Network Applications: HTTP/1.0

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http://zoo.cs.yale.edu/classes/cs433/

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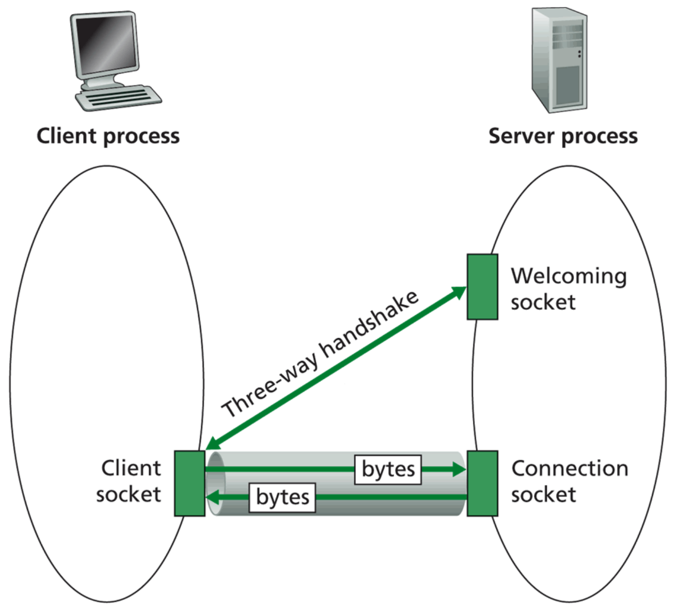
Admin

- Assignment 2 posted

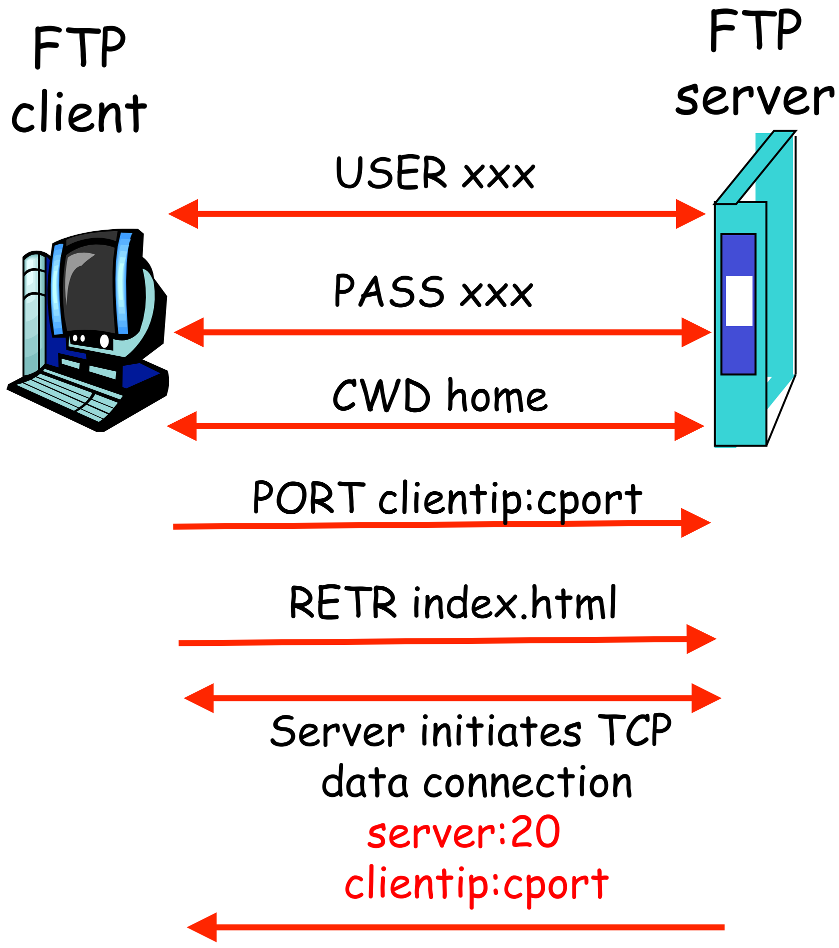
Recap: TCP Sockets

- TCP server socket demux by 4-tuple:
  - source IP address
  - source port number
  - dest IP address
  - dest port number



Recap: FTP

- A stateful protocol
  - state established by commands such as
    - USER/PASS, CWD, TYPE
- Multiple TCP connections
  - A control connection
  - Data connections
    - Two approaches: PORT vs PASV
    - GridFTP: concurrent data connections; block data transfer mode



Outline

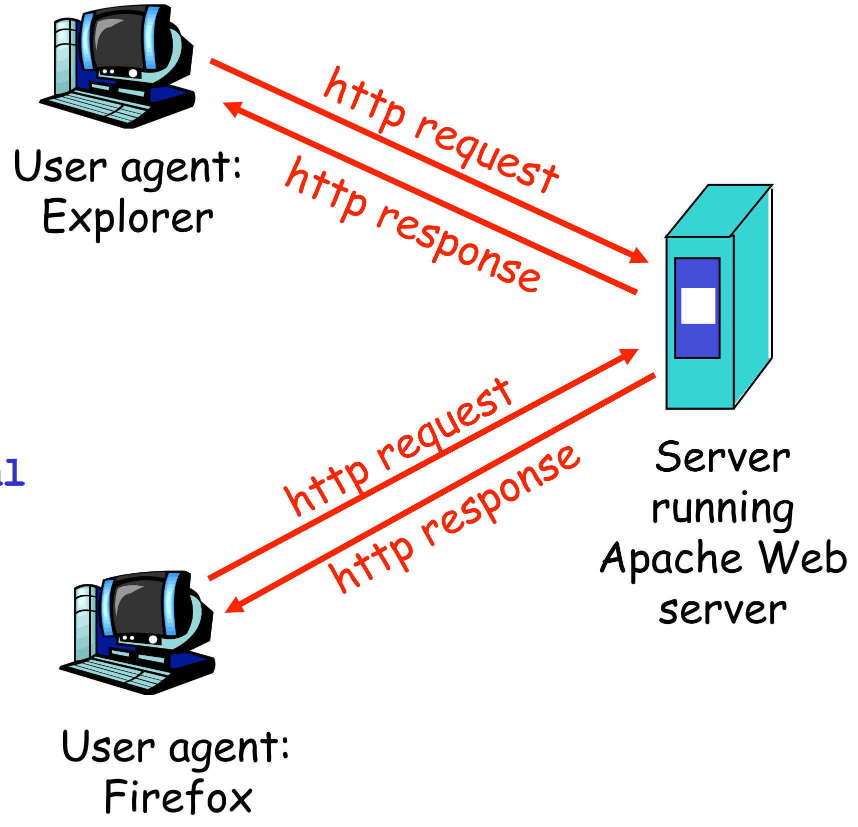
- Recap
- HTTP

From Opaque Files to Web Pages

- Web page:
  - authored in HTML
  - addressed by a URL
    - URL has two components:
      - host name, port number and
      - path name

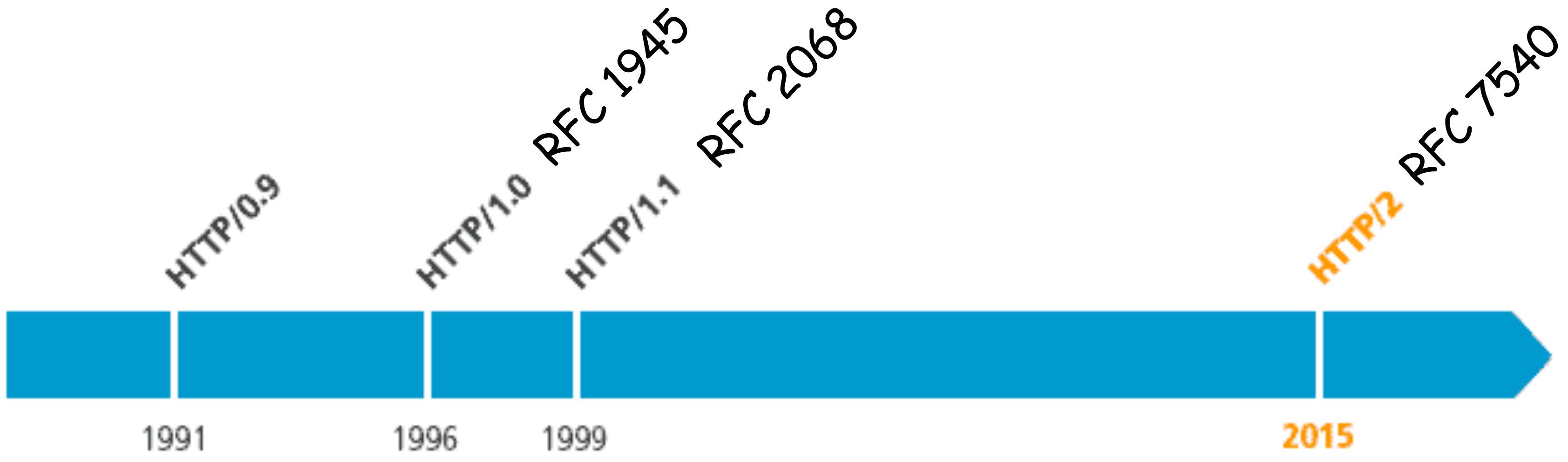
`http://www.cs.yale.edu:80/index.html`

- Most Web pages consist of:
  - base HTML page, and
  - several referenced objects



The Web pages are requested through HTTP: hypertext transfer protocol

HTTP is Still Evolving



HTTP 1.0 Message Flow

- Server waits for requests from clients

- Client initiates TCP connection (creates socket) to server, port 80
- Client sends request for a document
- Web server sends back the document
- TCP connection closed

- Client parses the document to find embedded objects (images)
  - repeat above for each image

HTTP 1.0 Message Flow (more detail)

Suppose user enters URL
www.cs.yale.edu/index.html

0. http server at host www.cs.yale.edu waiting for TCP connection at port 80.

1a. http client initiates TCP connection to http server (process) at www.cs.yale.edu. Port 80 is default for http server.

1b. server "accepts" connection, ack. client

2. http client sends http *request message* (containing URL) into TCP connection socket

3. http server receives request message, forms *response message* containing requested object (index.html), sends message into socket (the sending speed increases slowly, which is called slow-start)

time

HTTP 1.0 Message Flow (cont.)

4. http server closes TCP connection.

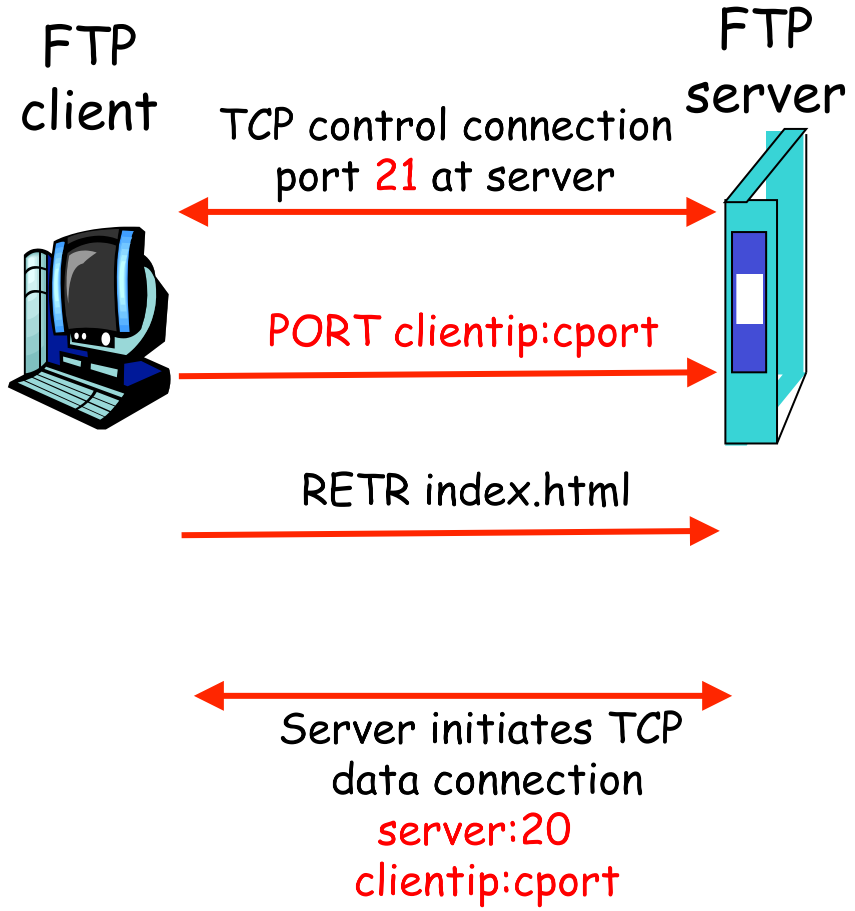
5. http client receives response message containing html file, parses html file, finds embedded image

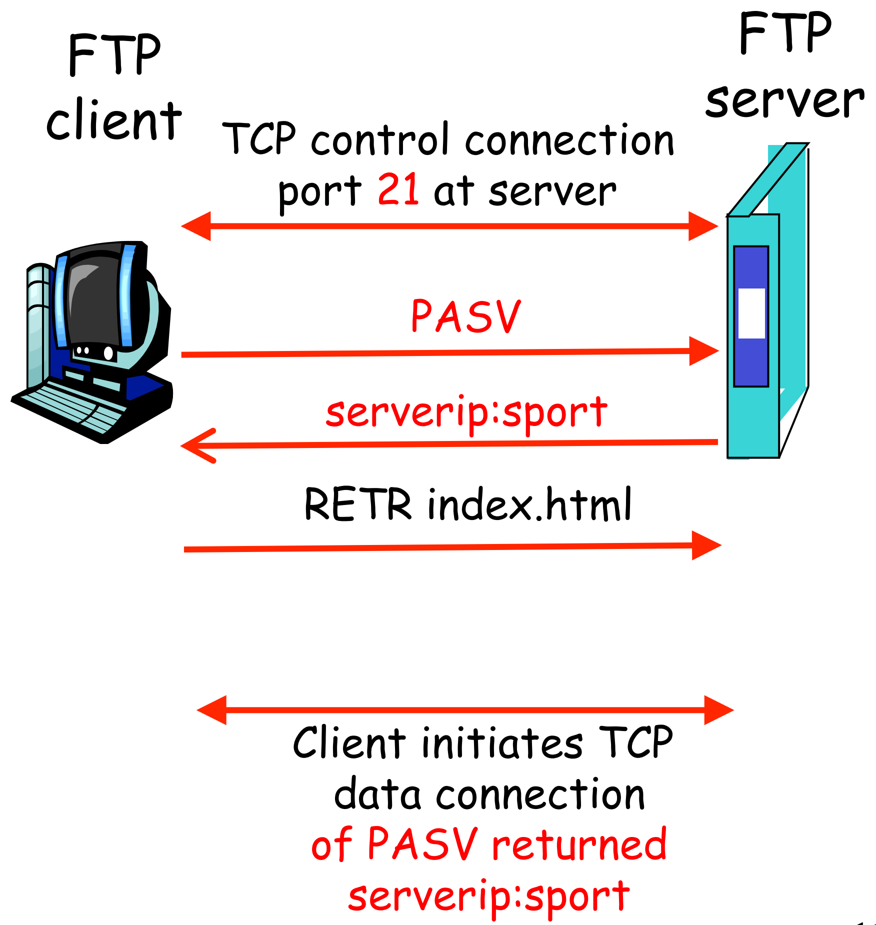
time

6. Steps 1-5 repeated for each of the embedded images

Discussion

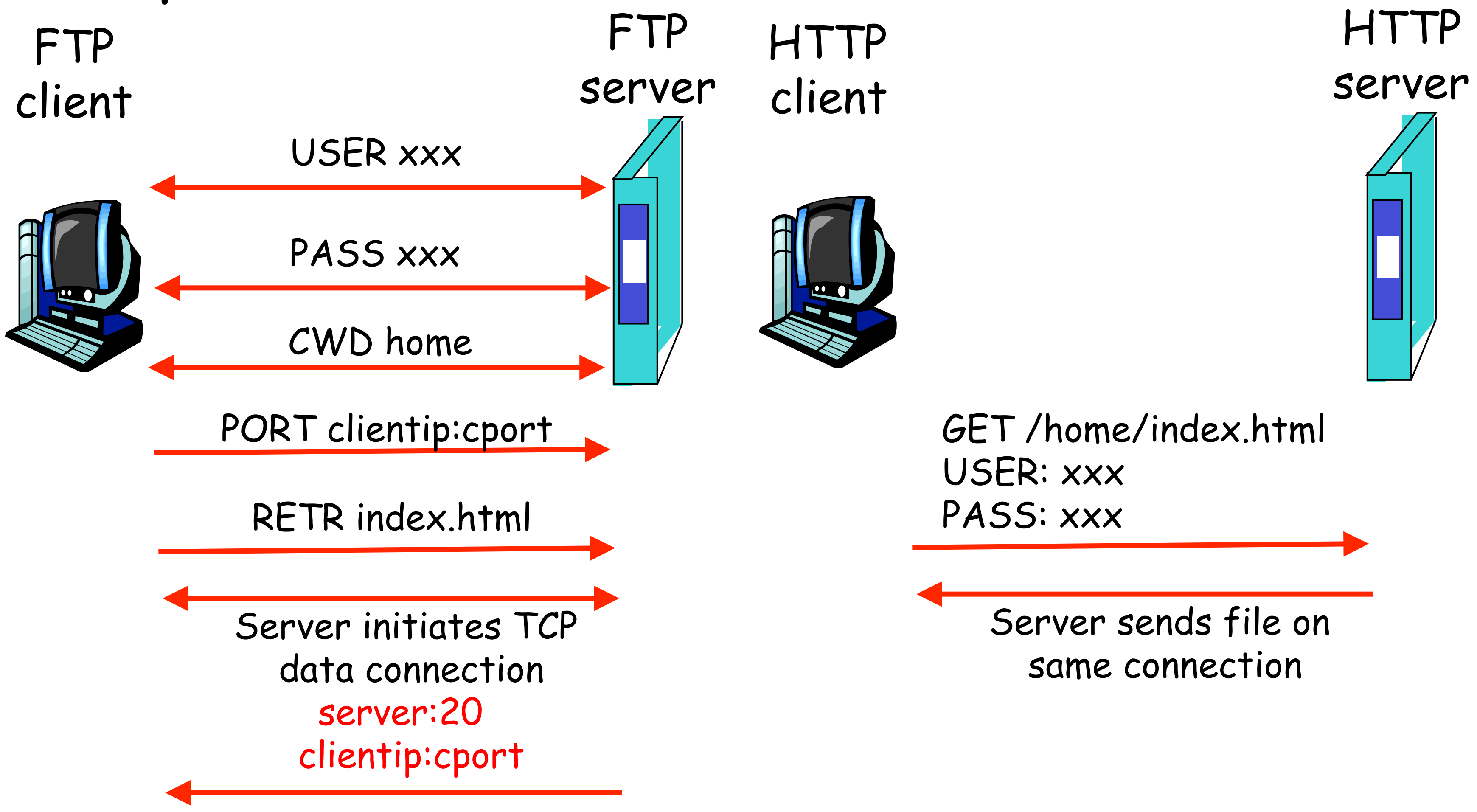
- How about we use FTP as HTTP?


FTP client
FTP server
TCP control connection port 21 at server
PORT clientip:cport
RETR index.html
Server initiates TCP data connection server:20 clientip:cport


FTP client
FTP server
TCP control connection port 21 at server
PASV
serverip:sport
RETR index.html
Client initiates TCP data connection of PASV returned serverip:sport

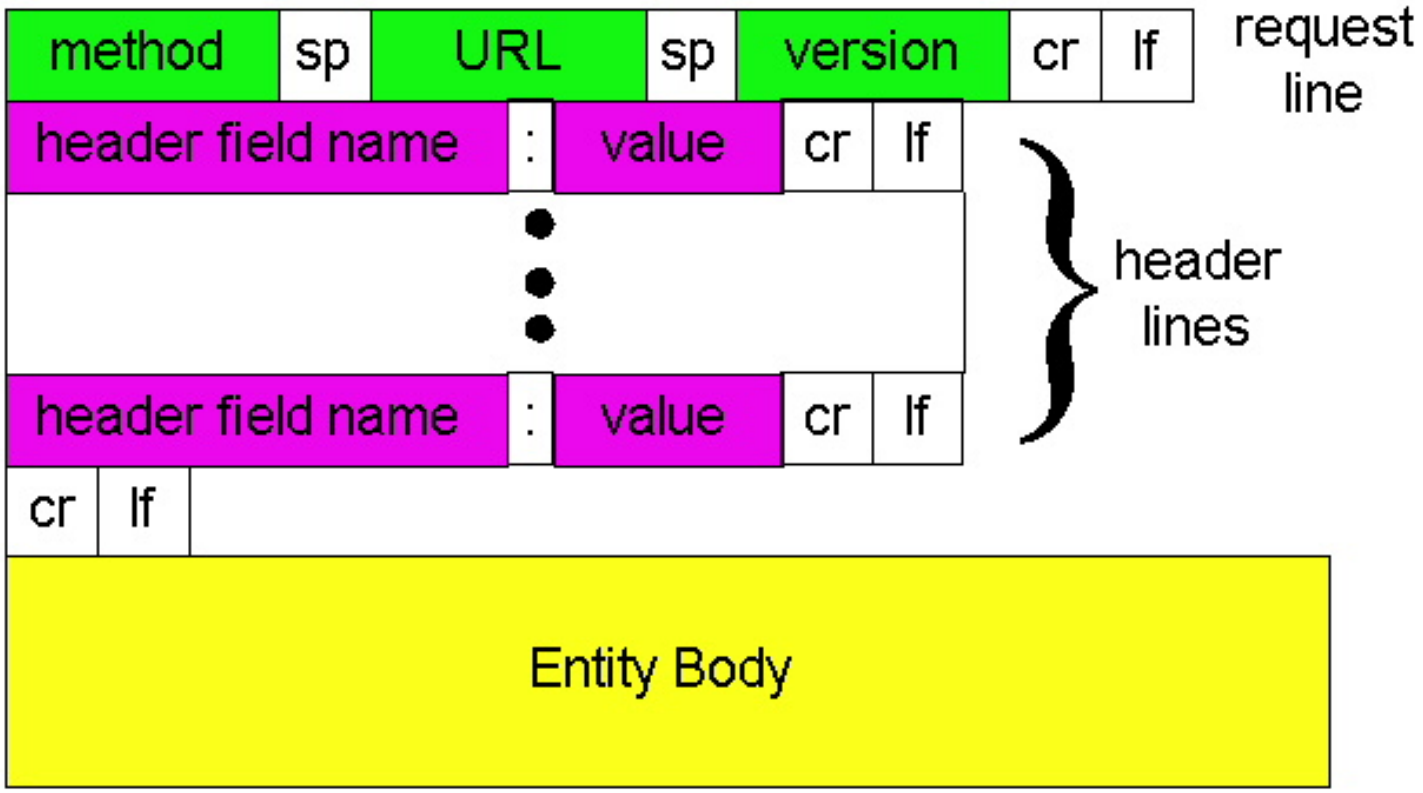
HTTP1.0 Message Flow

- HTTP1.0 servers are stateless servers: each request is self-contained



HTTP Request Message: General Format

- ASCII (human-readable format)



Trying out HTTP (client side) for yourself

1. Telnet to your favorite Web server:

```
telnet www.cs.yale.edu 80
```

Opens TCP connection to port 80 (default http server port) at www.cs.yale.edu. Anything typed in sent to port 80 at www.cs.yale.edu

2. Type in a GET http request:

```
GET /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 the http server.

Trying out HTTP (client side) for yourself

- Try telnet GET on www.yale.edu

HTTP Request Message Example: GET

Virtual host multiplexing

request line (GET, POST, HEAD, PUT, DELETE, TRACE … commands)

```
GET /somedir/page.html HTTP/1.0
Host: www.somechool.edu
Connection: close
User-agent: Mozilla/4.0
Accept: text/html, image/gif, image/jpeg
Accept-language: en

(extra carriage return, line feed)
```

header lines

Connection management

Carriage return, line feed indicates end of message

Content negotiation

HTTP Response Message

status line
(protocol
status code
status phrase)

header
lines

data, e.g.,
requested
html file

```
HTTP/1.0 200 OK
Date: Wed, 23 Jan 2008 12:00:15 GMT
Server: Apache/1.3.0 (Unix)
Last-Modified: Mon, 22 Jun 1998 …...
Content-Length: 6821
Content-Type: text/html

data data data data data ...
```

HTTP Response Status Codes

In the first line of the server->client response message. A few sample codes:

`200 OK`

- request succeeded, requested object later in this message

`301 Moved Permanently`

- requested object moved, new location specified later in this message (Location:)

`400 Bad Request`

- request message not understood by server

`404 Not Found`

- requested document not found on this server

`505 HTTP Version Not Supported`

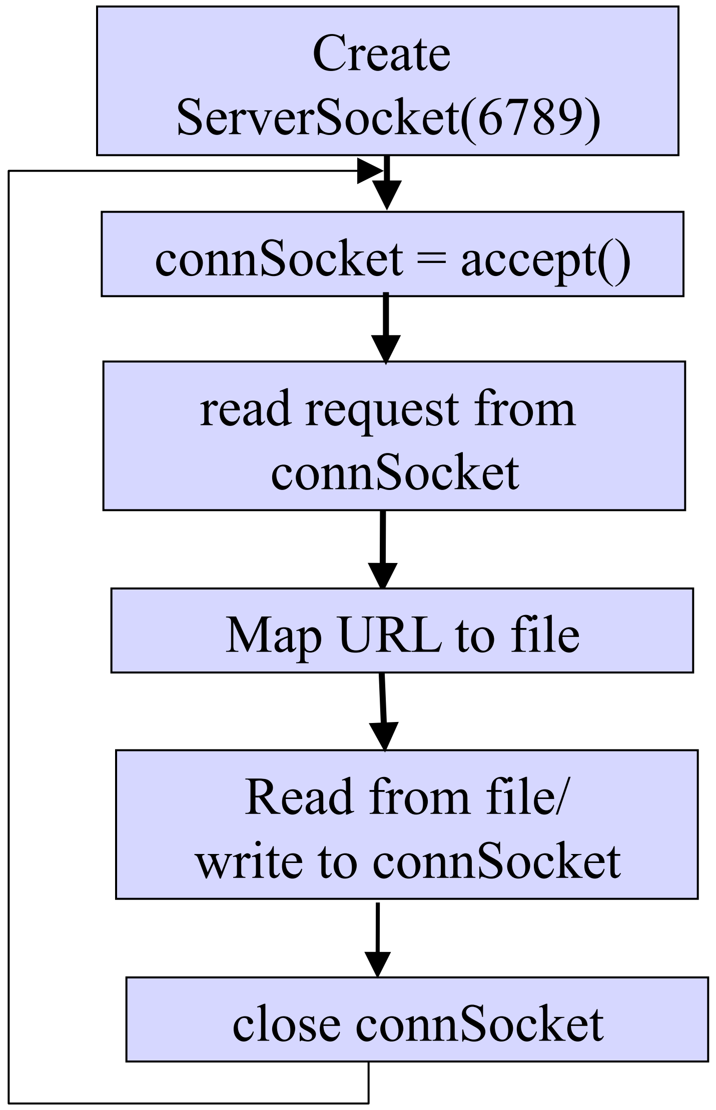
Trying Use Chrome to visit Course Page

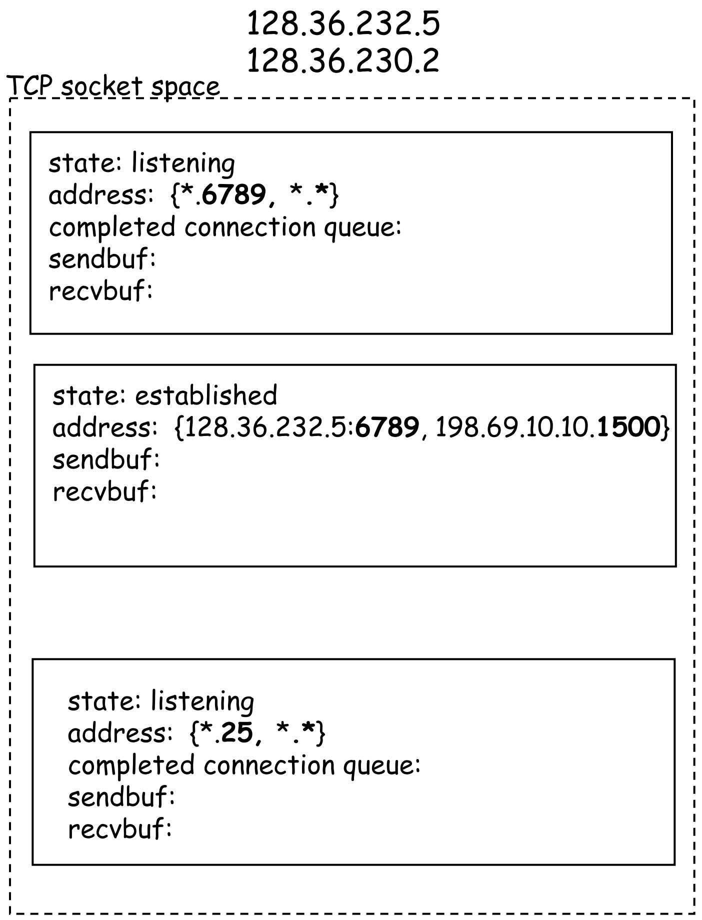
Design Exercise

- Workflow of an HTTP server processing a GET request that maps to a file:

```
GET /somedir/page.html HTTP/1.0
Host: www.somechool.edu
```

Basic HTTP Server Workflow


Create ServerSocket(6789)
connSocket = accept()
read request from connSocket
Map URL to file
Read from file/ write to connSocket
close connSocket



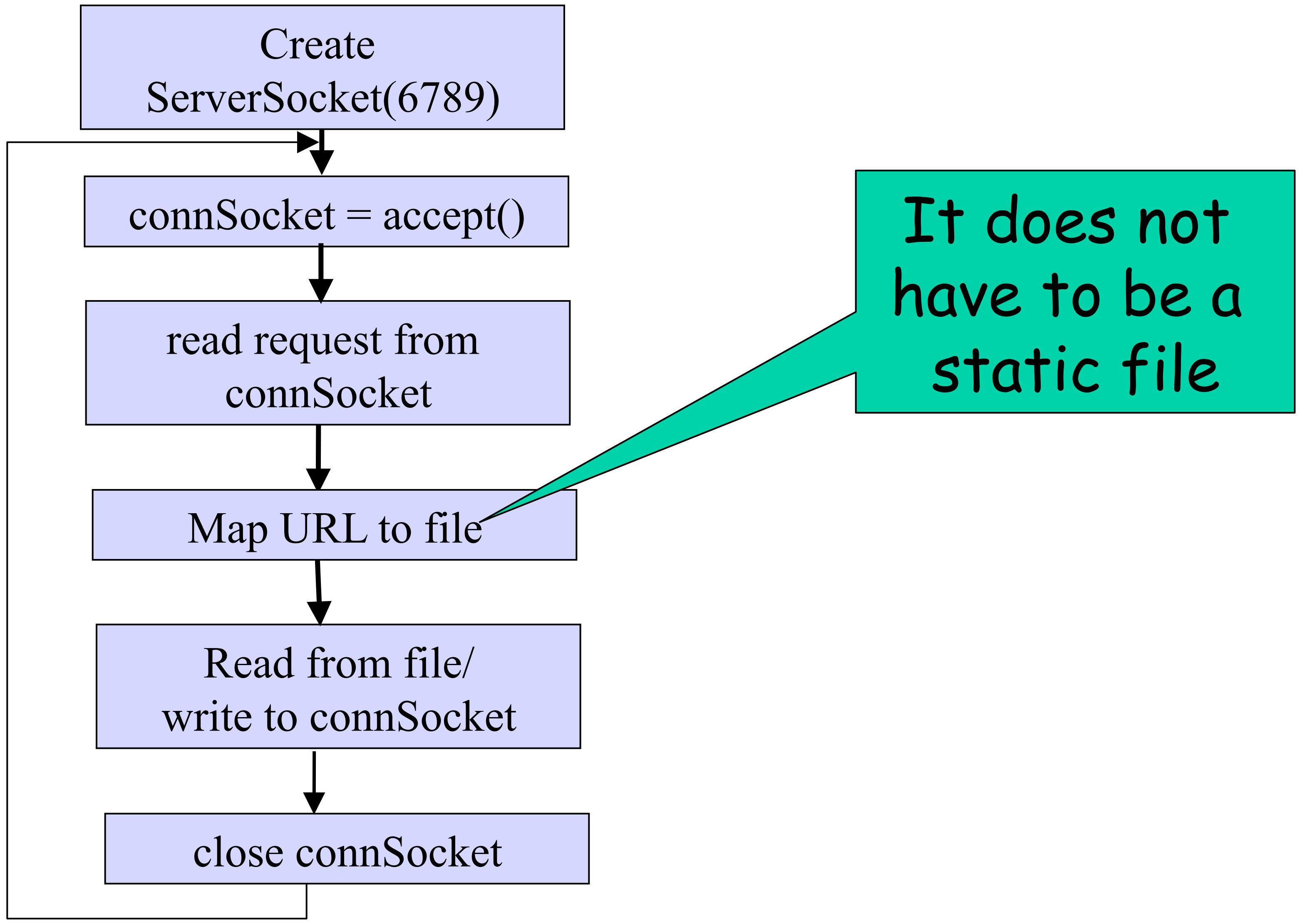
Example Code

- See BasicWebServer.java

- Try using telnet and real browser, and fetch
  - file1.html
  - index.html

  what difference in behavior?

Static -> Dynamic Content


Create ServerSocket(6789)
connSocket = accept()
read request from connSocket
Map URL to file
Read from file/ write to connSocket
close connSocket
It does not have to be a static file

Dynamic Content Pages

- There are multiple approaches to make dynamic web pages:
  - Embed code into pages (server side include)
    - http server includes an interpreter for the type of pages
  - Invoke external programs (http server is agnostic to the external program execution)

```
http://www.cs.yale.edu/index.shtml
http://www.cs.yale.edu/cgi-bin/ureserve.pl
http://www.google.com/search?q=Yale&sourceid=chrome
```

Example SSI

- See programming/examples-java-socket/BasicWebServer/ssi/index.shtml, header.shtml, …

Example SSI

- See programming/examples-java-socket/ BasicWebServer/ssi/index.shtml, header.shtml, …

- To enable ssi, need configuration to tell the web server (see conf/apache-htaccess)
  - https://httpd.apache.org/docs/2.2/howto/htaccess.html (Server Side Includes example)

CGI: Invoking External Programs

- Two issues
  - Input: Pass HTTP request parameters to the external program
  - Output: Redirect external program output to socket

Example: Typical CGI Implementation

- Starts the executable as a child process
  - Passes HTTP request as environment variables
    - `http://httpd.apache.org/docs/2.2/env.html`
    - CGI standard: http://www.ietf.org/rfc/rfc3875
  - Redirects input/output of the child process to the socket

Example: CGI

- Example:
  - `GET /search?q=Yale&sourceid=chrome HTTP/1.0`
  - setup environment variables, in particular $QUERY_STRING=`q=Yale&sourceid=chrome`
  - start `search` and redirect its input/output

https://docs.oracle.com/javase/7/docs/api/java/lang/ProcessBuilder.html

https://httpd.apache.org/docs/2.2/howto/htaccess.html
(CGI Example)

Example

- http://zoo.cs.yale.edu/classes/cs433/cs433-2016-spring/programming/examples-java-socket/BasicWebServer/cgi/price.cgi?appl

```
#!/usr/bin/perl -w

$company = $ENV{'QUERY_STRING'};
print "Content-Type: text/html\r\n";
print "\r\n";

print "<html>";
print "<h1>Hello! The price is ";

if ($company =~ /appl/) {
  my $var_rand = rand();
  print 450 + 10 * $var_rand;
} else {
  print "150";
}

print "</h1>";
print "</html>";
```

Client Using Dynamic Pages

- See ajax.html and wireshark for client code example

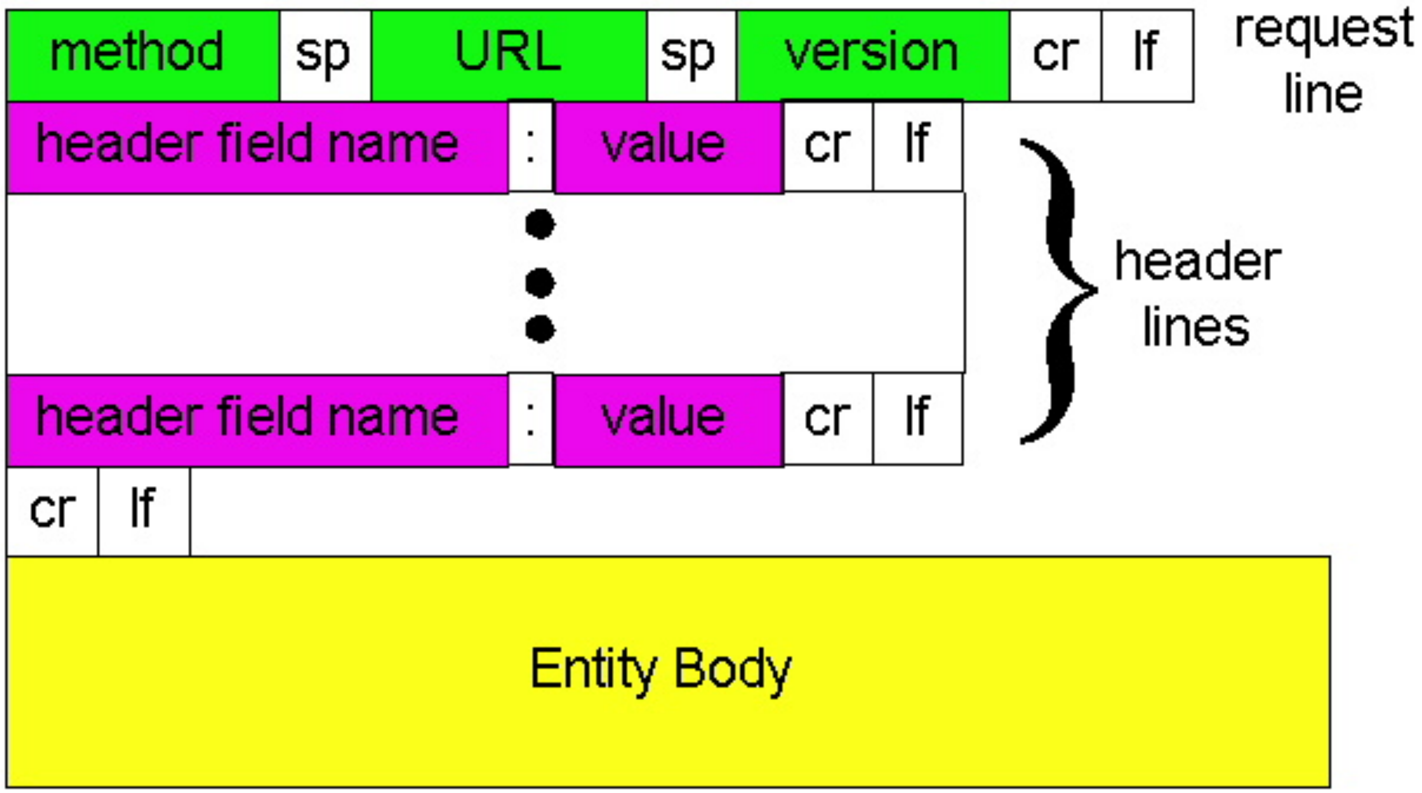
  http://zoo.cs.yale.edu/classes/cs433/cs433-2016-spring/programming/examples-java-socket/BasicWebServer/cgi/ajax.html

Discussions

- What features are missing in HTTP that we have covered so far?

HTTP: POST

- If an HTML page contains forms or parameter too large, they are sent using POST and encoded in message body



HTTP: POST Example

```
POST /path/script.cgi HTTP/1.0
User-Agent: MyAgent
Content-Type: application/x-www-form-urlencoded
Content-Length: 15

item1=A&item2=B
```

Example using nc:
programming/examples-java-socket/BasicWebServer/nc/

Stateful User-server Interaction: Cookies

Goal: no explicit application level session

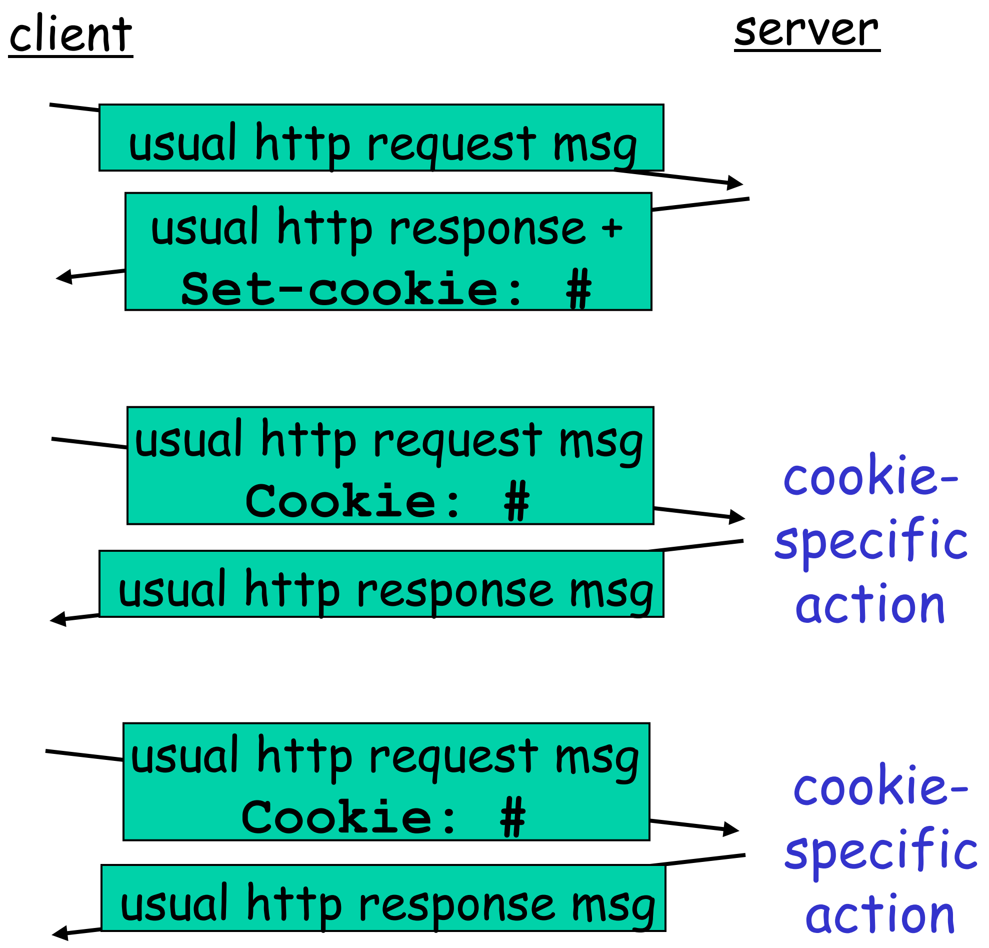
- Server sends "cookie" to client in response msg

  `Set-cookie: 1678453`

- Client presents cookie in later requests

  `Cookie: 1678453`

- Server matches presented-cookie with server-stored info
  - authentication
  - remembering user preferences, previous choices



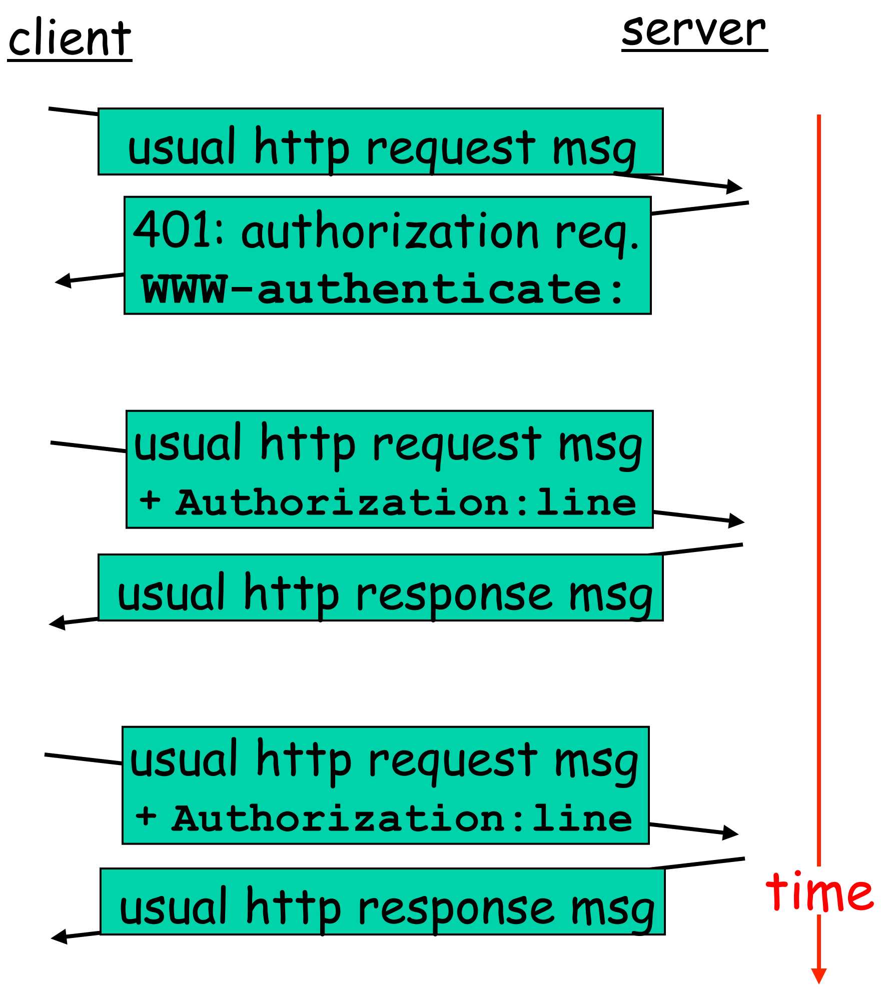
Authentication of Client Request

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

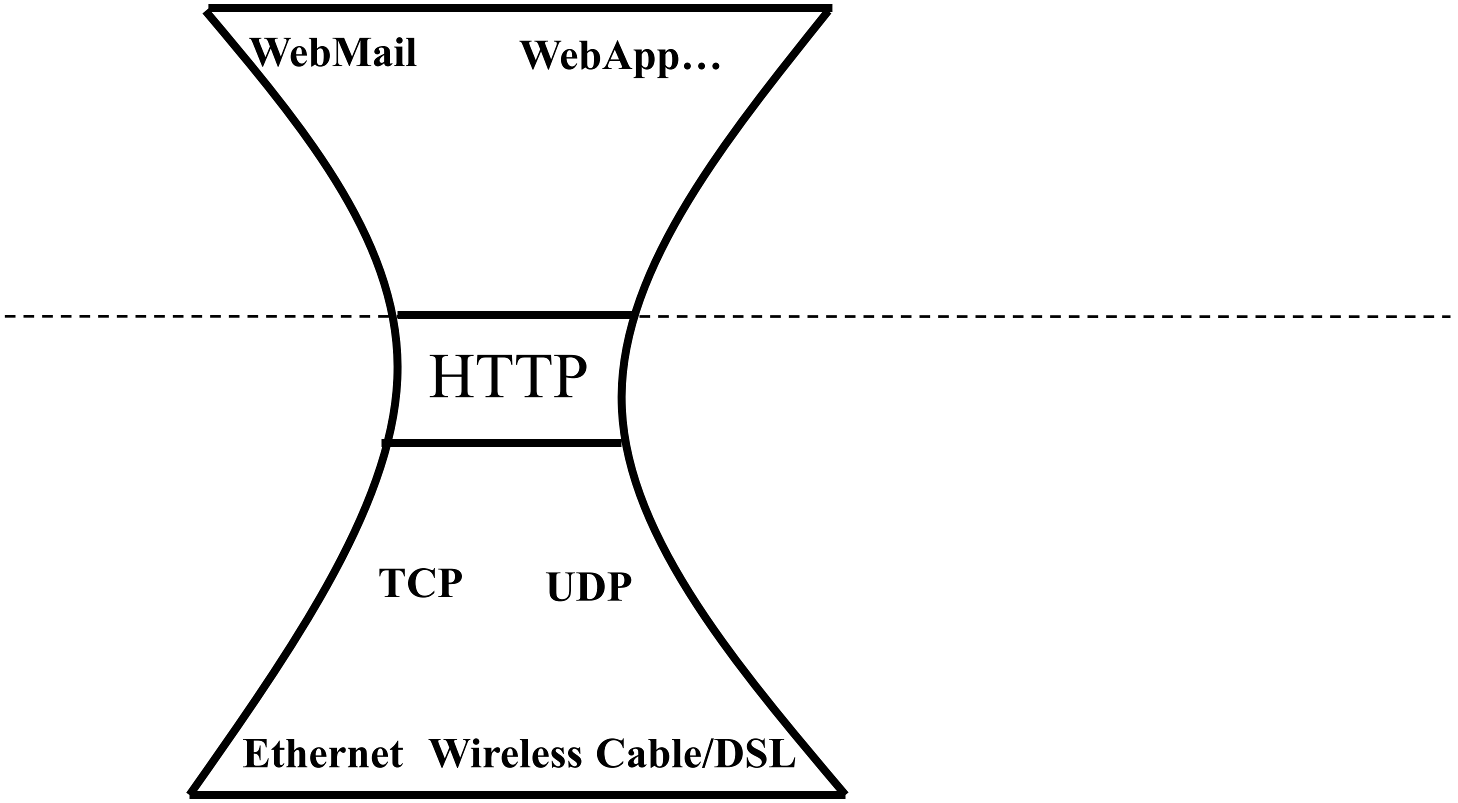


Browser caches name & password so that user does not have to repeatedly enter it.

Example: Amazon S3

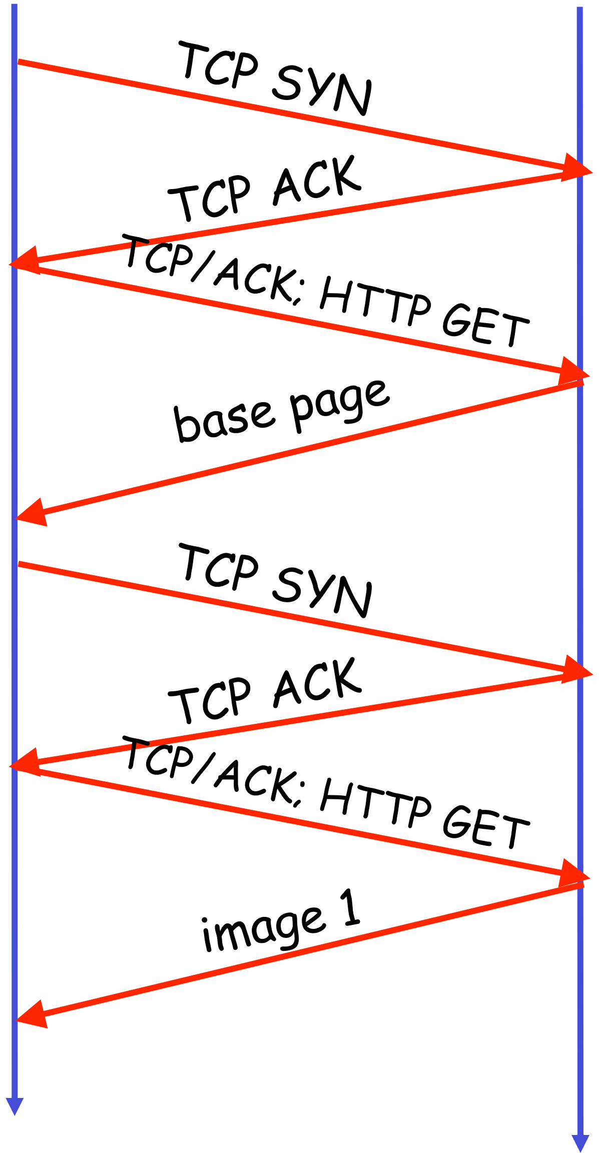
- Amazon S3 API
  - http://docs.aws.amazon.com/AmazonS3/latest/API/APIRest.html

HTTP as the Thin Waist



Protocol Flow of Basic HTTP/1.0

- >= 2 RTTs per object:
  - TCP handshake --- 1 RTT
  - client request and server responds --- at least 1 RTT (if object can be contained in one packet)



Discussion: How to Speedup HTTP/1.0