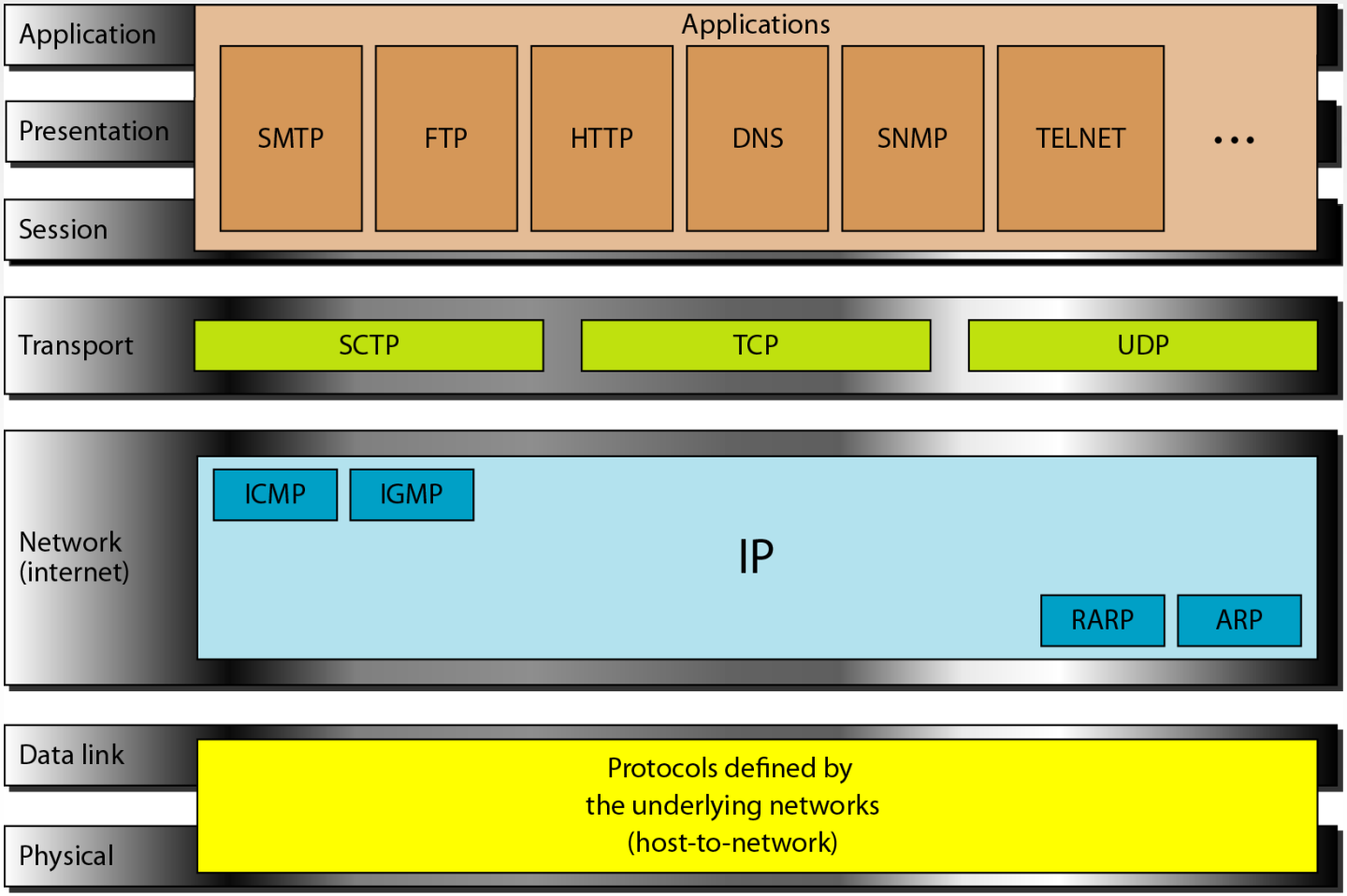
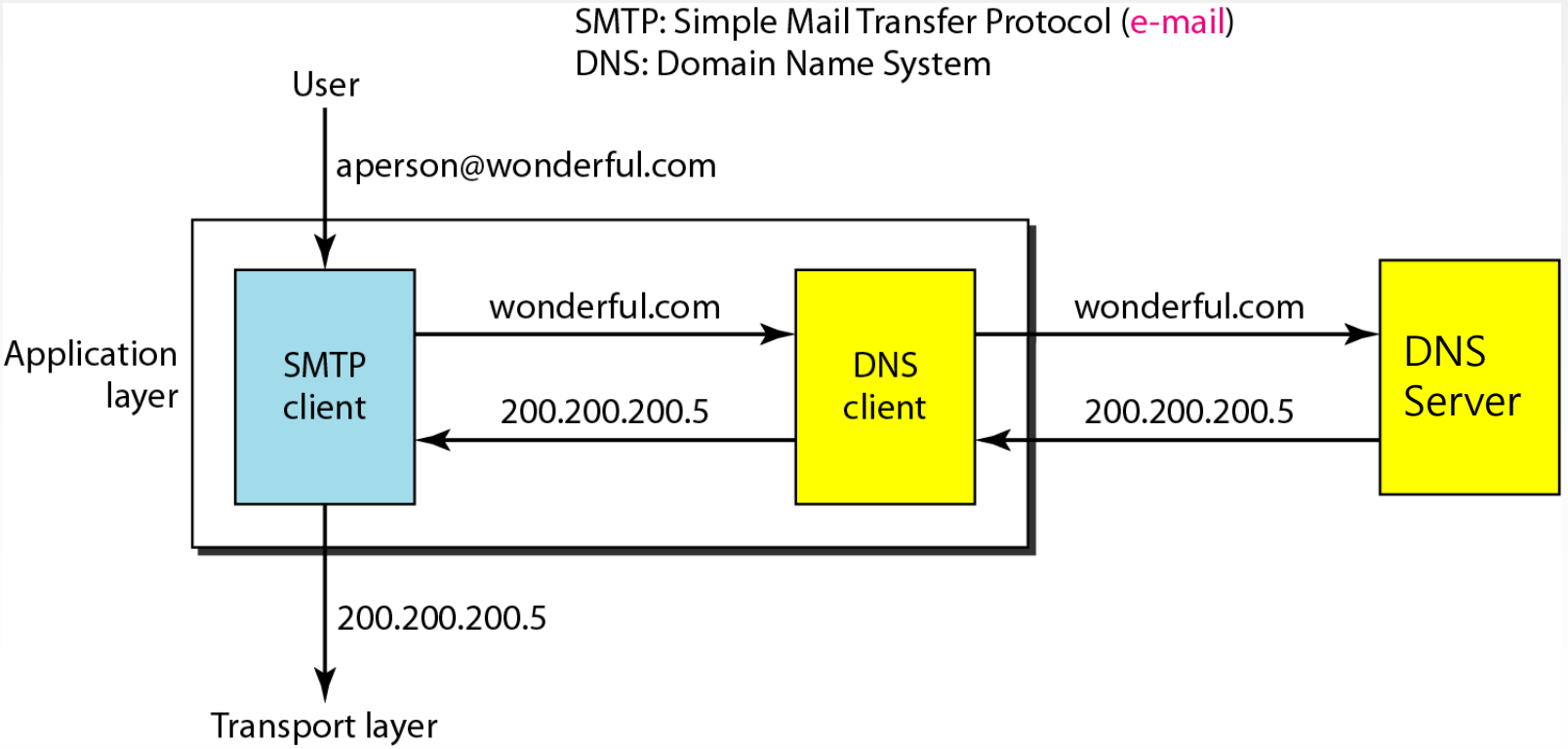
Application Layer

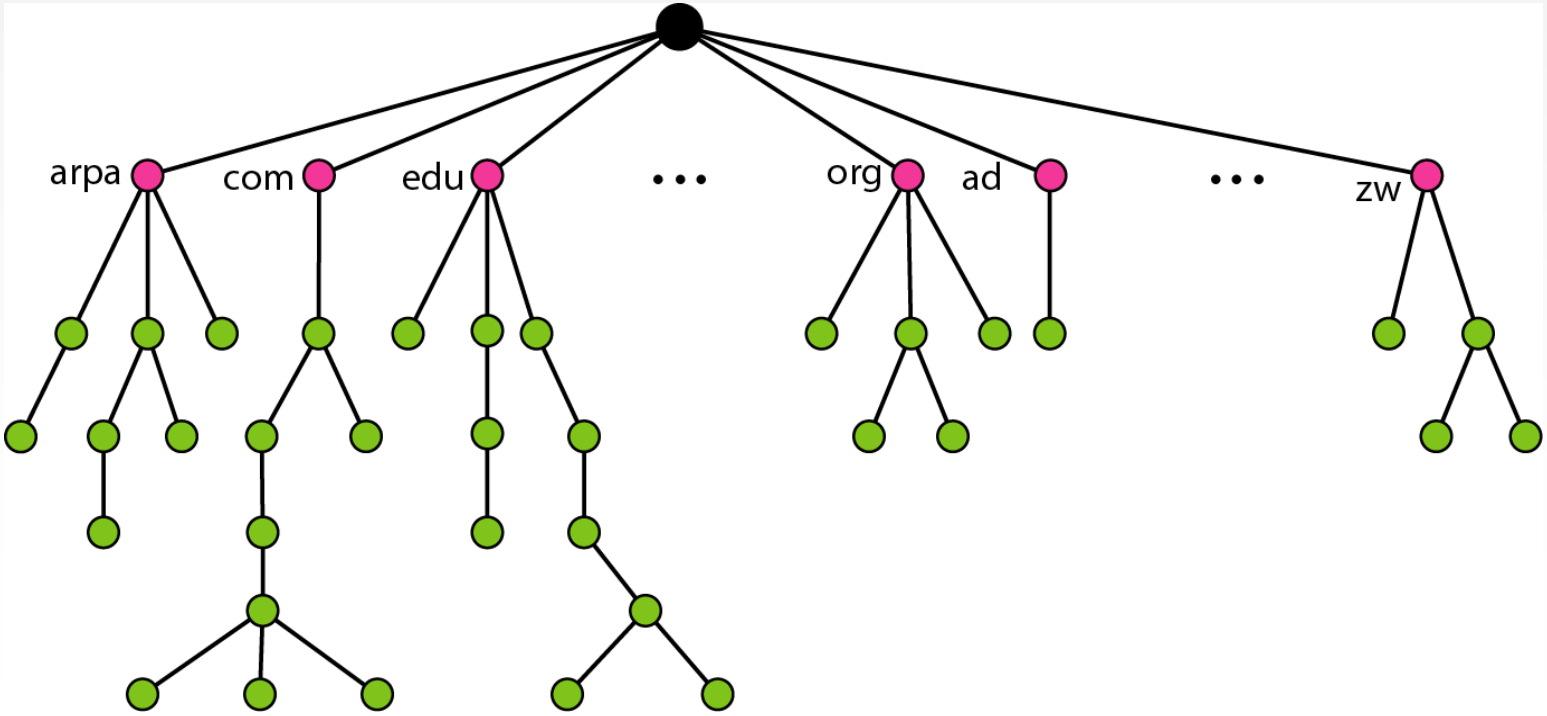

Application
Presentation
Session
Applications
SMTP
FTP
HTTP
DNS
SNMP
TELNET
• • •
Transport
SCTP
TCP
UDP
Network
(internet)
ICMP
IGMP
IP
RARP
ARP
Data link
Physical
Protocols defined by
the underlying networks
(host-to-network)

Example of using the DNS service

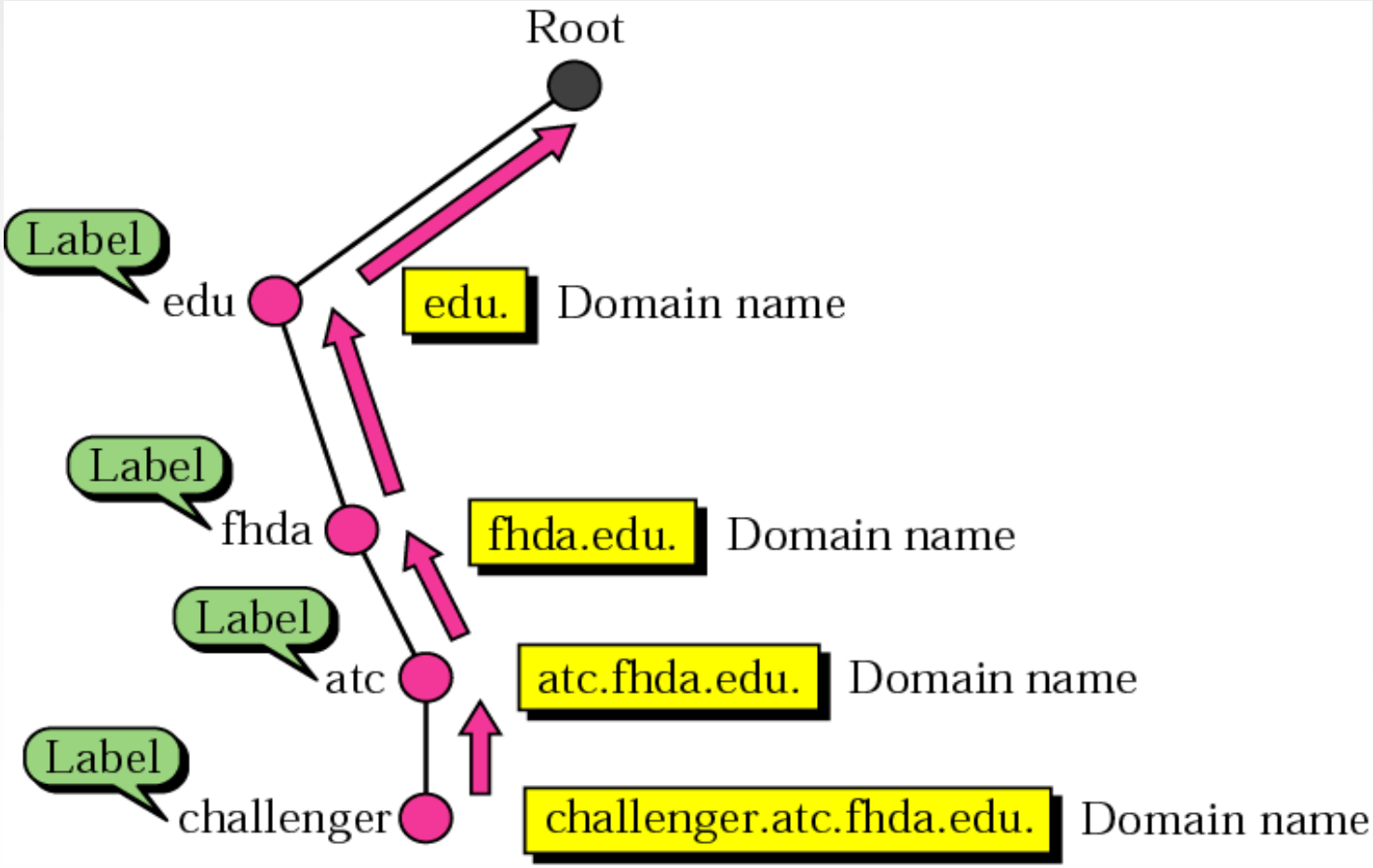


Domain Name Space

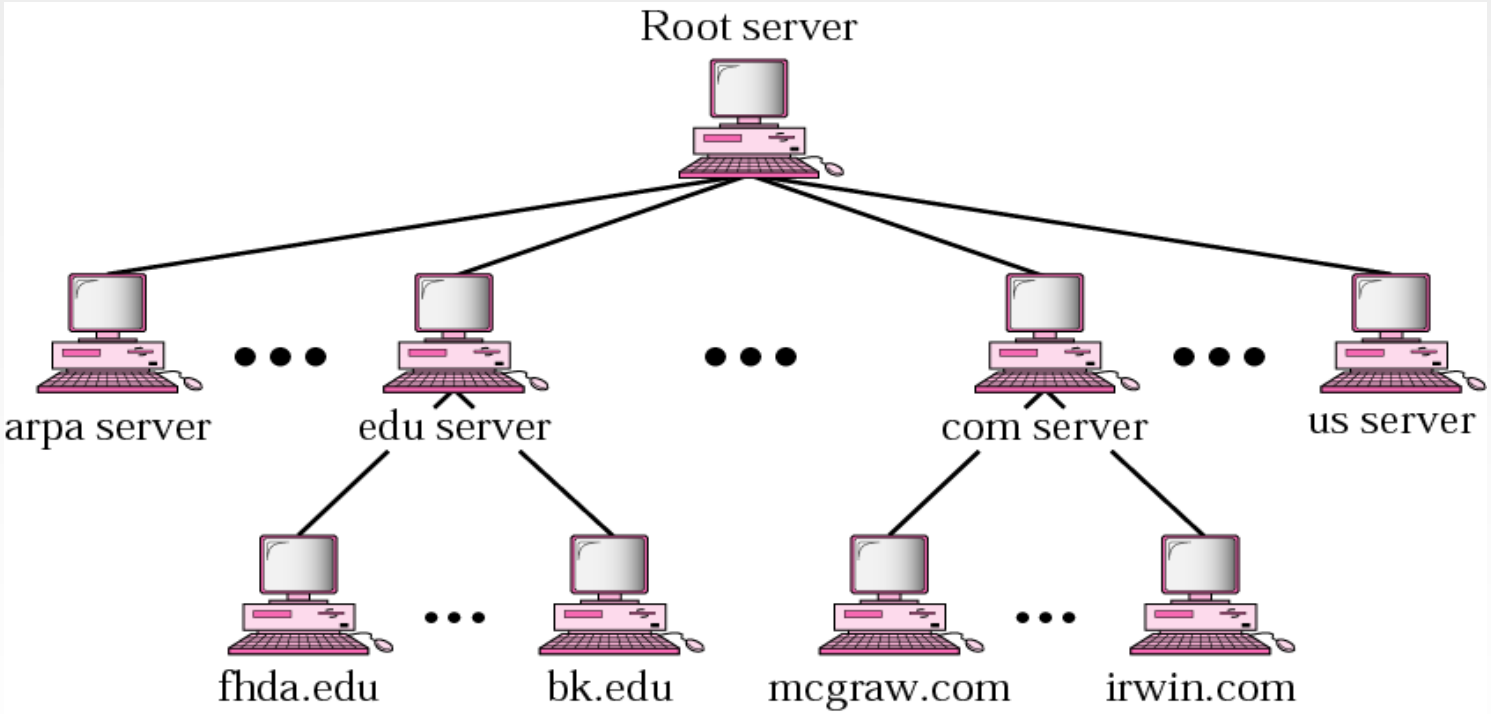
- Host File
- Flat name space, Hierarchical name space



Domain Names and Labels



Hierarchy of Name Servers

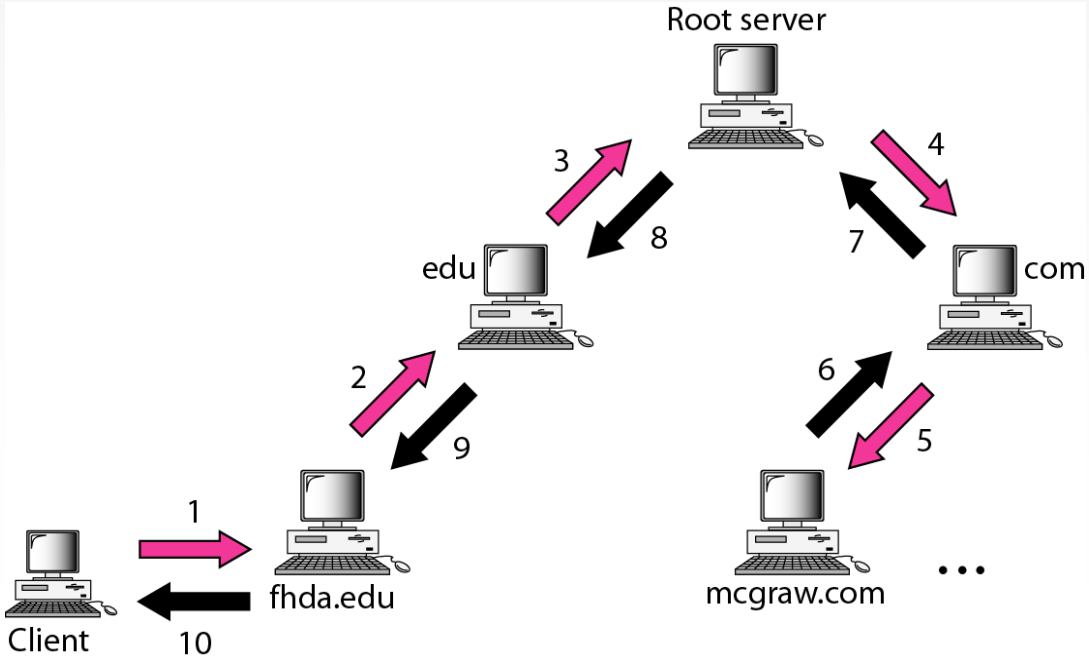


Generic Domain Labels

Label	*Description*
aero	Airlines and aerospace companies
biz	Businesses or firms (similar to "com")
com	Commercial organizations
coop	Cooperative business organizations
edu	Educational institutions
gov	Government institutions
info	Information service providers
int	International organizations
mil	Military groups
museum	Museums and other nonprofit organizations
name	Personal names (individuals)
net	Network support centers
org	Nonprofit organizations
pro	Professional individual organizations

Resolution

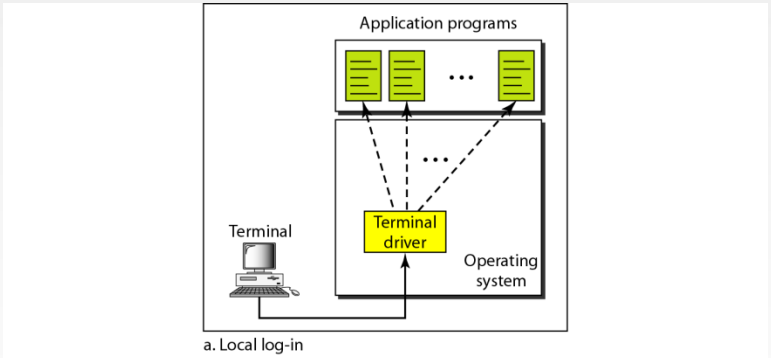
- Name-address resolution: a name to address/an address to a name
- Resolver: DNS client called by a host
- **Recursive resolution** and iterative resolution



Remote Logging, Electronic Mail and File Transfer

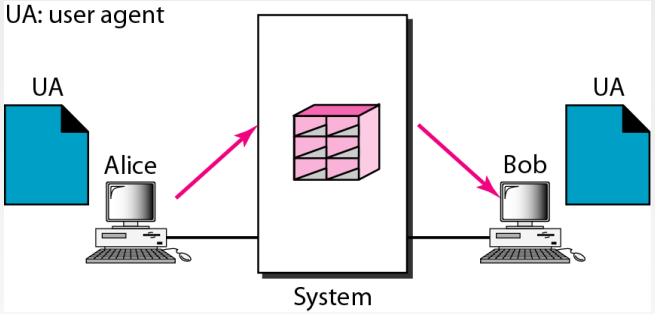
TELNET: Remote Logging

- TELNET is a general-purpose client/server application program

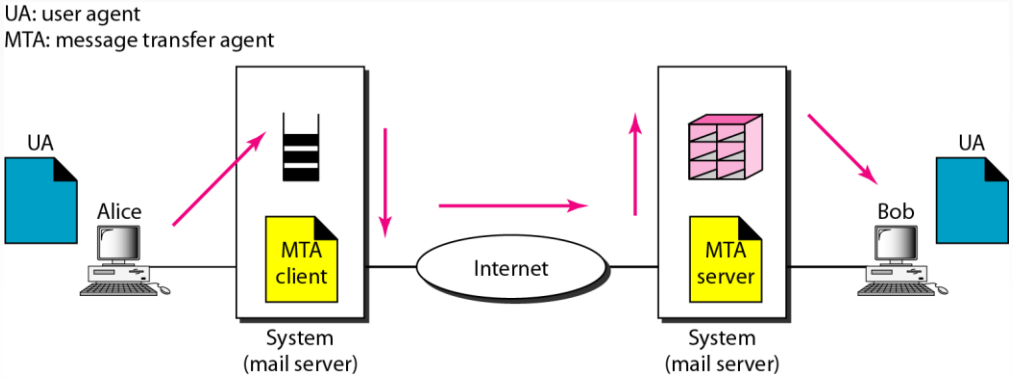


Electronic Mail:

- When the sender and the receiver of an e-mail are on the same system, we need only two user agents

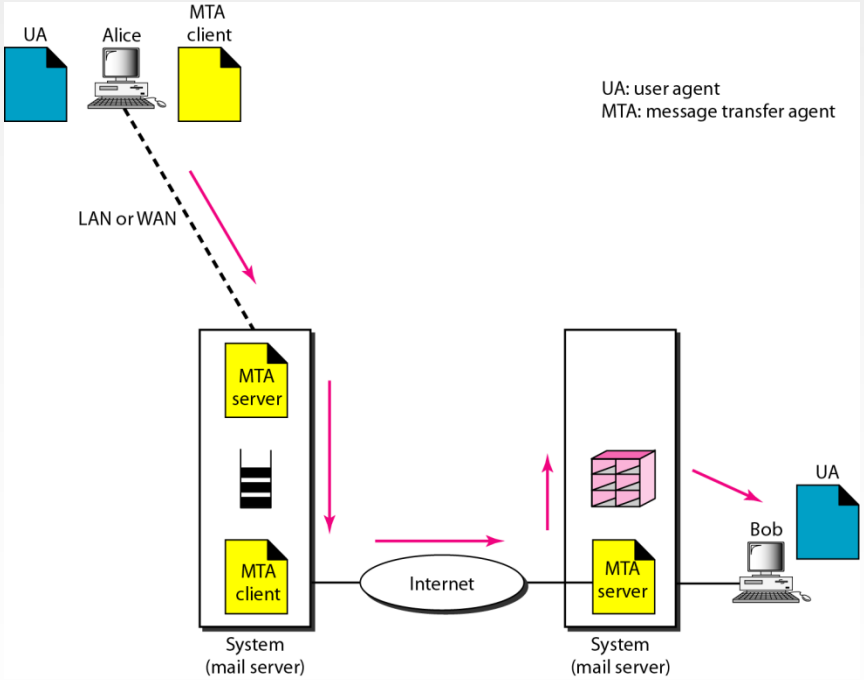


- When the sender and the receiver of an e-mail are on different systems, we need two UAs and a pair of MTAs (client and server).



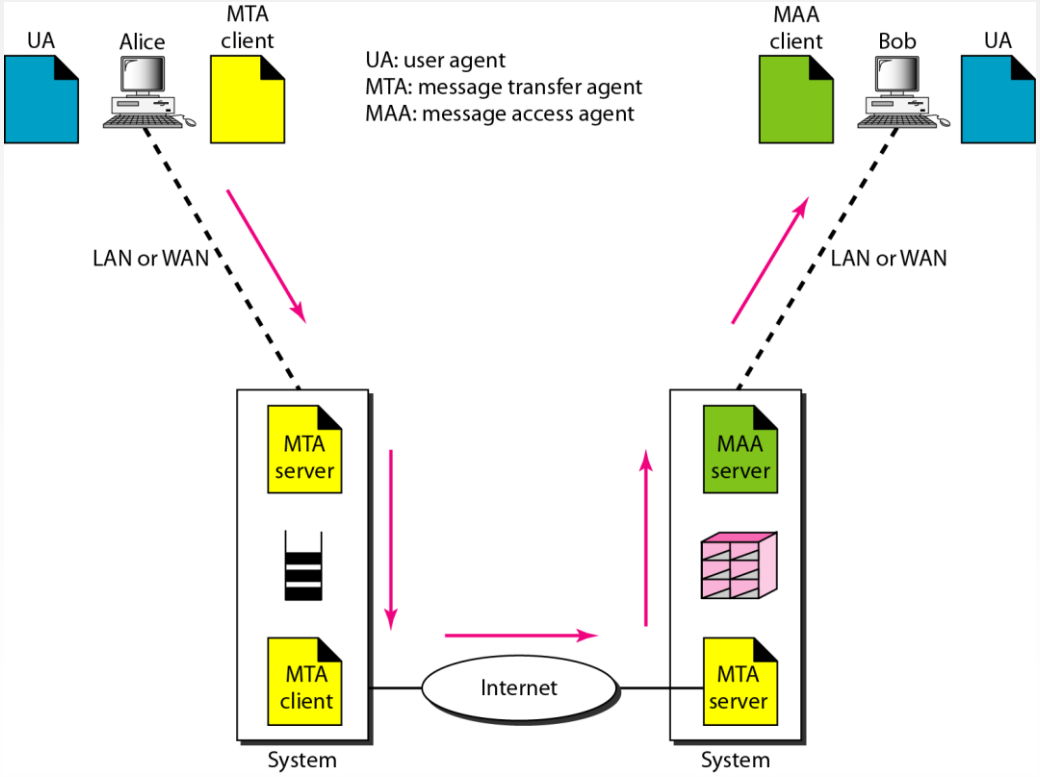
Electronic Mail (3)

- When the sender is connected to the mail server via a LAN or a WAN, we need two UAs and two pairs of MTAs



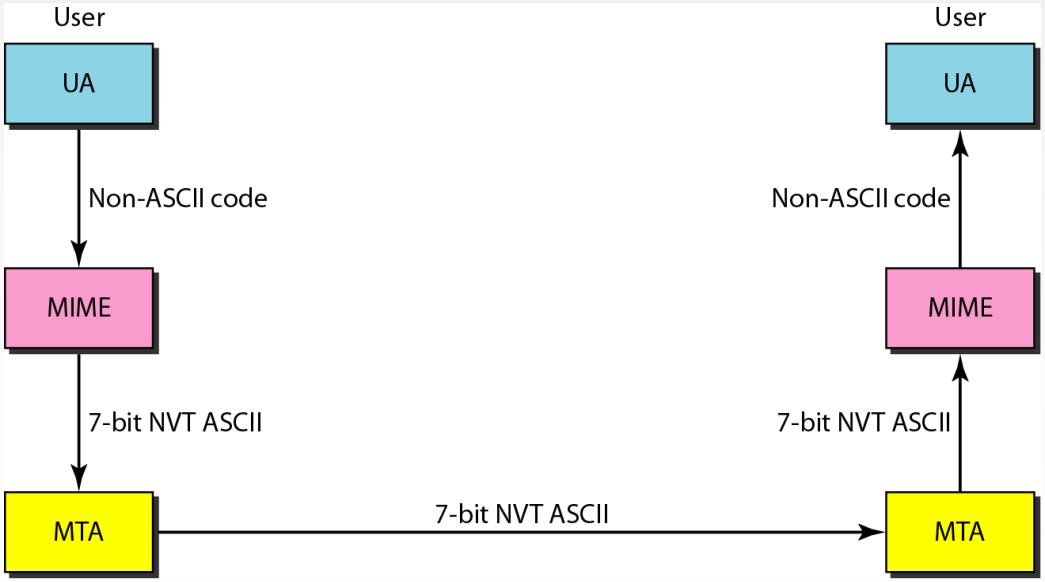
Electronic Mail (4)

- When both sender and receiver are connected to the mail server via a LAN or a WAN, we need two UAs, two pairs of MTAs and a pair of MAAs. This is the most common situation today.



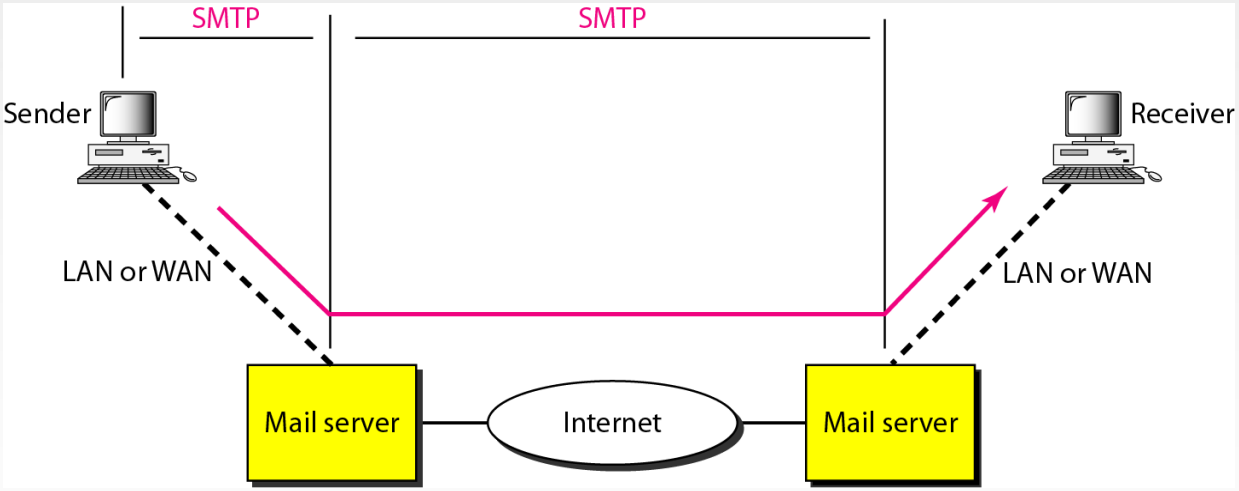
MIME

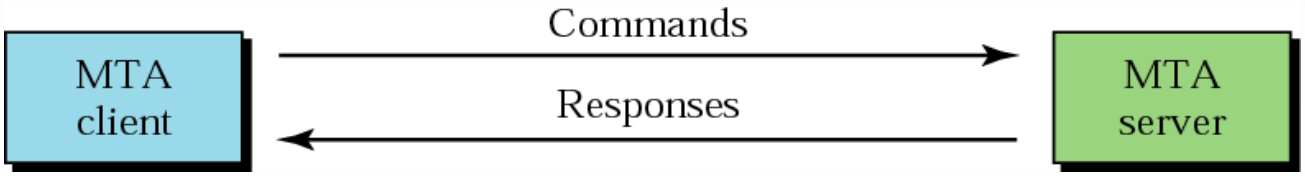
- Multipurpose Internet mail Extensions (MIME)
- Supplementary protocol that allows non-ASCII data to be sent through SMTP



Mail Transfer Agent (MTA): SMTP

- The actual mail transfer is done through MTA

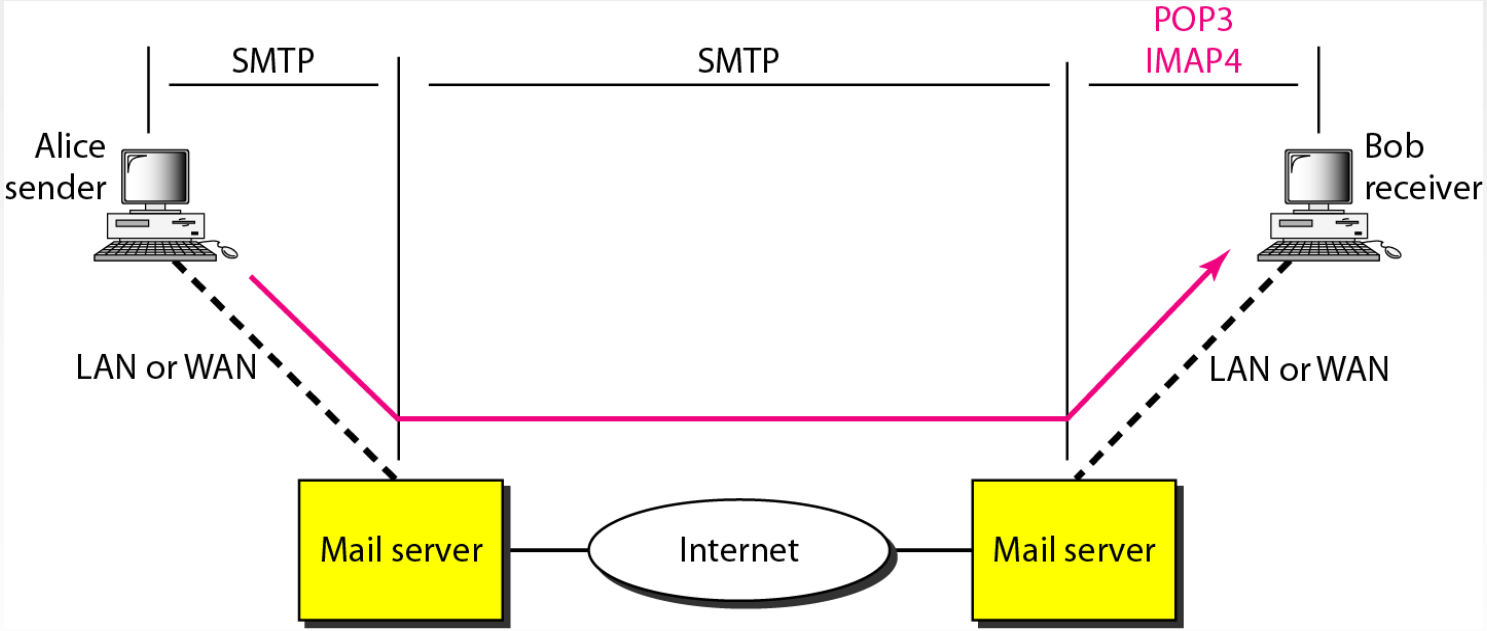




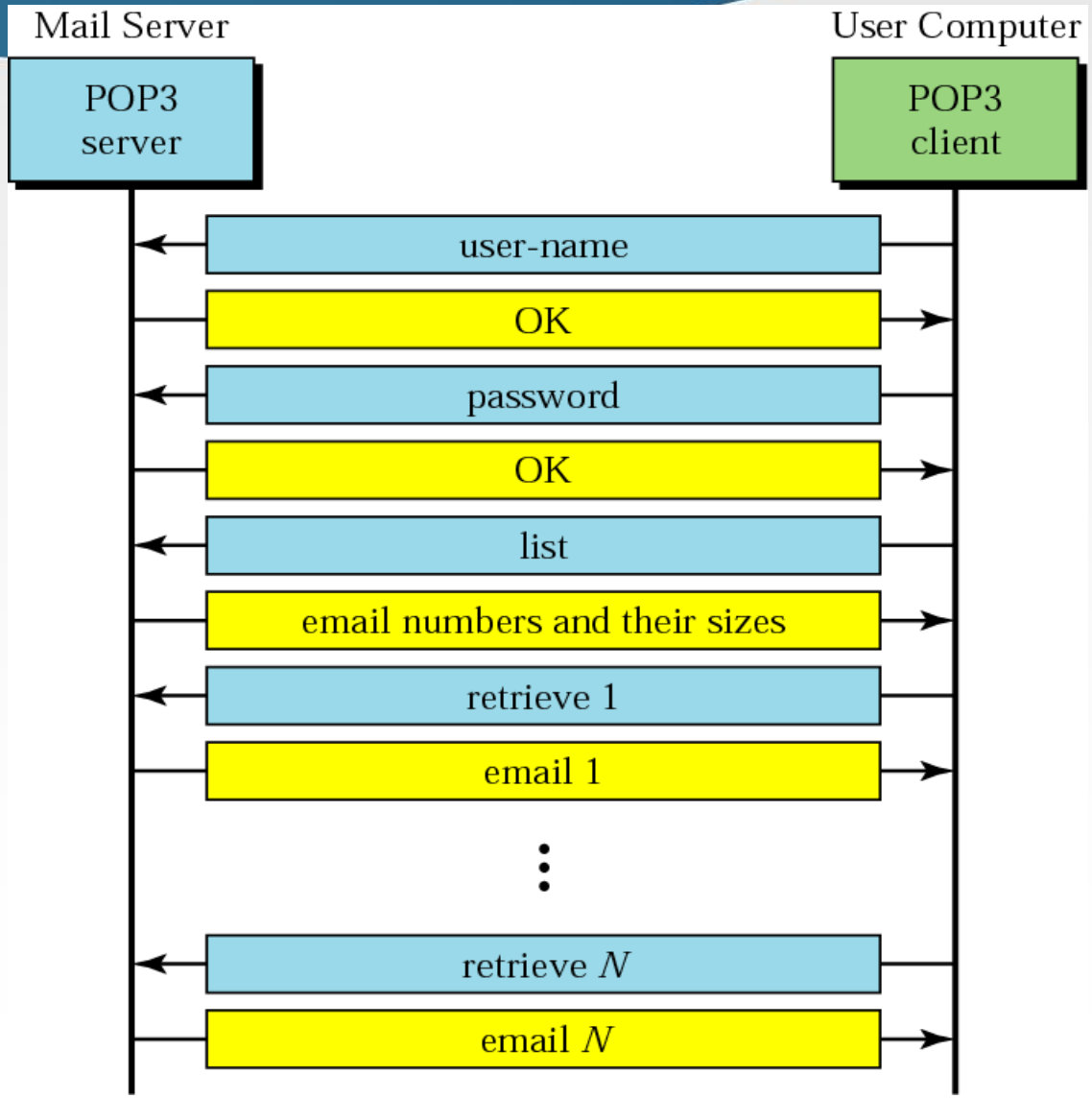
Mail Access Agent: POP and IMAP

- The third stage: pull protocol (SMTP is a push protocol for the first/second stages)
- Two mail access protocols
  - Post Office Protocol, version 3 (POP3)
  - Internet Mail Access Protocol, version 4 (IMAP4)
- POP3 is simple and limited in functionality
- IMAP4 is similar to POP3, but has more features with extra functions
  - A user can check the email header prior to downloading
  - A user can search the contents of the email for a specific string of characters prior to downloading
  - A user can create, delete, or rename mailboxes on the mail server
  - A user can create a hierarchy of mailboxes in a folder for email storage

POP3 and IMAP4

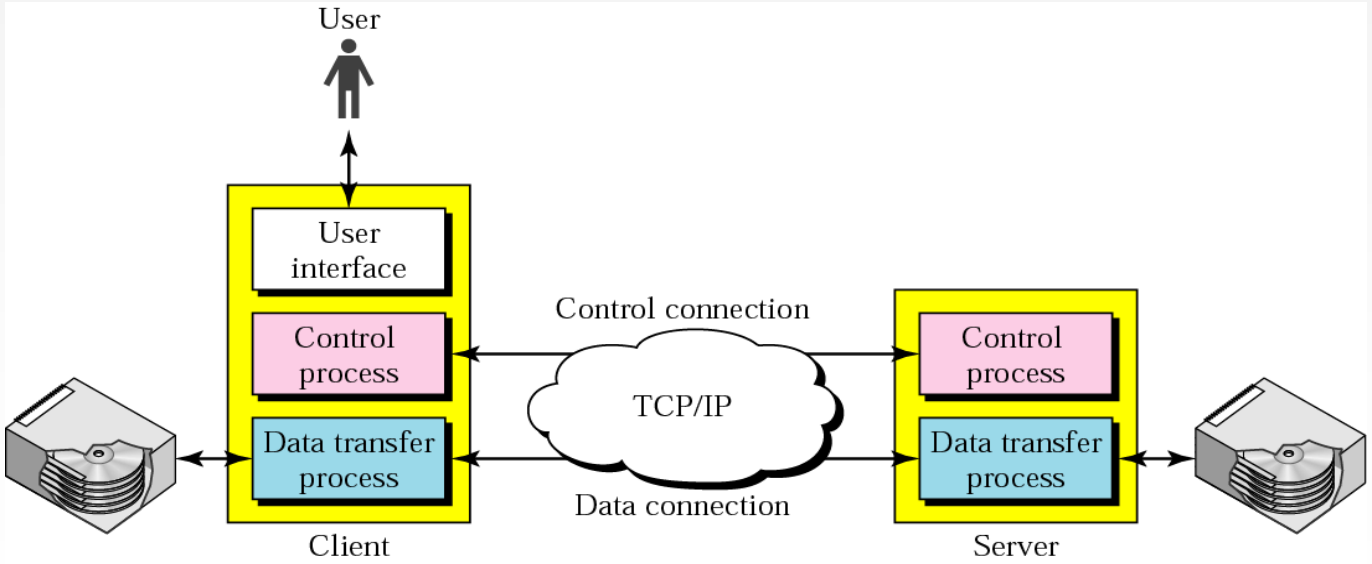


POP3


Mail Server
User Computer
POP3 server
POP3 client
user-name
OK
password
OK
list
email numbers and their sizes
retrieve 1
email 1
retrieve N
email N

File Transfer Protocol

- FTP 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.



FTP and Trivial FTP (TFTP)

- FTP is a complete, session-oriented, general purpose file transfer protocol. TFTP is used as a bare-bones special purpose file transfer protocol.
- FTP can be used interactively. TFTP allows only unidirectional transfer of files.
- FTP depends on TCP, is connection oriented, and provides reliable control. TFTP depends on UDP, requires less overhead, and provides virtually no control.
- FTP provides user authentication. TFTP does not.
- FTP uses well-known TCP port numbers: 20 for data and 21 for connection dialog. TFTP uses UDP port number 69 for its file transfer activity