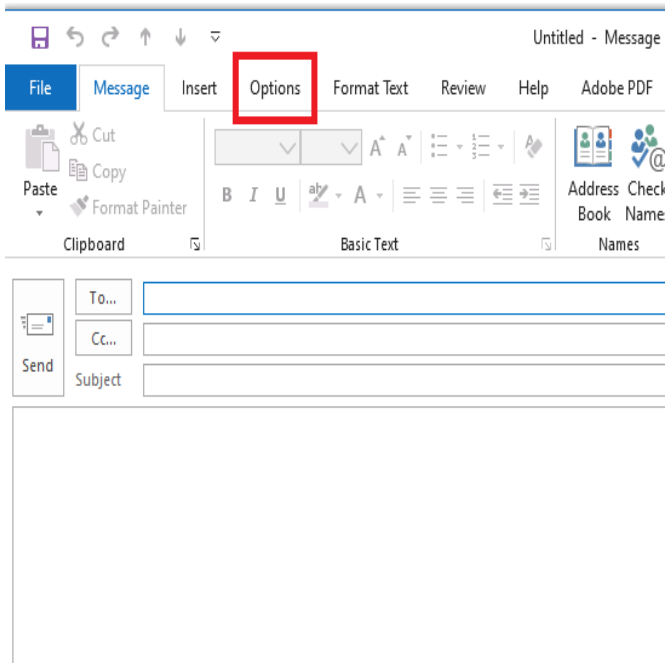


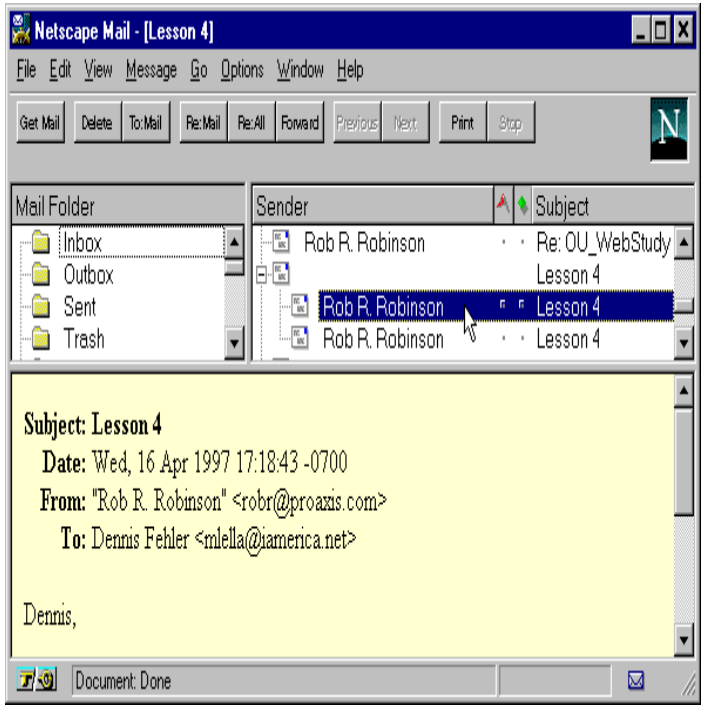


2.2 Electronic Mail

- Services of User Agents:
- Command driven user agents: mail, pine, elm
- **GUI based user agents: Eudora, Outlook and Netscape,**



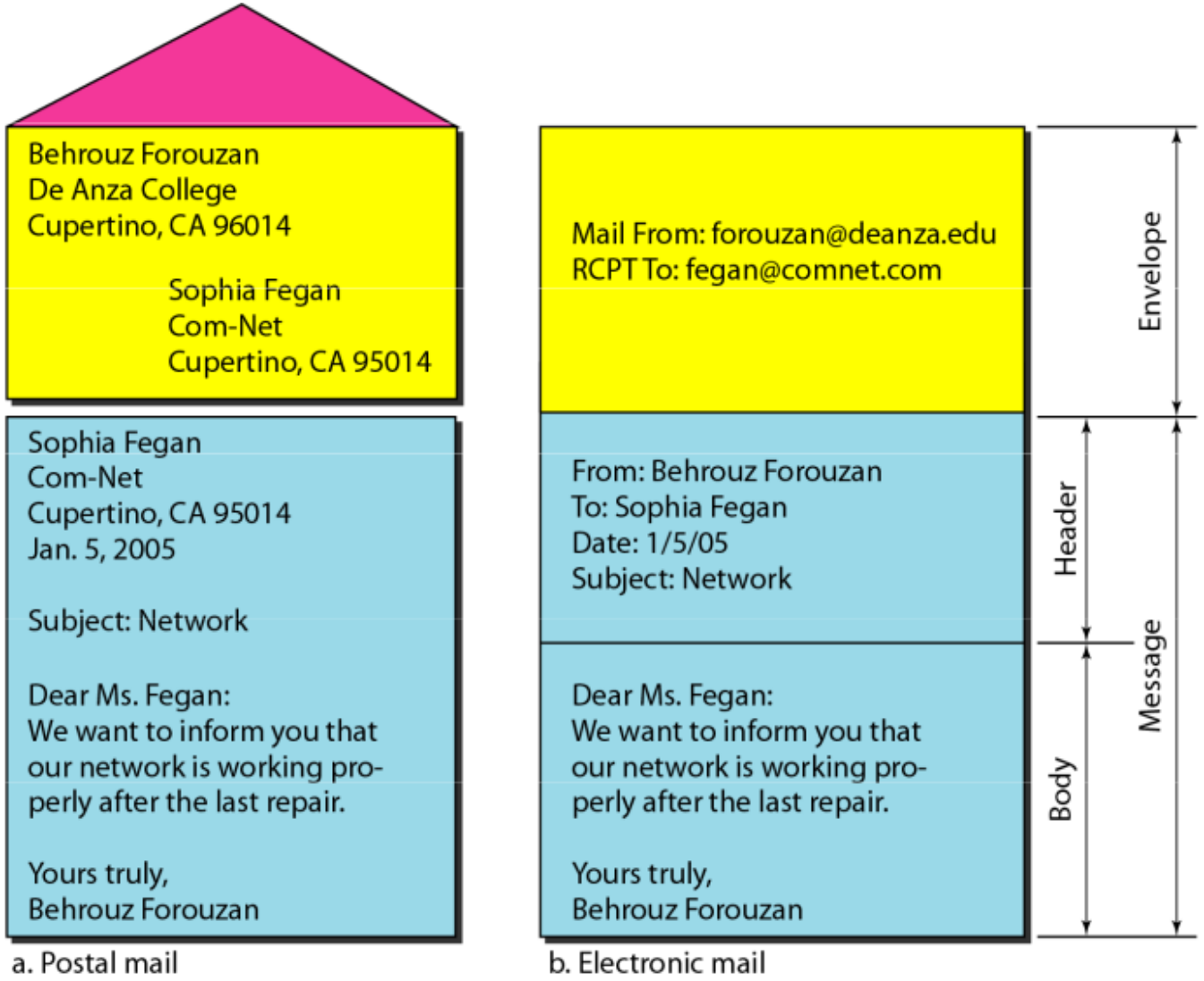




2.2 Electronic Mail

- Format of an Email
- Postal mail and electronic email

Email address:



2.2 Electronic Mail

- Limitations of SMTP (Simple Mail Transfer Protocol)
- SMTP has very simple structure
- It only sends messages in NVT-7 bit ASCII format
- It cannot be used to send languages do not support 7-bit ASCII format (eg: French, German etc)
- It cannot be used to send binary files or video or audio data.

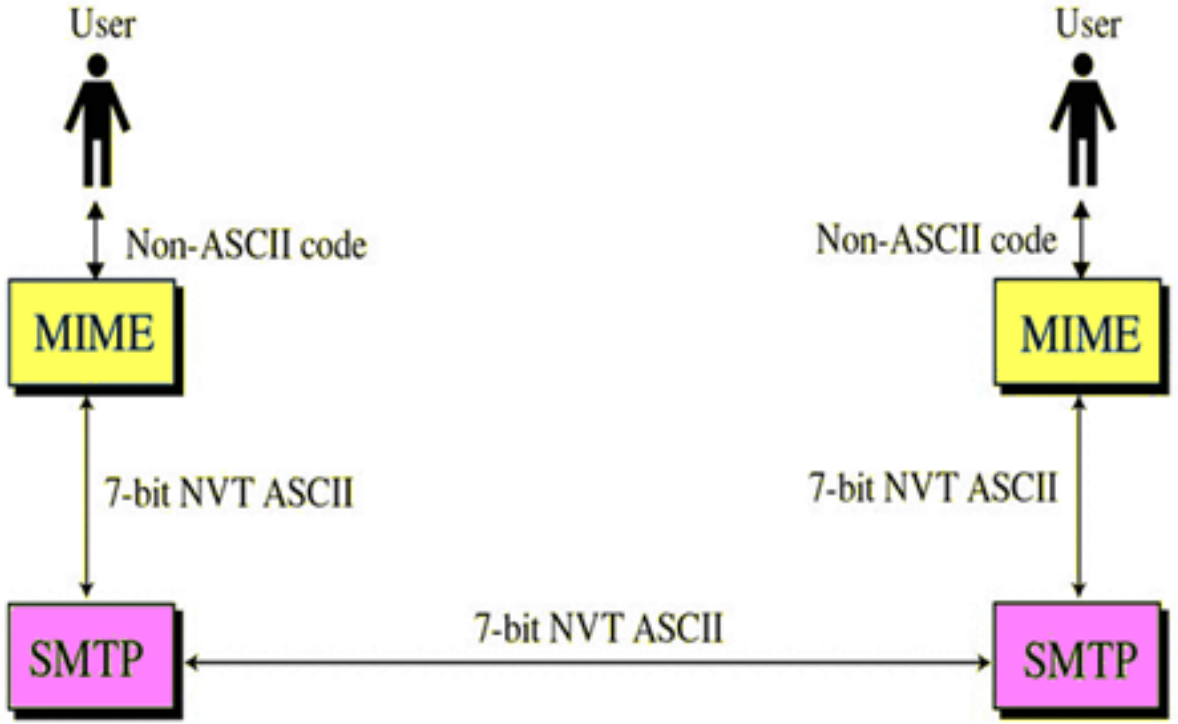
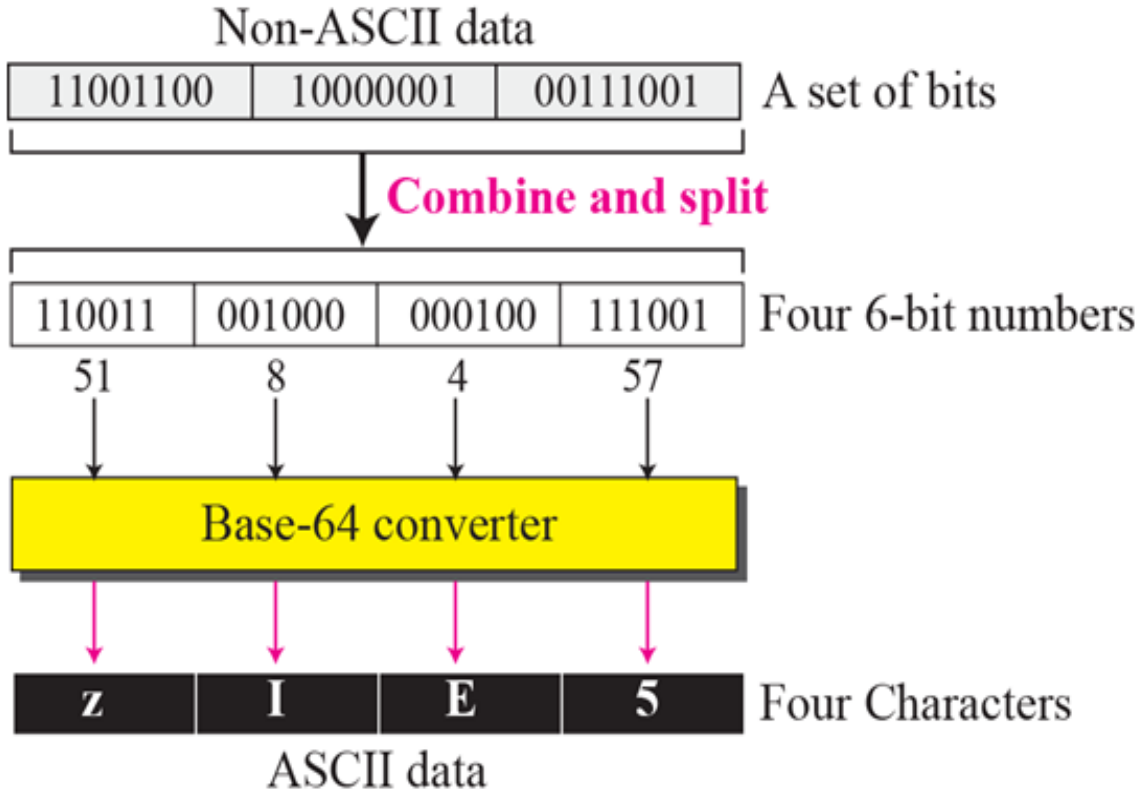


Fig: MIME

2.2 Electronic Mail

- NON ASCII to ASCII
- **ASCII: American Standard Code for Information Interchange**



2.2 Electronic Mail

QUESTION 9: **[2 Marks]**

Answer the following with respect to Multipurpose Internet Mail Extension (MIME) protocol. MIME transforms non-ASCII data at the sender site to NVT ASCII data and transform back to the original data at the receiver site.

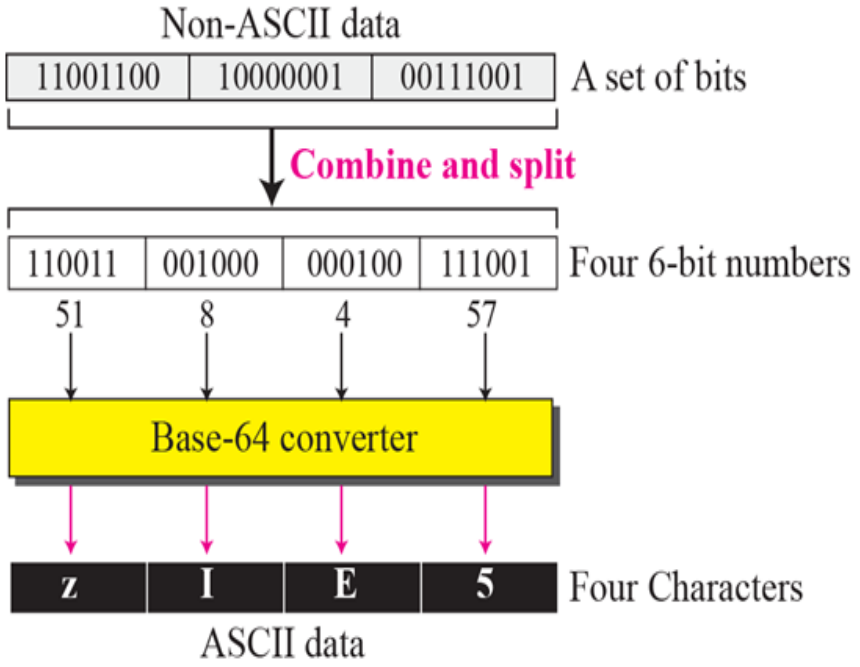
Assuming the usage of **Radix-64 conversion** method for performing Content-Transfer-Encoding in MIME protocol, perform the encoding of the following binary data.

Given binary data: **10110011 00100111 10111001**

Identify the equivalent codes based on the following Radix-64 table.

Table 16.16 *Radix-64 encoding table*

Value	*Code*	*Value*	*Code*	*Value*	*Code*	*Value*	*Code*	*Value*	*Code*	*Value*	*Code*
0	**A**	11	**L**	22	**W**	33	**h**	44	**s**	55	**3**
1	**B**	12	**M**	23	**X**	34	**i**	45	**t**	56	**4**
2	**C**	13	**N**	24	**Y**	35	**j**	46	**u**	57	**5**
3	**D**	14	**O**	25	**Z**	36	**k**	47	**v**	58	**6**
4	**E**	15	**P**	26	**a**	37	**l**	48	**w**	59	**7**
5	**F**	16	**Q**	27	**b**	38	**m**	49	**x**	60	**8**
6	**G**	17	**R**	28	**c**	39	**n**	50	**y**	61	**9**
7	**H**	18	**S**	29	**d**	40	**o**	51	**z**	62	**+**
8	**I**	19	**T**	30	**e**	41	**p**	52	**0**	63	**/**
9	**J**	20	**U**	31	**f**	42	**q**	53	**1**		
10	**K**	21	**V**	32	**g**	43	**r**	54	**2**		

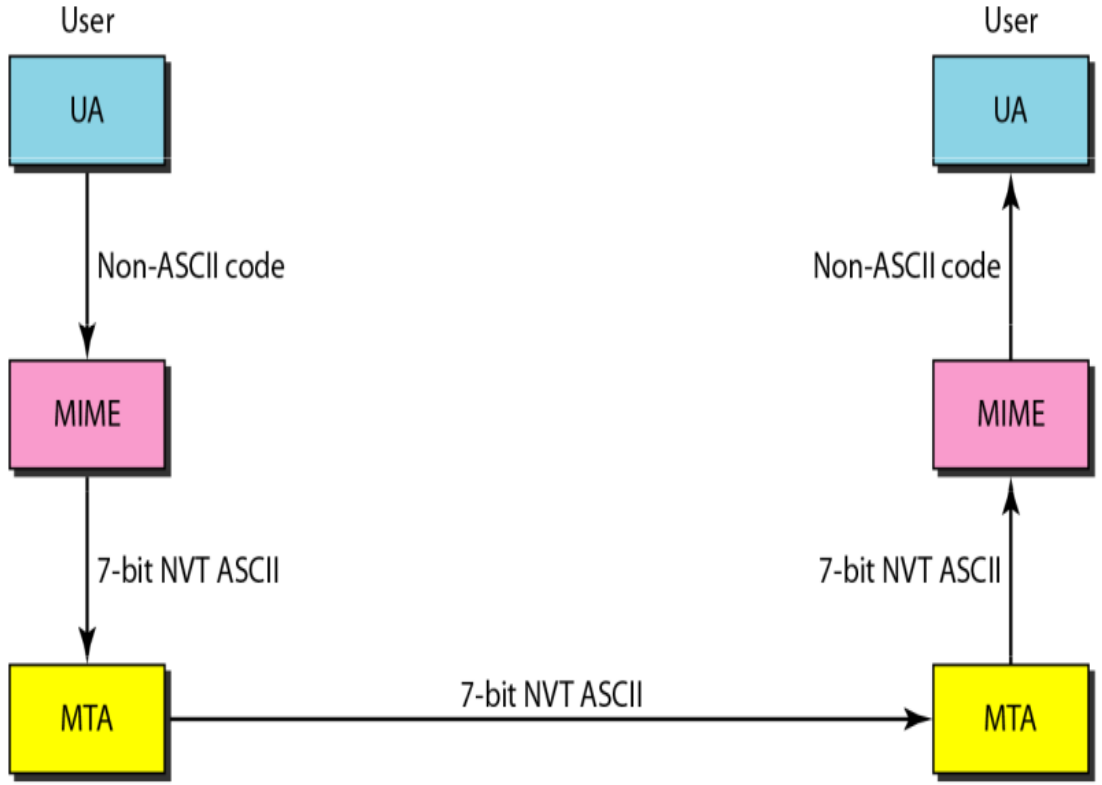


- 10110011 00100111 10111001

101100 110010 011110 111001
44 50 30 57
s y e 5

2.2 Electronic Mail

- MIME: Multipurpose Internet Mail Extension Protocol
- It can send multiple attachments with a single message.
- Unlimited message length
- Binary attachments (executables, images, audio, or video files) may be divided if needed.
- MIME provided support for varying content types and multi-part messages.



2.2 Electronic Mail

- MIME: Multipurpose Internet Mail Extension Protocol
- Header:

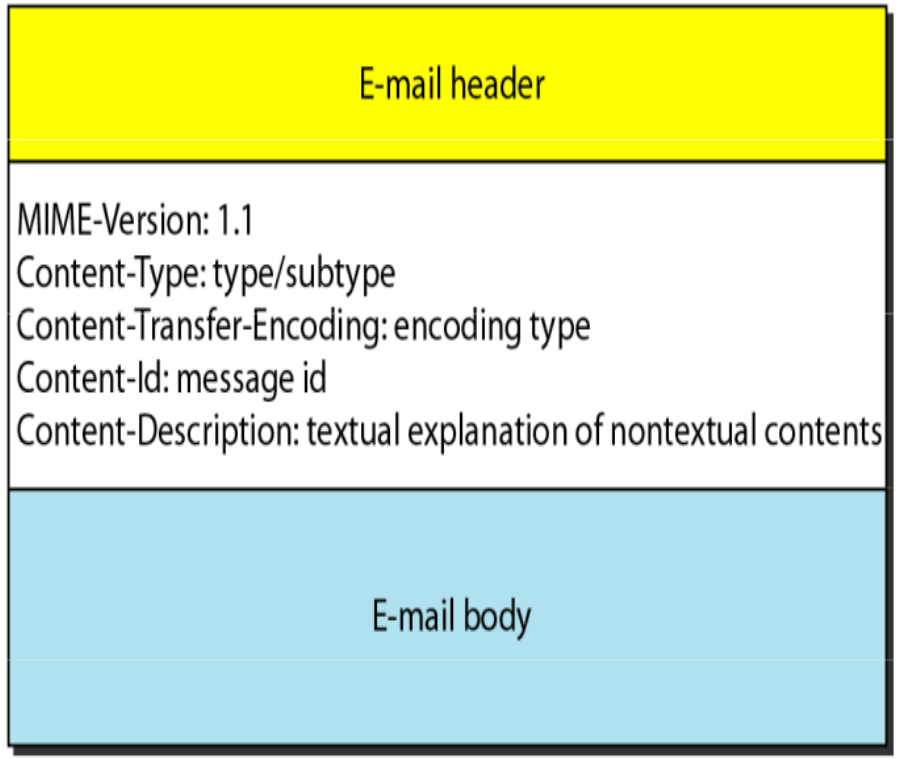


Table 26.5 ***Data types and subtypes in MIME***

Type	*Subtype*	*Description*
Text	Plain	Unformatted
	HTML	HTML format (see Chapter 27)
Multipart	Mixed	Body contains ordered parts of different data types
	Parallel	Same as above, but no order
	Digest	Similar to mixed subtypes, but the default is message/ RFC822
	Alternative	Parts are different versions of the same message
Message	RFC822	Body is an encapsulated message
	Partial	Body is a fragment of a bigger message
	External-Body	Body is a reference to another message
Image	JPEG	Image is in JPEG format
	GIF	Image is in GIF format
Video	MPEG	Video is in MPEG format
Audio	Basic	Single-channel encoding of voice at 8 kHz
Application	PostScript	Adobe PostScript
	Octet-stream	General binary data (8-bit bytes)

2.2 Electronic Mail

- MIME: Multipurpose Internet Mail Extension Protocol
- Header:

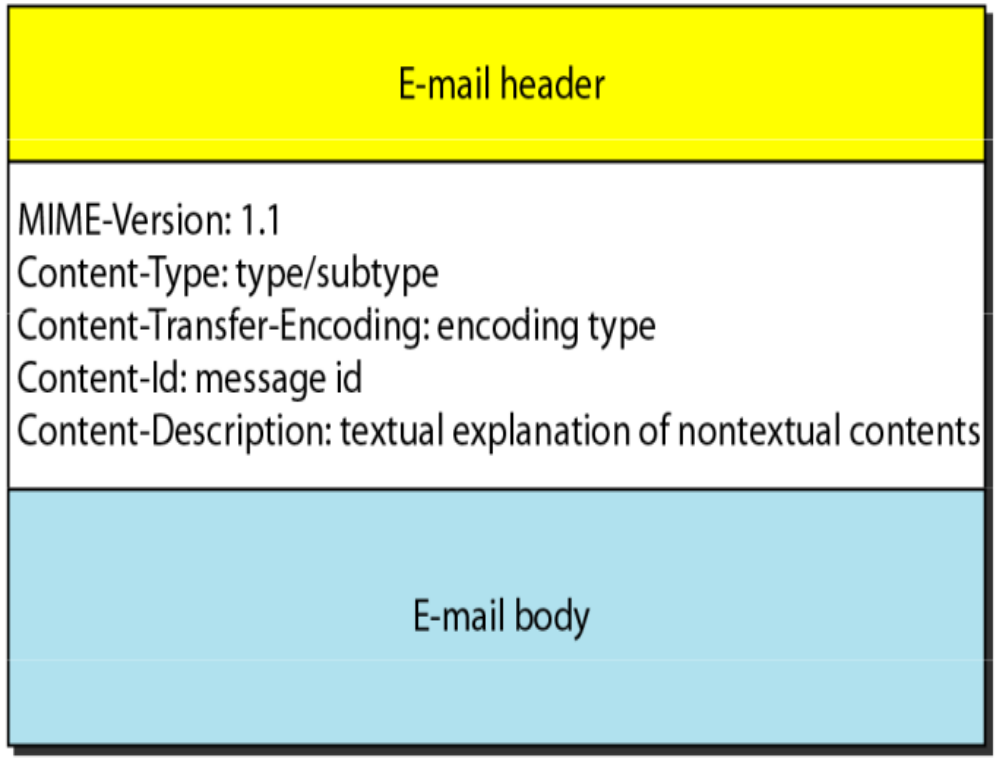
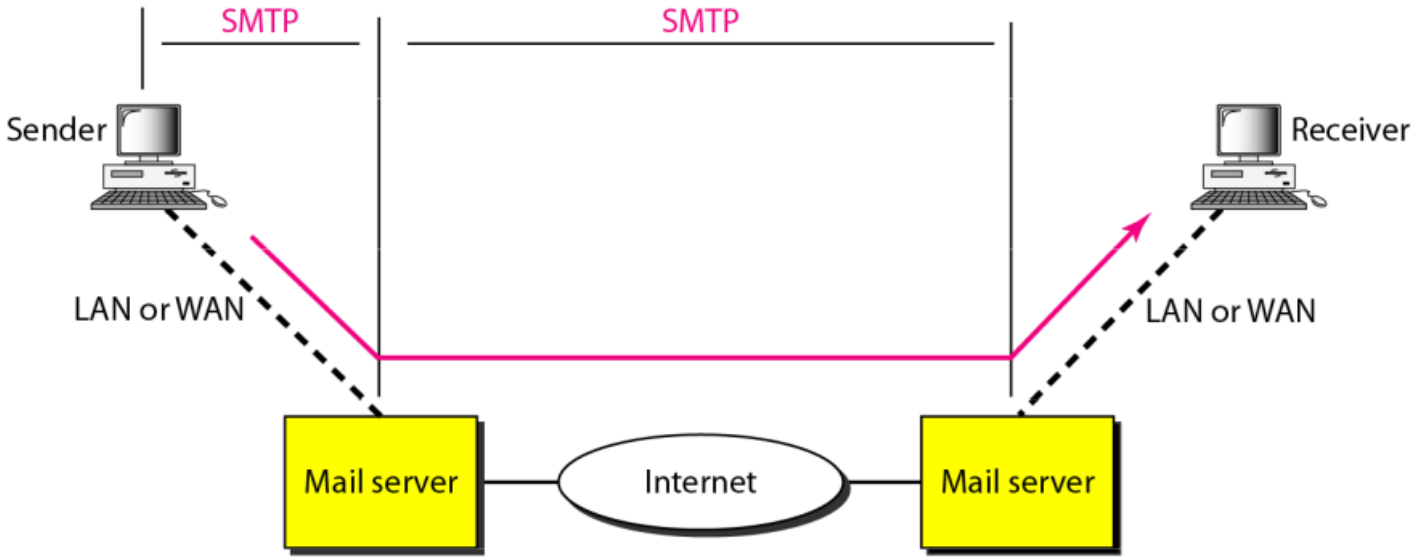


Table 26.6 *Content-transfer-encoding*

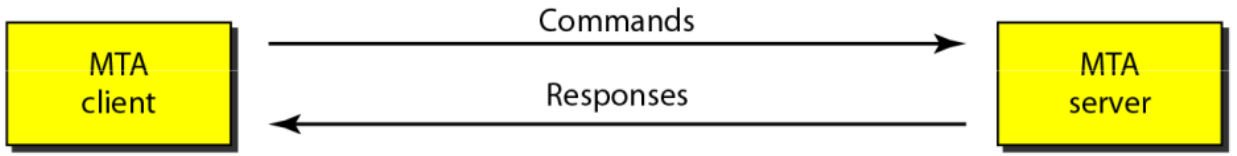
Type	*Description*
7-bit	NVT ASCII characters and short lines
8-bit	Non-ASCII characters and short lines
Binary	Non-ASCII characters with unlimited-length lines
Base-64	6-bit blocks of data encoded into 8-bit ASCII characters
Quoted-printable	Non-ASCII characters encoded as an equals sign followed by an ASCII code

2.2 Electronic Mail

- SMTP Range



Commands and Responses



2.2 Electronic Mail

- SMTP

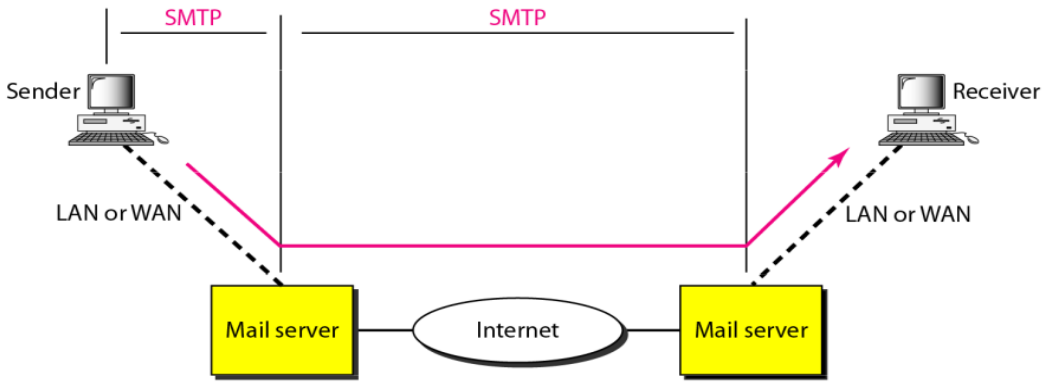


Table 26.7 *Commands*

Keyword	*Argument(s)*
HELO	Sender's host name
MAIL FROM	Sender of the message
RCPT TO	Intended recipient of the message
DATA	Body of the mail
QUIT	
RSET	
VRFY	Name of recipient to be verified
NOOP	
TURN	
EXPN	Mailing list to be expanded
HELP	Command name
SEND FROM	Intended recipient of the message
SMOL FROM	Intended recipient of the message
SMAL FROM	Intended recipient of the message

2.2 Electronic Mail

- SMTP

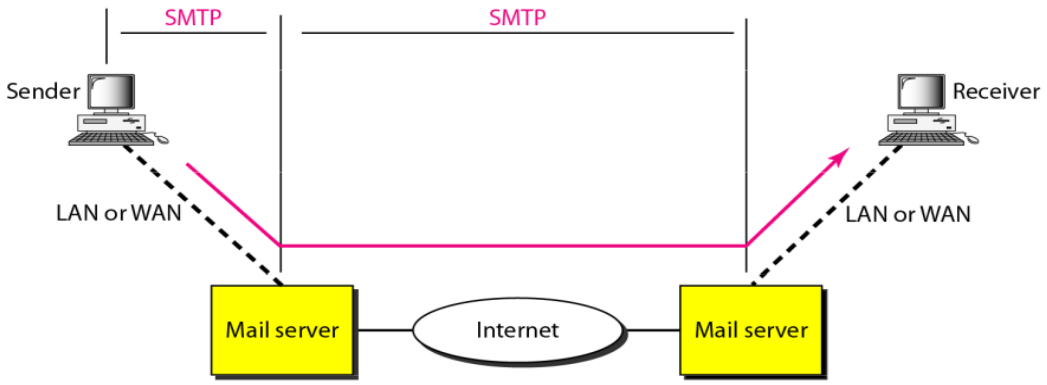


Table 26.8 ***Responses*** ***(continued)***

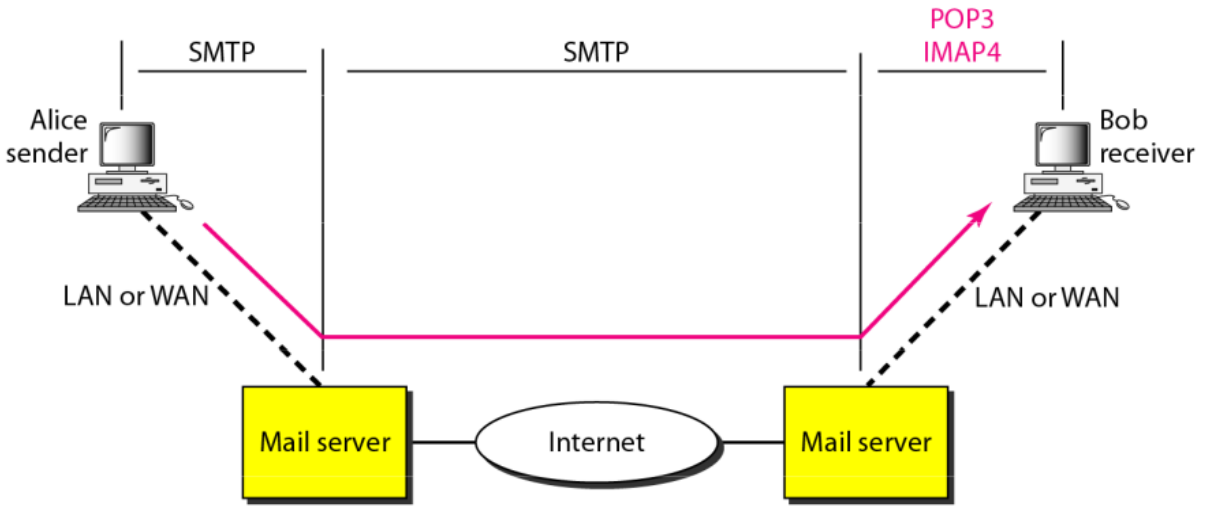
Code	*Description*
	Permanent Negative Completion Reply
500	Syntax error; unrecognized command
501	Syntax error in parameters or arguments
502	Command not implemented
503	Bad sequence of commands
504	Command temporarily not implemented
550	Command is not executed; mailbox unavailable
551	User not local
552	Requested action aborted; exceeded storage location
553	Requested action not taken; mailbox name not allowed
554	Transaction failed

Table 26.8 ***Responses***

Code	*Description*
	Positive Completion Reply
211	System status or help reply
214	Help message
220	Service ready
221	Service closing transmission channel
250	Request command completed
251	User not local; the message will be forwarded
	Positive Intermediate Reply
354	Start mail input
	Transient Negative Completion Reply
421	Service not available
450	Mailbox not available
451	Command aborted: local error
452	Command aborted: insufficient storage

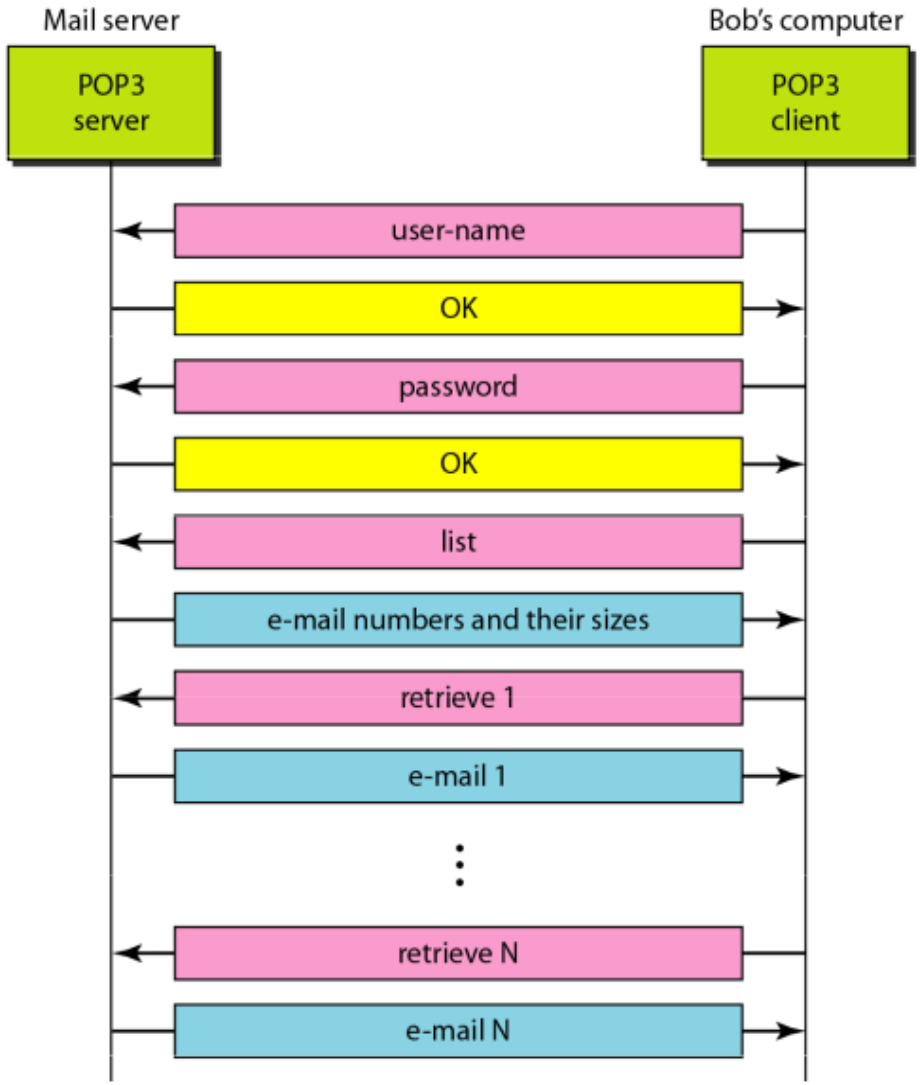
2.2 Electronic Mail

- POP 3 and IMAP4
- **POP 3 (Post Office Protocol 3)**
- It is a standard mail protocol used to receive emails from a remote server to a local email client.
- All emails will be downloaded to your local computer
- IMAP: Internet Message Access Protocol
- IMAP is a standard protocol for accessing e-mail from your local server.
- IMAP is client server protocol.
- Downloads email only when requested to read the email



2.2 Electronic Mail

- POP 3
- It is a standard mail protocol used to receive emails from a remote server to a local email client.
- Exchange of commands and response in POP3



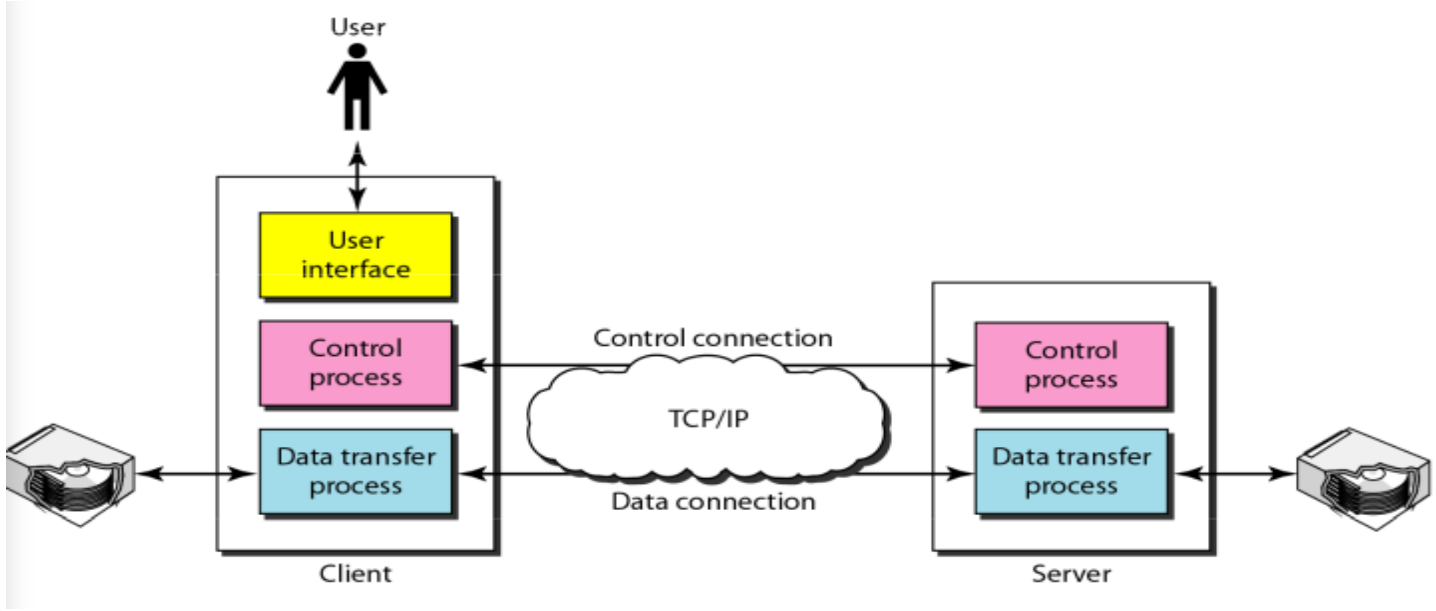
2.2 Electronic Mail

- POP 3 vs IMAP

	POP3	IMAP
Name	Post Office Protocol	Internet Messaging Access Protocol
Method	Always download new emails to local storage	Only message summary are downloaded until the message is selected
Email inbox	All mails are downloaded into Inbox folder	Preserves a main folder "imap.hyperoffice.com"
Access	Can only be accessed by one computer	Email can be manipulated to multiple devices
Storage	Emails are deleted from server once it is successfully downloaded by user	Emails are kept in server storage until the user decides to delete it
Port number used	110	143

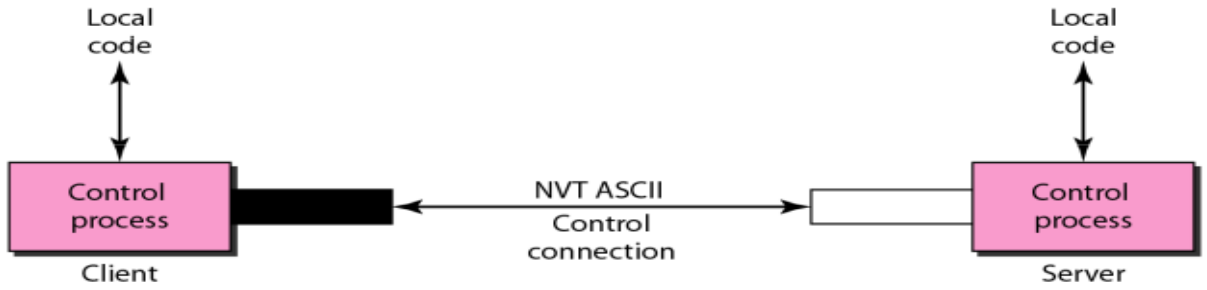
2.3 File Transfer (FTP)

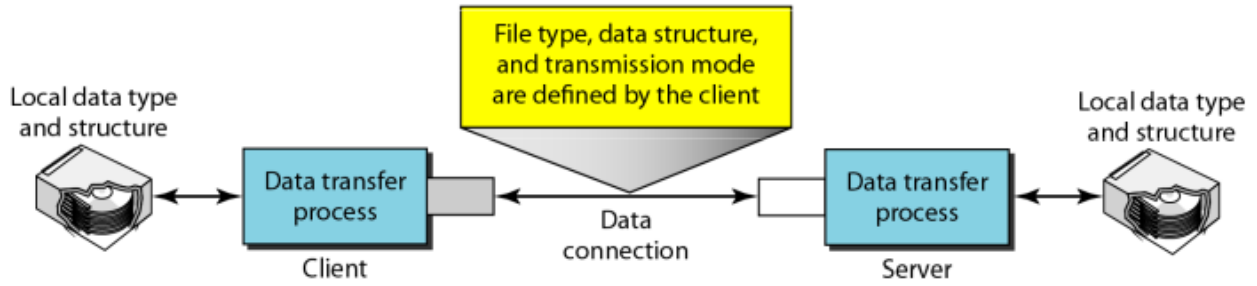
- Transferring files from one computer to another is one of the most common tasks expected from a networking or internetworking environment. As a matter of fact, the greatest volume of data exchange in the Internet today is due to file transfer.
- FTP: It uses the services of TCP . It needs two TCP connections
- The well-known port 21 is used for the control connection and the well- known port 20 is used for the data connection.



2.3 File Transfer (FTP)

- FTP: It uses the services of TCP . It needs two TCP connections
- The well-known port 21 is used for the control connection and the well-known port 20 is used for the data connection.





2.3 File Transfer (FTP)

1. After control connection FTP Sends 220 response.
2. The client sends name
3. The server responds with 331
4. Client sends password
5. Server responds with 230
6. Client sends ls reports command
7. Server responds with 150 and opens data connection
8. Server sends result of ls command
9. Client sends Quit
10. Server responds with 221

```
$ ftp voyager.deanza.fhda.edu
Connected to voyager.deanza.fhda.edu.
220 (vsFTPd 1.2.1)
530 Please login with USER and PASS.
Name (voyager.deanza.fhda.edu:forouzan): forouzan
331 Please specify the password.
Password:
230 Login successful.
Remote system type is UNIX.
Using binary mode to transfer files.
ftp> ls reports
227 Entering Passive Mode (153,18,17,11,238,169)
150 Here comes the directory listing.
drwxr-xr-x    2 3027     411          4096 Sep 24  2002 business
drwxr-xr-x    2 3027     411          4096 Sep 24  2002 personal
drwxr-xr-x    2 3027     411          4096 Sep 24  2002 school
226 Directory send OK.
ftp> quit
221 Goodbye.
```

2.3 File Transfer (FTP)

Anonymous File Transfer Protocol (FTP) **enables remote users to use the FTP server without an assigned user ID and password**.

```
$ ftp internic.net
Connected to internic.net
220 Server ready
Name: anonymous
331 Guest login OK, send "guest" as password
Password: guest
ftp > pwd
257 '/' is current directory
ftp > ls
200 OK
150 Opening ASCII mode
bin
. . .
. . .
. . .
ftp > close
221 Goodbye
ftp > quit
```

Reference

- “Data Communications and Networking”, Behrouz A. Forouzan, 5th Edition, McGraw Hill, 2017.

Thank You