CS348: Computer Networks

E-MAIL (SMTP, POP3, IMAP4); FTP

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Electronic mail (E-mail)

- Allows users to exchange messages.
- It is an asynchronous communication medium.

- In HTTP,
  - the server program is running all the time, waiting for a request from a client.
  - when the request arrives, the server provides the service.

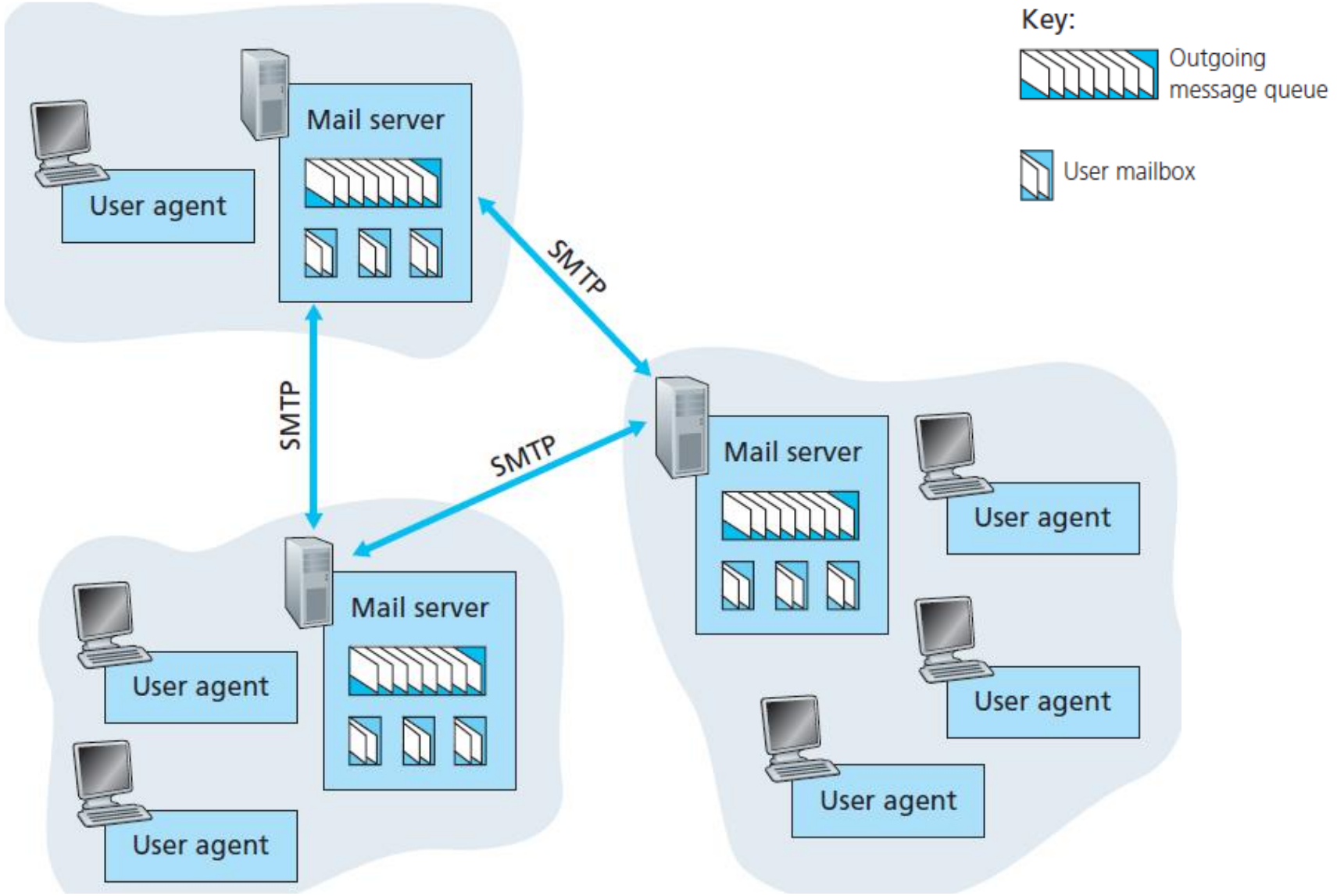
- In E-mail:
  - It is considered as one-way transaction.
  - Sender may expect a response, but this is not a mandate.

  - it is neither feasible nor logical for the receiver to run a server program and wait until someone sends an e-mail to him.

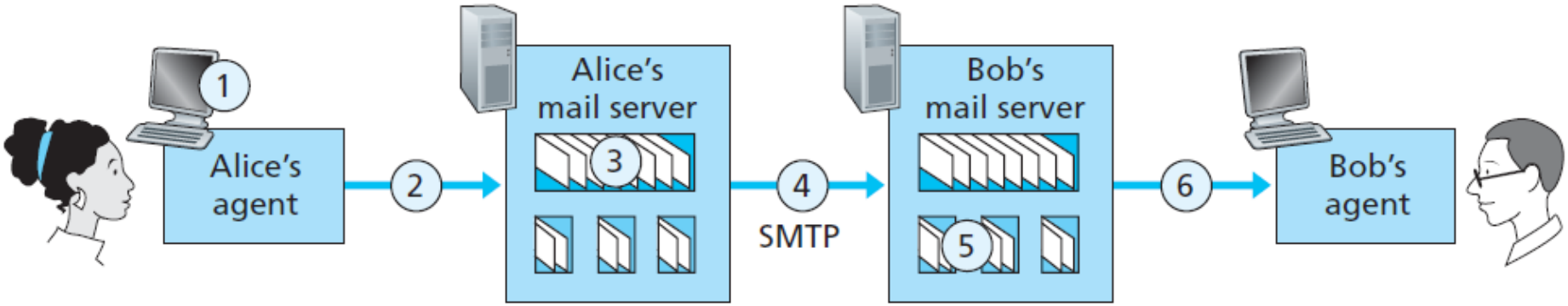
  - the idea of client/server programming should be implemented in another way: using intermediate servers.

  - both the end users run only client programs when they want, and the intermediate servers apply the client/server paradigm

High-level view of Internet e-mail system



Architecture



- User agent
  - allows user to read, reply to, forward, save, and compose messages.
  - e.g., Microsoft Outlook, Google Gmail
- Mail server
  - form the core of the e-mail infrastructure
- Mailbox
  - Each user has a mailbox located in one of the mail servers.
- Application-layer protocol
  - transfer mail from the sender's mail server to the recipient's mail server
  - e.g., Simple Mail Transfer Protocol (SMTP)
  - SMTP has two sides: a client side, and a server side

Journey of a message

sender's user agent --> sender's mail server --> recipient's mail server --> recipient's user agent

SMTP v/s HTTP

- HTTP transfers files (also called objects) from a Web server to a Web client (typically a browser)
- SMTP transfers files (that is, e-mail messages) from one mail server to another mail server.

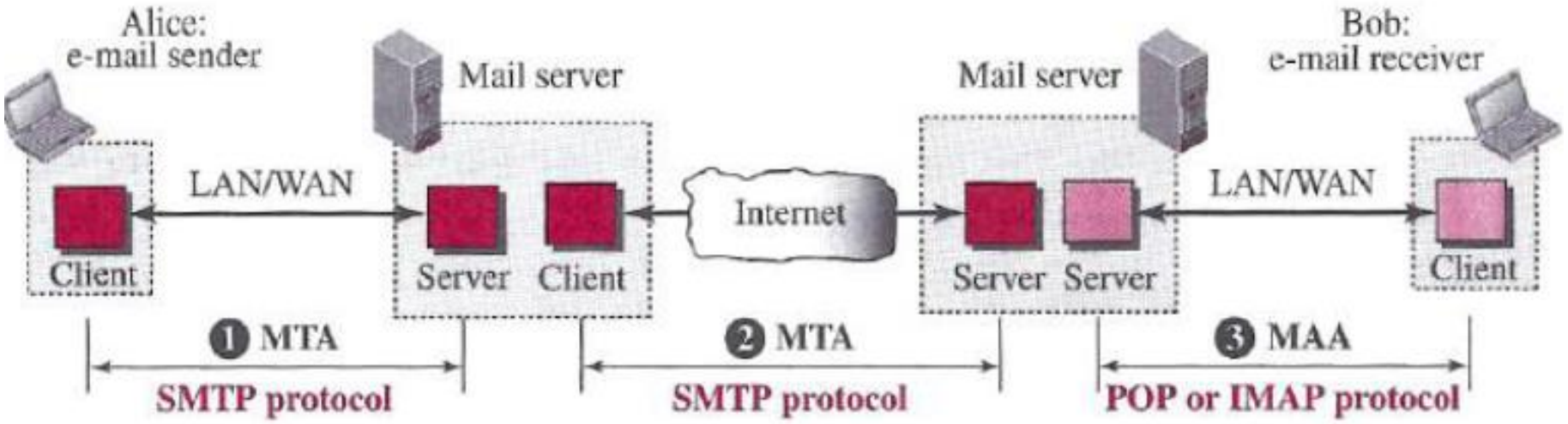
- Both persistent HTTP and SMTP use persistent connections

- HTTP is mainly a **pull protocol** - someone loads information on a Web server and users use HTTP to pull the information from the server at their convenience
- SMTP is primarily a **push protocol -** the sending mail server pushes the file to the receiving mail server.

- In HTTP, TCP connection is initiated by the machine that wants to receive the file
- In SMTP, the TCP connection is initiated by the machine that wants to send the file

- SMTP requires each message, including the body of each message, to be in 7-bit ASCII format. This restriction made sense in the early 1980s when transmission capacity was scarce.
- HTTP data does not impose this restriction.

Message Access Protocol: POP,IMAP



- Once SMTP delivers the message from Alice's mail server to Bob's mail server, the message is placed in Bob's mailbox.
- Until the early 1990s, Bob used to read his mail by logging onto the server.

- But today, mail access uses a client-server architecture - typical user reads e-mail with a client that executes on the user's end system

- Bob's user agent can't use SMTP to obtain the messages because SMTP is a push protocol
- Mail access protocols use by Bob's user agent
  - Post Office Protocol—Version 3 (POP3),
  - Internet Mail Access Protocol – version 4 (IMAP4)

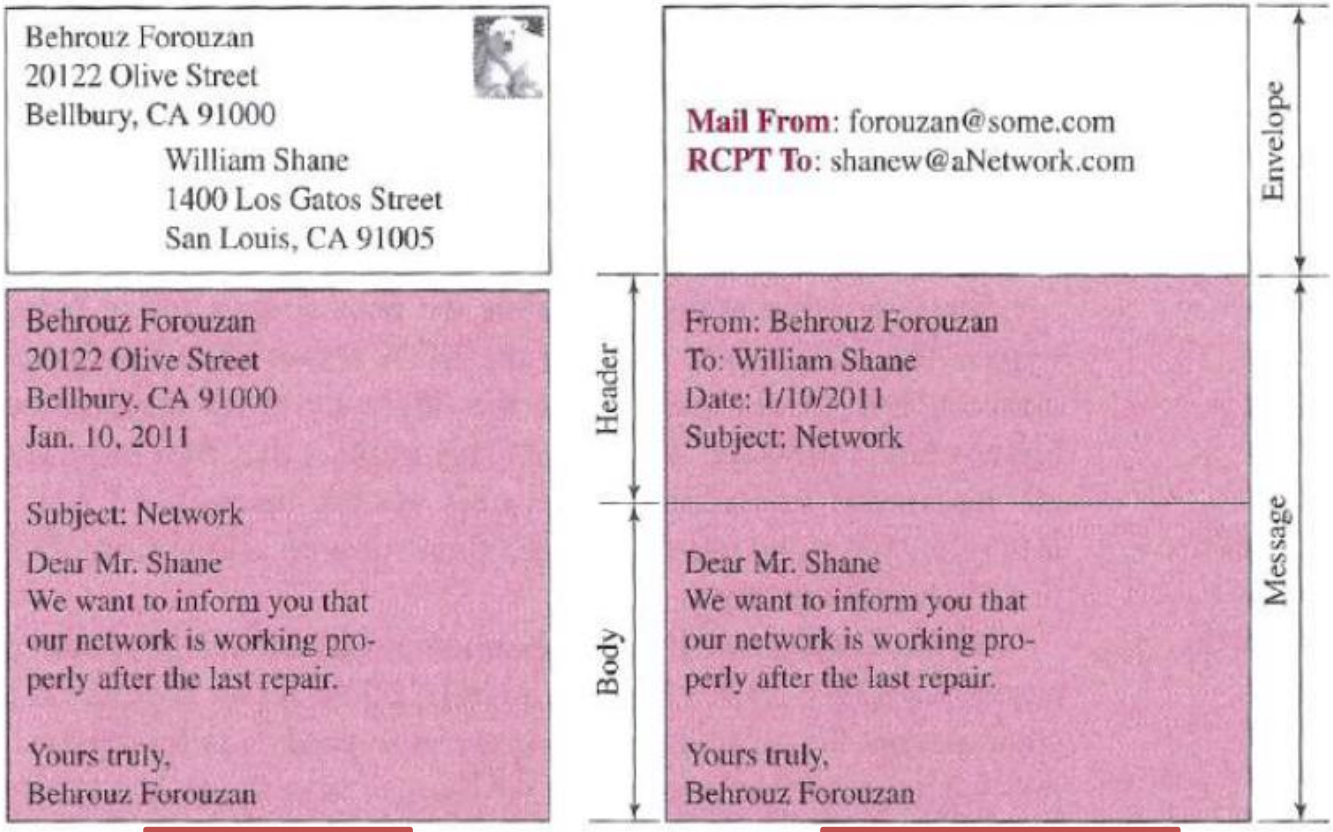
Mail Transfer Phases

- The following three mail transfer phases begins as soon as
  - the TCP connection is established to the well-known port 25 (for non-encrypted version)
  - Note: After a client has made a TCP connection the SMTP protocol starts its connection phase.

- The process of transferring a mail message occurs in three phases:
  - Mail transfer connection establishment by SMTP,
  - Perform mail transfer,
  - Mail transfer connection termination by SMTP.

Cont…

- To **send mail**, the user, through the user agent (UA), creates mail that looks very similar to postal mail.



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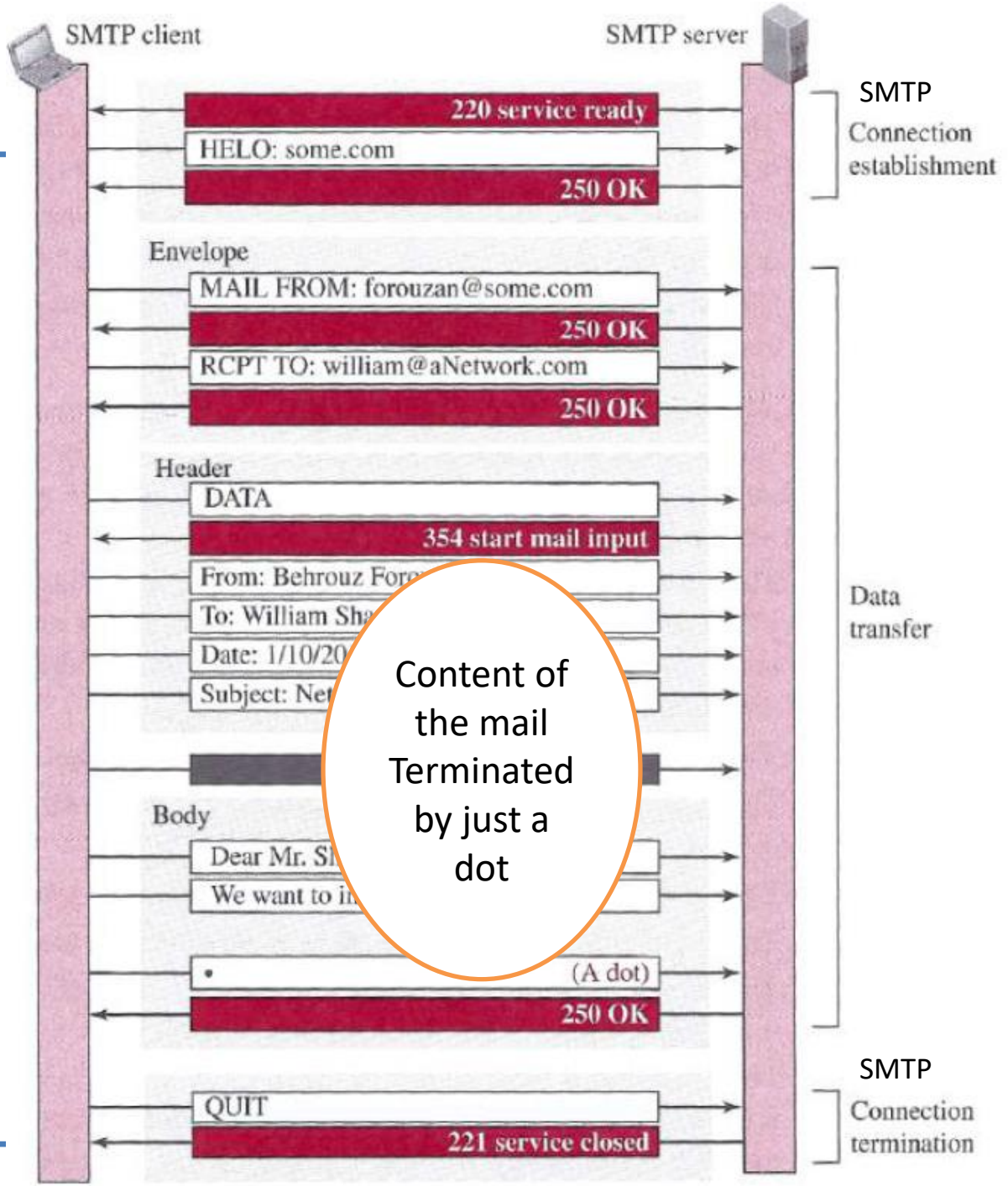
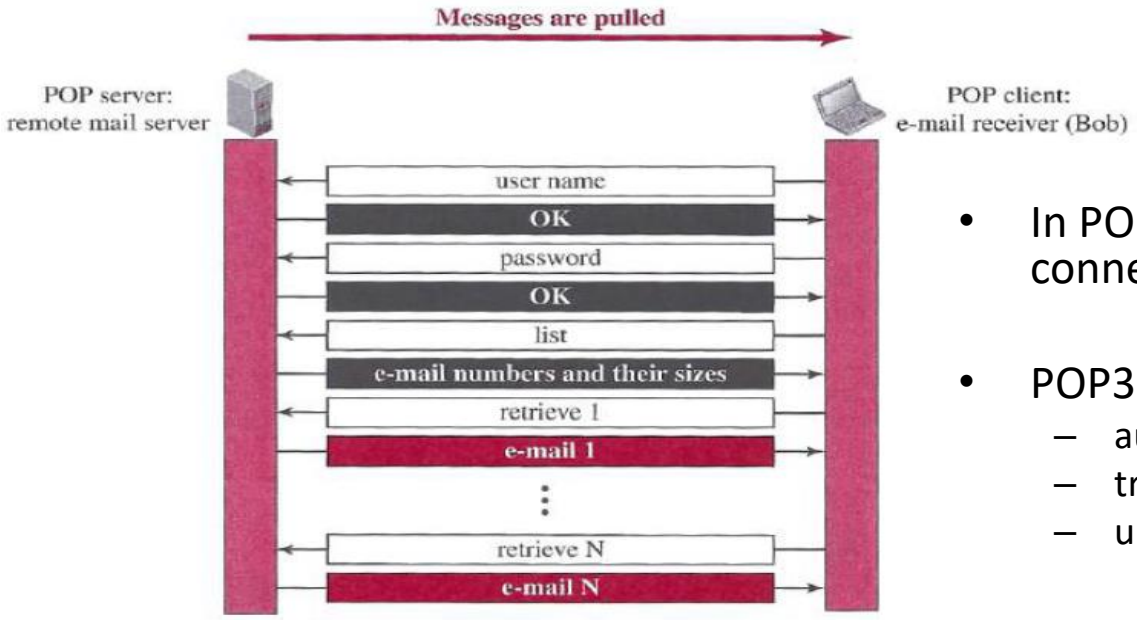
Message exchange between SMTP client and server:

- SMTP **server** sends code 220 (service ready) to tell the client that it is ready to receive mail.
- The **client** sends the HELO message to identify itself, using its domain name.
- The **server** responds with code 250 (request command completed)
- Other commands: MAIL FROM; RCPT TO; DATA; QUIT



POP3



- In POP3, user agent (UA) opens a TCP connection to the mail server on port 110.
- POP3 progresses through three phases:
  - authorization,
  - transaction, and
  - update

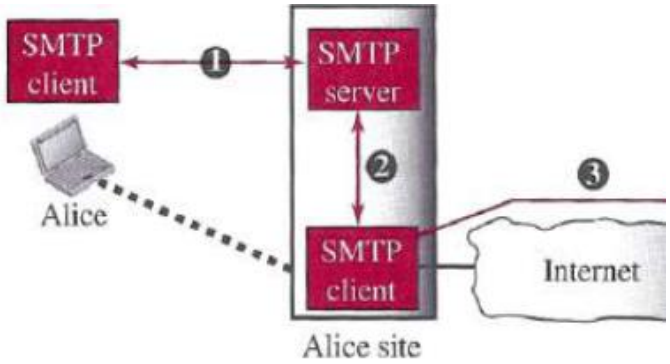
- In POP3 transaction, the user agent (UA) issues commands, and the server replies to each command with a response. Two possible responses: +OK; and –ERR
- User agent can be configured to two modes:
  - "download and delete"
  - "download and keep."
- The download-and-delete mode partitions Bob's mail messages over the machines – downloaded to the accessing PC, and removed from the mail server

IMAP4

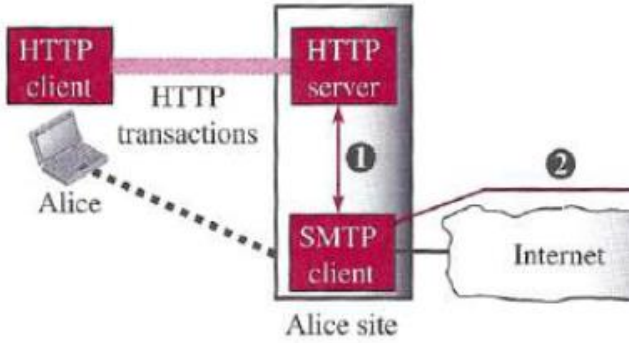
- IMAP4 is similar to POP3, but it **has more features**; IMAP4 is more powerful and more complex.
- IMAP4 provides the following extra functions:
  - A user can check the e-mail header prior to downloading.
  - A user can search the contents of the e-mail for a specific string of characters prior to downloading.
  - A user can partially download e-mail.
    - This is especially useful if bandwidth is limited and the e-mail contains multimedia with high bandwidth requirements.
  - An IMAP server will associate each message with a folder.
  - A user can create, delete, or rename mailboxes (i.e. folders) on the mail server.
  - A user can create a hierarchy of mailboxes in a folder for e-mail storage.

Web-Based Mail

- An email client, email reader or more formally mail user agent (UA) is a computer program used to access and manage a user's email.
  - E.g. Mozilla Thunderbird, IMAP clients, Lotus Notes clients – Use SMTP to send, IMAP/POP to receive
- Webmail (or web-based email) is any email client implemented as a web application running on a web server. – Use HTTP to send and receive
- Webmail's main advantage over the use of a desktop email client is the ability to send and receive email anywhere from a web browser.
- Webmail's main disadvantage is the need to be connected to the Internet while using it.
  - E.g., Outlook/Hotmail, Yahoo, and Google.



Desktop Mail user agent uses SMTP



Webmail uses HTTP

E-Mail Security

- The protocol discussed so far does not provide any security provisions per se.
- e-mail exchanges can be secured using two **application-layer securities** designed in particular for e-mail systems
  - Pretty Good Privacy (PGP)
  - Secure/Multipurpose Internet Mail Extensions (S/MIME)

FTP (File Transfer Protocol)

- In a typical FTP session, the user is sitting in front of one host (the local host) and wants to transfer files to or from a remote host

- user accessing the remote account
  - user must provide a user identification and a password.

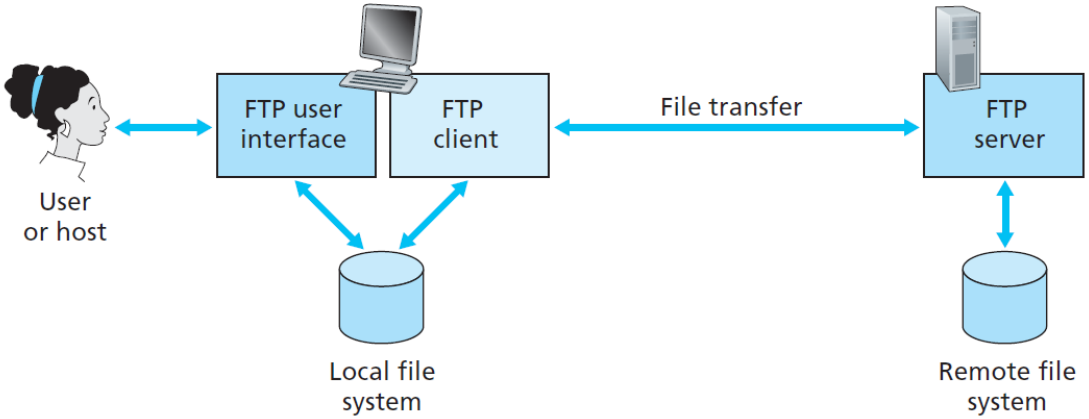
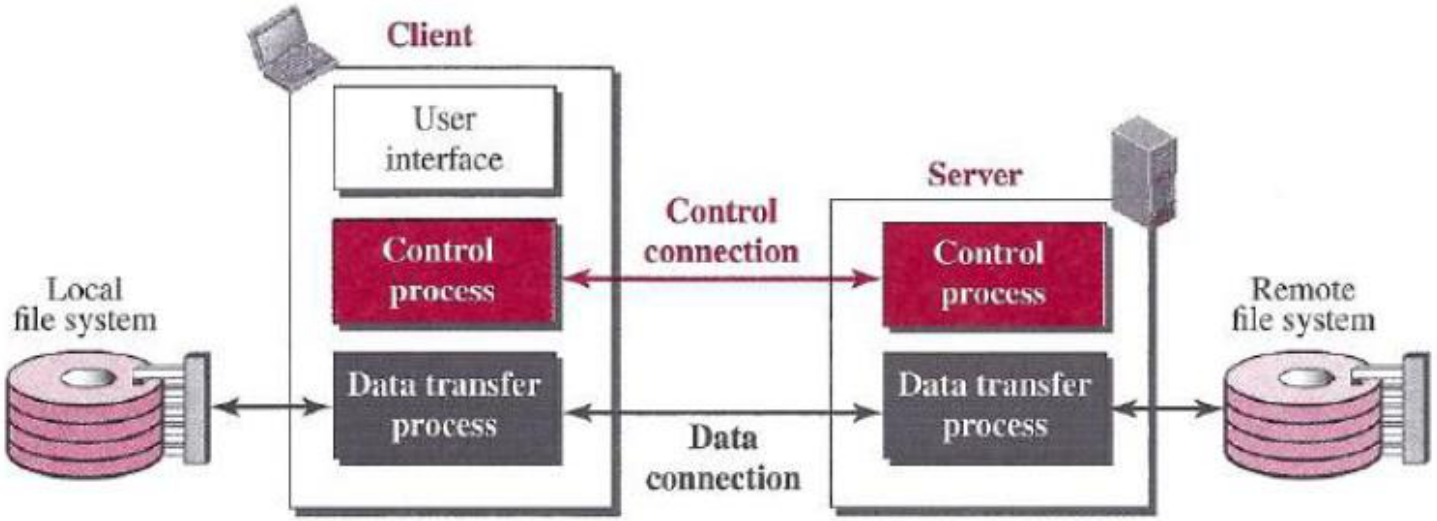


Figure 2.14 ♦ FTP moves files between local and remote file systems

- FTP **must address** the following:
  - two systems may use different file name conventions
  - two systems may have different ways to represent data
  - two systems may have different directory structures

Basic Model of FTP



- The client has three components:
  - the user interface,
  - the client control process, and
  - the client data transfer process.
- The server has two components:
  - the server control process and
  - the server data transfer process.
- There are **two connections**:
  - control connection
  - data connection

Cont…

- The two connections in FTP have different lifetimes.
  - The control connection remains connected during the entire interactive FTP session.
  - The data connection is opened and then closed for each file transfer activity

- FTP server uses two well-known TCP ports:
  - port 21 is used for the control connection,
  - port 20 is used for the data connection.

- Benefits for having two separate connections:
  - You can have multiple data transfers running at a time without having to establish multiple control connections.
  - No need for complicated framing on the control connection.
  - Handling special cases, like cancelling a data connection, is simpler.

Control Connection

- Control communication is achieved through commands and responses.
- During this control connection, commands are sent from the client to the server and responses are sent from the server to the client.
- The client side of FTP sends the user id and password over this control connection.
- Every FTP command generates at least one response
- A response has two parts:
  - Three-digit number : defines the code
  - Text : defines needed parameters or further explanations

Table 26.5 *Some responses in FTP*

Code	*Description*
125	Data connection open
150	File status OK
200	Command OK
220	Service ready
221	Service closing

Table 26.4 *Some FTP commands*

Command	*Argument(s)*	*Description*
ABOR		Abort the previous command
CDUP		Change to parent directory
CWD	Directory name	Change to another directory
DELE	File name	Delete a file
LIST	Directory name	List subdirectories or files
MKD	Directory name	Create a new directory
PASS	User password	Password

Data Connection

- When the server side receives a command for a file transfer over the control connection (either to, or from, the remote host), the server side initiates a TCP data connection to the client side.

- FTP sends exactly one file over a data connection and then closes the data connection. For multiple files, it uses multiple data connection.

- How data connection is started from server end?
  - The client, not the server, issues a **passive open** using an ephemeral port (>1023).
  - Using the PORT command the client sends this port number to the server.
  - The server receives the port number and issues an **active open** using the well-known port 20 and the received ephemeral port number.

- Passive Open: A process performs a *passive OPEN* by contacting TCP and saying "I am here, and I am waiting for clients that may wish to talk to me to send me a message on the following port number". The *OPEN* is called ***passive*** **because** aside from indicating that I am listening, the process does nothing.

- Active OPEN: A process using TCP takes the "active role" and initiates the connection by actually sending a TCP message to start the connection (a SYN message).

Communication over Data Connection

- The **heterogeneity** problem is resolved by defining three attributes of communication:
  - file type: *ASCII*, *EBCDIC*, or *image* file.
  - data structure: *file, record,* or *page* structure
  - transmission mode: *stream, block,* or *compressed* mode

- The file structure format (used by default) has no structure. It is a continuous stream of bytes.

- In the record structure, the file is divided into *records.* This can be used only with text files.

- In the page structure, the file is divided into pages, with each page having a page number and a page header.

HTTP v/s FTP

- HTTP and FTP
  - Are both application layer protocols
  - are both file transfer protocols
  - they both run on top of TCP

  - FTP uses two parallel TCP connections to transfer a file, a *control connection* and a *data connection*.
  - HTTP sends request and response header lines into the same TCP connection that carries the transferred file itself

  - FTP is said to send its control information out-of-band
  - HTTP is said to send its control information in-band

  - with FTP, the control connection remains open throughout the duration of the user session, but a new data connection is created for each file transferred within a session (that is, the data connections are non-persistent)

  - Throughout a session, the FTP server must maintain state about the user.
  - HTTP, on the other hand, is stateless —it does not have to keep track of any user state.

Security for FTP

- The FTP protocol was designed when security was not a big issue.
- Although FTP requires a password, the password is sent in plaintext (unencrypted)

- To be secure, one can add a Secure Socket Layer (SSL) between the FTP application layer and the TCP layer.
- In this case FTP is called SSL-FTP

Thanks!