Chapter 2: outline

2.1 principles of network applications

2.2 Web and HTTP

2.3 electronic mail

- SMTP, POP3, IMAP

2.4 DNS

2.5 P2P applications

2.6 video streaming and content distribution networks

2.7 socket programming with UDP and TCP

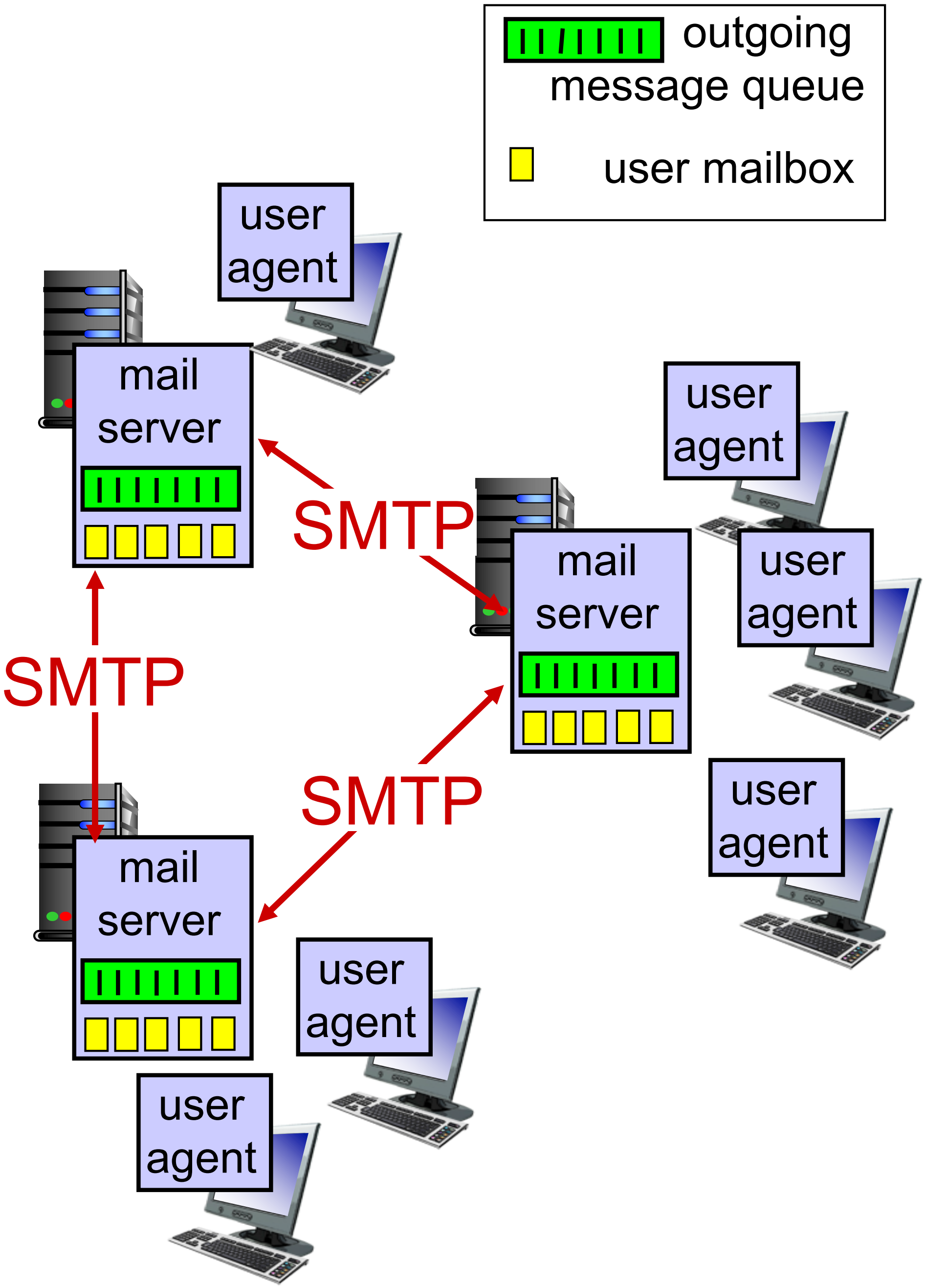
Electronic mail

Three major components:

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

User Agent

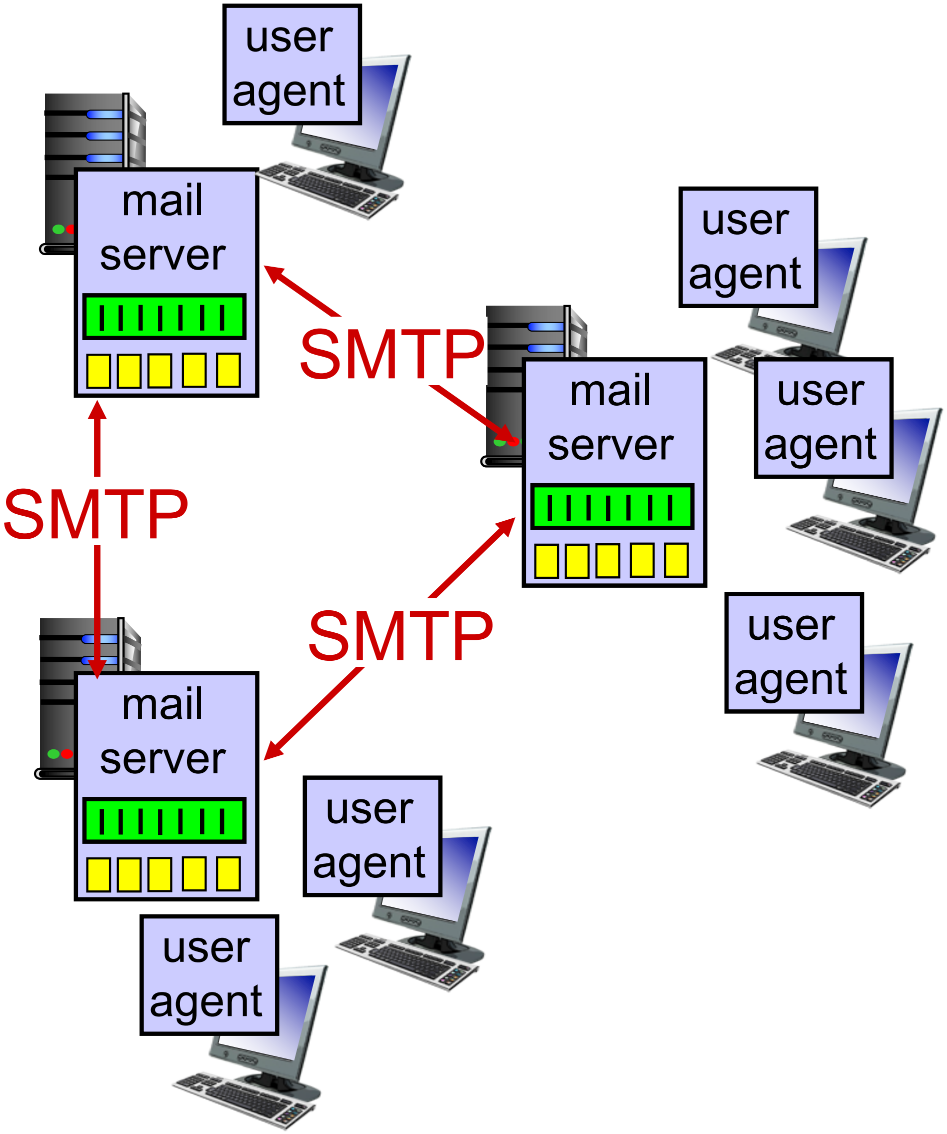
- a.k.a. “mail reader”
- composing, editing, reading mail messages
- e.g., Outlook, Thunderbird, iPhone mail client
- outgoing, incoming messages stored on server



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 (no relaying)
- three phases of transfer
  - handshaking (greeting)
  - transfer of messages
  - closure
- command/response interaction (like HTTP)
  - commands: ASCII text
  - response: status code and phrase
- messages must be in 7-bit ASCI

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

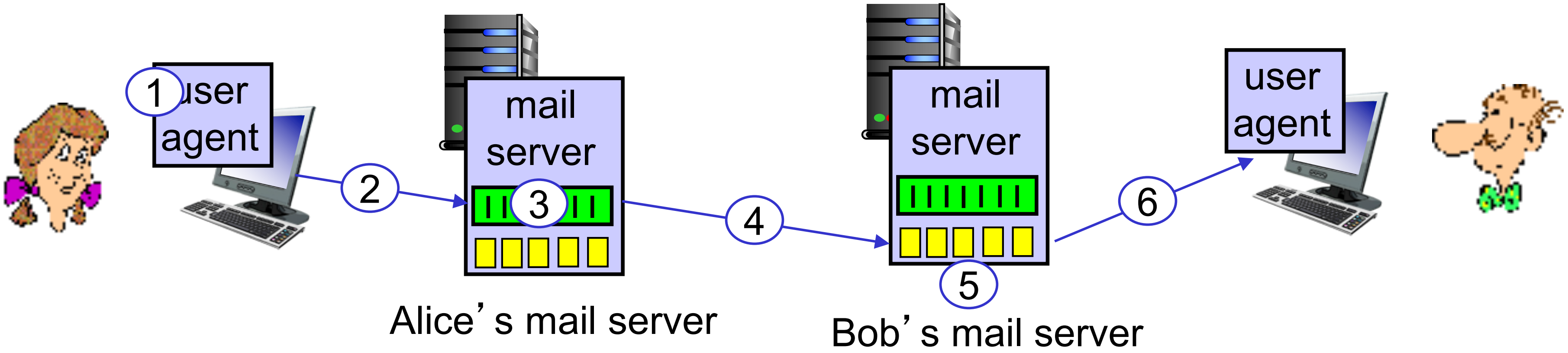
3) client side of SMTP opens TCP connection with Bob's mail server

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

Q: why do we need the servers?



Try SMTP interaction for yourself:

- **`telnet servername 25`**
- see 220 reply from server
- enter HELO, MAIL FROM, RCPT TO, DATA, QUIT commands

above lets you send email without using email client (reader)

Sample SMTP interaction (from your book)

```
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
```

```
From: alice@crepes.fr
To: bob@hamburger.edu
Subject: Test

[Message Body in ASCII]
.
```

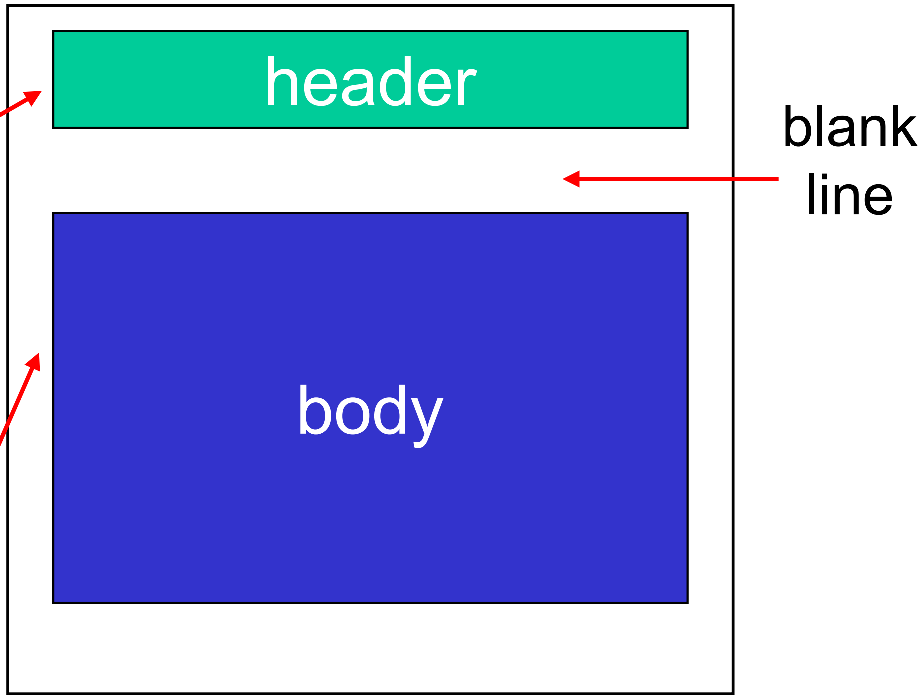
Mail message format

SMTP: protocol for exchanging email messages

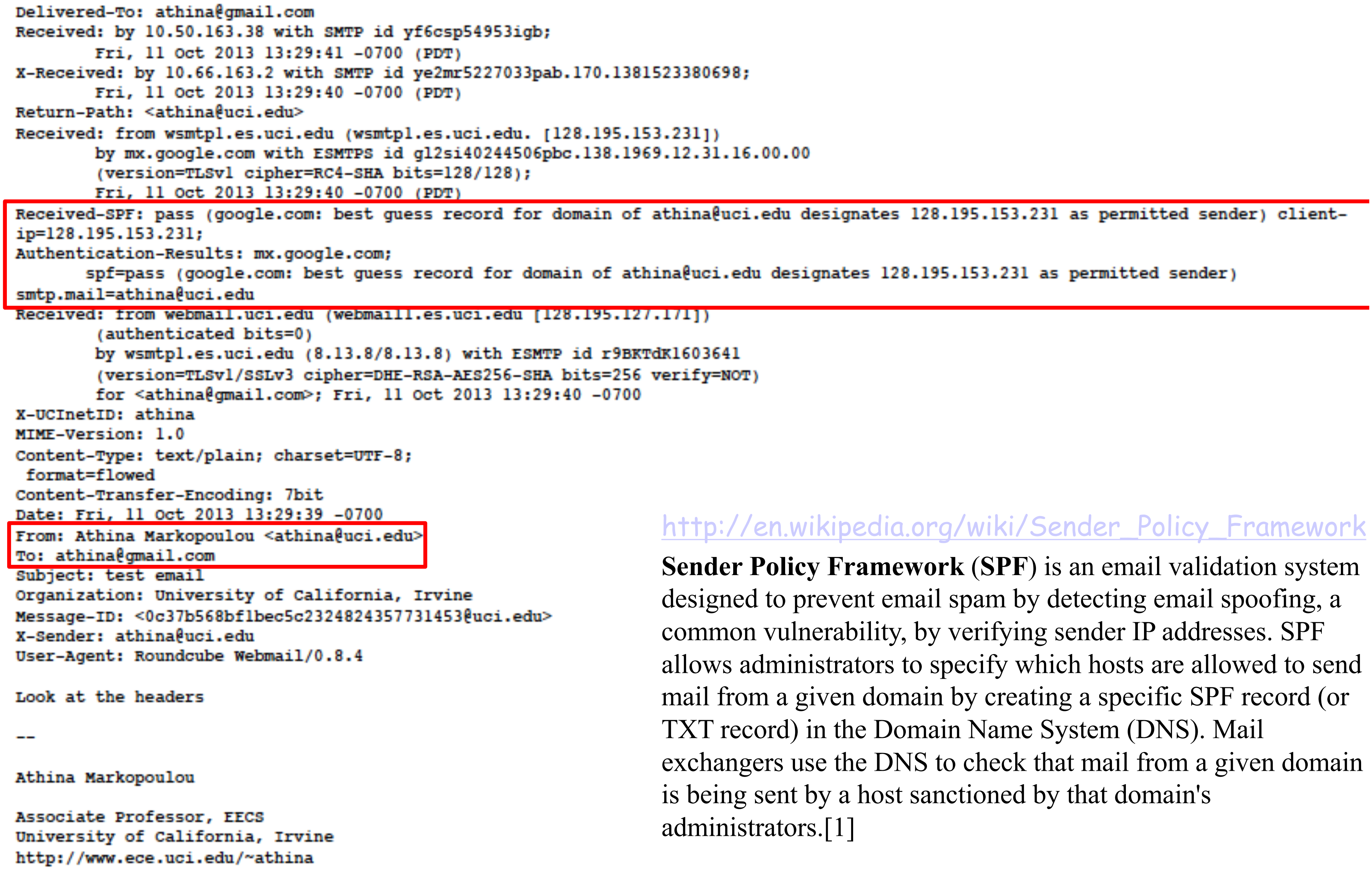
RFC 822: standard for text message format:

- header lines, e.g.,
  - To:
  - From:
  - Subject:

  different from SMTP MAIL FROM, RCPT TO: commands [RFC 2821]!
- Body: the "message"
  - ASCII characters only



Sender Policy Framework (SPF): RFC 4408



```
Delivered-To: athina@gmail.com
Received: by 10.50.163.38 with SMTP id yf6csp54953igb;
        Fri, 11 Oct 2013 13:29:41 -0700 (PDT)
X-Received: by 10.66.163.2 with SMTP id ye2mr5227033pab.170.1381523380698;
        Fri, 11 Oct 2013 13:29:40 -0700 (PDT)
Return-Path: <athina@uci.edu>
Received: from wsmtp1.es.uci.edu (wsmtp1.es.uci.edu. [128.195.153.231])
        by mx.google.com with ESMTPS id gl2si40244506pbc.138.1969.12.31.16.00.00
        (version=TLSv1 cipher=RC4-SHA bits=128/128);
        Fri, 11 Oct 2013 13:29:40 -0700 (PDT)
Received-SPF: pass (google.com: best guess record for domain of athina@uci.edu designates 128.195.153.231 as permitted sender) client-
ip=128.195.153.231;
Authentication-Results: mx.google.com;
       spf=pass (google.com: best guess record for domain of athina@uci.edu designates 128.195.153.231 as permitted sender)
smtp.mail=athina@uci.edu
Received: from webmail.uci.edu (webmail1.es.uci.edu [128.195.127.171])
        (authenticated bits=0)
        by wsmtp1.es.uci.edu (8.13.8/8.13.8) with ESMTP id r9BKTdK1603641
        (version=TLSv1/SSLv3 cipher=DHE-RSA-AES256-SHA bits=256 verify=NOT)
        for <athina@gmail.com>; Fri, 11 Oct 2013 13:29:40 -0700
X-UCInetID: athina
MIME-Version: 1.0
Content-Type: text/plain; charset=UTF-8;
 format=flowed
Content-Transfer-Encoding: 7bit
Date: Fri, 11 Oct 2013 13:29:39 -0700
From: Athina Markopoulou <athina@uci.edu>
To: athina@gmail.com
Subject: test email
Organization: University of California, Irvine
Message-ID: <0c37b568bf1bec5c2324824357731453@uci.edu>
X-Sender: athina@uci.edu
User-Agent: Roundcube Webmail/0.8.4

Look at the headers

--

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```
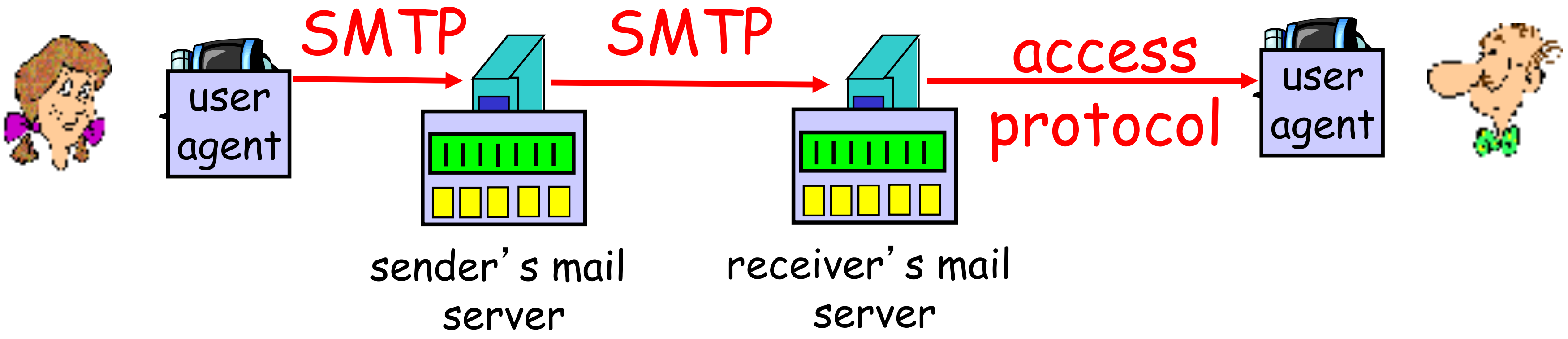

http://en.wikipedia.org/wiki/Sender_Policy_Framework

Sender Policy Framework (**SPF**) is an email validation system designed to prevent email spam by detecting email spoofing, a common vulnerability, by verifying sender IP addresses. SPF allows administrators to specify which hosts are allowed to send mail from a given domain by creating a specific SPF record (or TXT record) in the Domain Name System (DNS). Mail exchangers use the DNS to check that mail from a given domain is being sent by a host sanctioned by that domain's administrators.[1]

What can be done about spoofing/spam



- Spam detection, machine learning
  - Too late! >90% of email is spam and discarded

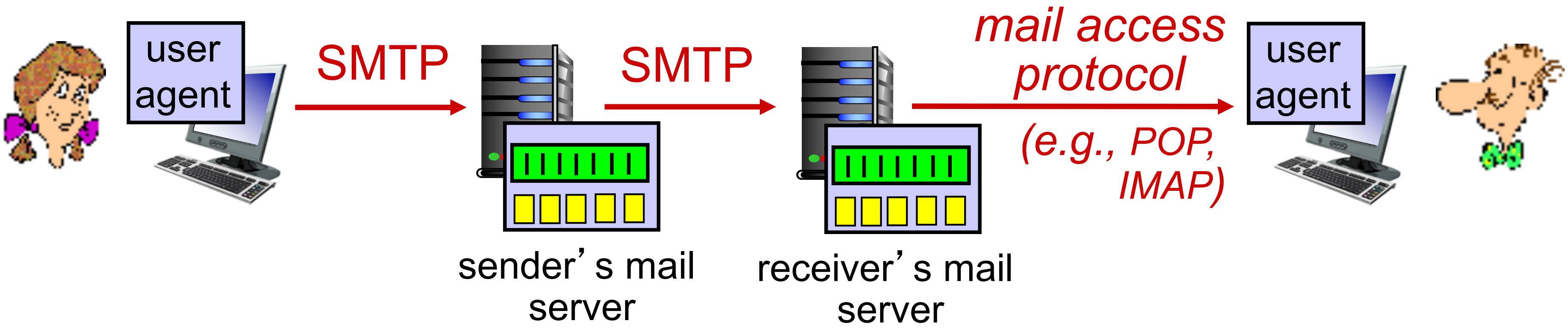
- Authentication
  - Authentication end-to-end (PGP keys)
  - User must login (authenticate) to the server, before sending an email

- SMTP servers are more trustworthy than mail agents
  - Turn off relaying by SMTP server
  - SMTP servers also in DNS → receiving SMTP server can check IP of sending SMTP server (SPF)

SMTP vs HTTP

SMTP	HTTP
Transfer messages (files)	Transfer webpages (files)
Push-based	Pull-based
persistent connections	persistent or non-persistent
SMTP requires message (header & body) to be in 7-bit ASCII	also have ASCII command/response interaction, status codes
SMTP: multiple objects sent in multipart msg	HTTP: each object encapsulated in its own response msg
SMTP server uses CRLF.CRLF to determine end of message	HTTP terminates with CRLF CRLF

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 messages on server
  - HTTP: gmail, Hotmail, Yahoo! Mail, etc.
- Q: Why not use SMTP for last hop?

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
- Folders and messages on local machine(s) are not ideal for the "nomadic" user

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

Web-based email

- Server-browser via HTTP
- E.g.: yahoo, gmail, webmail