# CS 43: Computer Networks

08: Email and SMTP

October 1, 2020

# Where we are

Application: the application (e.g., the Web, Email)

Transport: end-to-end connections, reliability

Network: routing

Link (data-link): framing, error detection

Physical: 1's and 0's/bits across a medium (copper, the air, fiber)

# Last class

- Identifiers and addressing

- Domain Name System
  - DNS Protocol,  messages
  - Iterative vs. Recursive resolvers
  - Caching
  - DNS Attacks

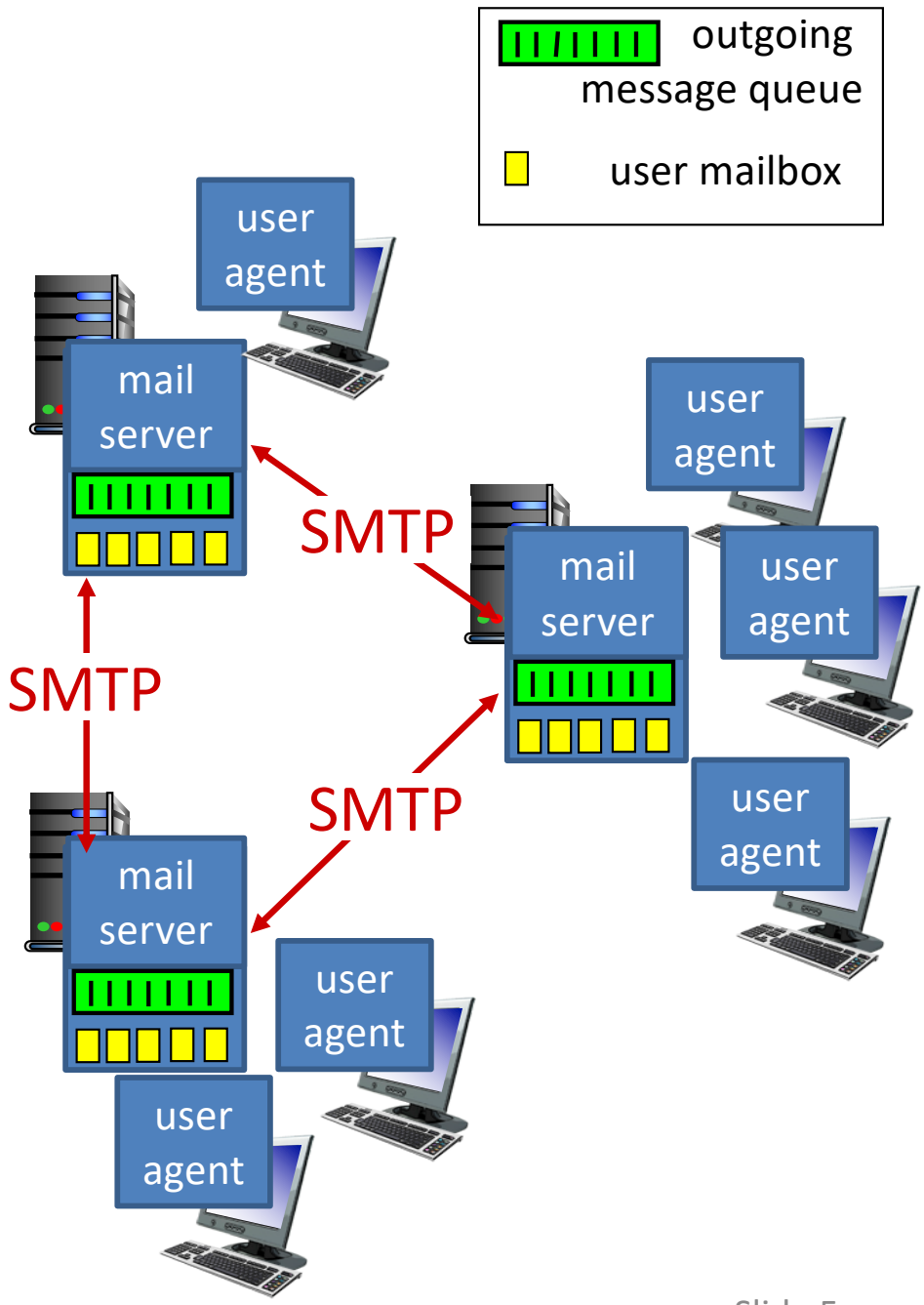
# Today

- Three main parts to email:
  - Mail User Agent
  - Mail Transfer Agent
  - SMTP protocol used to negotiate transfers
- SMTP Protocol
- Mail Access Protocols
  - POP3
  - IMAP
  - Webmail

# Electronic mail

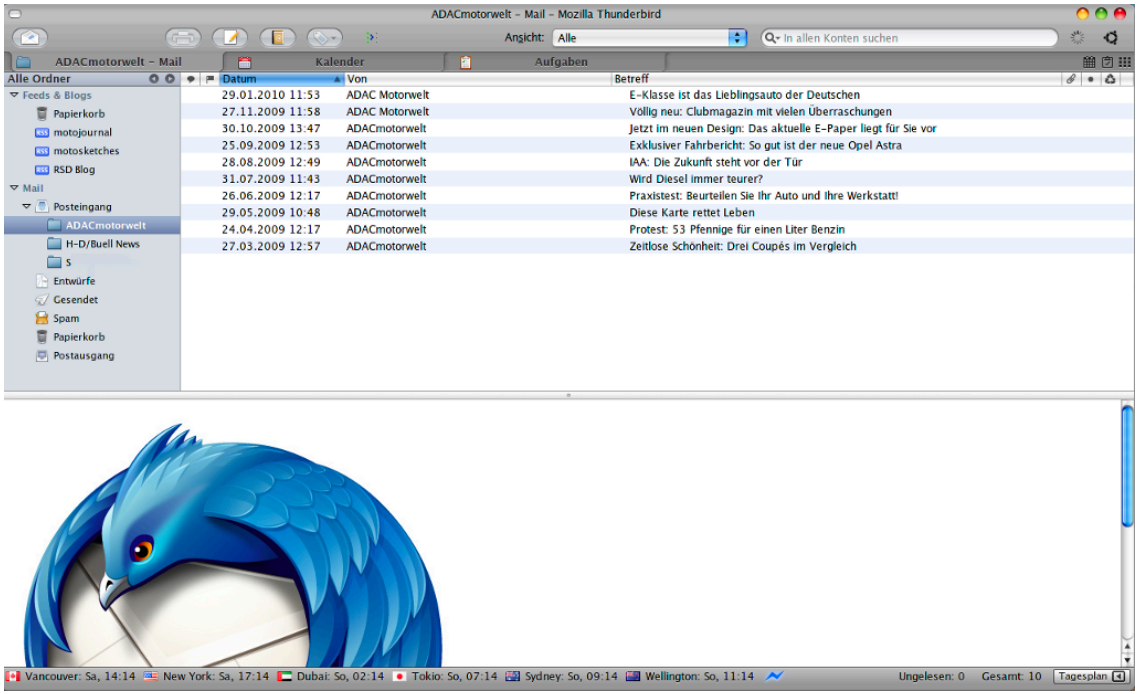
Three major components:

- mail user agent (MUA)
- mail transfer agent (MTA)
- simple mail transfer protocol



# Mail User Agent a.k.a “mail reader”

- composing, editing, reading mail messages
- Outlook, Thunderbird, iPhone mail client



# Mail Transfer Agent. a.k.a 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 (one-way)
  - client: sending mail server
  - “server”: receiving mail server

# If you were designing email, what would happen when Alice sends an email to Bob?

A. Alice mail **client** -> Bob's mail **server**

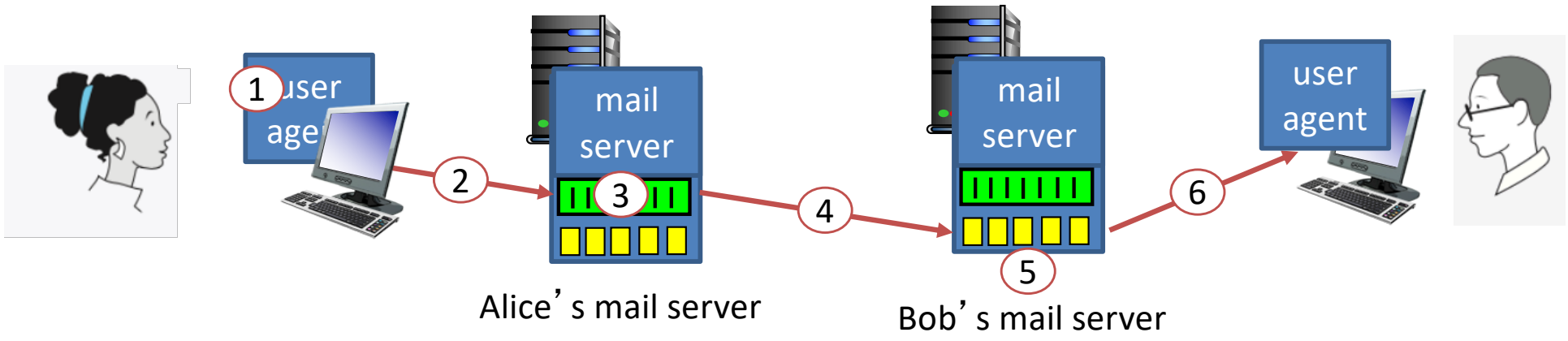
B. Alice mail **server** -> Bob's mail **server**

C. Alice mail **client** -> Bob's mail **client**

D. Alice mail **server** -> Bob's mail **client**

# Scenario: Alice sends message to Bob

1) Alice uses a MUA to compose message "to" bob@swarthmore.edu
2) Alice's MUA 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 MUA to read message



# Mail Servers: Ever Vigilant

- Always on, because they always need to be ready to accept mail.

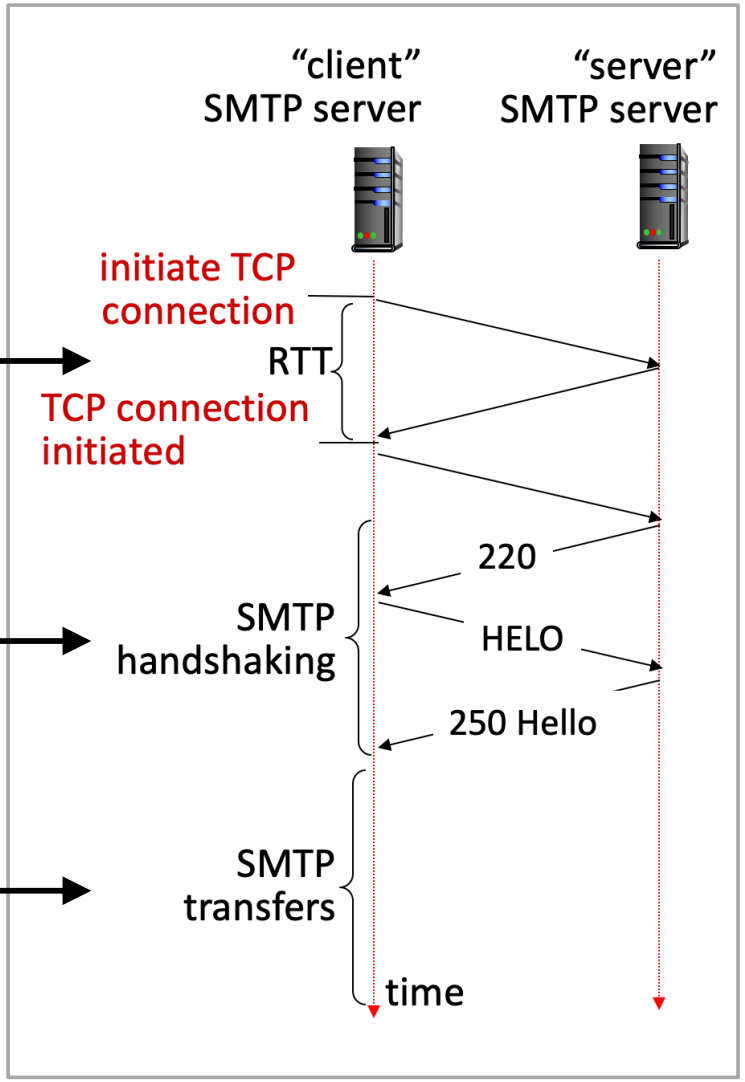
- Usually owned by ISP
  - You use the email server for either Swarthmore College, or the CS department.

# Simple Mail Transfer: SMTP [RFC 2821]

- TCP: reliably transfer email message from client to server, port 25
- Direct transfer: sending server to receiving server
- Messages must be in 7-bit ASCII
- Command/response interaction (like HTTP, FTP)
  - commands: ASCII text
  - response: status code and phrase

# Simple Mail Transfer: SMTP [RFC 2821]

- Direct transfer: sending server to receiving server
- TCP connection on port 25
  - from sending mail server (client)
  - to receiving mail server (server)
- Three phases of transfer
  - handshaking (greeting), MAIL FROM:, RCPT TO:
  - transfer of messages
  - closure

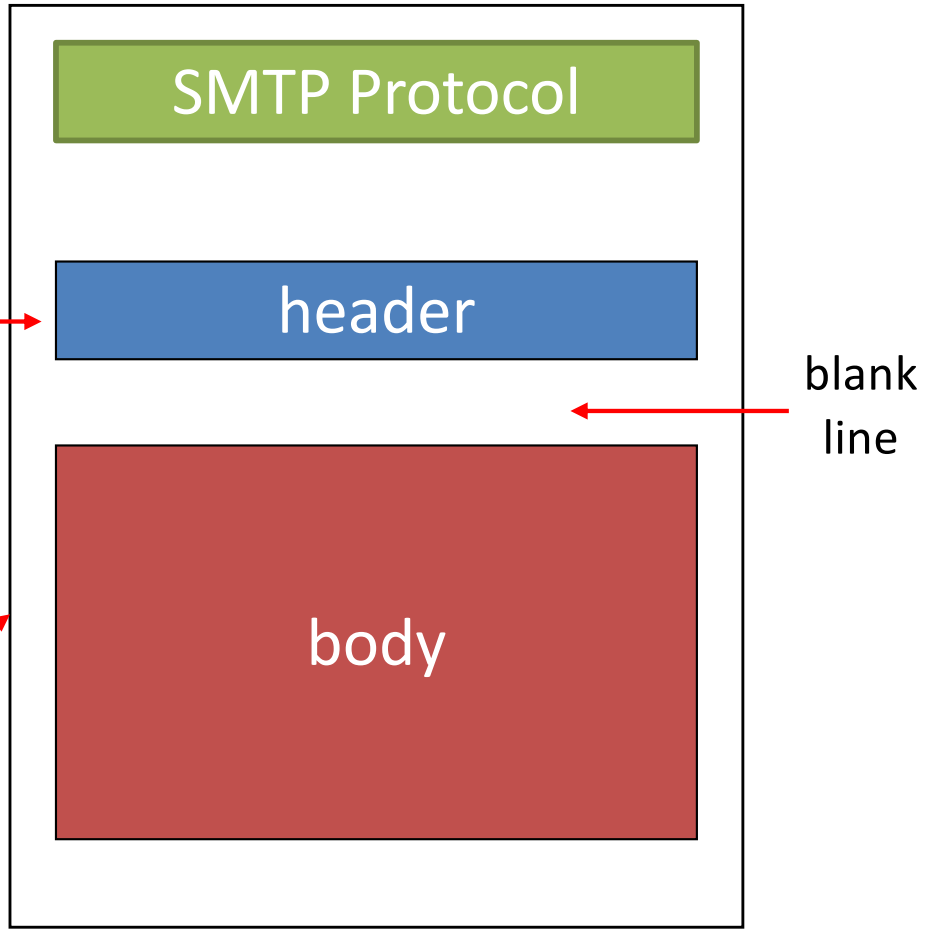


# SMTP Message Format

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
  - Signal EOM with "\r\n.\r\n"



# Try SMTP interaction for yourself:

- **`telnet allspice.cs.swarthmore.edu 25`**
- You should see a 220 reply from the server.
- enter HELO, MAIL FROM, RCPT TO, DATA, QUIT commands

(lets you send email without using email client (MUA))

# Demo

# Sample SMTP interaction

$ telnet allspice.cs.swarthmore.edu 25

Trying 130.58.68.9…

Connected to allspice.cs.swarthmore.edu

220 allspice.cs.swarthmore.edu ESMTP Postfix

HELO cs.swarthmore.edu

250 allspice.cs.swarthmore.edu

MAIL FROM:<chaganti@cs.swarthmore.edu>

250 2.1.0 OK

RCPT TO:<chaganti@cs.swarthmore.edu>

250 2.1.5 OK

DATA

354 End data with <CR><LF>.<CR><LF>

To: Vasanta Chaganti <chaganti@cs.swarthmore.edu>

From: Vasanta Chaganti <chaganti@cs.swarthmore.edu>

Subject: Telnet test message

This is a test message, via telnet, to myself.

.

# Sample SMTP interaction

$ telnet allspice.cs.swarthmore.edu 25

Trying 130.58.68.9…

Connected to allspice.cs.swarthmore.edu

220 allspice.cs.swarthmore.edu ESMTP Postfix

HELO cs.swarthmore.edu

250 allspice.cs.swarthmore.edu

MAIL FROM:<chaganti@cs.swarthmore.edu>

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DATA

354 End data with <CR><LF>.<CR><LF>

To: Vasanta Chaganti <chaganti@cs.swarthmore.edu>

From: Vasanta Chaganti <chaganti@cs.swarthmore.edu>

Subject: Telnet test message

This is a test message, via telnet, to myself.

End of message:
CRLF (Dot) CRLF

# What keeps us from entering a fake information (e.g., FROM address)?

A. Nothing.

B. The MTA checks that the FROM is valid.

C. We enter a name/password logging into the MTA.

# Fun Demo

# Wait, this seems too horrible to be true. Surely we can prevent header forging?

(How or why not?)

A. Yes

B. No

# Message Signing

1. Sender creates cryptographic public/private key pair, publishes public key to the world.

2. Sender uses private key to sign messages.

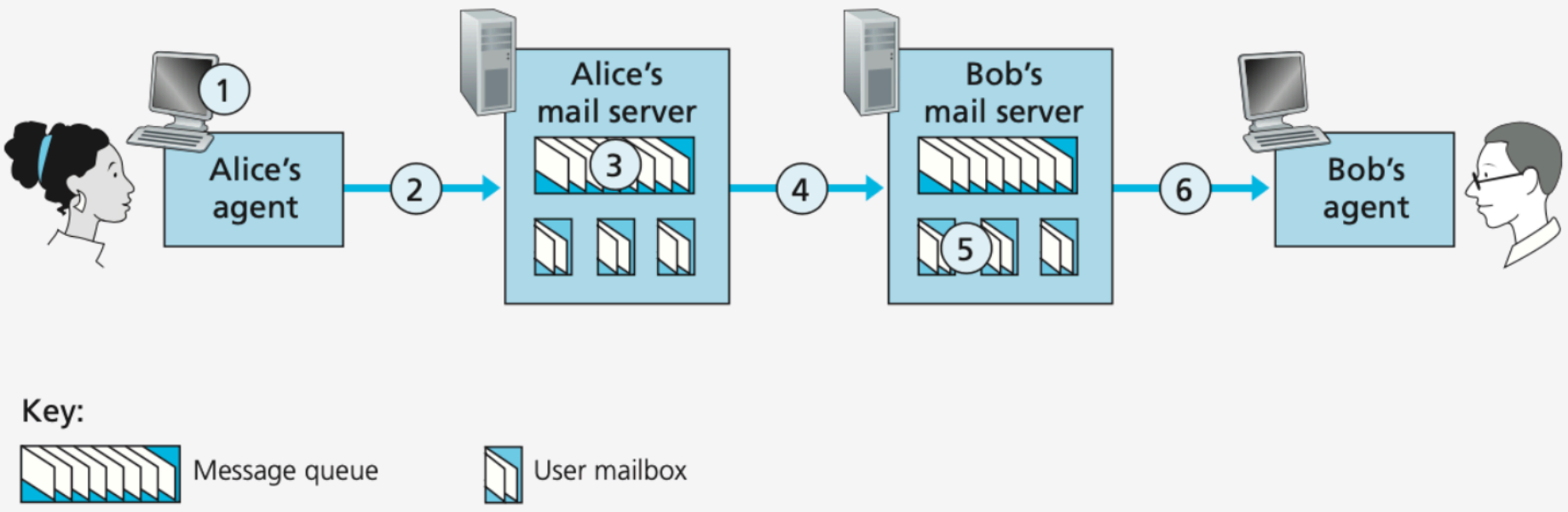
3. Receiver can verify*, using published public key, that only the holder of the corresponding private key could have sent the message.

* With very high probability.

# Message Signing: Challenges

- Disseminating public keys
  - How do you trust that the published public key isn't also a lie?
- It's more work, can't be bothered…
  - Adoption is very low

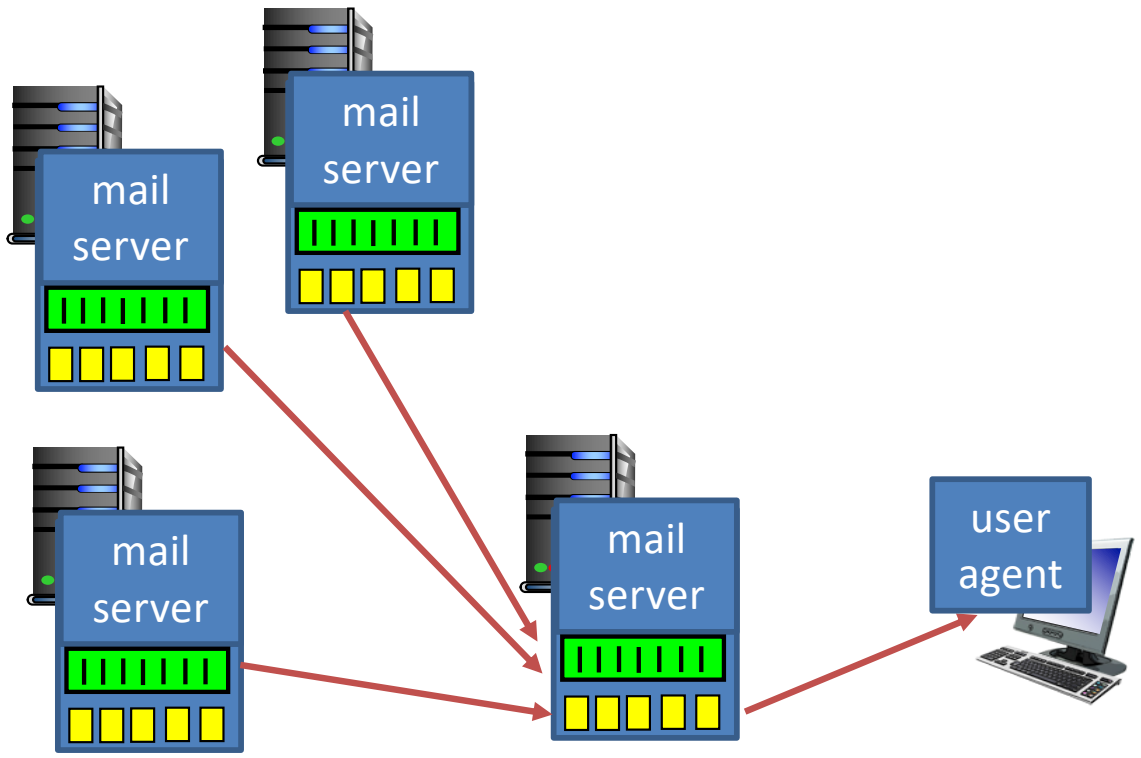
# Logging In / Passwords



# Logging In / Passwords

Any mail server may need to send a message to Bob's.

Tough for them all to share credentials…




# SMTP versus HTTP

- HTTP: pull
- SMTP: push

- Both have ASCII command/response interaction, status codes

- HTTP: each object encapsulated in its own response message

- SMTP: multiple objects sent in multipart message

# SMTP: final words

- SMTP uses persistent connections
  - Can send multiple emails in one session
- SMTP requires message (header & body) to be in 7-bit ASCII
- SMTP server uses CRLF.CRLF to determine end of message

# If SMTP only allows 7-bit ASCII, how do we send pictures/videos/files via email?

A. We encode these objects as 7-bit ASCII

B. We use a different protocol instead of SMTP

C. We're really sending links to the objects, rather than the objects themselves

# Base 64

- Designed to be an efficient way to send binary data as a string
- Uses A-Z, a-z,0-9, “+” and “/” as digits
- A number with digits $d_n d_{n-1} \ldots\ldots d_1 d_0$ = $64^n * d_n + 64^{n-1} * d_{n-1} + \ldots + 64^* d_1 + d_0$
- Recall from CS 31: Other non-base-10 number systems (binary, octal, hex).

# Multipurpose Internet Mail Extensions (MIME)

- Special formatting instructions

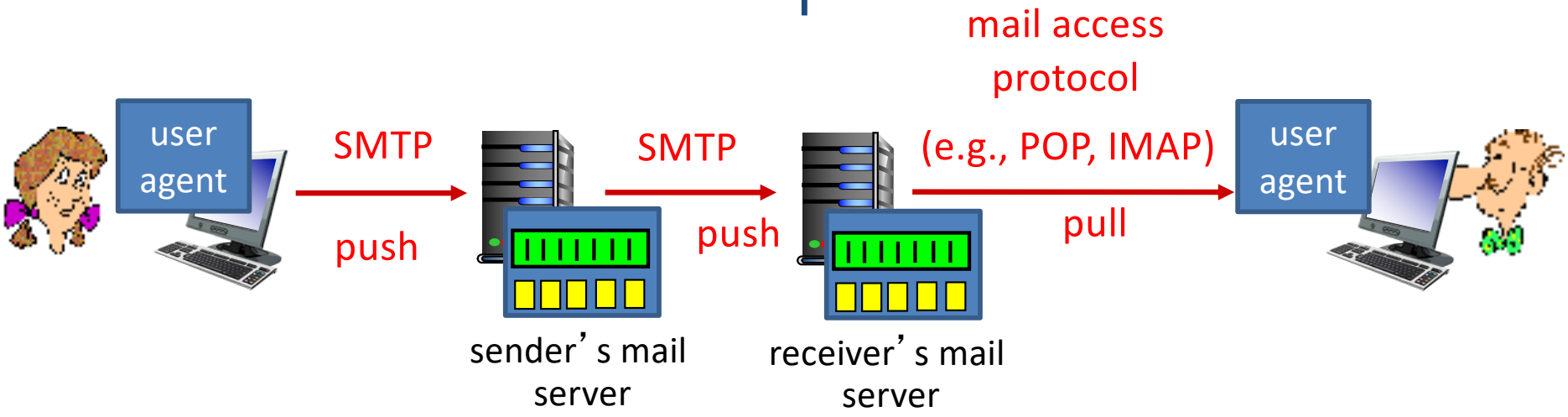
- Indicated in the header portion of message (not SMTP)
  - SMTP does *not* care, just looks like message data

- Supports
  - Text in character sets other than ASCII
  - Non-text attachments
  - Message bodies with multiple parts
  - Header information in non-ASCII character sets

# MIME

- Adds optional headers
  - Designed to be compatible with non-MIME email clients
  - Both clients must understand it to make sense of it
- Specifies content type, other necessary information
- Designates a boundary between email text and attachments

# Mail access protocols




- SMTP: delivery/storage to receiver's server
- mail access protocol: retrieval from server
  - POP: Post Office Protocol: authorization, download
  - IMAP: Internet Mail Access Protocol: more features, including manipulation of stored messages on server
  - HTTP: gmail, Hotmail, Yahoo! Mail, etc.

# 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
```

# More about POP3

- Previous example uses "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
- Limitations:
  - Can't retrieve just the headers
  - Can't impose structure on messages

# 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
- Can request pieces of a message (e.g., text parts without large attachments)

# Webmail

- Uses a web browser
- Sends emails using HTTP rather than POP3 or IMAP
- Mail is stored on the 3rd party webmail company's servers

# Summary

- Three main parts to email:
  - Mail User Agent (mail client): read / write for humans
  - Mail Transfer Agent: server that accepts / sends messages
  - SMTP protocol used to negotiate transfers

- No SMTP support for fraud detection