CSCE 463/612 Networks and Distributed Processing Fall 2020

Application Layer II

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Chapter 2: Roadmap

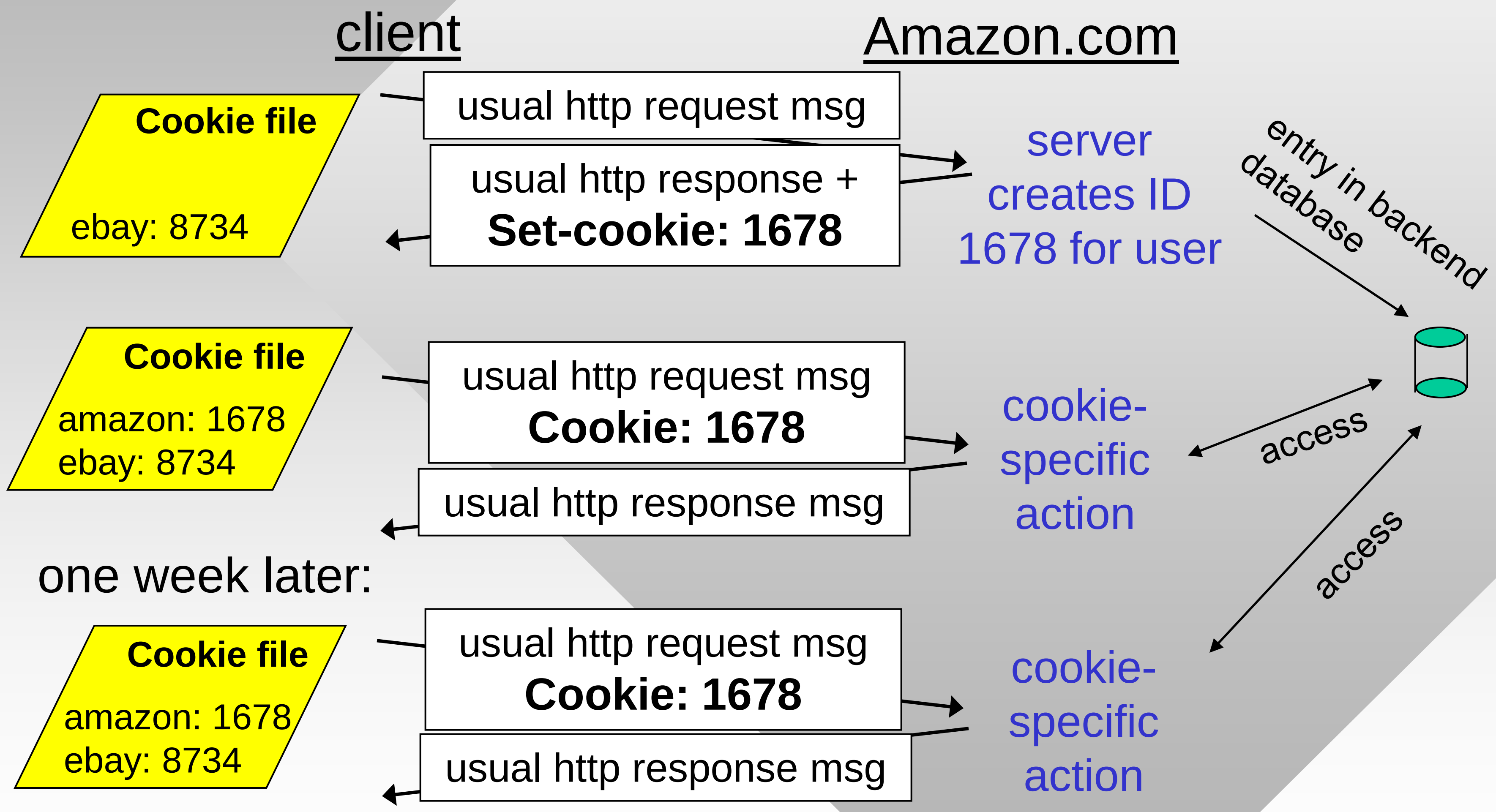
User-Server State: Cookies

- User visits the same web site multiple times
  - Doesn't want to type password or make selections each time
- Website remembers info about the user
  - Pages viewed, items bought, credit cards used
  - Zip code and cable channels (tvguide.com)
  - Weather.com (zip)
  - Amazon shopping cart

Four components:

- Cookie header line in the HTTP response message
- Cookie file kept on user's host and managed by user's browser
- Cookie header line in HTTP request message
- Back-end database at website

Cookies: Keeping State



Cookie Example

Non-persistent cookies expire when browser is closed; *persistent* ones are preserved until a future expiration time (“Expires=” attribute)

```
telnet irl.cs.tamu.edu 80
GET / HTTP/1.0

HTTP/1.1 200 OK
Connection: close
Date: Tue, 18 Sep 2007 18:47:25 GMT
Server: Microsoft-IIS/6.0
MicrosoftOfficeWebServer: 5.0_Pub
X-Powered-By: ASP.NET
Content-Length: 6916
Content-Type: text/html
Set-Cookie: ASPSESSIONIDACSRQCTQ=PIGHLBAAJICJONABJFINMLOA;
  path=/
Cache-control: private
```

path prefix where cookie is valid

cookie value

shared caching not allowed

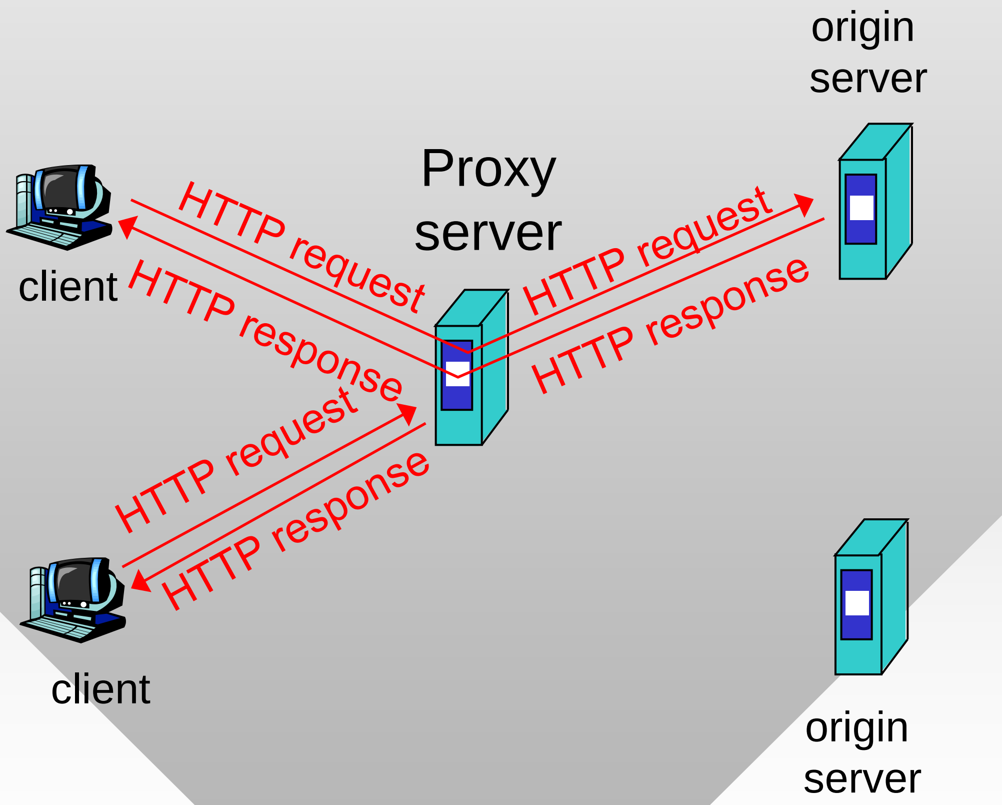
Cookies (continued)

- Cookie file location is browser-dependent
  - For example, Internet Explorer: C:\Users\<*user*>\AppData\Roaming\Microsoft\Windows\Cookies
  - Impersonation is possible by copying or intercepting your cookies (through sniffing and malicious scripting)
- Other privacy issues
  - Websites accumulate data about users (form input, actions), share this information with others
  - So-called third-party (tracking) cookies
- Incognito browsing mode starts with no cookies
  - New cookies are accepted and kept until browser is closed

Web Caches (Proxy Server)

Goal: satisfy client request without involving origin server

- Browser explicitly sends requests via cache or cache intercepts all outgoing HTTP traffic
  - Object in cache: cache returns object
  - Else cache requests object from origin server, then returns object to client



More About Web Caching

- Cache acts as both client and server
- Typically cache is installed by your ISP, university, or company at some network border

Why web caching?

- Reduce response time for client request
- Reduce traffic on the access link

Why web caching (cont'd)

- Reduce load on the servers and allow them to scale to a larger number of users
- Increase security – cached pages can be scanned for viruses before user download is allowed
- Filter URLs to prevent undesirable destinations

Caching Example

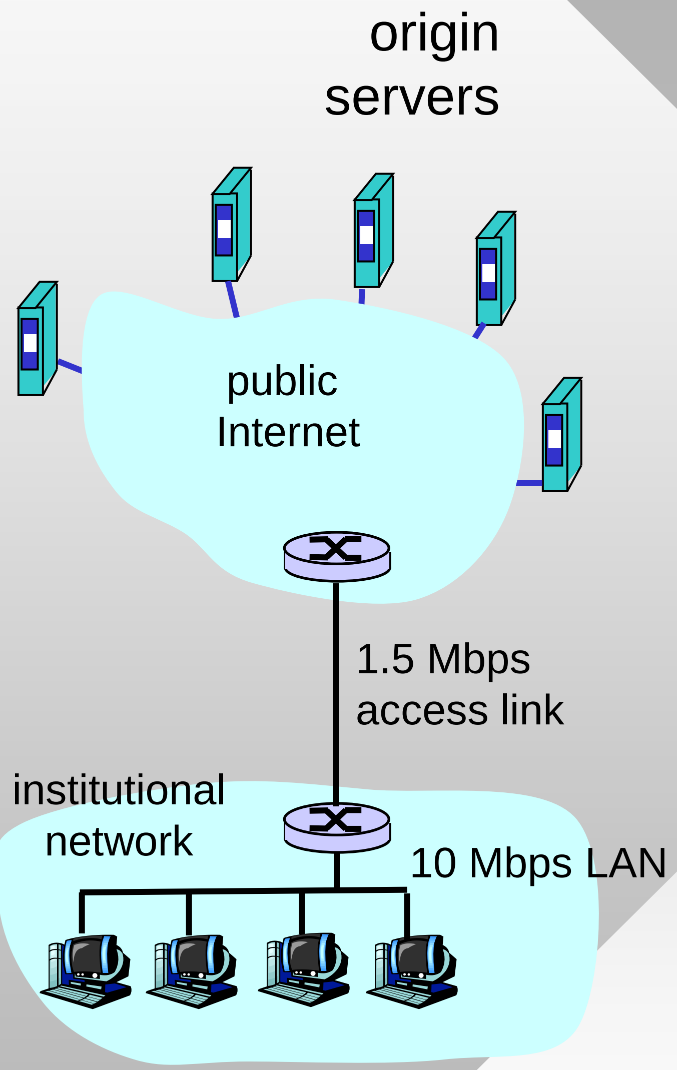
Assumptions

- Average object size = 100,000 bits
- Average request rate from institution’s browsers to origin servers = 15/sec
- Delay from ISP router to any origin server and back to router = 2 sec

Consequences

- Utilization on LAN = 15%
- Utilization on access link = 100%
- Total delay = Internet delay + access delay + LAN delay =

= 2 sec + access queuing delay + milliseconds



Caching Example (cont)

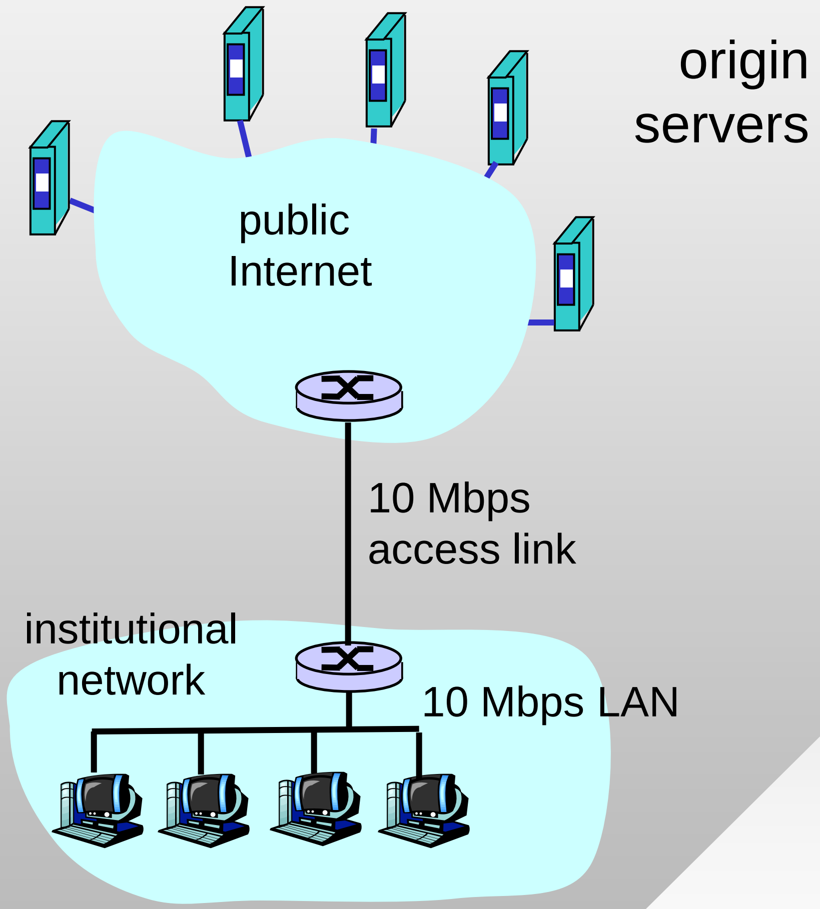
Possible solution

- Increase bandwidth of access link to, say, 10 Mbps

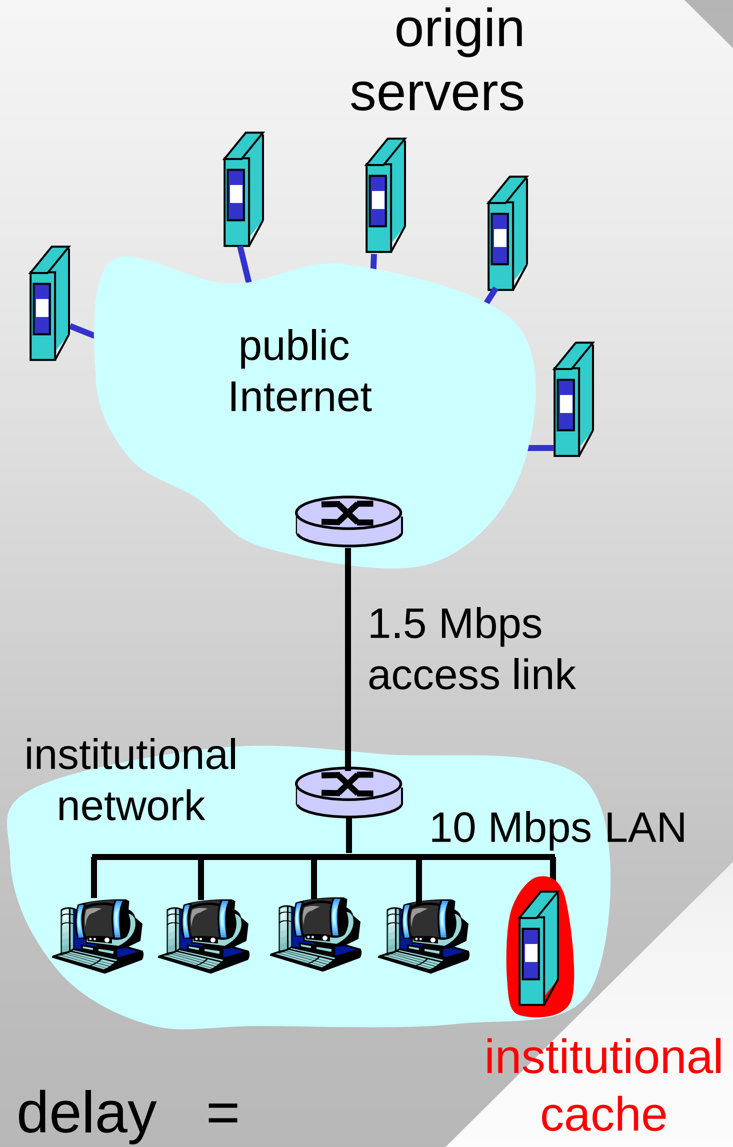
Consequences

- Utilization on LAN = 15%
- Utilization on access link = 15%
- Total delay = Internet delay + access delay + LAN delay

  = 2 sec + msecs + msecs
- Often a costly upgrade



Caching Example (cont)



Install cache

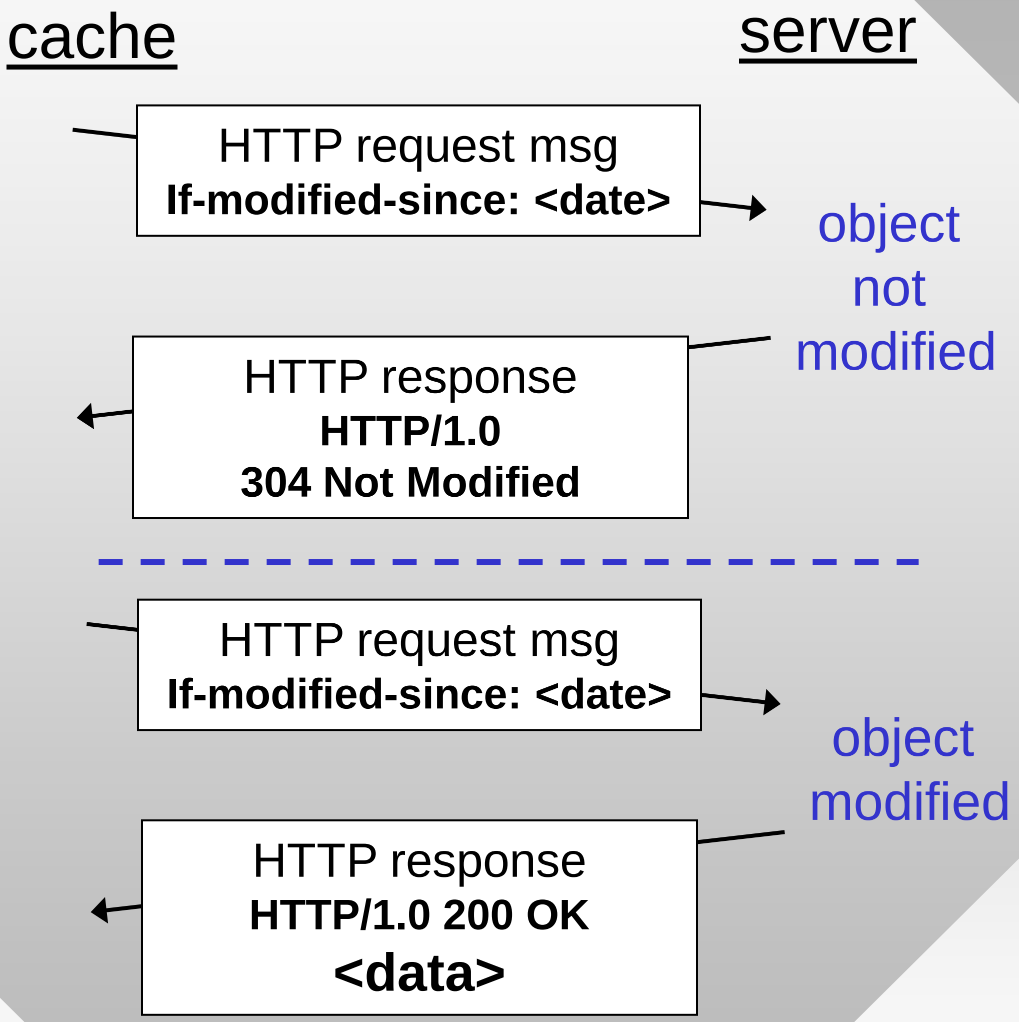
- Suppose hit rate is 40%

Consequences

- 40% of requests will be satisfied almost immediately
- 60% requests satisfied by origin server
- Utilization of access link reduced to 60%, resulting in small queuing delays
- Total average delay = Internet delay + access delay + LAN delay = 0.6 * 2.0 secs + msecs $\approx$ 1.2 secs

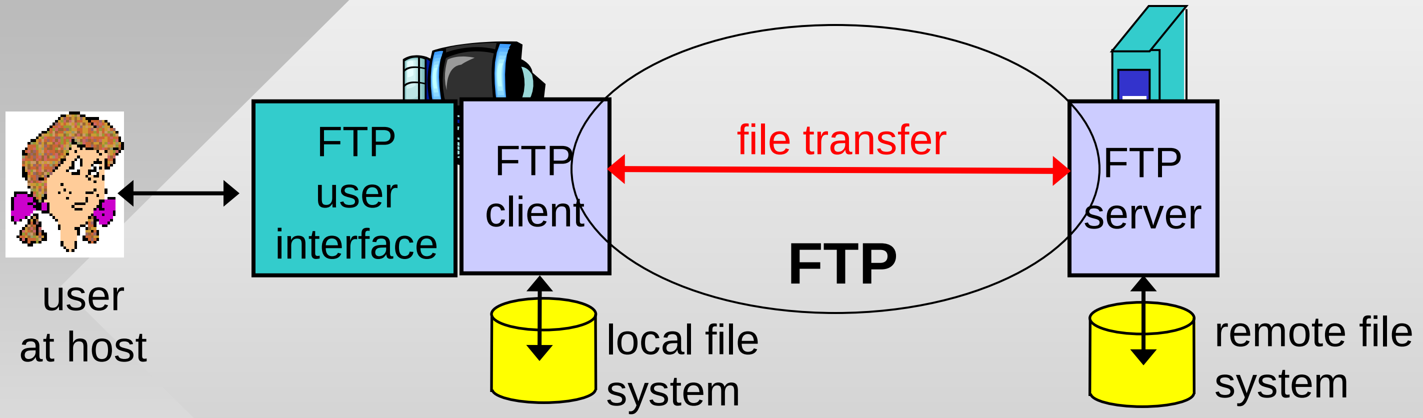
Conditional GET

- Goal: don't send object if cache has up-to-date cached version
  - Cache: specify date of cached copy in HTTP request
  - Server: response contains no object if cached copy is up-to-date
- Expires field in header
  - Server may provide date when content expires
  - `Expires: Sat, 01 Oct 2011 16:00:00 GMT`



Chapter 2: Roadmap

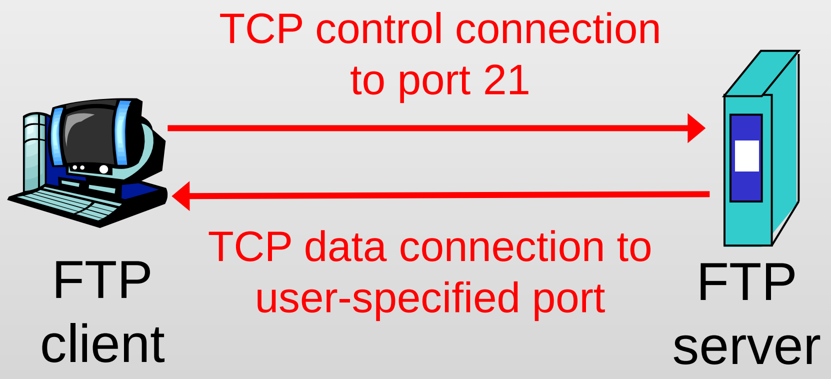
FTP: The File Transfer Protocol



- Transfer file to/from remote host
- Client/server model
  - *client:* initiates the transfer (either to/from remote)
  - *server:* accepts connection on remote host
- FTP: RFC 959 (1985)
- FTP server: port 21

FTP: Separate Control, Data Connections

- FTP client contacts server on port 21 to open control connection
  - Obtains authorization over this channel
  - Sends commands for file transfer and/or directory listing
- Active mode (default): server opens data connection to the client
  - One for each command


TCP control connection to port 21
TCP data connection to user-specified port
FTP client
FTP server

- Passive mode:
  - Data connection opened by client
  - Useful when client is behind a firewall
- After transferring object, sender closes data connection

FTP Commands, Responses

Sample commands:

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

Connection management

- Active mode (PORT)
  - PORT tells the server to which <IP, port> to issue a connect
  - Third party IP is OK in theory, DDoS possibility
- Passive mode (PASV)
  - PASV forces the server to open a new socket to which the client can connect

FTP Example

commands do not work until user is authorized

```
telnet ftp.gnu.org 21
220 GNU FTP server ready
HELO
530 Please login with USER and PASS
USER anonymous
230-Due to U.S. Export Regulations, all cryptographic software on this
230-site is subject to the following legal notice:
230-    This site includes publicly available encryption source code
...
230 Login successful.
PORT 128,194,135,66,10,5
```

specifies IP 128.194.135.66 and port number 2565

```
----------- passive example
PASV
227 Entering Passive Mode (140,186,70,20,154,15)
```

status code

IP 140.186.70.20 and port 39439

Chapter 2: Roadmap

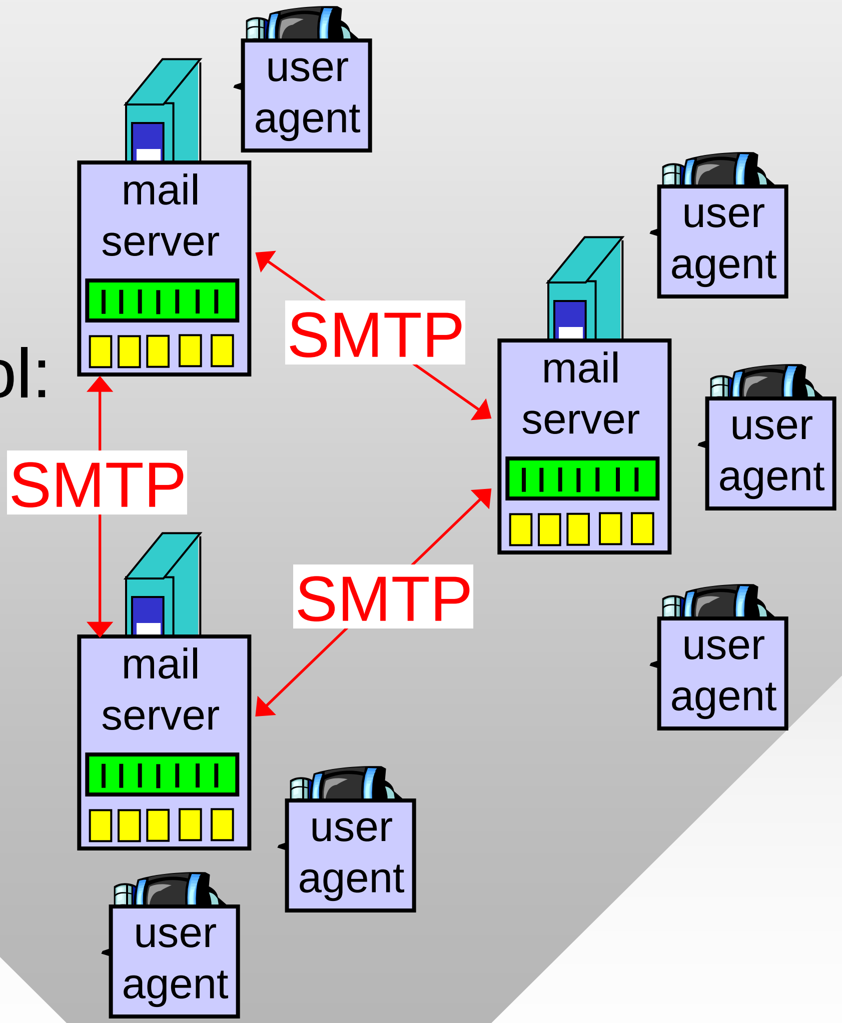
Electronic Mail

Three major components:

- User agents
- Mail servers
- Simple mail transfer protocol: SMTP

User Agent (UA)

- Mail reader – composing, editing, reading mail messages
  - pine, outlook, elm, thunderbird, iphone



Electronic Mail: Mail Servers

🟩 outgoing message queue

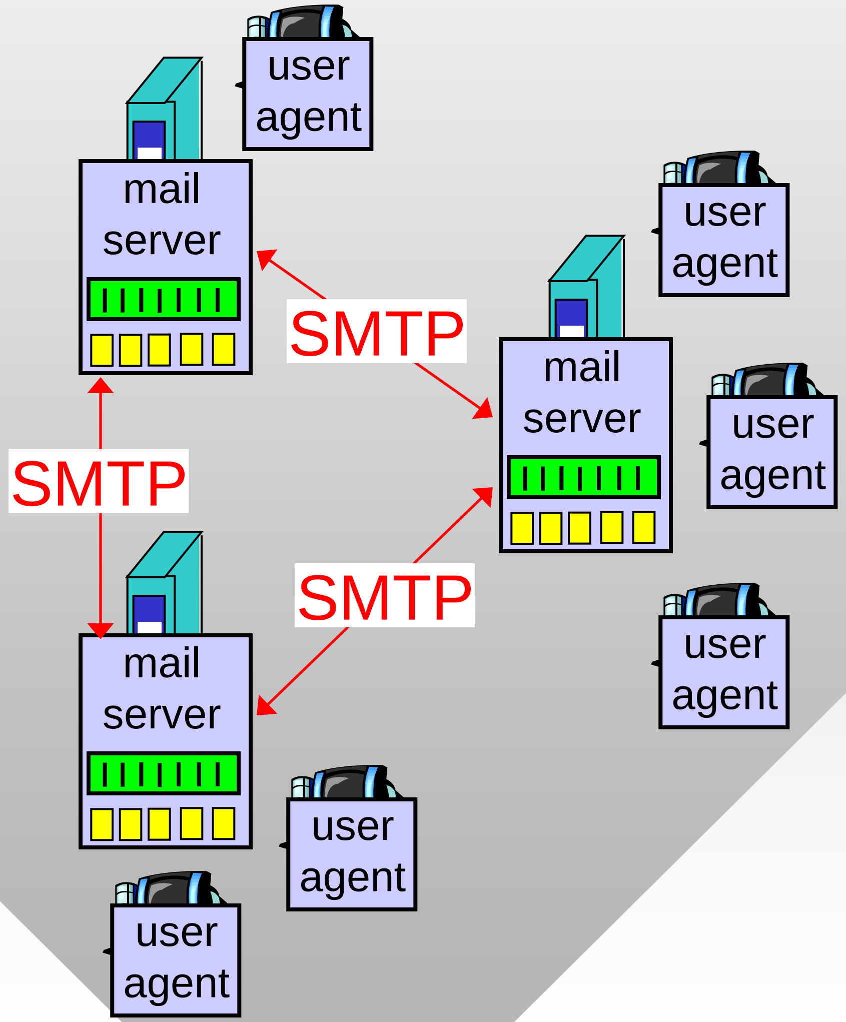
🟨 user mailbox

Mail Servers

- Message queue of outgoing (to be sent) mail messages
- Mailbox contains incoming messages for user

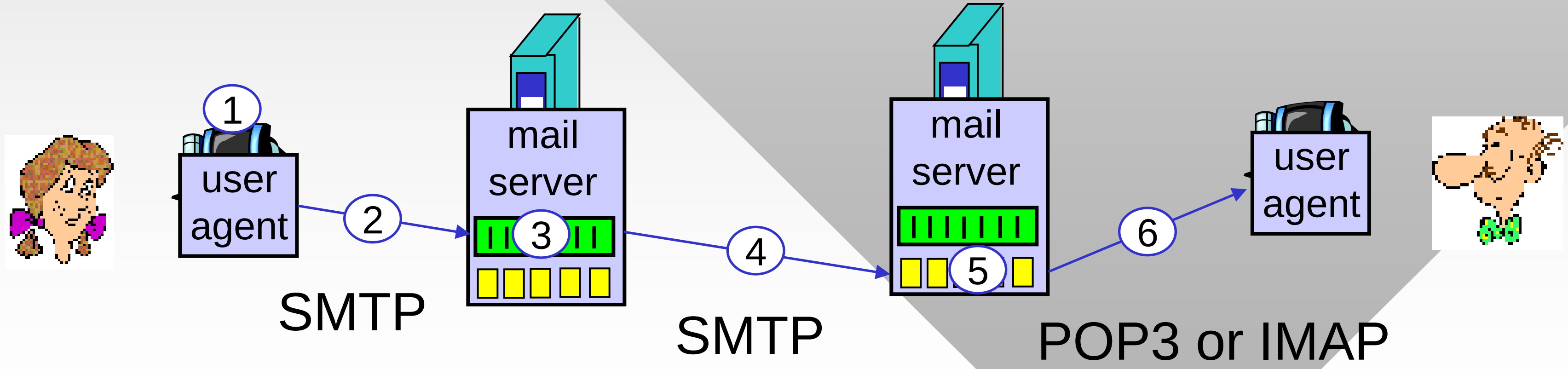
SMTP protocol

- Used by mail servers to send email messages
  - Client: sending mail server
  - Server: receiving mail server



Scenario: Alice Sends Message to Bob

1) Alice uses UA to compose message and “to” `bob@someschool.edu`
2) Alice’s UA sends message to her mail server
3) Message accepted and placed in outgoing queue
4) SMTP client sends message to Bob’s server
5) Bob’s mail server places the message in Bob’s mailbox
6) Bob invokes his user agent to read message



Electronic Mail: SMTP [RFC 821, 974, 1869, 2821]

- Original RFC in 1982, latest version in 2001
- Uses TCP to reliably transfer email message from client to server, port 25
- Three phases of transfer
  - SMTP handshake (greeting)
  - Transfer of messages
  - Closure
- Command/response interaction
  - Commands: ASCII text separated by \r\n
  - Response: status code and phrase (one line)

Sample SMTP Interaction

```
telnet mail.cs.tamu.edu 25
220 pine.cs.tamu.edu ESMTP Sendmail 8.12.9/8.12.9;
Mon, 20 Sep 2004 15:52:57 -0500 (CDT)
HELO viper.cs.tamu.edu
250 pine.cs.tamu.edu Hello irl-viper.cs.tamu.edu
[128.194.135.66], pleased to meet you
MAIL FROM:<dmitri@cs.tamu.edu>
250 2.1.0 <dmitri@cs.tamu.edu>... Sender ok
RCPT TO:<dmitri@cs.tamu.edu>
250 2.1.5 <dmitri@cs.tamu.edu>... Recipient ok
DATA
354 Enter mail, end with "." on a line by itself
Hello
Blah-blah-blah
.
250 2.0.0 i8KKqvvk027391 Message accepted for delivery
QUIT
221 2.0.0 pine.cs.tamu.edu closing connection
```

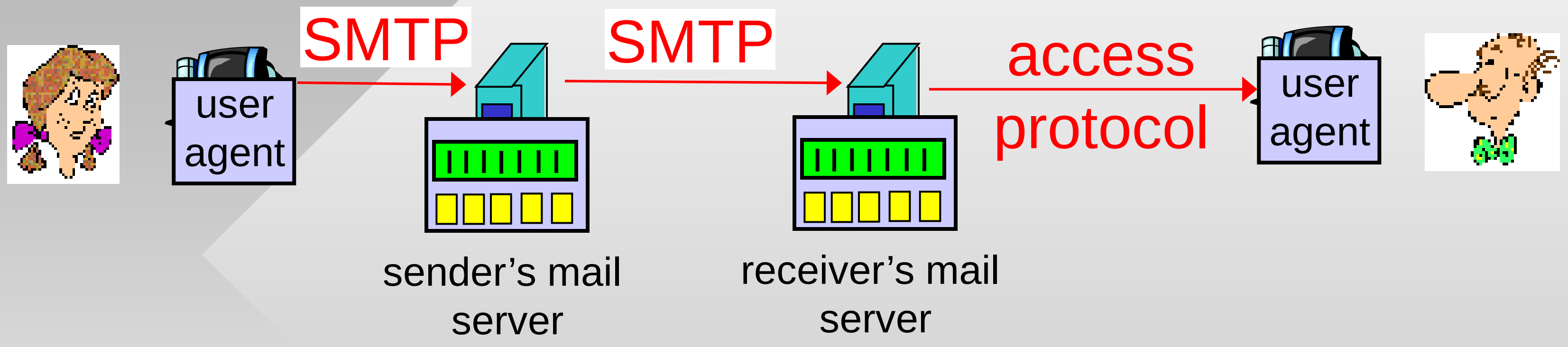
SMTP: Final Words

- SMTP uses non-pipelined persistent connections
- SMTP requires message (header & body) in 7-bit ASCII (codes < 128)
  - Additional restrictions may exist for the line length
- SMTP server uses `\r\n.\r\n` to determine the end of message
  - Solution: UA inserts a dot in front of all lines already starting with a dot

Comparison with HTTP:

- HTTP: pull, SMTP: push
- Both have ASCII command/response interaction, status codes
- HTTP: each object encapsulated in its own request/response msg
- SMTP: multiple objects sent in one msg separed by special tokens

Mail Access Protocols



- SMTP: delivery/storage to receiver's server
- Mail access protocol: retrieval from server
  - POP3: Post Office Protocol v3 [RFC 1939] – port 110
    - Authorization (agent <-->server) and download
  - IMAP: Internet Mail Access Protocol [RFC 1730] – port 143
    - More features (more complex)
    - Manipulation of stored messages on server
  - HTTP: Hotmail, Yahoo!, Gmail, etc.

POP3 Protocol

- Server responses
  - +OK
  - -ERR

Authorization phase

- Client commands:
  - user: declare username
  - pass: password

Transaction phase, client:

- list: list message #s
- retr: retrieve message by number
- dele: delete
- quit

```
telnet mail.cs.tamu.edu 110
+OK POP3 server ready
user bob
+OK
pass hungry
+OK user successfully logged on
```

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

POP3 (More) and IMAP

More about POP3

- Example used “download and delete” mode
- “Download-and-keep”
  - Multiple copies of message on different clients
- POP3 is stateless across sessions
  - Server assigns unique IDs to each message
  - Command UIDL lists IDs
  - UA determines new messages by remembering IDs of downloaded email

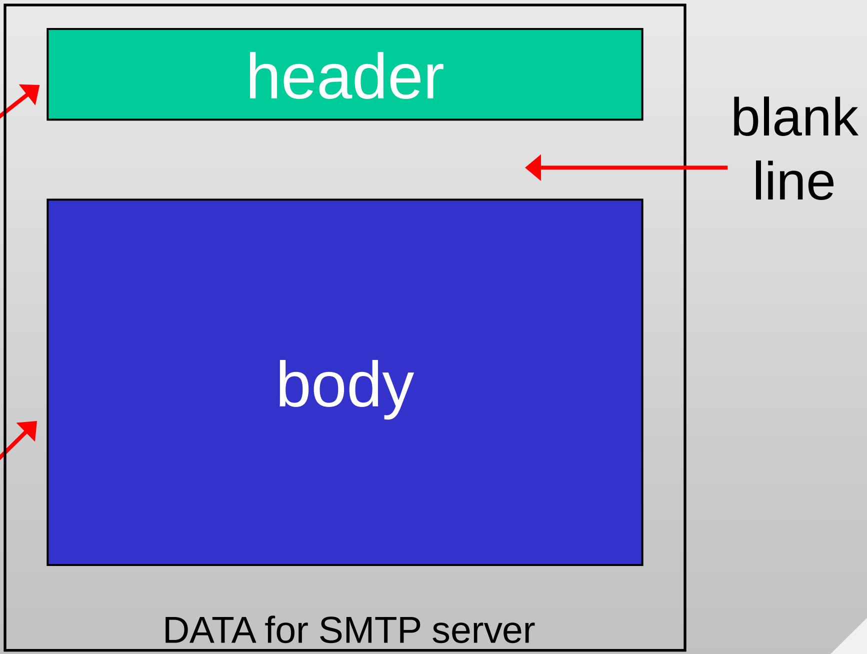
IMAP

- Keeps message status (folder membership, read/unread, flagged, replied to) at the server: stateful protocol
- More feature for the user, but more computationally expensive for the server

Mail Message Format

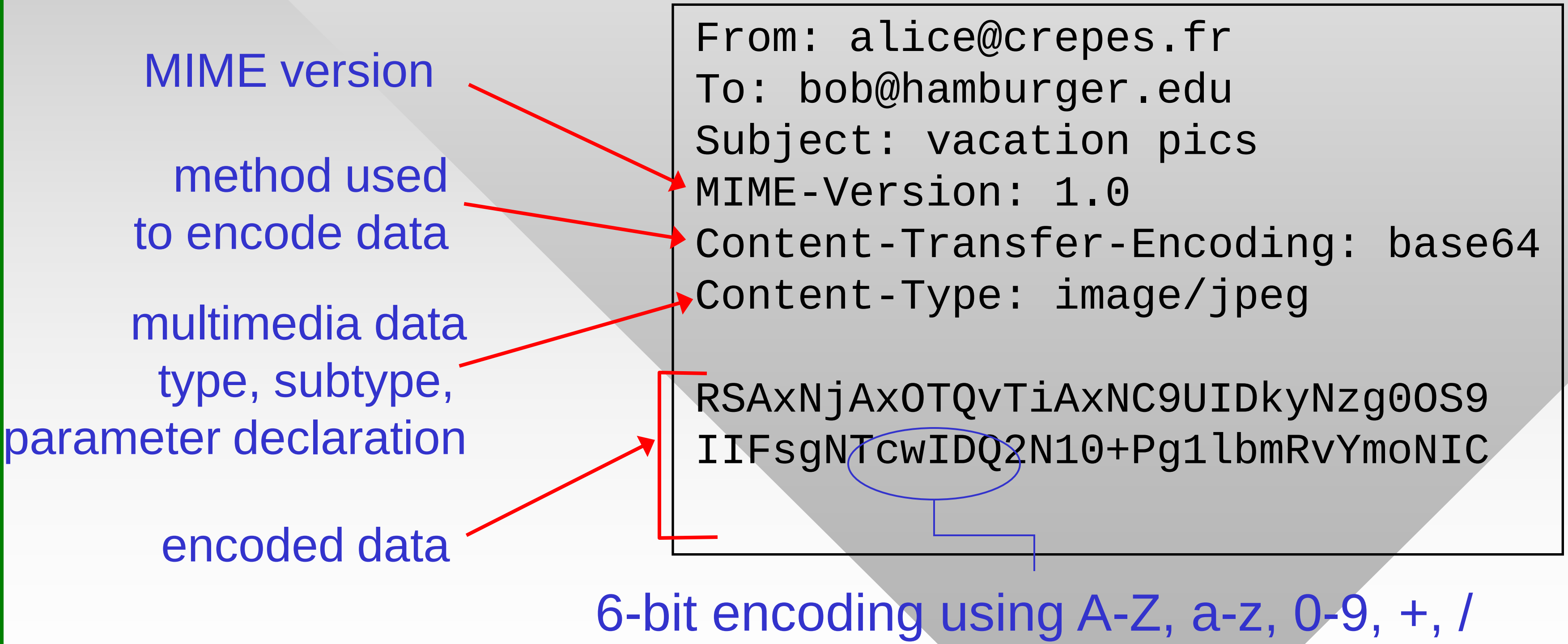
- SMTP: protocol for exchanging email msgs
- RFC 822: standard for text message format
- Header lines, e.g.,
  - To:
  - From:
  - Subject:

  Different from SMTP commands!
- Body
  - The “message”, 7-bit ASCII characters only



Message Format: MIME

- MIME: Multipurpose Internet Mail Extensions, RFCs 2045, 2056 (1996)
  - Additional lines in header declare MIME content type



```
From: alice@crepes.fr
To: bob@hamburger.edu
Subject: vacation pics
MIME-Version: 1.0
Content-Transfer-Encoding: base64
Content-Type: image/jpeg

RSAxNjAxOTQvTiAxNC9UIDkyNzg0OS9
IIFsgNTcwIDQ2N10+Pg1lbmRvYmoNIC
```

MIME version
method used to encode data
multimedia data type, subtype, parameter declaration
encoded data
6-bit encoding using A-Z, a-z, 0-9, +, /

Message Format: MIME 2

- Multiple objects separated by a specific boundary

```
Content-Type: multipart/mixed;
    boundary="----=_NextPart_000_0074_01C6DB4C.731EBEB0"

This is a multi-part message in MIME format.

------=_NextPart_000_0074_01C6DB4C.731EBEB0
Content-Type: text/plain;charset="iso-8859-1"
Content-Transfer-Encoding: 7bit

Some text message here...

------=_NextPart_000_0074_01C6DB4C.731EBEB0
Content-Type: application/pdf;name="9-18-06.pdf"
Content-Transfer-Encoding: base64
```