

Transport service requirements of common apps

Application	Data loss	Bandwidth	Time Sensitive
file transfer	no loss	elastic	no
e-mail	no loss	elastic	no
Web documents	loss-tolerant	elastic	no
real-time audio/video	loss-tolerant	audio: 5Kb-1Mb video: 10Kb-5Mb	yes, 100's msec
stored audio/video	loss-tolerant	same as above	yes, few secs
interactive games	loss-tolerant	few Kbps up	yes, 100's msec
financial apps	no loss	elastic	yes and no

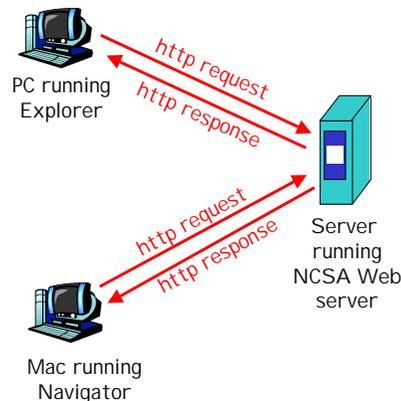
Internet apps: their protocols and transport protocols

Application	Application layer protocol	Underlying transport protocol
e-mail	smtp [RFC 821]	TCP
remote terminal access	telnet [RFC 854]	TCP
Web	http [RFC 2068]	TCP
file transfer	ftp [RFC 959]	TCP
streaming multimedia	proprietary (e.g. RealNetworks)	TCP or UDP
remote file server	NSF	TCP or UDP
Internet telephony	proprietary (e.g., Vocaltec)	typically UDP

WWW: the http protocol

http: hypertext transfer protocol

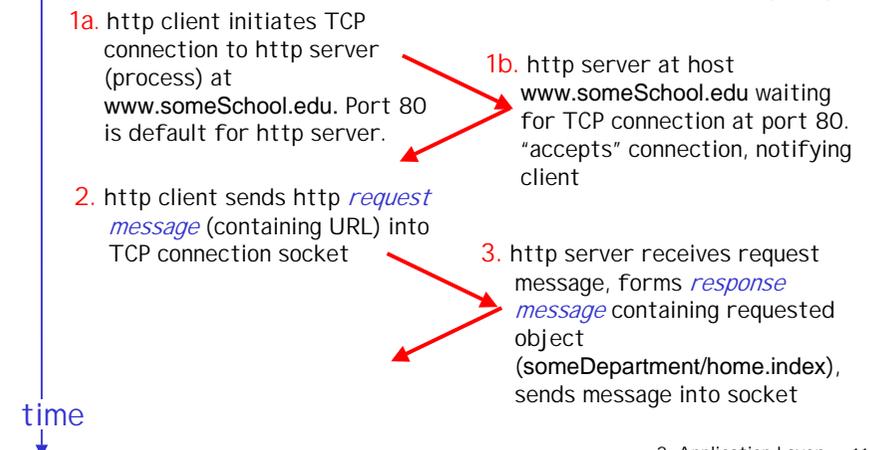
- WWW's application layer protocol
- client/server model
 - *client*: browser that requests, receives, "displays" WWW objects
 - *server*: WWW server sends objects in response to requests
- http1.0: RFC 1945
- http1.1: RFC 2068



http example

Suppose user enters URL

`www.someSchool.edu/someDepartment/home.index` (contains text, references to 10 jpeg images)



http example (cont.)

- time ↓
4. http server closes TCP connection.
 5. http client receives response message containing html file, displays html. Parsing html file, finds 10 referenced jpeg objects
 6. Steps 1-5 repeated for each of 10 jpeg objects
- **non-persistent connection:** one object in each TCP connection
 - some browsers create multiple TCP connections *simultaneously* - one per object
 - **persistent connection:** multiple objects transferred within one TCP connection

http message format: request

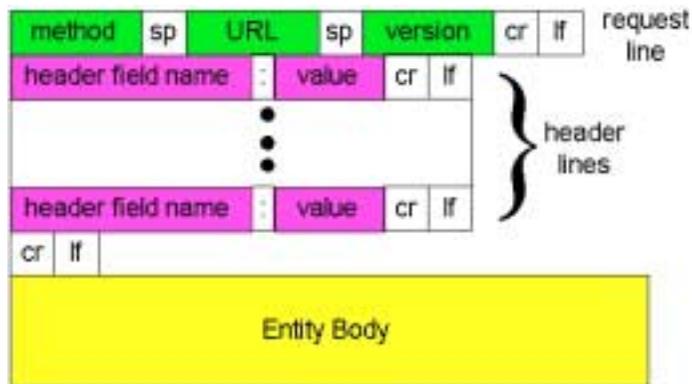
- two types of http messages: *request, response*
- **http request message:**
 - ASCII (human-readable format)

request line (GET, POST, HEAD commands) → GET /somedir/page.html HTTP/1.1

header lines → Connection: close
User-agent: Mozilla/4.0
Accept: text/html, image/gif, image/jpeg
Accept-language: fr

Carriage return, line feed (extra carriage return, line feed) indicates end of message

http request message: general format



http message format: reply

status line (protocol status code status phrase) → HTTP/1.1 200 OK

header lines → Connection: close
Date: Thu, 06 Aug 1998 12:00:15 GMT
Server: Apache/1.3.0 (Unix)
Last-Modified: Mon, 22 Jun 1998
Content-Length: 6821
Content-Type: text/html

data, e.g., requested html file → data data data data data ...

Trying out http (client side) for yourself

1. Telnet to your favorite WWW server:

```
telnet www.eurecom.fr 80
```

Opens TCP connection to port 80 (default http server port) at www.eurecom.fr. Anything typed in sent to port 80 at www.eurecom.fr

2. Type in a GET http request:

```
GET /~ross/index.html HTTP/1.0
```

By typing this in (hit carriage return twice), you send this minimal (but complete) GET request to http server

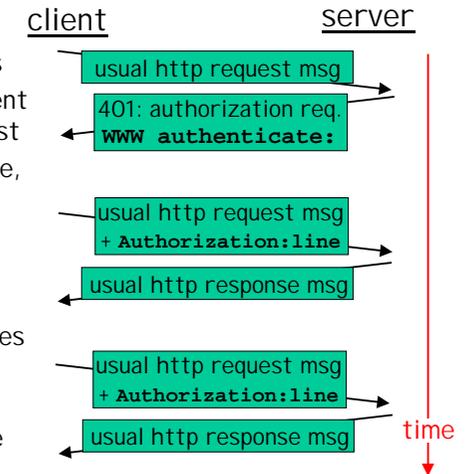
3. Look at response message sent by http server!

User-server interaction: authentication

Authentication goal: control

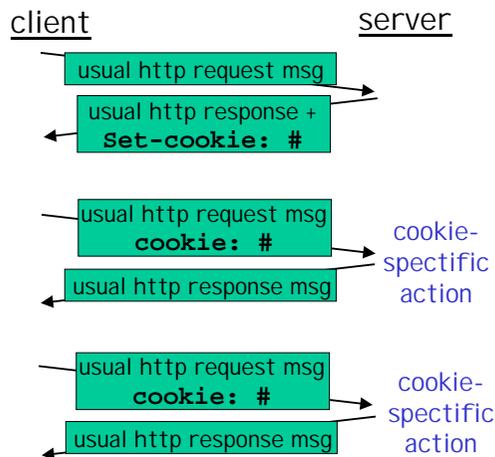
access to server documents

- **stateless:** client must present authorization in each request
- **authorization:** typically name, password
 - **authorization:** header line in request
 - if no authorization presented, server refuses access, sends **WWW authenticate:** header line in response



User-server interaction: cookies

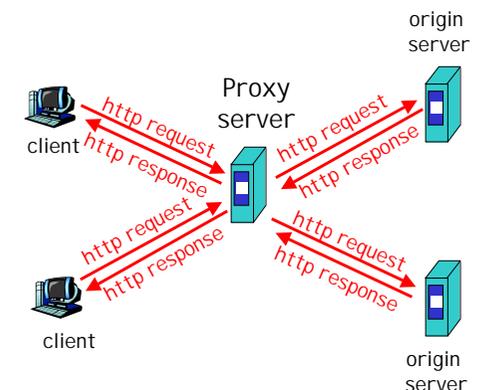
- server sends "cookie" to client in response
 - Set-cookie: #
- client present cookie in later requests
 - cookie: #
- server matches presented-cookie with server-stored cookies
 - authentication
 - remembering user preferences, previous choices



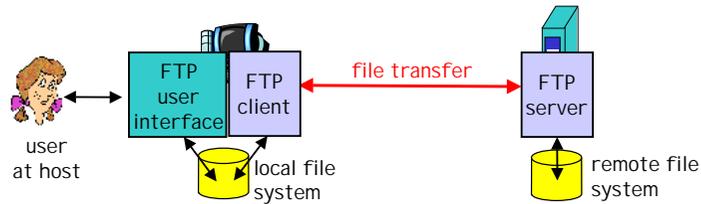
Web Caches (proxy server)

Goal: satisfy client request without involving origin server

- user sets browser: WWW accesses via web cache
- client sends all http requests to web cache
 - if object at web cache, web cache immediately returns object in http response
 - else requests object from origin server, then returns http response to client



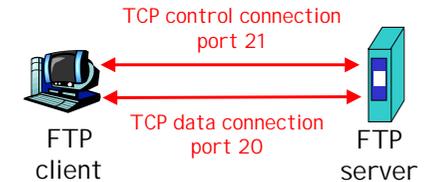
ftp: the file transfer protocol



- ❑ 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, specifying TCP as transport protocol
- ❑ two parallel TCP connections opened:
 - **control**: exchange commands, responses between client, server.
"out of band control"
 - **data**: file data to/from server
- ❑ 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**

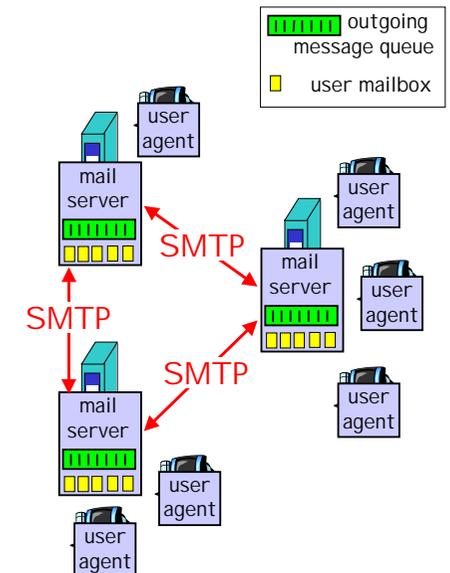
Electronic Mail

Three major components:

- ❑ user agents
- ❑ mail servers
- ❑ simple mail transfer protocol: smtp

User Agent

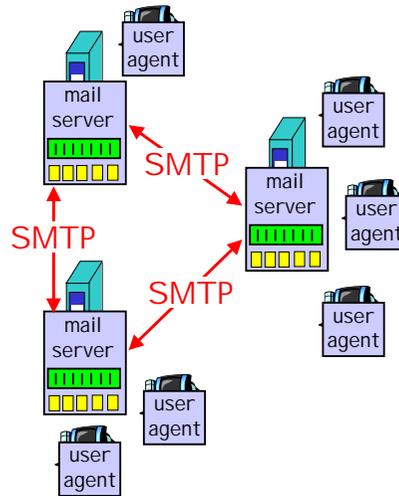
- ❑ a.k.a. "mail reader"
- ❑ composing, editing, reading mail messages
- ❑ e.g., Eudora, pine, elm, Netscape Messenger
- ❑ outgoing, incoming messages stored on server



Electronic Mail: mail servers

Mail Servers

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



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Electronic Mail: smtp [RFC 821]

- ❑ uses tcp to reliably transfer email msg from client to server, port 25
- ❑ direct transfer: sending server to receiving server
- ❑ three phases of transfer
 - handshaking (greeting)
 - transfer
 - closure
- ❑ command/response interaction
 - **commands**: ASCII text
 - **response**: status code and phrase

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Sample smtp interaction

```
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
```

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smtp: final words

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)

Comparison with http

- ❑ http: pull
- ❑ email: push
- ❑ both have ASCII command/response interaction, status codes
- ❑ http: multiple objects in file sent in separate connections
- ❑ smtp: multiple message parts sent in one connection

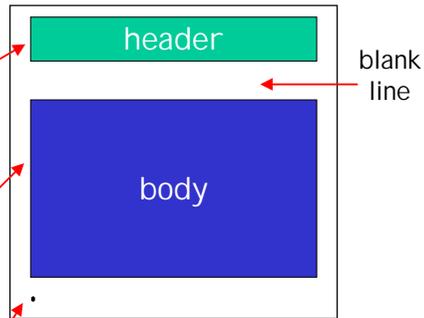
2: Application Layer 30

Mail message format

smtp: protocol for exchanging email msgs

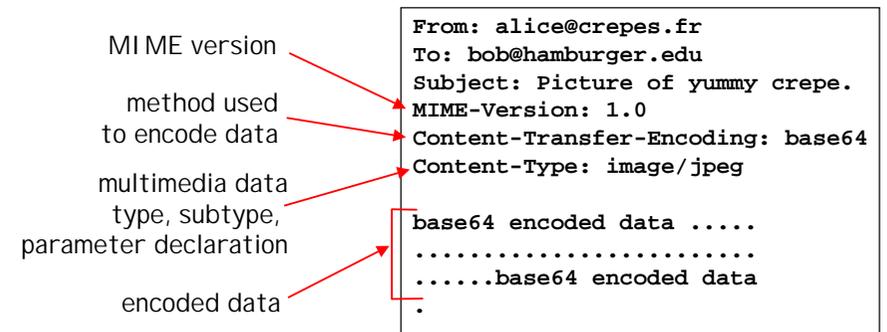
RFC 822: standard for text message format:

- header lines, e.g.,
 - To:
 - From:
 - Subject:*different from smtp commands!*
- body
 - the "message", ASCII characters only
- line containing only `.`



Message format: multimedia extensions

- MIME: multimedia mail extension, RFC 2045, 2056
- additional lines in msg header declare MIME content type



MIME types

Text

- example subtypes: **plain**, **html**

Image

- example subtypes: **jpeg**, **gif**

Audio

- example subtypes: **basic** (8-bit mu-law encoded), **32kadpcm** (32 kbps coding)

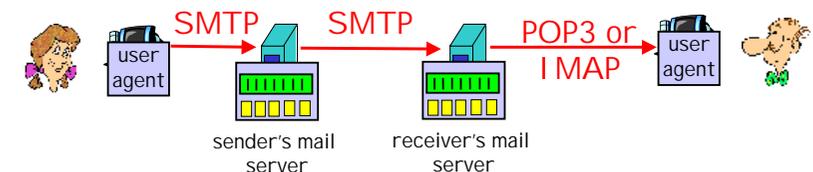
Video

- example subtypes: **mpeg**, **quicktime**

Application

- other data that must be processed by reader before "viewable"
- example subtypes: **msword**, **octet-stream**

Mail access protocols



- SMTP: delivery/storage to receiver's server
- Mail access protocol: retrieval from server
 - POP: Post Office Protocol [RFC 1939]
 - authorization (agent <->server) and download
 - IMAP: Internet Mail Access Protocol [RFC 1730]
 - more features (more complex)
 - manipulation of stored msgs on server

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 alice
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
```