

Chapter 2: outline

2.1 principles of network applications

- app architectures
- app requirements

2.2 Web and HTTP

2.3 FTP

2.4 electronic mail

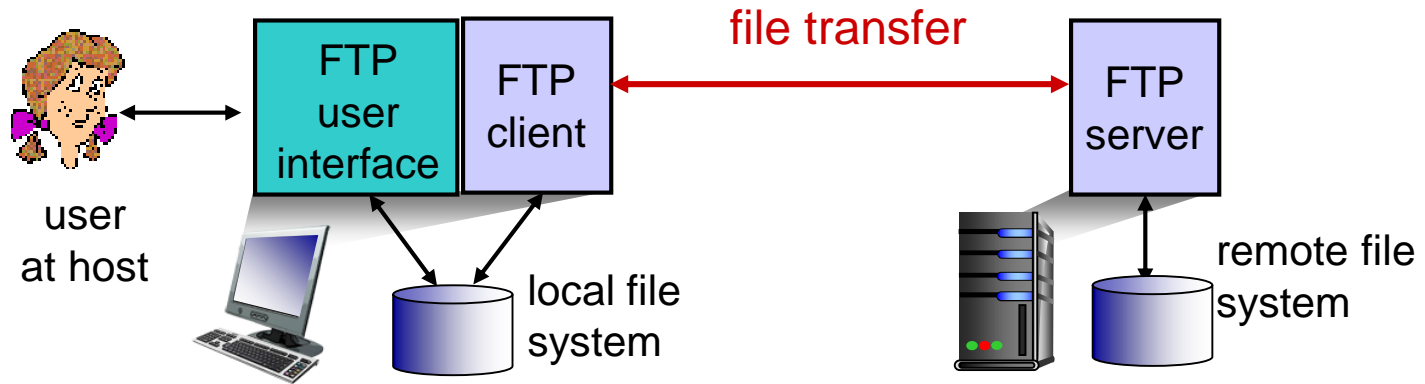
- SMTP, POP3, IMAP

2.5 DNS

2.6 P2P applications

2.7 socket programming with UDP and TCP

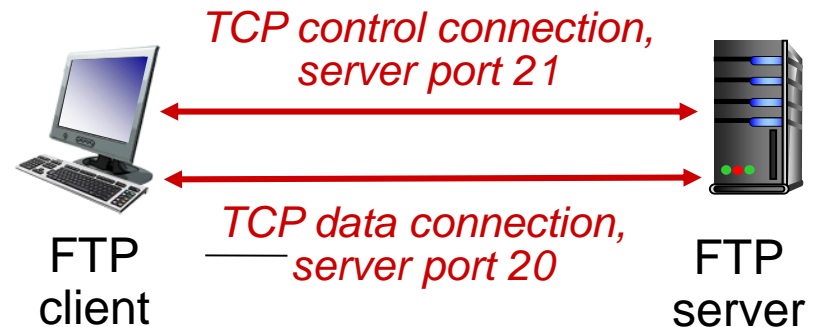
FTP: the file transfer protocol



- ❖ transfer file to/from remote host
- ❖ client/server model
 - **client**: side that initiates transfer (either to/from remote)
 - **server**: remote host
- ❖ ftp: RFC 959
- ❖ ftp server: port 21

FTP: separate control, data connections

- ❖ FTP client contacts FTP server at port 21, using TCP
- ❖ client authorized over control connection
- ❖ client browses remote directory, sends commands over control connection
- ❖ when server receives file transfer command, **server** opens 2nd TCP data connection (for file) to client
- ❖ after transferring one file, server closes data connection



- ❖ server opens another TCP data connection to transfer another file
- ❖ control connection: **"out of band"**
- ❖ FTP server maintains "state": current directory, earlier authentication

FTP commands, responses

sample commands:

- ❖ sent as ASCII text over control channel
- ❖ **USER *username***
- ❖ **PASS *password***
- ❖ **LIST** return list of file in current directory
- ❖ **RETR *filename*** retrieves (gets) file
- ❖ **STOR *filename*** stores (puts) file onto remote host

sample return codes

- ❖ status code and phrase (as in HTTP)
- ❖ **331 Username OK, password required**
- ❖ **125 data connection already open; transfer starting**
- ❖ **425 Can't open data connection**
- ❖ **452 Error writing file**

FTP doesn't cut it nowadays

totally insecure

- ❖ SFTP is the encrypted version
- ❖ Normally on port 22
 - Same port as SSH, because it IS using SSH

Chapter 2: outline

2.1 principles of network applications

- app architectures
- app requirements

2.2 Web and HTTP

2.3 FTP

2.4 electronic mail

- SMTP, POP3, IMAP

2.5 DNS

2.6 P2P applications

2.7 socket programming with UDP and TCP

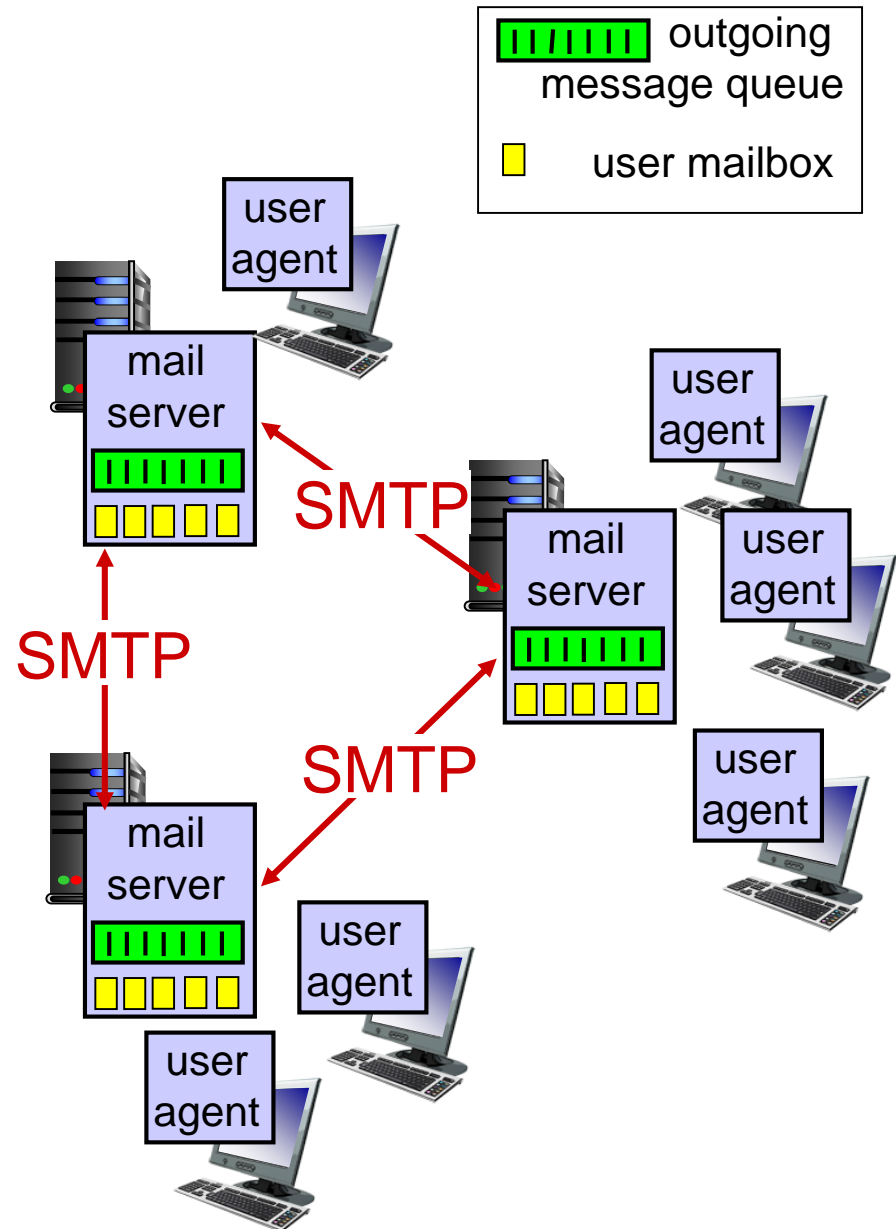
Electronic mail

Three major components:

- ❖ user agents
- ❖ mail servers
- ❖ simple mail transfer protocol: SMTP

User Agent

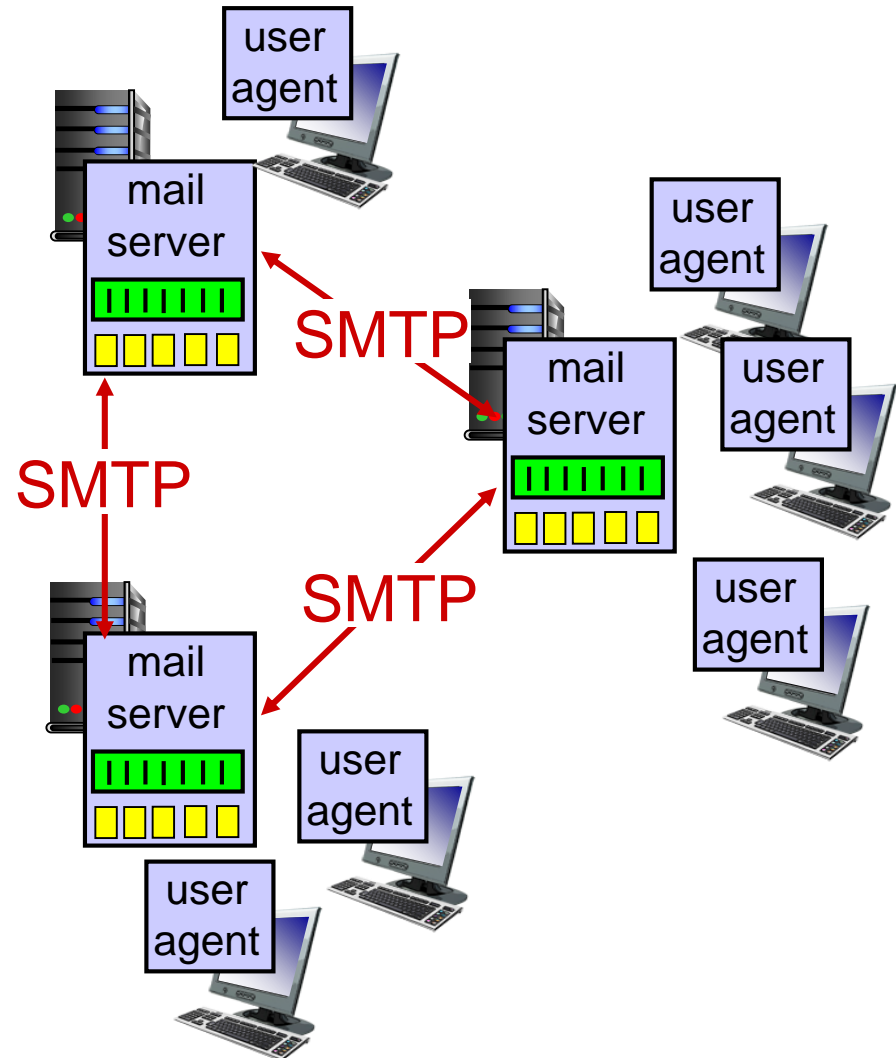
- ❖ a.k.a. "mail reader"
- ❖ composing, editing, reading mail messages
- ❖ e.g., Outlook, Thunderbird, iPhone mail client
- ❖ outgoing, incoming messages stored on server



Electronic mail: mail servers

mail servers:

- ❖ *mailbox* contains incoming messages for user
- ❖ *message queue* of outgoing (to be sent) mail messages
- ❖ *SMTP protocol* between mail servers to send email messages
 - client: sending mail server
 - "server": receiving mail server

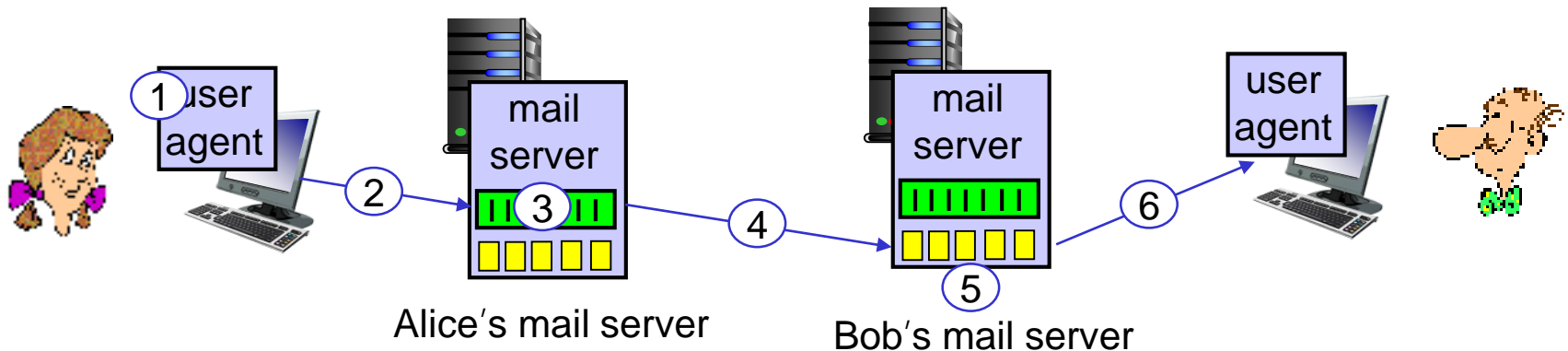


Electronic Mail: SMTP [RFC 2821]

- ❖ uses TCP to reliably transfer email message from client to server, port 25
- ❖ direct transfer: sending server to receiving server
- ❖ three phases of transfer
 - handshaking (greeting)
 - transfer of messages
 - closure
- ❖ command/response interaction (like HTTP, FTP)
 - **commands:** ASCII text
 - **response:** status code and phrase
- ❖ messages must be in 7-bit ASCII

Scenario: Alice sends message to Bob

- 1) Alice uses UA to compose message "to" `bob@someschool.edu`
- 2) Alice's UA sends message to her mail server; message placed in message queue
- 3) client side of SMTP opens TCP connection with Bob's mail server
- 4) SMTP client sends Alice's message over the TCP connection
- 5) Bob's mail server places the message in Bob's mailbox
- 6) Bob invokes his user agent to read message



Sample SMTP interaction – no security

```
S: 220 hamburger.edu
C: HELO crepes.fr
S: 250 Hello crepes.fr, pleased to meet you
C: MAIL FROM: <alice@crepes.fr>
S: 250 alice@crepes.fr... Sender ok
C: RCPT TO: <bob@hamburger.edu>
S: 250 bob@hamburger.edu ... Recipient ok
C: DATA
S: 354 Enter mail, end with "." on a line by itself
C: Do you like ketchup?
C: How about pickles?
C: .
S: 250 Message accepted for delivery
C: QUIT
S: 221 hamburger.edu closing connection
```

Sample SMTP interaction – w/ security

First step Generate an authentication key

```
$ perl -MMIME::Base64 -e 'print encode_base64("\000myemail\@gmail.com\000mypassword")'
AG5pY2UudHJ5QGdtYWlsLmNvbQBub210c25vdG15cGFzc3dvcmQ=
```

Sample SMTP interaction – w/ security

```
$ openssl s_client -connect smtp.gmail.com:465 -crlf -ign_eof
[... lots of openssl output ...]
220 mx.google.com ESMTP m46sm11546481eeh.9
EHLO localhost
250-mx.google.com at your service, [1.2.3.4]
250-SIZE 35882577
250-8BITMIME
250-AUTH LOGIN PLAIN XOAUTH
250 ENHANCEDSTATUSCODES
AUTH PLAIN AG5pY2UudHJ5QGdtYWlsLmNvbQBub2l0c25vdG15cGFzc3dvcmQ=
235 2.7.0 Accepted
MAIL FROM: <gryphius-demo@gmail.com>
250 2.1.0 OK m46sm11546481eeh.9
rcpt to: <somepoorguy@example.com>
250 2.1.5 OK m46sm11546481eeh.9
DATA
354 Go ahead m46sm11546481eeh.9
Subject: it works

yay!
.
250 2.0.0 OK 1339757532 m46sm11546481eeh.9
quit
221 2.0.0 closing connection m46sm11546481eeh.9
read:errno=0
```

SMTP: final words

- ❖ SMTP uses persistent connections
- ❖ SMTP requires message (header & body) to be in 7-bit ASCII
- ❖ SMTP server uses CRLF.CRLF to determine end of message

comparison with HTTP:

- ❖ HTTP: pull
- ❖ SMTP: push
- ❖ both have ASCII command/response interaction, status codes
- ❖ HTTP: each object encapsulated in its own response msg
- ❖ SMTP: multiple objects sent in multipart msg

Mail message format

SMTP: protocol for exchanging email msgs

RFC 822: standard for text message format:

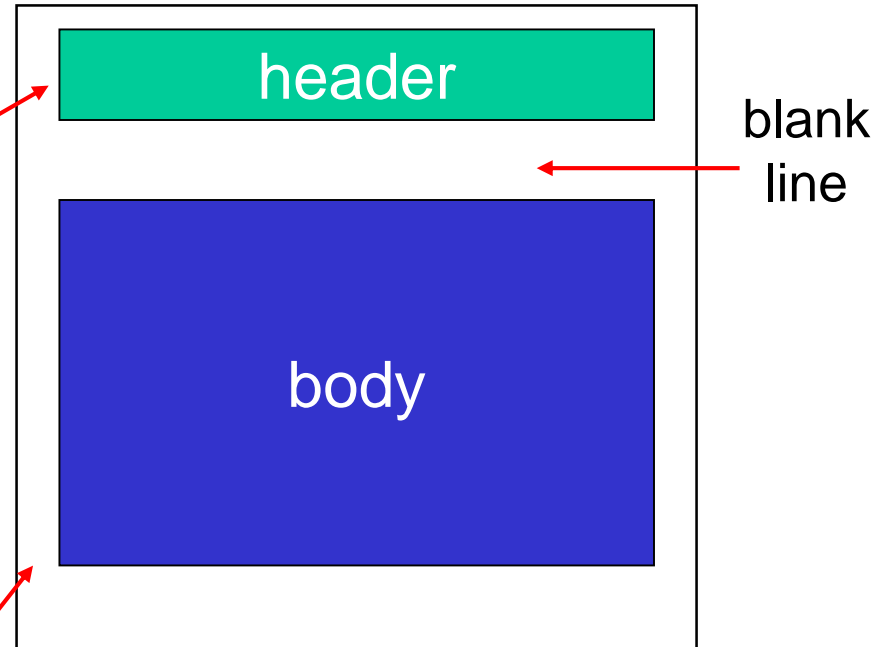
❖ header lines, e.g.,

- To:
- From:
- Subject:

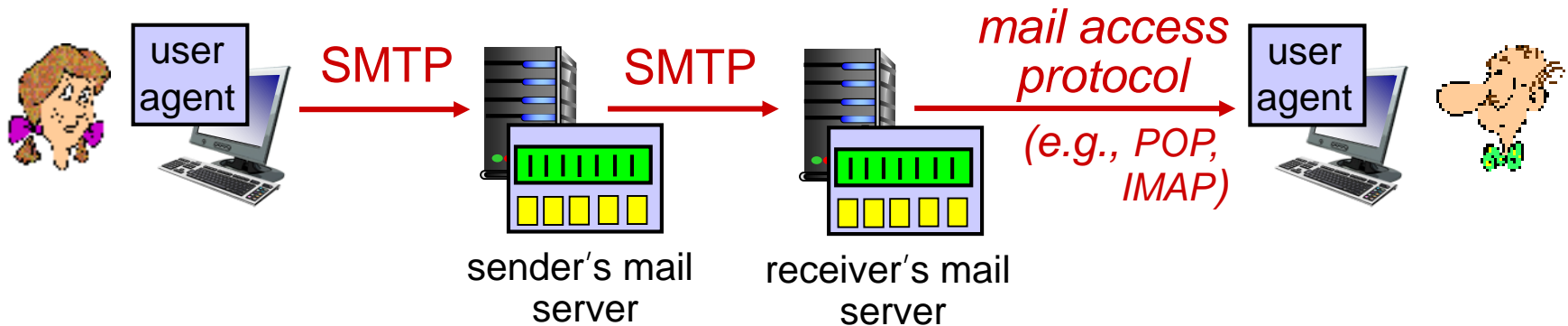
different from SMTP MAIL
FROM, RCPT TO:
commands!

❖ Body: the "message"

- ASCII characters only



Mail access protocols



- ❖ **SMTP**: delivery/storage to receiver's server
- ❖ mail access protocol: retrieval from server
 - **POP**: Post Office Protocol [RFC 1939]: authorization, download
 - **IMAP**: Internet Mail Access Protocol [RFC 1730]: more features, including manipulation of stored msgs on server
 - **HTTP**: gmail, Hotmail, Yahoo! Mail, etc.
 - **Exchange**: Microsoft's implementation, de facto for business

POP3 protocol

authorization phase

- ❖ client commands:
 - **user**: declare username
 - **pass**: password
- ❖ server responses
 - **+OK**
 - **-ERR**

transaction phase, client:

- ❖ **list**: list message numbers
- ❖ **retr**: retrieve message by number
- ❖ **dele**: delete
- ❖ **quit**

```
S: +OK POP3 server ready
C: user bob
S: +OK
C: pass hungry
S: +OK user successfully logged on

C: list
S: 1 498
S: 2 912
S: .
C: retr 1
S: <message 1 contents>
S: .
C: dele 1
C: retr 2
S: <message 1 contents>
S: .
C: dele 2
C: quit
S: +OK POP3 server signing off
```

POP3 (more) and IMAP

more about POP3

- ❖ previous example uses POP3 “download and delete” mode
 - Bob cannot re-read e-mail if he changes client
- ❖ POP3 “download-and-keep”: copies of messages on different clients
- ❖ POP3 is stateless across sessions

IMAP

- ❖ keeps all messages in one place: at server
- ❖ allows user to organize messages in folders
- ❖ keeps user state across sessions:
 - names of folders and mappings between message IDs and folder name

Microsoft Exchange

winning

- ❖ Uses proprietary protocol called MAPI
- ❖ Managed by Microsoft Exchange Server
- ❖ Includes (near-instant) synchronization of calendar, email, contacts, etc. across many devices at once
- ❖ De facto business email system

Chapter 2: outline

2.1 principles of network applications

- app architectures
- app requirements

2.2 Web and HTTP

2.3 FTP

2.4 electronic mail

- SMTP, POP3, IMAP

2.5 DNS

2.6 P2P applications

2.7 socket programming with UDP and TCP