Computer Networks 1
(Mạng Máy Tính 1)

Lectured by: Dr. Phạm Trần Vũ

MEng. Nguyễn Cao Đạt

Lecture 10:
Application Layer

Application Layer

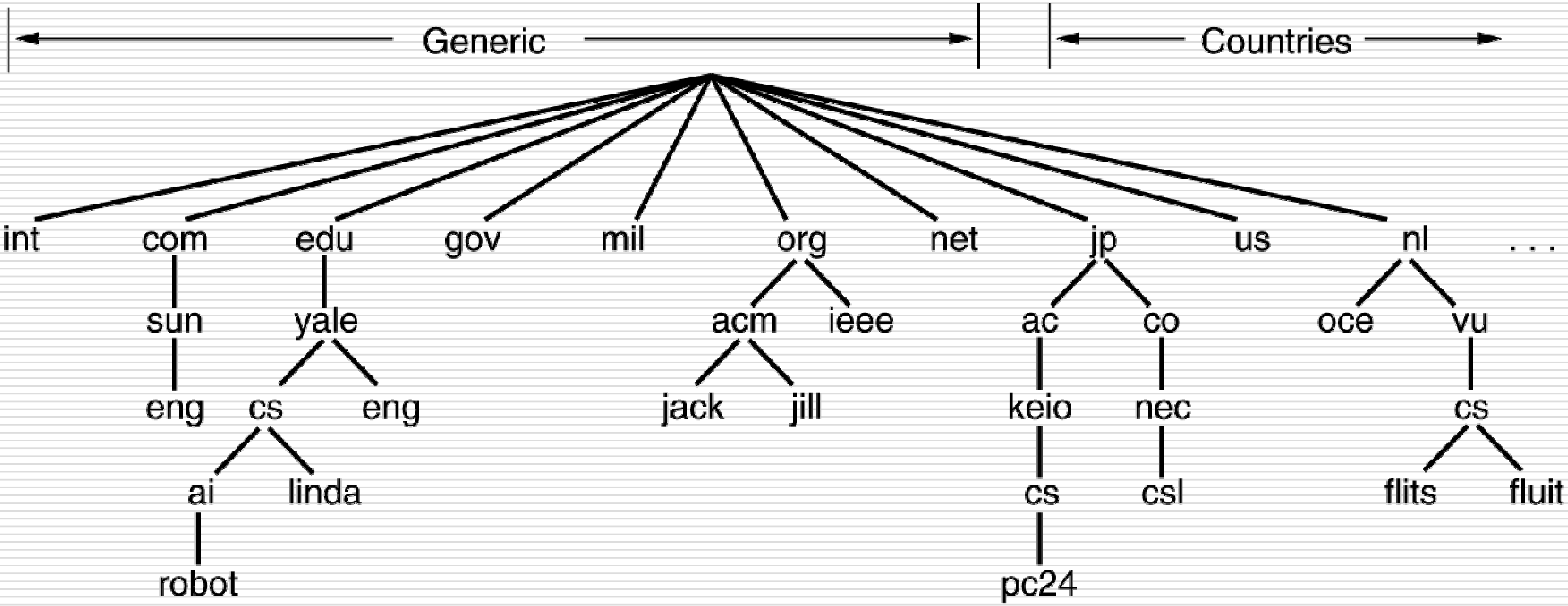
- Where our applications are running
- Using services provided by layers below
- We will look at:
  - Domain Name System
  - Email
  - File Transfer Protocol
  - World Wide Web

Domain Name System - DNS

- IP addresses can be used to identify a host machine on the Internet
  - As people moves around, the addresses need to be changed accordingly as well
- ASCII names have been invented to decouple host names and their IPs to provide more flexibility
- The DNS was invented to manage and resolve host names into IP addresses

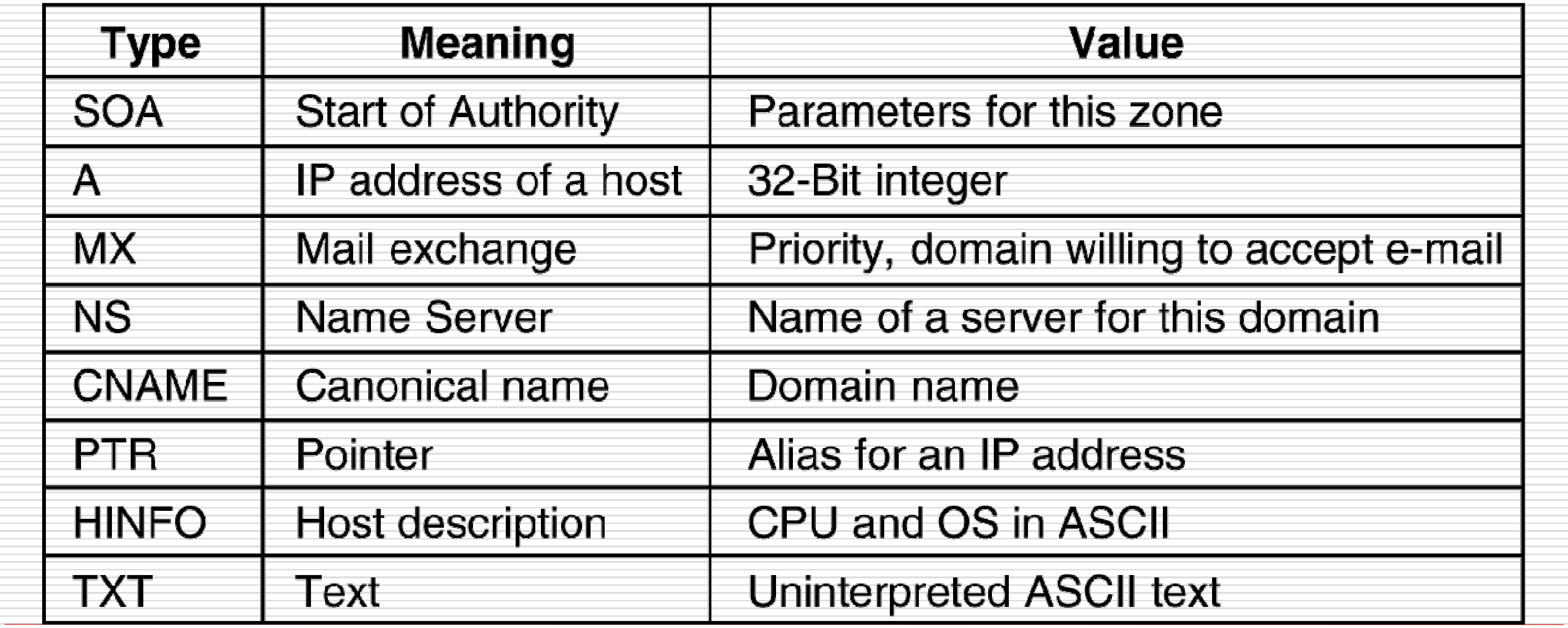
The DNS Name Space

A portion of the Internet domain name space.



Resource Records

- Every domain has a set of records associated with
- The principal DNS resource records types.



Type	Meaning	Value
SOA	Start of Authority	Parameters for this zone
A	IP address of a host	32-Bit integer
MX	Mail exchange	Priority, domain willing to accept e-mail
NS	Name Server	Name of a server for this domain
CNAME	Canonical name	Domain name
PTR	Pointer	Alias for an IP address
HINFO	Host description	CPU and OS in ASCII
TXT	Text	Uninterpreted ASCII text

Resource Records (2)

```
; Authoritative data for cs.vu.nl
cs.vu.nl.         86400  IN  SOA     star boss (952771,7200,7200,2419200,86400)
cs.vu.nl.         86400  IN  TXT     "Divisie Wiskunde en Informatica."
cs.vu.nl.         86400  IN  TXT     "Vrije Universiteit Amsterdam."
cs.vu.nl.         86400  IN  MX      1 zephyr.cs.vu.nl.
cs.vu.nl.         86400  IN  MX      2 top.cs.vu.nl.

flits.cs.vu.nl.   86400  IN  HINFO   Sun Unix
flits.cs.vu.nl.   86400  IN  A       130.37.16.112
flits.cs.vu.nl.   86400  IN  A       192.31.231.165
flits.cs.vu.nl.   86400  IN  MX      1 flits.cs.vu.nl.
flits.cs.vu.nl.   86400  IN  MX      2 zephyr.cs.vu.nl.
flits.cs.vu.nl.   86400  IN  MX      3 top.cs.vu.nl.
www.cs.vu.nl.     86400  IN  CNAME   star.cs.vu.nl
ftp.cs.vu.nl.     86400  IN  CNAME   zephyr.cs.vu.nl

rowboat                  IN  A       130.37.56.201
                         IN  MX      1 rowboat
                         IN  MX      2 zephyr
                         IN  HINFO   Sun Unix

little-sister            IN  A       130.37.62.23
                         IN  HINFO   Mac MacOS

laserjet                 IN  A       192.31.231.216
                         IN  HINFO   "HP Laserjet IIISi" Proprietary
```

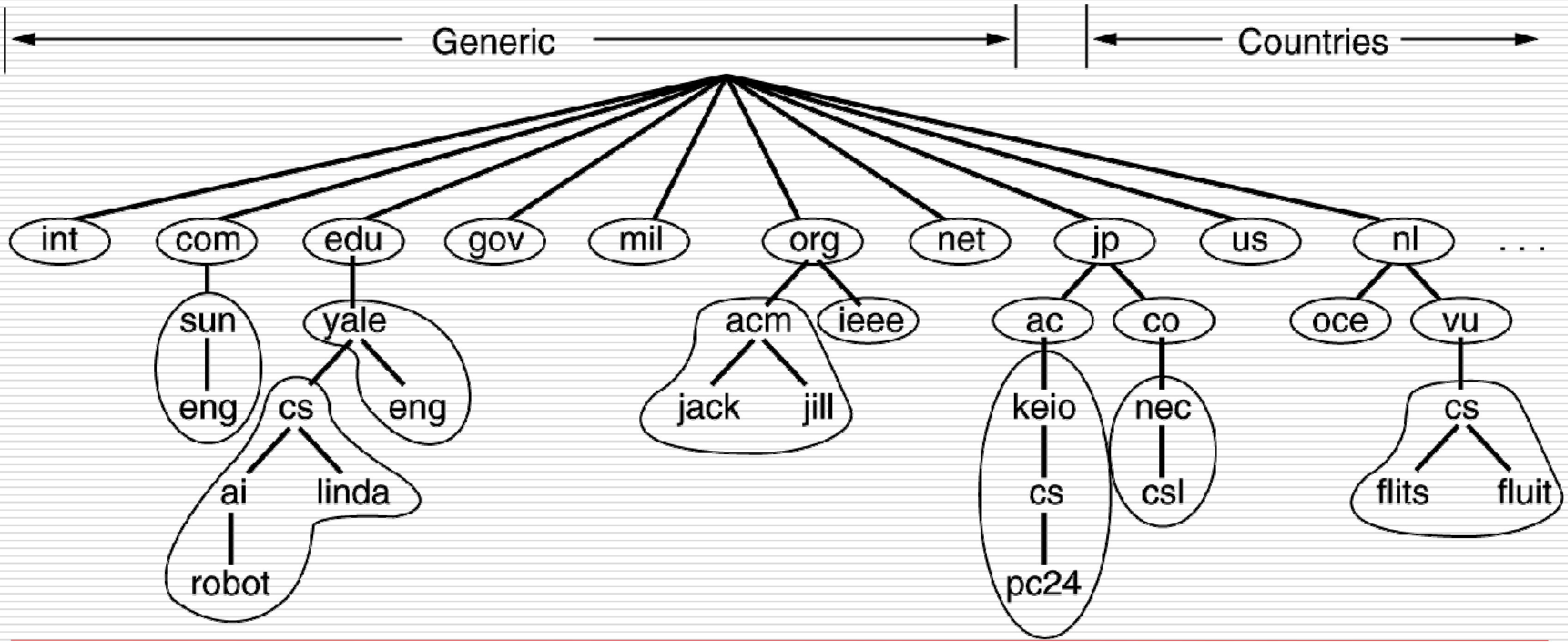
A portion of a possible DNS database for *cs.vu.nl.*

Resource Records (3)

```
hcmut.edu.vn.   IN SOA  hcmut-server.hcmut.edu.vn. webmaster.hcmut.edu.vn. (
                  2004110800;    serial
                  7200;          refresh
                  3600;          retry
                  604800;        expire
                  86400 );       minimum
hcmut.edu.vn.                  86400  IN     NS          vnuserv.vnuhcm.edu.vn.
hcmut.edu.vn.                  86400  IN     NS          server.vnuhcm.edu.vn.
hcmut.edu.vn.                  86400  IN     MX   0      webmailserv.hcmut.edu.vn.
hcmut.edu.vn.                  86400  IN     MX    5     vnuserv.vnuhcm.edu.vn.
hcmut-server.hcmut.edu.vn. 86400  IN     A           172.28.2.2
stu-mailserv.hcmut.edu.vn.  86400  IN     A           172.28.2.3
webmailserv.hcmut.edu.vn.  86400  IN     A           172.28.2.4
pop3.student.hcmut.edu.vn. 86400  IN     CNAME       stu-mailserv.hcmut.edu.vn.
www.student.hcmut.edu.vn  86400  IN     CNAME       stu-mailserv.hcmut.edu.vn.
```

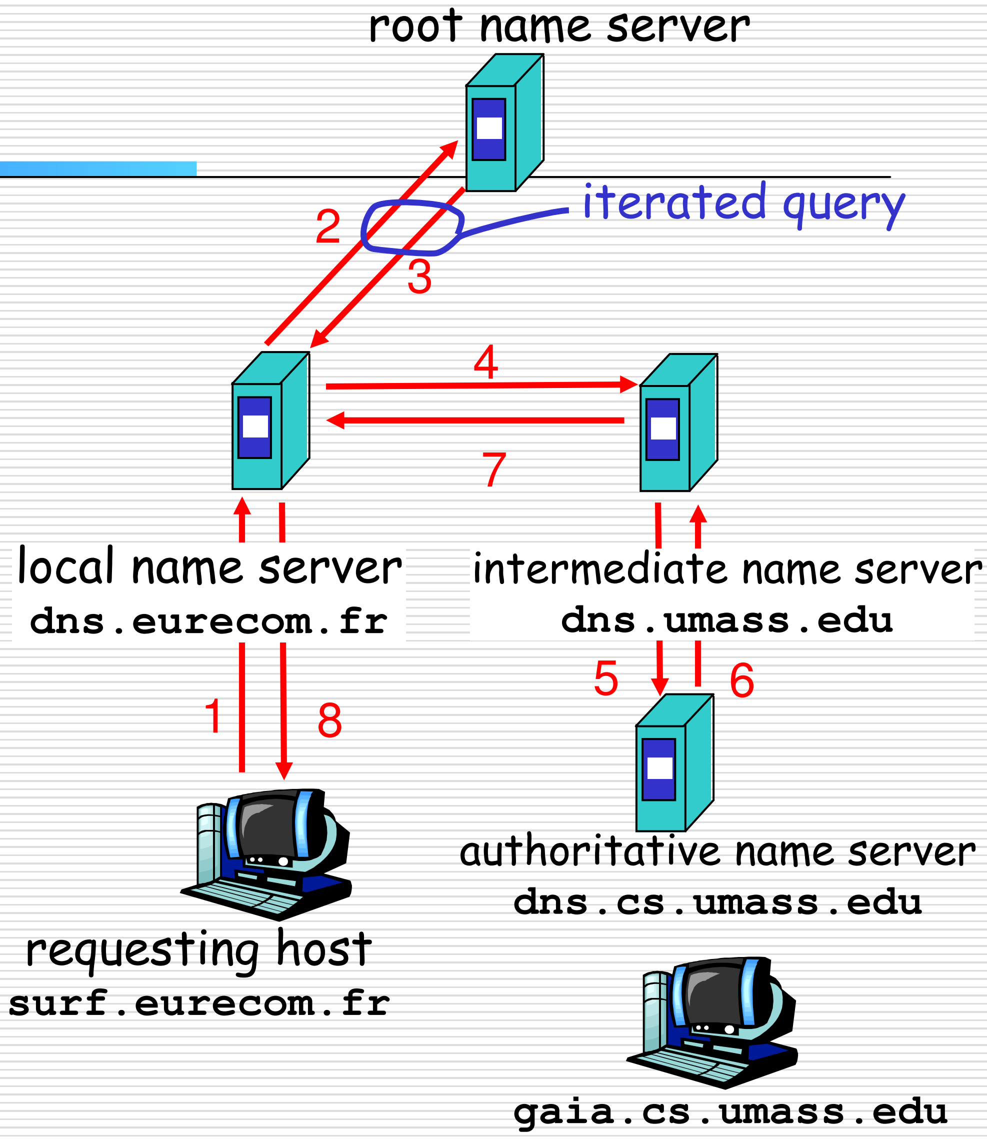
Name Servers

- DNS Name Space is organised into nop-overlapping zones
- Each zone has Name Servers holding information about it



DNS - Query

- recursive query
  - puts burden of name resolution on contacted name server.
  - heavy load ?
- iterated query
  - contacted server replies with name of server to contact.
  - “I don’t know this name, but ask this server”

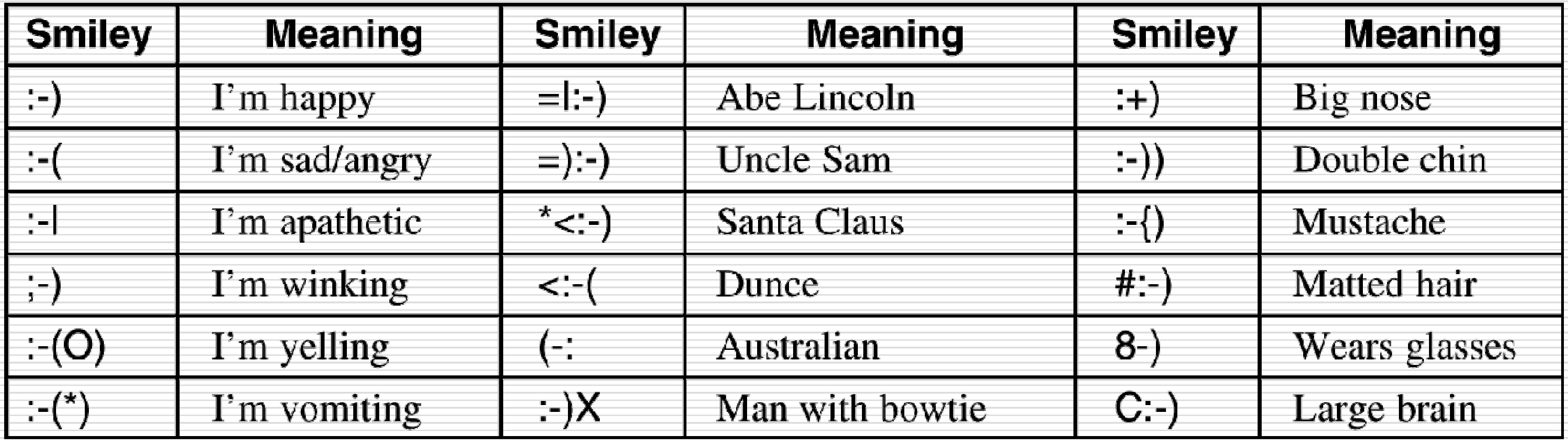


Electronic Mail – Email (or E-mail)

- Has been around since the early days of Internet
- Is widely used today
- Informal form of communication
- Simple and easy to use

Electronic Mail (2)

Some smileys :-).



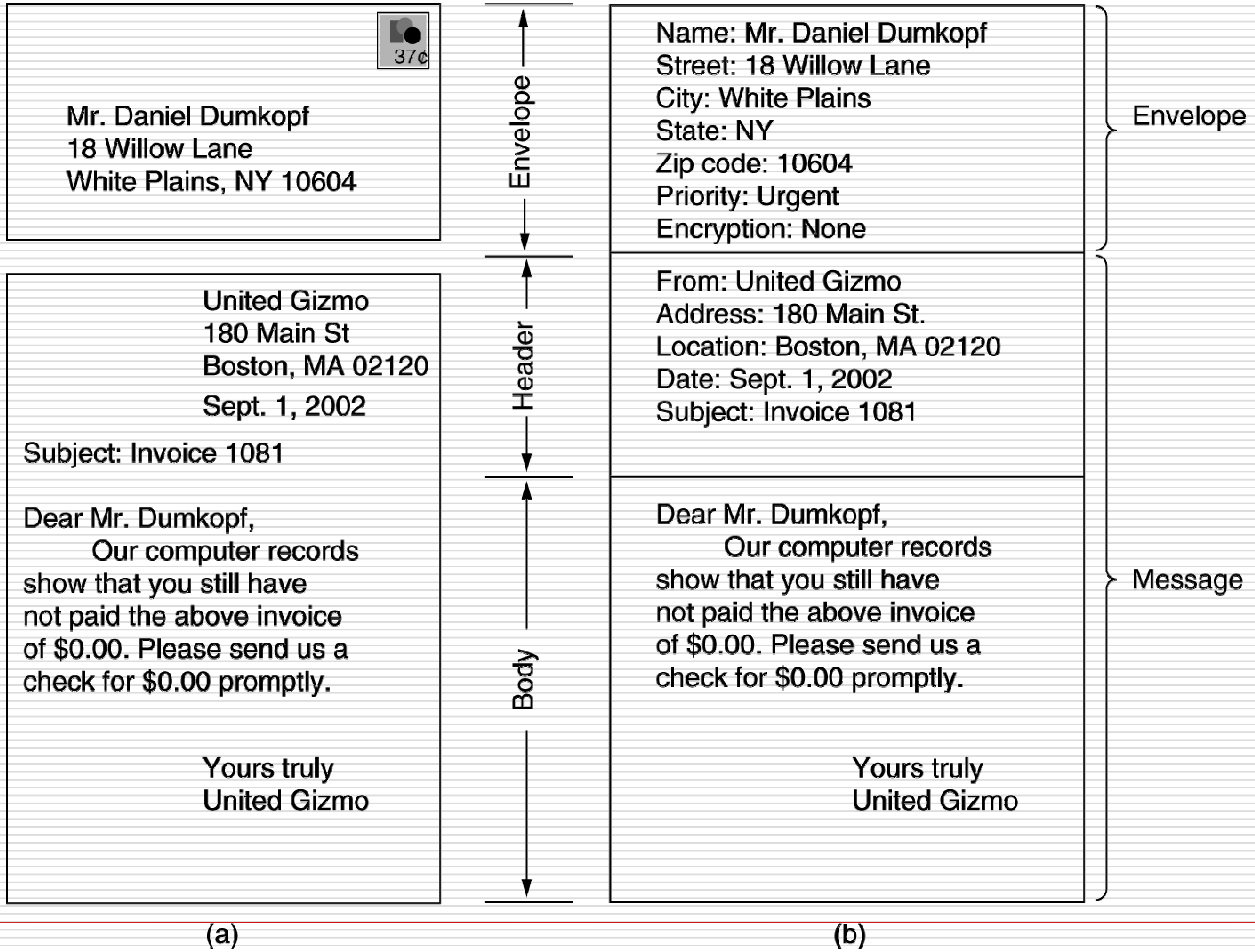
Smiley	Meaning	Smiley	Meaning	Smiley	Meaning
:-)	I'm happy	=|:-)	Abe Lincoln	:+)	Big nose
:-(	I'm sad/angry	=):-)	Uncle Sam	:-))	Double chin
:-|	I'm apathetic	*<:-)	Santa Claus	:-{)	Mustache
;-)	I'm winking	<:-(	Dunce	#:-)	Matted hair
:-(O)	I'm yelling	(-:	Australian	8-)	Wears glasses
:-(*)	I'm vomiting	:-)X	Man with bowtie	C:-)	Large brain

Architecture and Services

Basic email functions

- Composition
- Transfer
- Reporting
- Displaying
- Disposition

Email Message Structure



Mr. Daniel Dumkopf
18 Willow Lane
White Plains, NY 10604

United Gizmo
180 Main St
Boston, MA 02120

Sept. 1, 2002

Subject: Invoice 1081

Dear Mr. Dumkopf,
Our computer records show that you still have not paid the above invoice of $0.00. Please send us a check for $0.00 promptly.

Yours truly
United Gizmo

Name: Mr. Daniel Dumkopf
Street: 18 Willow Lane
City: White Plains
State: NY
Zip code: 10604
Priority: Urgent
Encryption: None

From: United Gizmo
Address: 180 Main St.
Location: Boston, MA 02120
Date: Sept. 1, 2002
Subject: Invoice 1081

Dear Mr. Dumkopf,
Our computer records show that you still have not paid the above invoice of $0.00. Please send us a check for $0.00 promptly.

Yours truly
United Gizmo

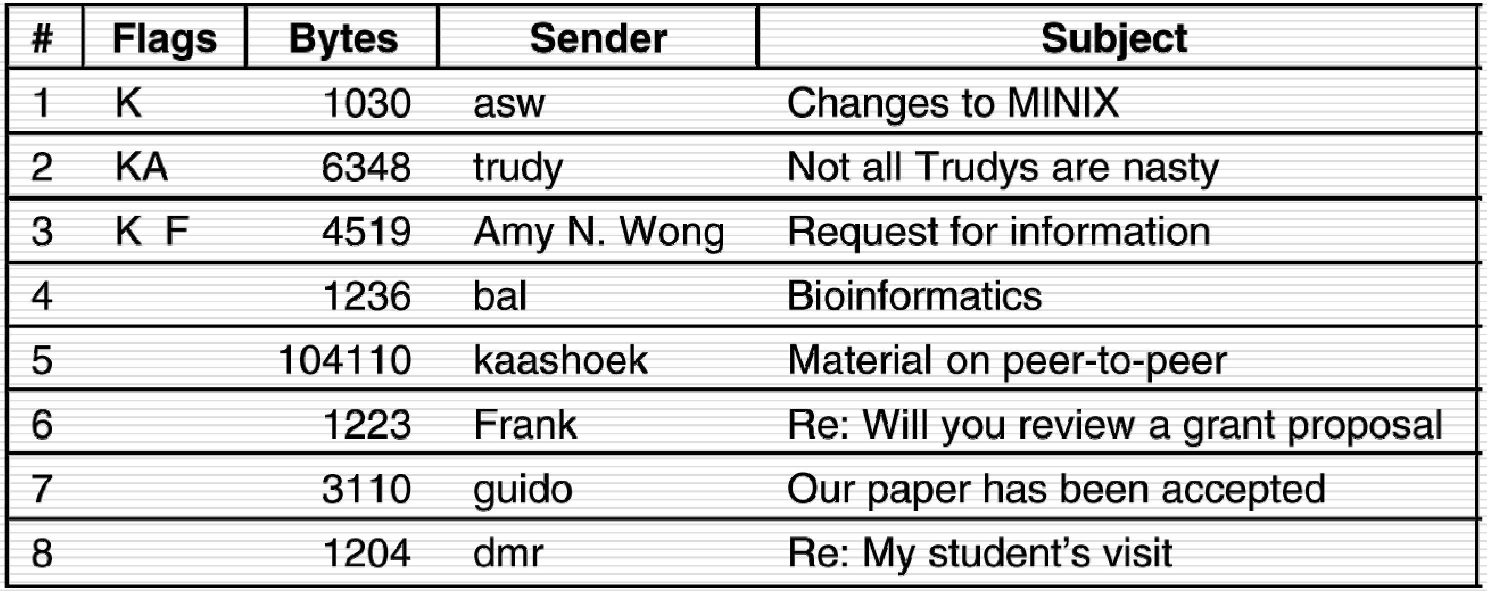
Envelopes and messages. (a) Paper mail. (b) Electronic mail.

Email Systems

- Has two basic parts:
  - User agent: a program that accepts a variety of commands for composing, receiving, and replying to messages, as well as for manipulating mailboxes
  - Message transfer agents: relaying messages from the originator to the recipient

Reading E-mail

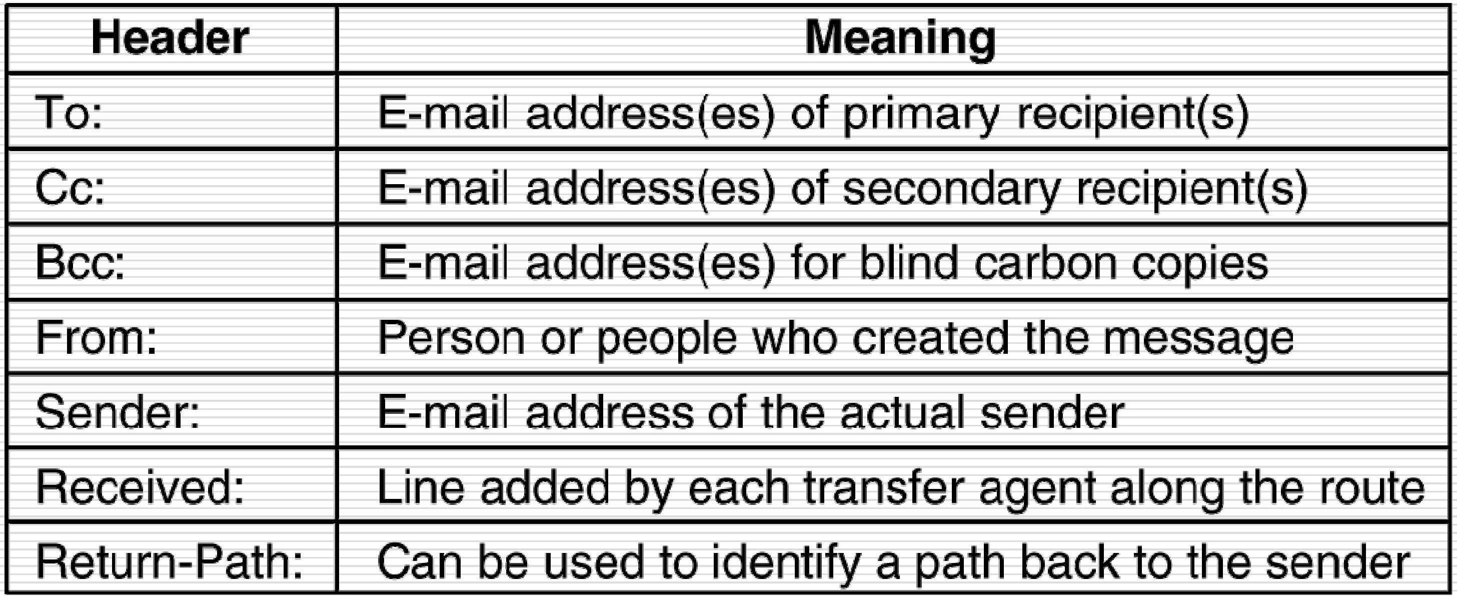
An example display of the contents of a mailbox.



#	Flags	Bytes	Sender	Subject
1	K	1030	asw	Changes to MINIX
2	KA	6348	trudy	Not all Trudys are nasty
3	K F	4519	Amy N. Wong	Request for information
4		1236	bal	Bioinformatics
5		104110	kaashoek	Material on peer-to-peer
6		1223	Frank	Re: Will you review a grant proposal
7		3110	guido	Our paper has been accepted
8		1204	dmr	Re: My student's visit

Message Formats

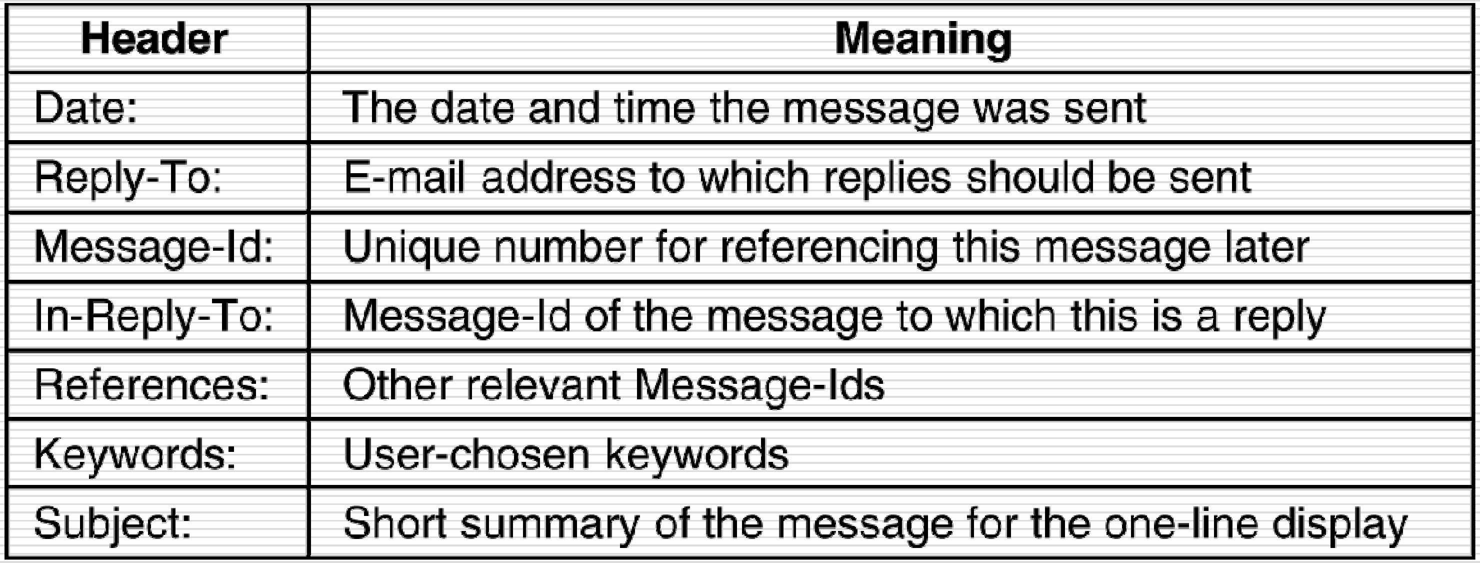
RFC 822 header fields related to message transport.



Header	Meaning
To:	E-mail address(es) of primary recipient(s)
Cc:	E-mail address(es) of secondary recipient(s)
Bcc:	E-mail address(es) for blind carbon copies
From:	Person or people who created the message
Sender:	E-mail address of the actual sender
Received:	Line added by each transfer agent along the route
Return-Path:	Can be used to identify a path back to the sender

Message Formats (2)

Some fields used in the RFC 822 message header.



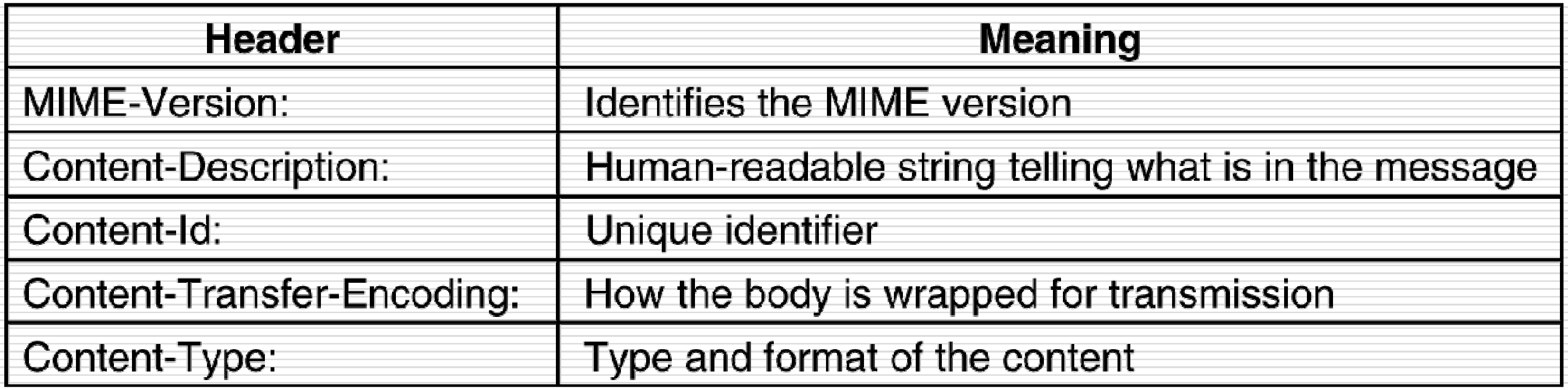
Header	Meaning
Date:	The date and time the message was sent
Reply-To:	E-mail address to which replies should be sent
Message-Id:	Unique number for referencing this message later
In-Reply-To:	Message-Id of the message to which this is a reply
References:	Other relevant Message-Ids
Keywords:	User-chosen keywords
Subject:	Short summary of the message for the one-line display

MIME – Multipurpose Internet Mail Extensions

- Some problems when using ASCII formatted messages:
  - Languages with accents (French, German).
  - Languages in non-Latin alphabets (Hebrew, Russian).
  - Languages without alphabets (Chinese, Japanese).
  - Messages not containing text at all (audio or images).
- MINE adds structure to the message body and defines encoding rules for non-ASCII messages

MIME (2)

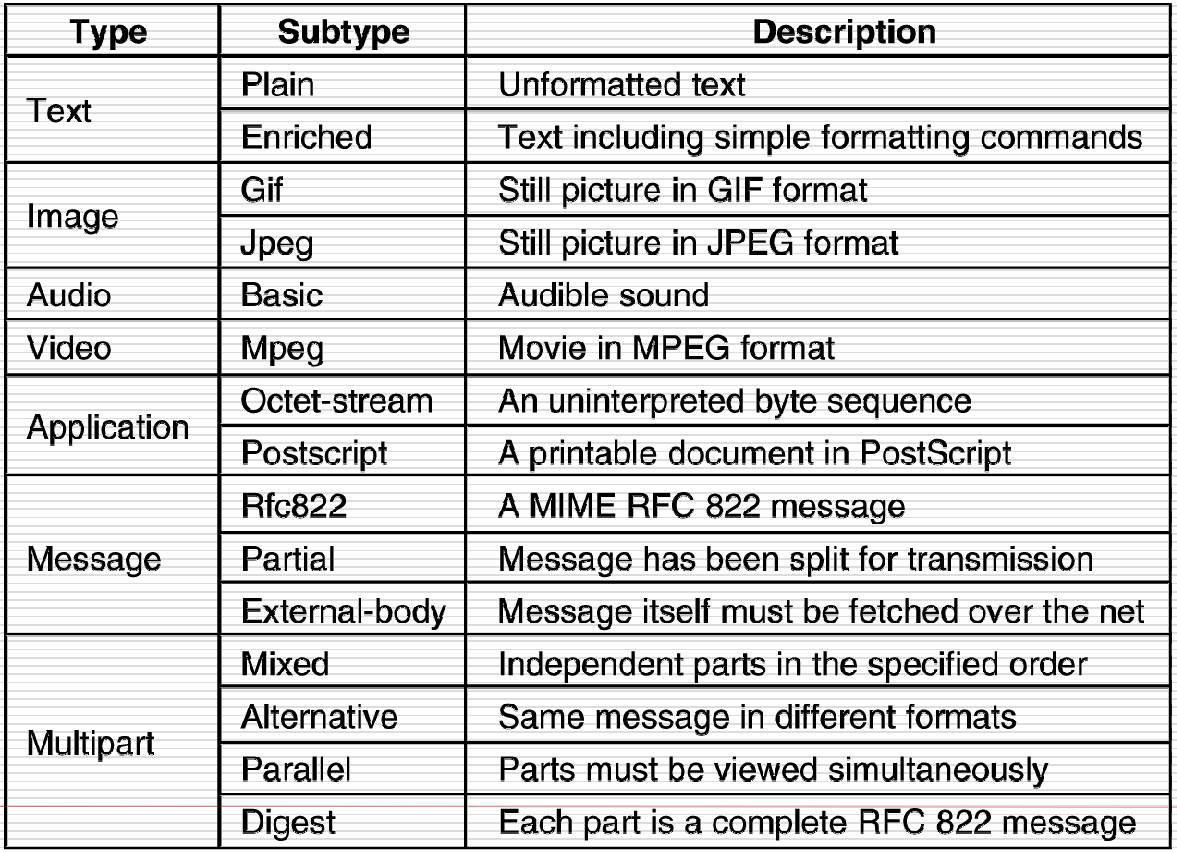
RFC 822 headers added by MIME.



Header	Meaning
MIME-Version:	Identifies the MIME version
Content-Description:	Human-readable string telling what is in the message
Content-Id:	Unique identifier
Content-Transfer-Encoding:	How the body is wrapped for transmission
Content-Type:	Type and format of the content

MIME (3)

The MIME types and subtypes defined in RFC 2045.



Type	Subtype	Description
Text	Plain	Unformatted text
	Enriched	Text including simple formatting commands
Image	Gif	Still picture in GIF format
	Jpeg	Still picture in JPEG format
Audio	Basic	Audible sound
Video	Mpeg	Movie in MPEG format
Application	Octet-stream	An uninterpreted byte sequence
	Postscript	A printable document in PostScript
Message	Rfc822	A MIME RFC 822 message
	Partial	Message has been split for transmission
	External-body	Message itself must be fetched over the net
Multipart	Mixed	Independent parts in the specified order
	Alternative	Same message in different formats
	Parallel	Parts must be viewed simultaneously
	Digest	Each part is a complete RFC 822 message

Message Transfer

- Message transfer agents are daemons running on mail servers
- Use Simple Mail Transfer Protocol
- Use TCP on port 25

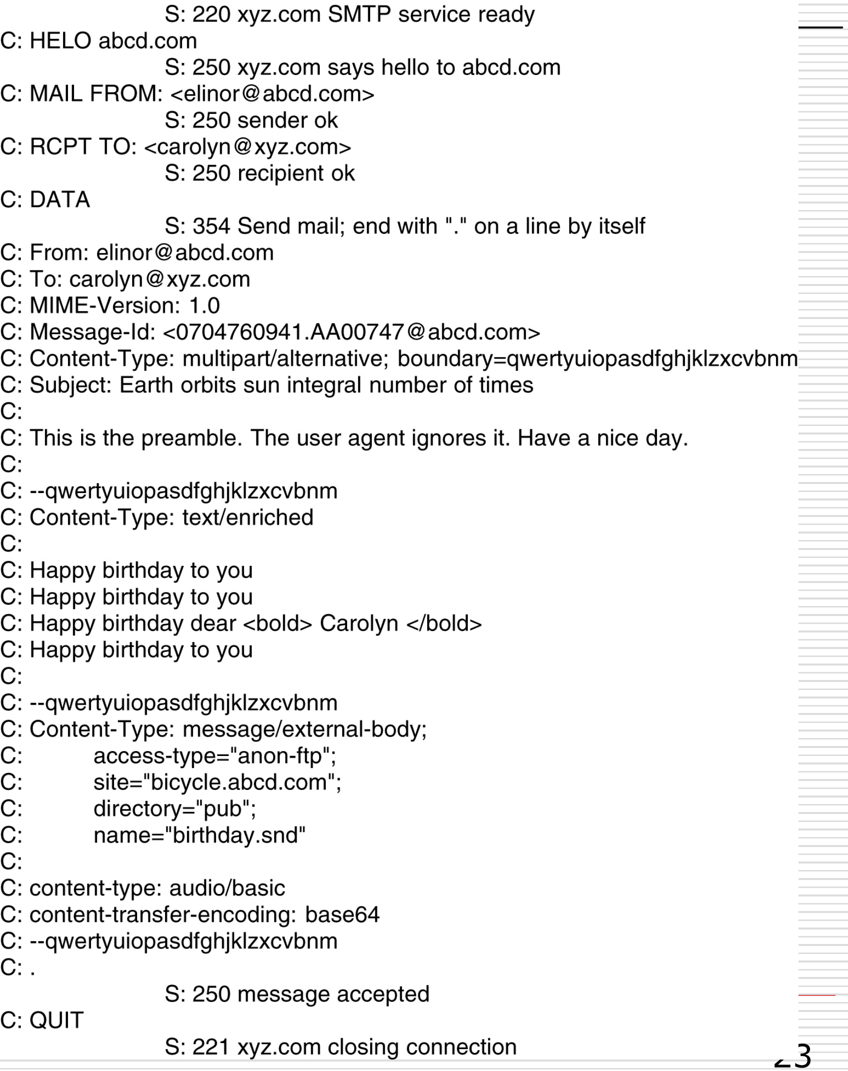
Message Transfer (2)

Transferring a message

from *elinore@abc.com*

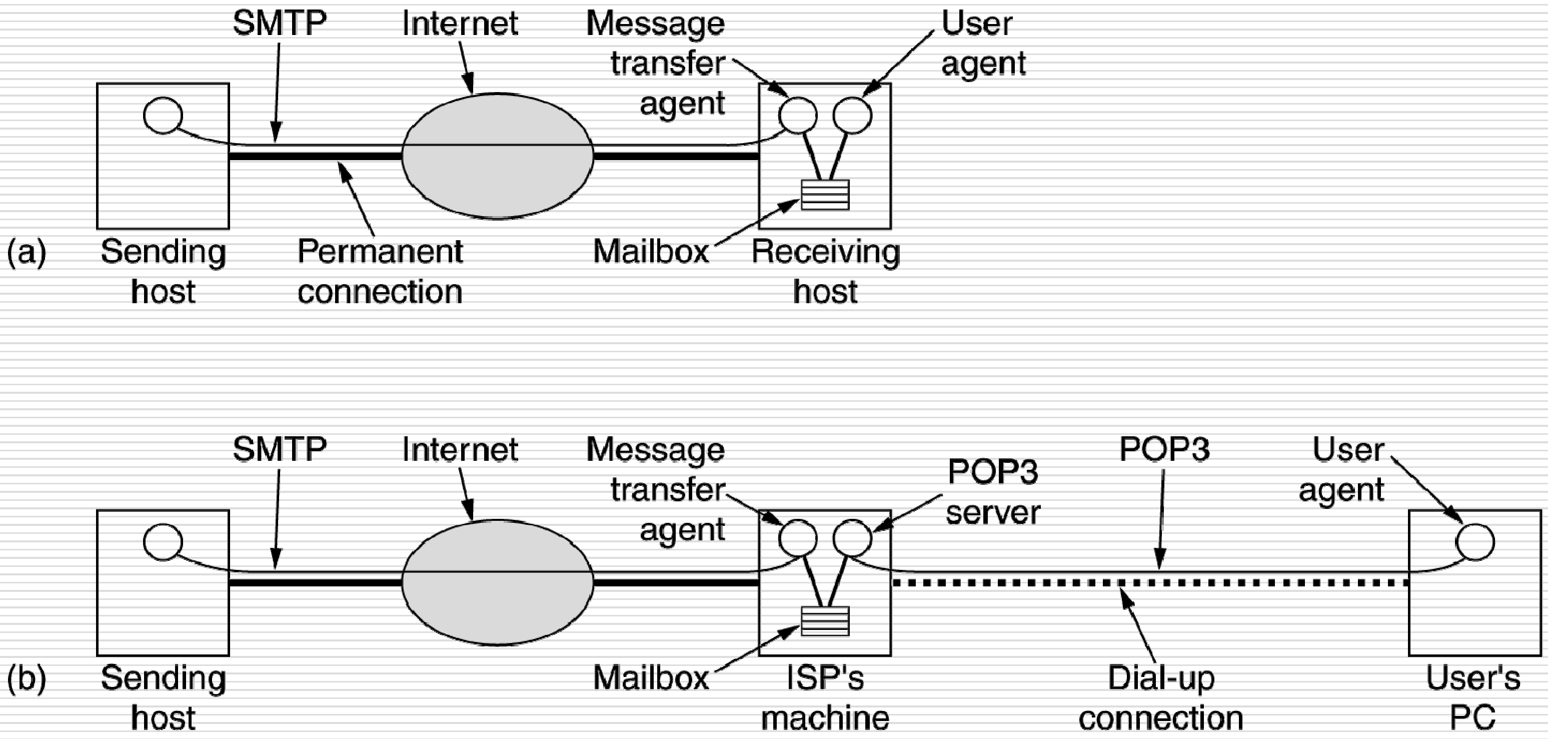
to *carolyn@xyz.com*

Using SMTP.



```
                        S: 220 xyz.com SMTP service ready
C: HELO abcd.com
                        S: 250 xyz.com says hello to abcd.com
C: MAIL FROM: <elinor@abcd.com>
                        S: 250 sender ok
C: RCPT TO: <carolyn@xyz.com>
                        S: 250 recipient ok
C: DATA
                        S: 354 Send mail; end with "." on a line by itself
C: From: elinor@abcd.com
C: To: carolyn@xyz.com
C: MIME-Version: 1.0
C: Message-Id: <0704760941.AA00747@abcd.com>
C: Content-Type: multipart/alternative; boundary=qwertyuiopasdfghjklzxcvbnm
C: Subject: Earth orbits sun integral number of times
C:
C: This is the preamble. The user agent ignores it. Have a nice day.
C:
C: --qwertyuiopasdfghjklzxcvbnm
C: Content-Type: text/enriched
C:
C: Happy birthday to you
C: Happy birthday to you
C: Happy birthday dear <bold> Carolyn </bold>
C: Happy birthday to you
C:
C: --qwertyuiopasdfghjklzxcvbnm
C: Content-Type: message/external-body;
C:         access-type="anon-ftp";
C:         site="bicycle.abcd.com";
C:         directory="pub";
C:         name="birthday.snd"
C:
C: content-type: audio/basic
C: content-transfer-encoding: base64
C: --qwertyuiopasdfghjklzxcvbnm
C: .
                        S: 250 message accepted
C: QUIT
                        S: 221 xyz.com closing connection
```

Final Delivery



(a) Sending and reading mail when the receiver has a permanent Internet connection and the user agent runs on the same machine as the message transfer agent. (b) Reading e-mail when the receiver has a dial-up connection to an ISP.

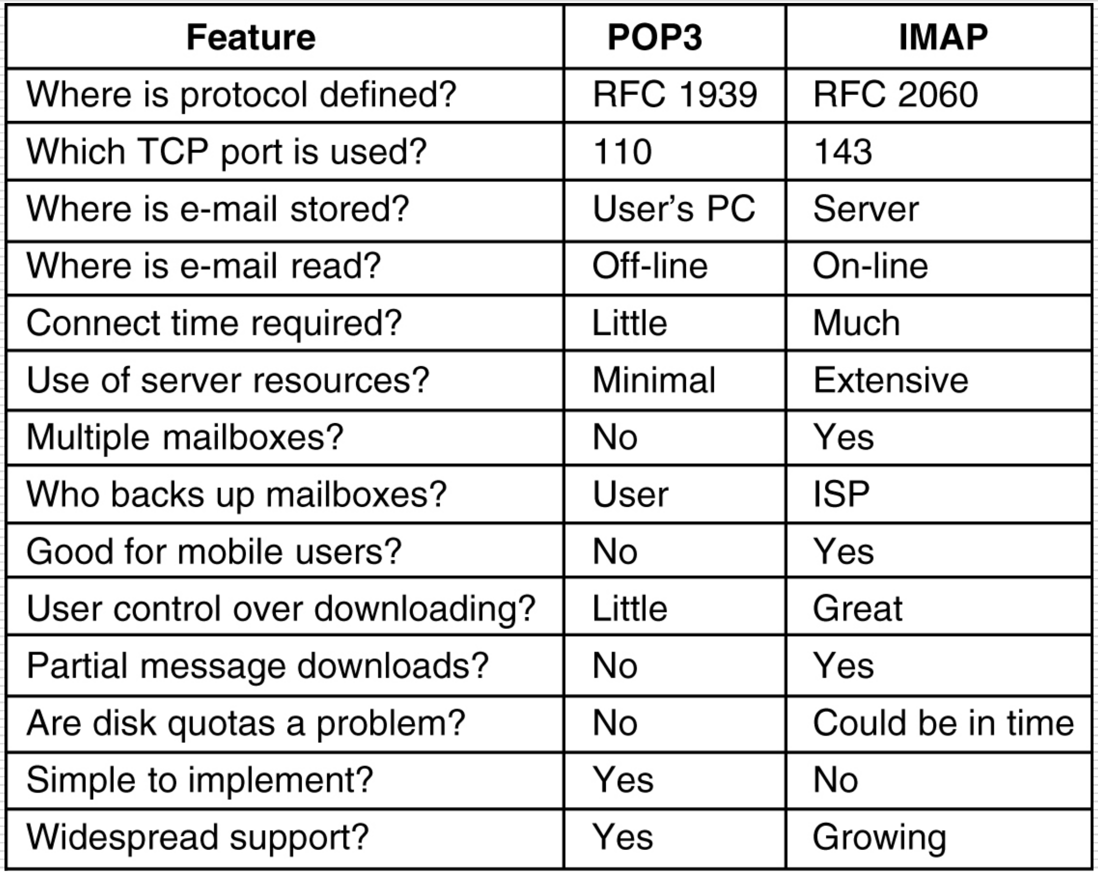
POP3

- Post Office Protocol Version 3
- Use TCP on port 110
- Is used to download messages from a mail server to client computers
- Example: Using POP3 to fetch three messages.

```
                    S: +OK POP3 server ready
C: USER carolyn
                    S: +OK
C: PASS vegetables
                    S: +OK login successful
C: LIST
                    S: 1 2505
                    S: 2 14302
                    S: 3 8122
                    S: .
C: RETR 1
                    S: (sends message 1)
C: DELE 1
C: RETR 2
                    S: (sends message 2)
C: DELE 2
C: RETR 3
                    S: (sends message 3)
C: DELE 3
C: QUIT
                    S: +OK POP3 server disconnecting
```

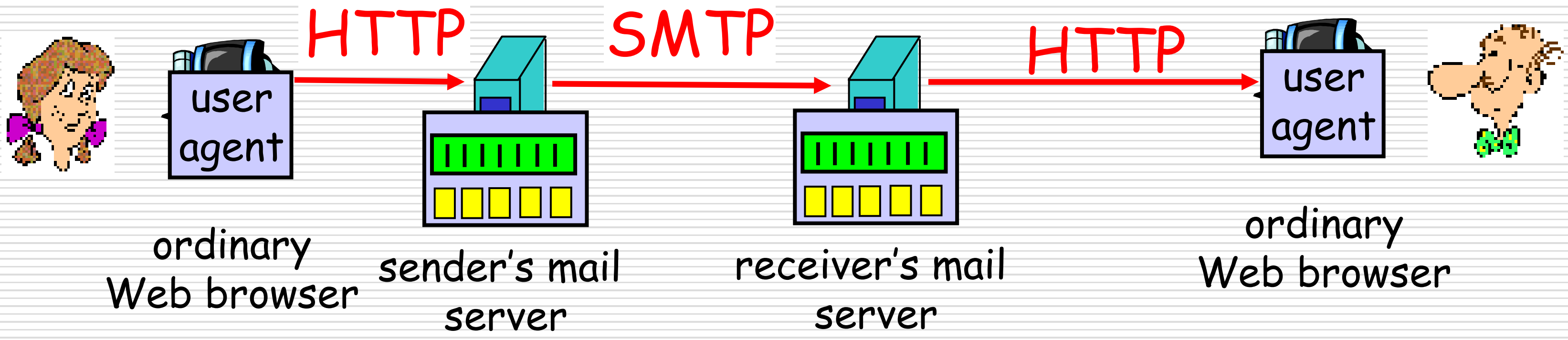
IMAP (Internet Message Access Protocol)

- POP3 is not convenient when users frequently use different machines to read email from servers, as emails have to be downloaded to different computers more or less random
- IMAP can resolve this issues as emails will be always on the servers
- A comparison of POP3 and IMAP.



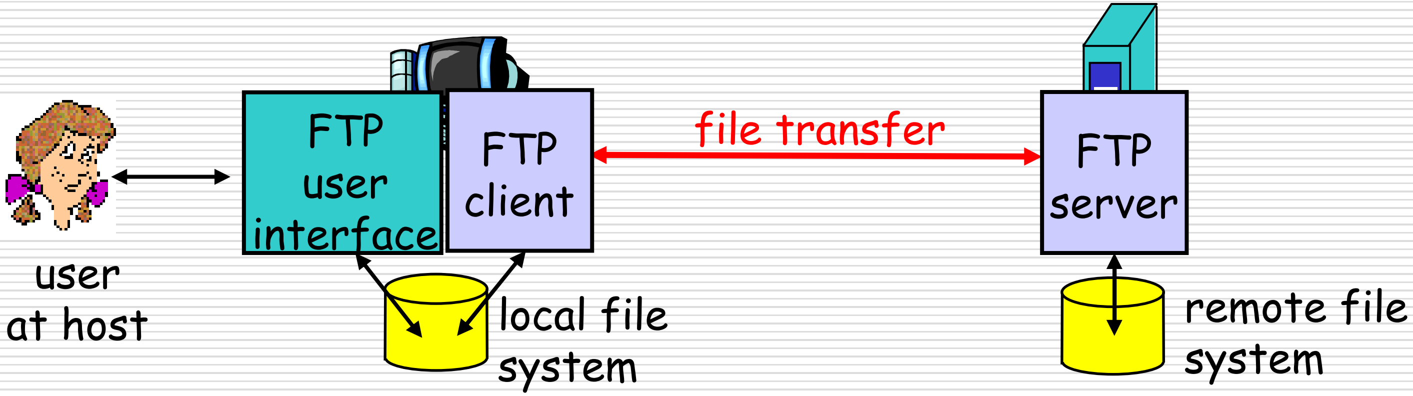
Feature	POP3	IMAP
Where is protocol defined?	RFC 1939	RFC 2060
Which TCP port is used?	110	143
Where is e-mail stored?	User's PC	Server
Where is e-mail read?	Off-line	On-line
Connect time required?	Little	Much
Use of server resources?	Minimal	Extensive
Multiple mailboxes?	No	Yes
Who backs up mailboxes?	User	ISP
Good for mobile users?	No	Yes
User control over downloading?	Little	Great
Partial message downloads?	No	Yes
Are disk quotas a problem?	No	Could be in time
Simple to implement?	Yes	No
Widespread support?	Yes	Growing

Web Mail



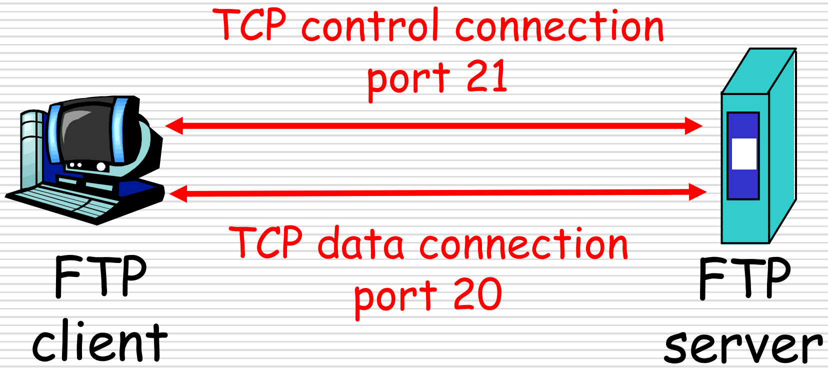
- Convenient for the user on the go (Internet Café, WebTV, …)
- User can organize their hierarchy of folders on servers
- May be slow:
  - server typically far from client
  - interaction with server through CGI scripts

FTP - File Transfer Protocol



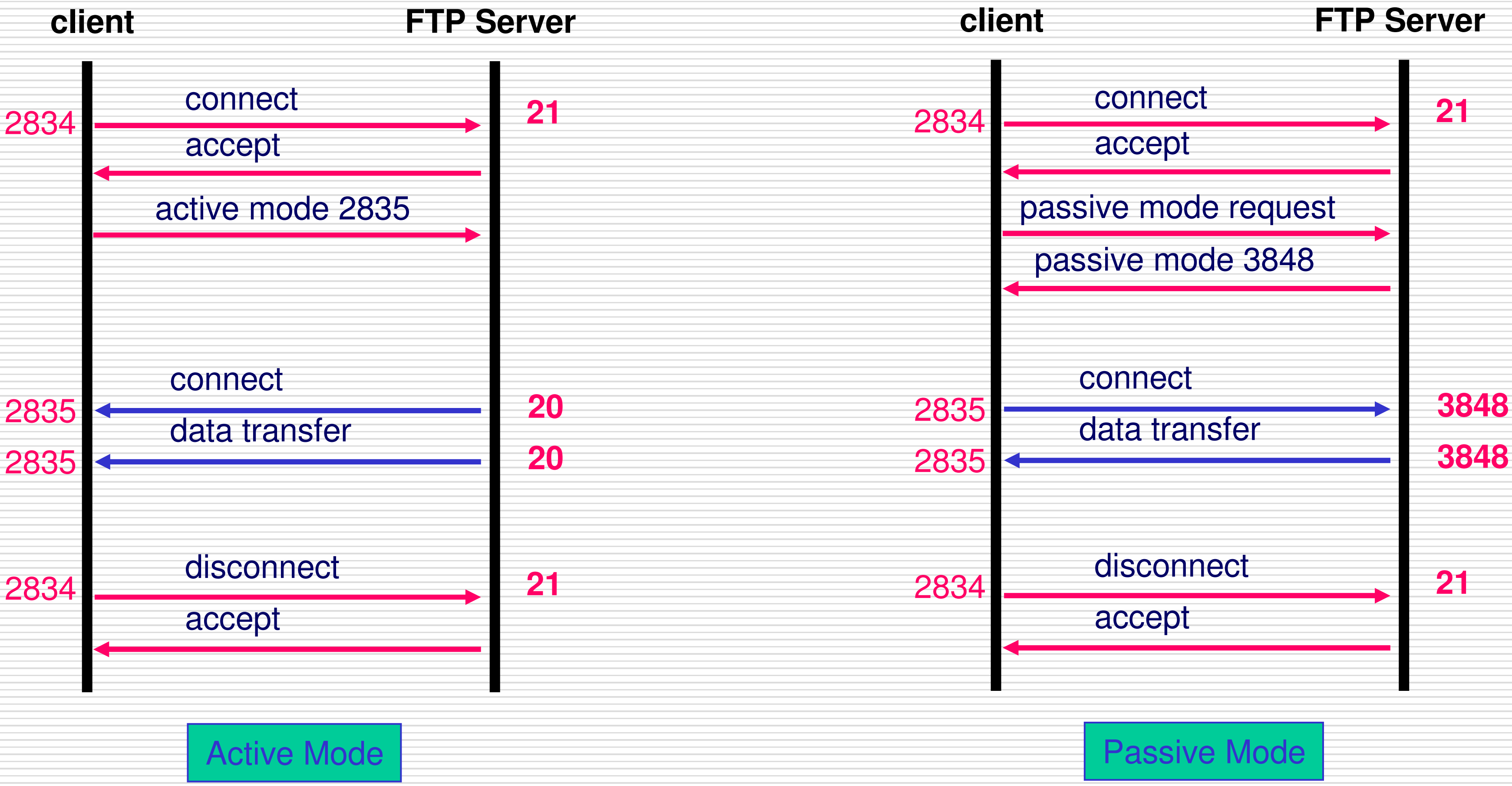
- transfer file to/from remote host
- client/server model
  - *client:* side that initiates transfer (either to/from remote)
  - *server:* remote host
- ftp: RFC 959
- ftp server: port 21

FTP - Out of band control



- 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.
  - data: file data to/from server.
- ftp server maintains "state": current directory, earlier authentication.

FTP - Transfer Mode

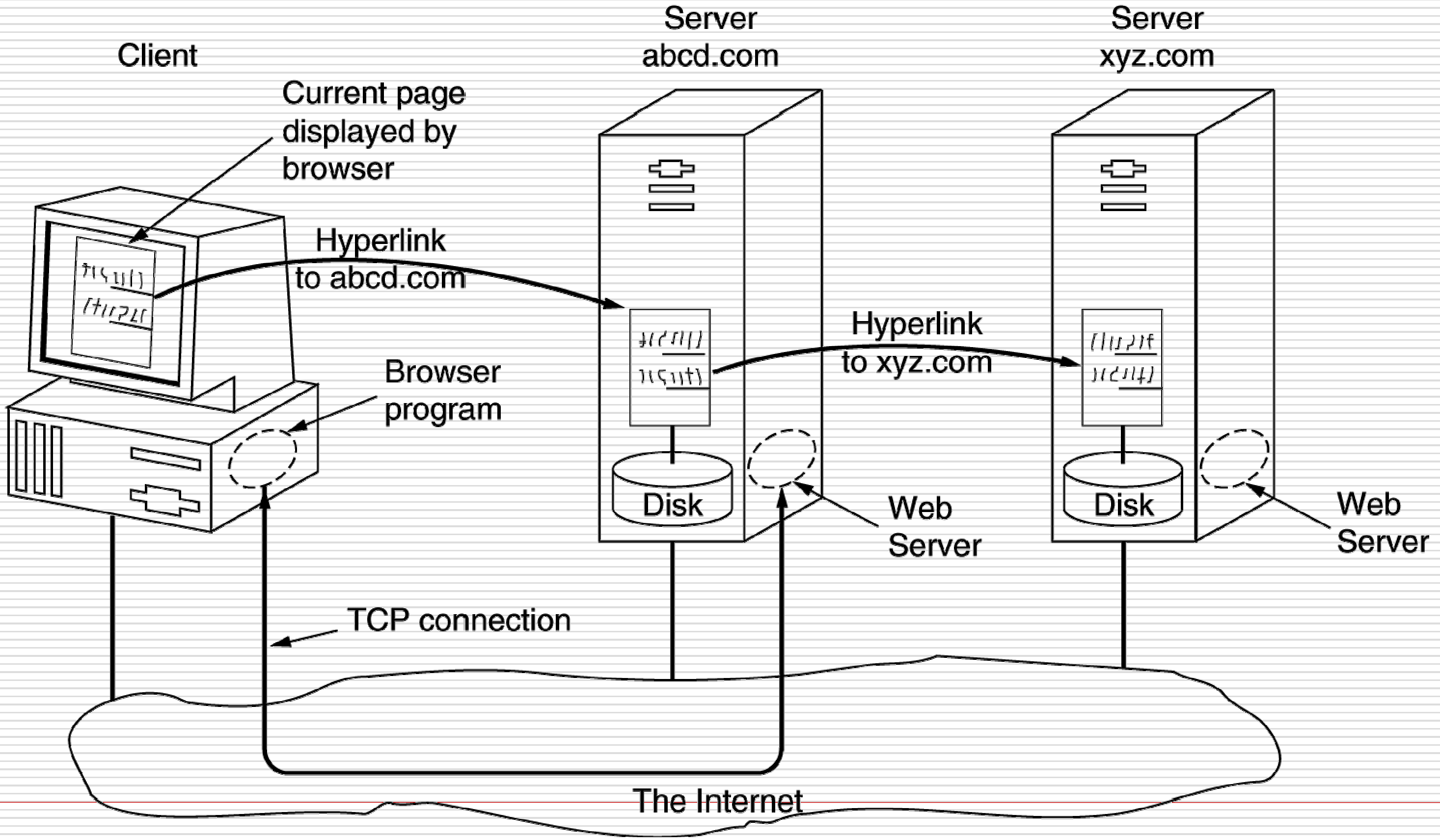


The World Wide Web

- Began in 1989 at CERN (Switzerland) by Tim Berners-Lee
- To be discussed
  - Architectural Overview
  - Static Web Documents
  - Dynamic Web Documents
  - HTTP – The HyperText Transfer Protocol

Architectural Overview

The parts of the Web model.



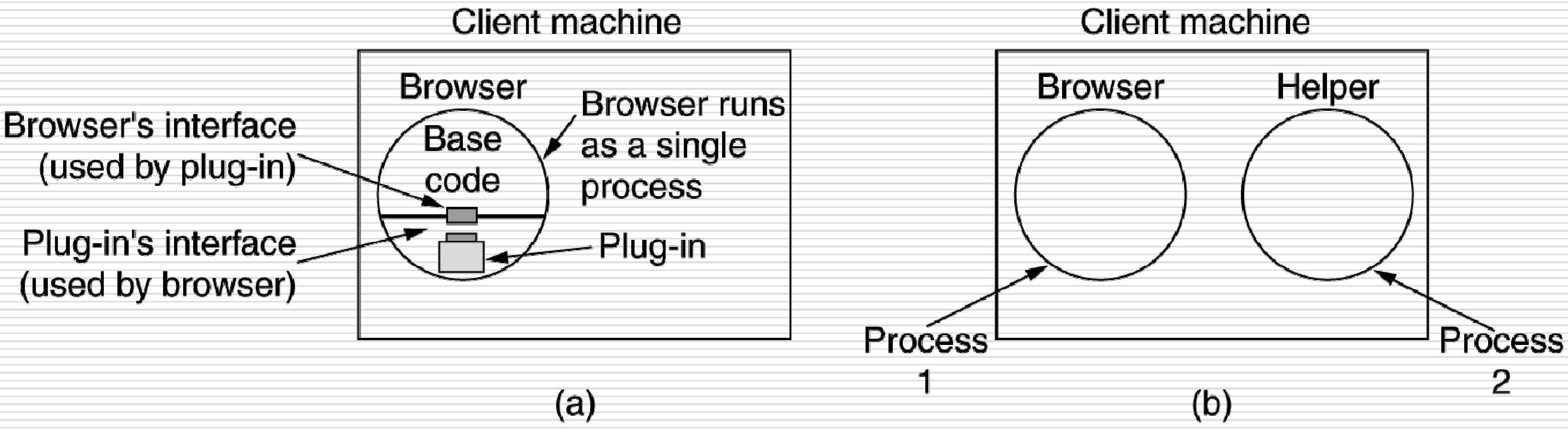
The Client Side

- Steps carried out by the browsers
  1. The browser determines the URL (by seeing what was selected).
  2. The browser asks DNS for the IP address of www.itu.org.
  3. DNS replies with 156.106.192.32.
  4. The browser makes a TCP connection to port 80 on 156.106.192.32.
  5. It then sends over a request asking for file /home/index.html.
  6. The www.itu.org server sends the file /home/index.html.
  7. The TCP connection is released.
  8. The browser displays all the text in /home/index.html.
  9. The browser fetches and displays all images in this file.

The Client Side (2)

- To display contents other HTML, e.g. PDF file or a movie clip, browsers use plug-ins or helper applications

(a) A browser plug-in. (b) A helper application.

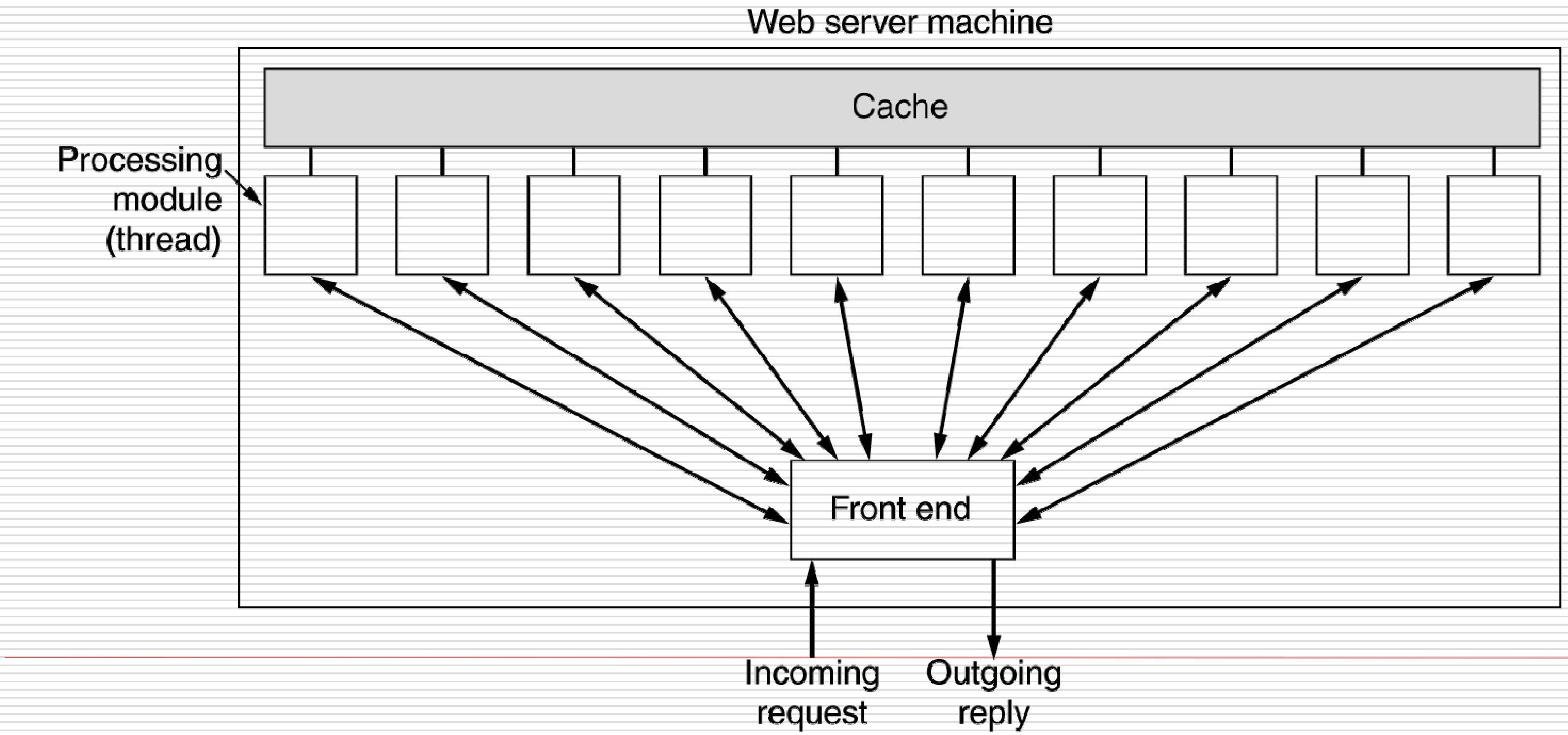


The Client Side

- Generally, steps that a server performs
  1. Accept a TCP connection from a client (a browser).
  2. Get the name of the file requested.
  3. Get the file (from disk).
  4. Return the file to the client.
  5. Release the TCP connection

The Server Side (2)

A multithreaded Web server with a front end and processing modules.



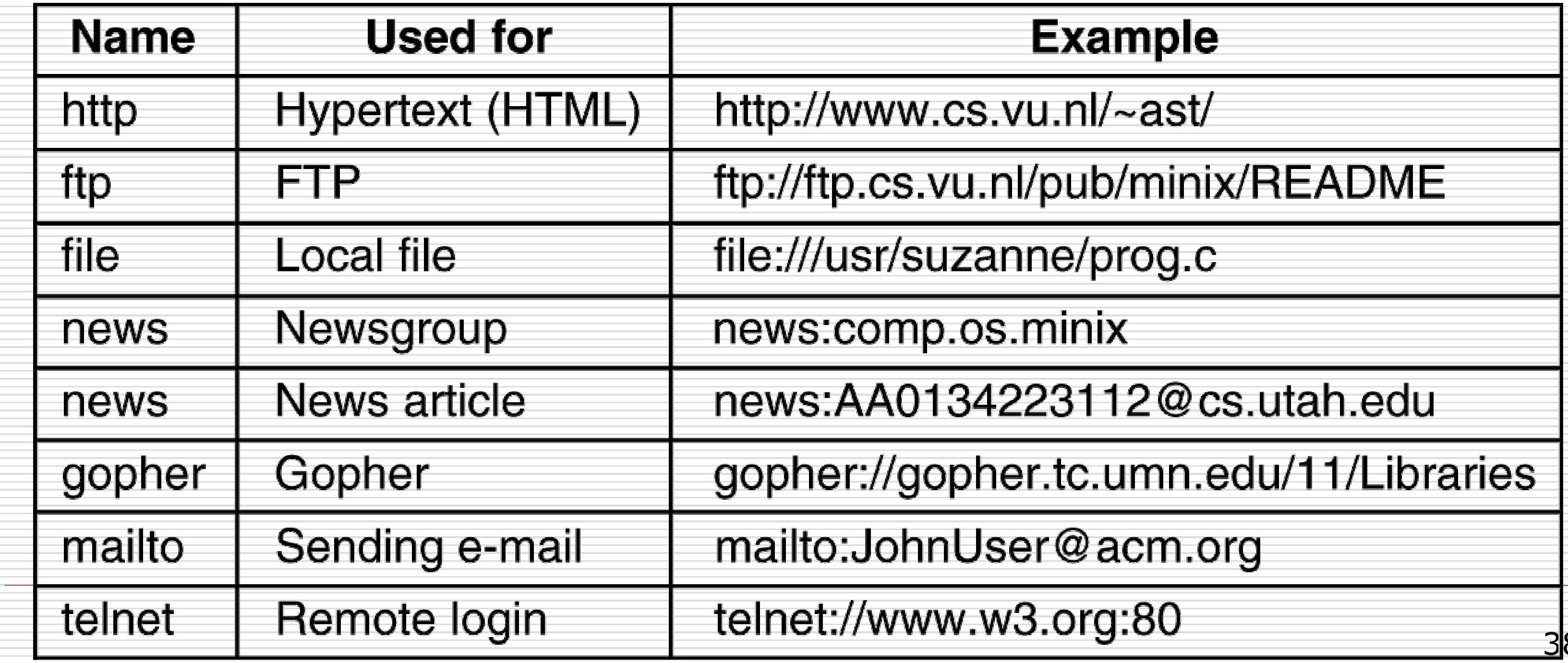
The Server Side (3)

- Steps performed by modern web servers
  1. Resolve the name of the Web page requested.
  2. Authenticate the client.
  3. Perform access control on the client.
  4. Perform access control on the Web page.
  5. Check the cache.
  6. Fetch the requested page from disk.
  7. Determine the MIME type to include in the response.
  8. Take care of miscellaneous odds and ends.
  9. Return the reply to the client.
  10. Make an entry in the server log.

URLs – Uniform Resource Locators

- URLs are used to refer to resources in the Internet, such as a web page

Some common URLs.



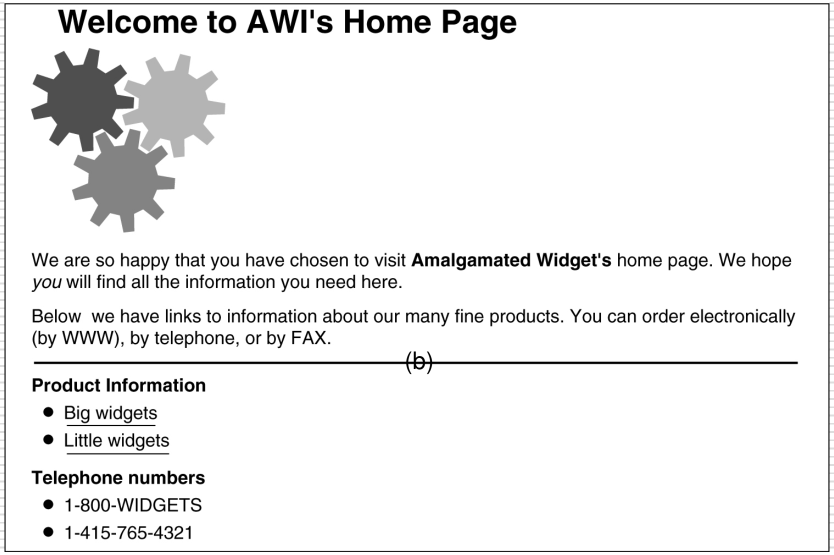
Name	Used for	Example
http	Hypertext (HTML)	http://www.cs.vu.nl/~ast/
ftp	FTP	ftp://ftp.cs.vu.nl/pub/minix/README
file	Local file	file:///usr/suzanne/prog.c
news	Newsgroup	news:comp.os.minix
news	News article	news:AA0134223112@cs.utah.edu
gopher	Gopher	gopher://gopher.tc.umn.edu/11/Libraries
mailto	Sending e-mail	mailto:JohnUser@acm.org
telnet	Remote login	telnet://www.w3.org:80

HTML – HyperText Markup Language

(a) The HTML for a sample Web page. (b) The formatted page.

```
<html>
<head><title> AMALGAMATED   WIDGET,  INC. </title> </head>
<body> <h1> Welcome to AWI's  Home Page</h1>
<img src="http://www.widget.com/images/logo.gif" ALT="AWI  Logo"> <br>
We are so happy that you have chosen to visit <b> Amalgamated  Widget's </b>
home page. We hope <i> you </i> will  find  all  the information you  need here.
<p>Below we have links to information  about  our  many fine products.
You can order  electronically  (by WWW), by  telephone, or by fax. </p>
<hr>
<h2> Product information  </h2>
<ul>
   <li>  <a href="http://widget.com/products/big">  Big widgets </a>
   <li>  <a href="http://widget.com/products/little">   Little widgets </a>
</ul>
<h2> Telephone numbers</h2>
<ul>
   <li>  By telephone: 1-800-WIDGETS
   <li>  By fax:  1-415-765-4321
</ul>
</body>
</html>
```

(a)



Welcome to AWI's Home Page

We are so happy that you have chosen to visit **Amalgamated Widget's** home page. We hope *you* will find all the information you need here.

Below we have links to information about our many fine products. You can order electronically (by WWW), by telephone, or by FAX.

(b)

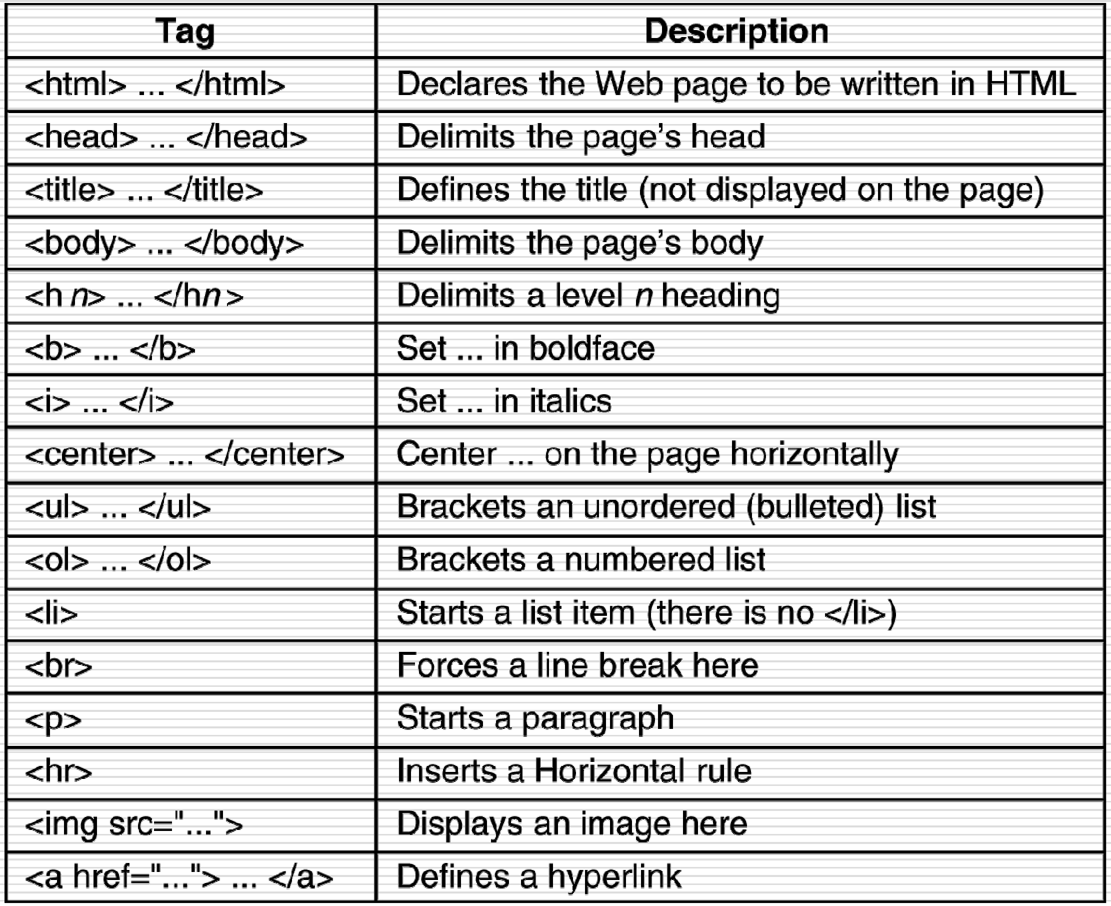
Product Information

- Big widgets
- Little widgets

Telephone numbers

- 1-800-WIDGETS
- 1-415-765-4321

HTML Tags

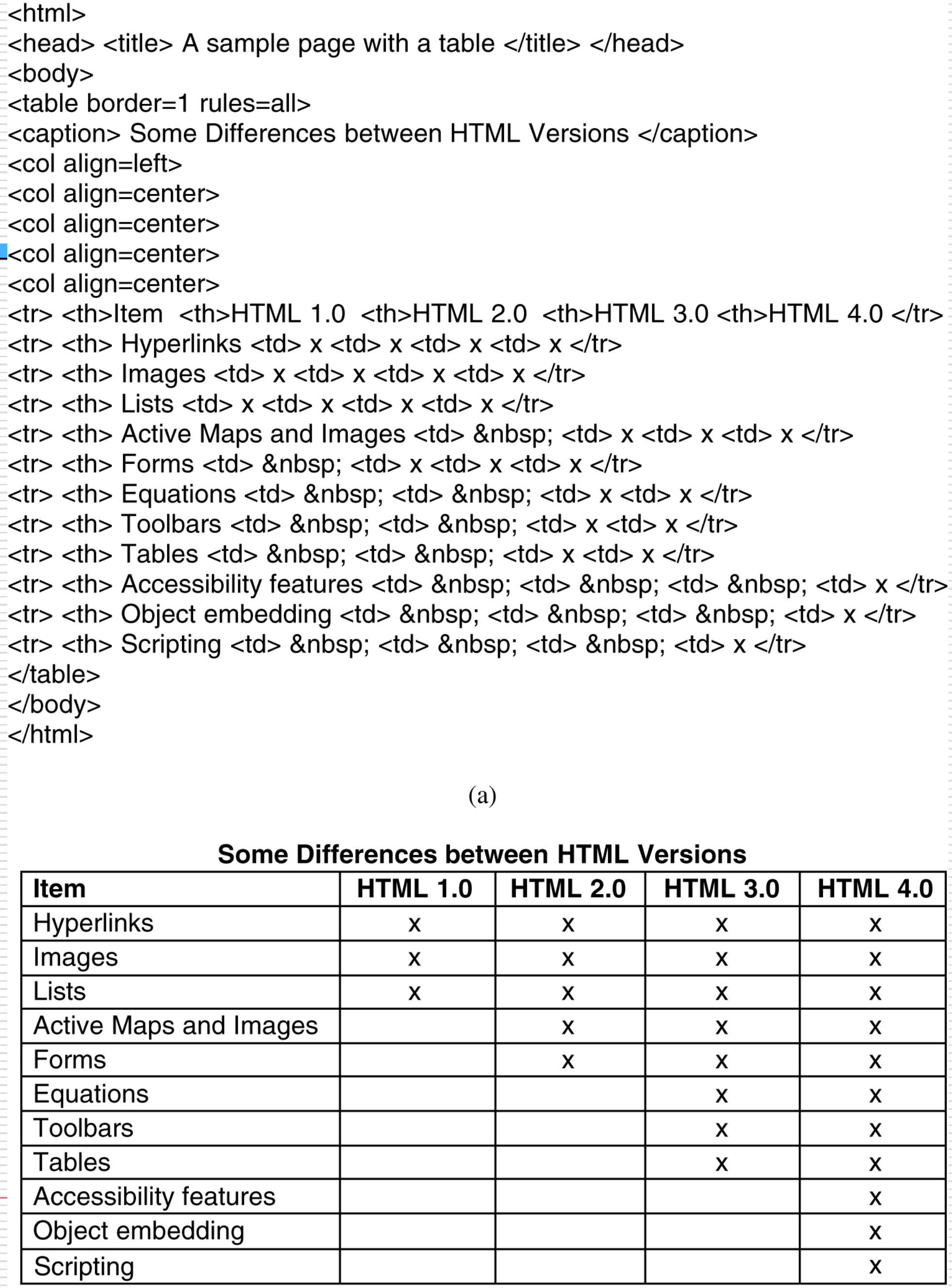


Tag	Description
<html> ... </html>	Declares the Web page to be written in HTML
<head> ... </head>	Delimits the page's head
<title> ... </title>	Defines the title (not displayed on the page)
<body> ... </body>	Delimits the page's body
<h*n*> ... </h*n*>	Delimits a level *n* heading
<b> ... </b>	Set ... in boldface
<i> ... </i>	Set ... in italics
<center> ... </center>	Center ... on the page horizontally
<ul> ... </ul>	Brackets an unordered (bulleted) list
<ol> ... </ol>	Brackets a numbered list
<li>	Starts a list item (there is no </li>)
<br>	Forces a line break here
<p>	Starts a paragraph
<hr>	Inserts a Horizontal rule
<img src="...">	Displays an image here
<a href="..."> ... </a>	Defines a hyperlink

Tables

(a) An HTML table.

(b) A possible rendition of this table.



```
<html>
<head> <title> A sample page with a table </title> </head>
<body>
<table border=1 rules=all>
<caption> Some Differences between HTML Versions </caption>
<col align=left>
<col align=center>
<col align=center>
<col align=center>
<col align=center>
<tr> <th>Item  <th>HTML 1.0  <th>HTML 2.0  <th>HTML 3.0 <th>HTML 4.0 </tr>
<tr> <th> Hyperlinks <td> x <td> x <td> x <td> x </tr>
<tr> <th> Images <td> x <td> x <td> x <td> x </tr>
<tr> <th> Lists <td> x <td> x <td> x <td> x </tr>
<tr> <th> Active Maps and Images <td> &nbsp; <td> x <td> x <td> x </tr>
<tr> <th> Forms <td> &nbsp; <td> x <td> x <td> x </tr>
<tr> <th> Equations <td> &nbsp; <td> &nbsp; <td> x <td> x </tr>
<tr> <th> Toolbars <td> &nbsp; <td> &nbsp; <td> x <td> x </tr>
<tr> <th> Tables <td> &nbsp; <td> &nbsp; <td> x <td> x </tr>
<tr> <th> Accessibility features <td> &nbsp; <td> &nbsp; <td> &nbsp; <td> x </tr>
<tr> <th> Object embedding <td> &nbsp; <td> &nbsp; <td> &nbsp; <td> x </tr>
<tr> <th> Scripting <td> &nbsp; <td> &nbsp; <td> &nbsp; <td> x </tr>
</table>
</body>
</html>
```

(a)

Some Differences between HTML Versions

Item	**HTML 1.0**	**HTML 2.0**	**HTML 3.0**	**HTML 4.0**
Hyperlinks	x	x	x	x
Images	x	x	x	x
Lists	x	x	x	x
Active Maps and Images		x	x	x
Forms		x	x	x
Equations			x	x
Toolbars			x	x
Tables			x	x
Accessibility features				x
Object embedding				x
Scripting				x

(b)

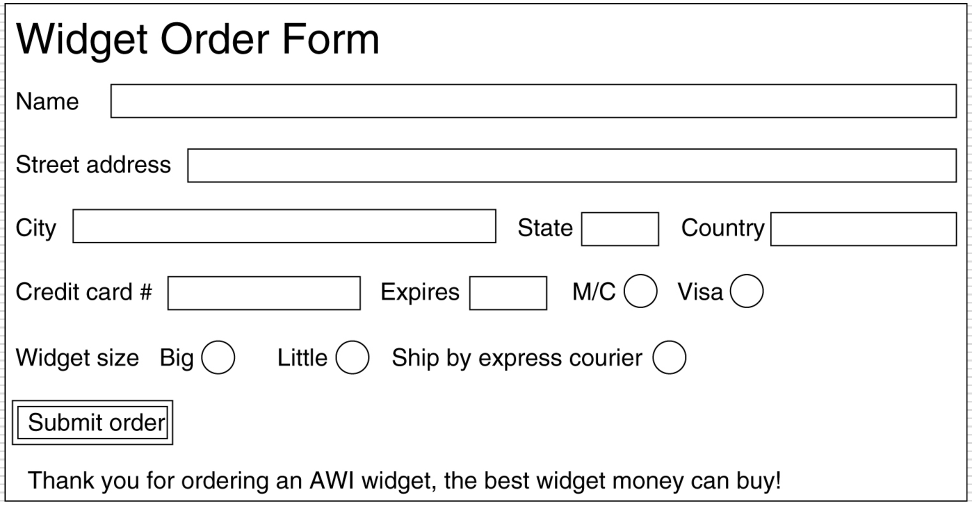
Forms

(a) The HTML for an order form.

(b) The formatted page.

```
<html>
<head> <title> AWI CUSTOMER ORDERING FORM </title> </head>
<body>
<h1> Widget Order Form </h1>
<form ACTION="http://widget.com/cgi-bin/widgetorder" method=POST>
<p> Name <input name="customer" size=46> </p>
<p> Street Address <input name="address" size=40> </p>
<p> City <input name="city" size=20> State <input name="state" size =4>
Country <input name="country" size=10> </p>
<p> Credit card # <input name="cardno" size=10>
Expires <input name="expires" size=4>
M/C <input name="cc" type=radio value="mastercard">
VISA <input name="cc" type=radio value="visacard"> </p>
<p> Widget size Big <input name="product" type=radio value="expensive">
Little <input name="product" type=radio value="cheap">
Ship by express courier <input name="express" type=checkbox> </p>
<p><input type=submit value="submit order"> </p>
Thank you for ordering an AWI widget, the best widget money can buy!
</form>
</body>
</html>
```

(a)



Widget Order Form

Name

Street address

City State Country

Credit card # Expires M/C ○ Visa ○

Widget size Big ○ Little ○ Ship by express courier ○

Submit order

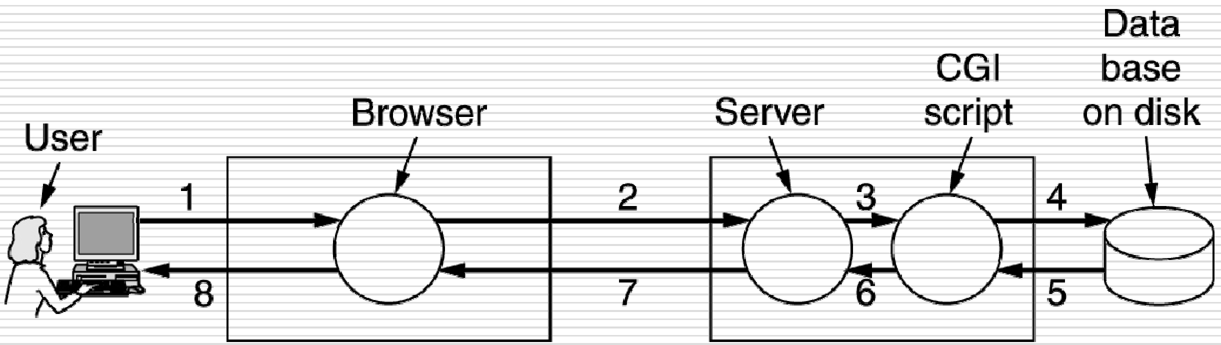
Thank you for ordering an AWI widget, the best widget money can buy!

(b)

Dynamic Web Documents

- Web contents are generated dynamically on demand
- Dynamic Web documents are now popular in the Internet
- Dynamic contents can be generated on client side or/and server side

Server Side Dynamic Web Documents

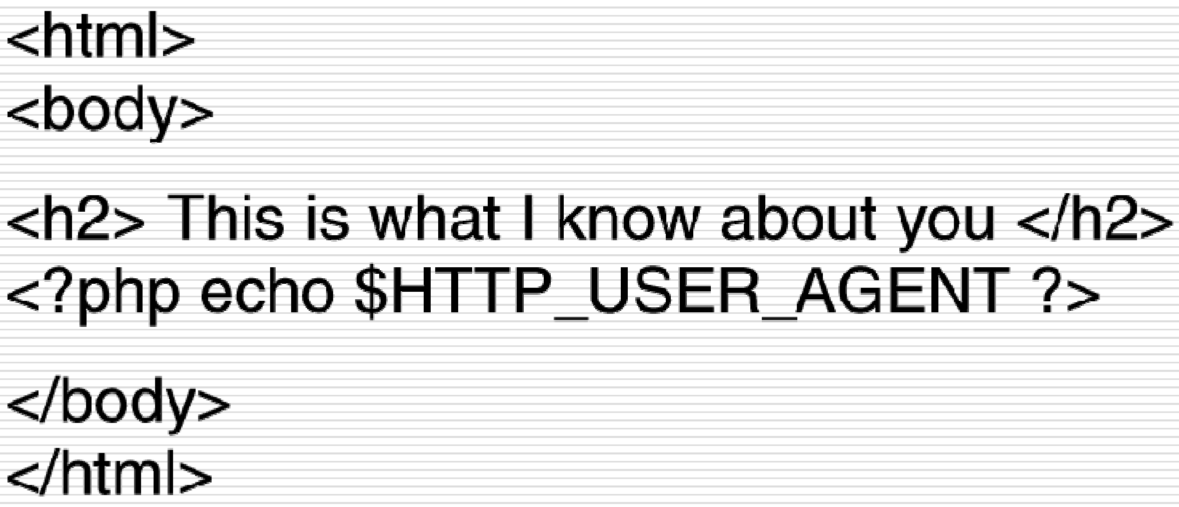


1. User fills in form
2. Form sent back
3. Handed to CGI
4. CGI queries DB
5. Record found
6. CGI builds page
7. Page returned
8. Page displayed

Steps in processing the information from an HTML form.

Server Side Dynamic Web Documents (2)

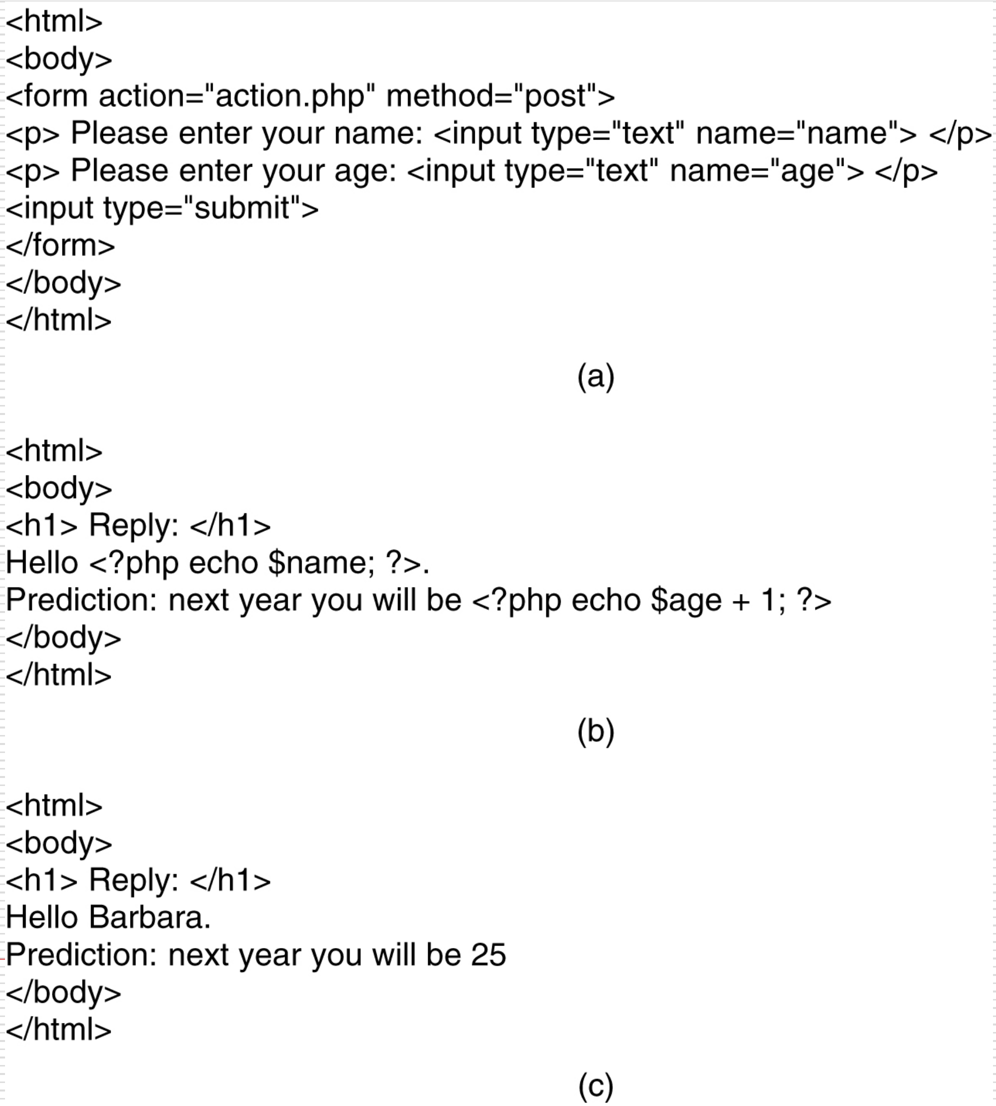
A sample HTML page with embedded PHP.



```
<html>
<body>

<h2> This is what I know about you </h2>
<?php echo $HTTP_USER_AGENT ?>

</body>
</html>
```

Server Side Dynamic Web Documents (3)

(a) A Web page containing a form. (b) A PHP script for handling the output of the form. (c) Output from the PHP script when the inputs are "Barbara" and 24 respectively.



```
<html>
<body>
<form action="action.php" method="post">
<p> Please enter your name: <input type="text" name="name"> </p>
<p> Please enter your age: <input type="text" name="age"> </p>
<input type="submit">
</form>
</body>
</html>
```

(a)

```
<html>
<body>
<h1> Reply: </h1>
Hello <?php echo $name; ?>.
Prediction: next year you will be <?php echo $age + 1; ?>
</body>
</html>
```

(b)

```
<html>
<body>
<h1> Reply: </h1>
Hello Barbara.
Prediction: next year you will be 25
</body>
</html>
```

(c)

Client-Side Dynamic Web Page Generation

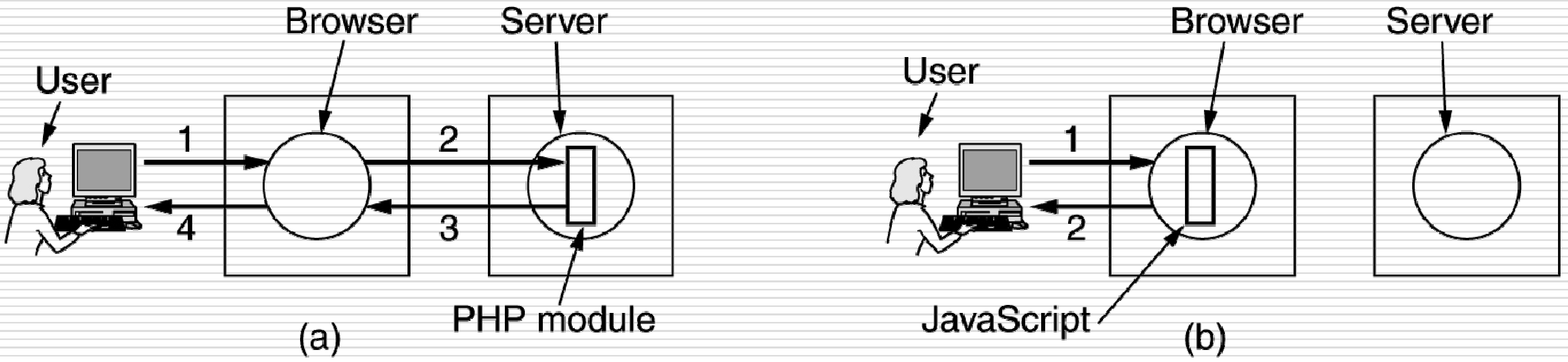
Use of JavaScript for processing a form.

```
<head>
<script language="javascript" type="text/javascript">
function response(test  form) {
   var person = test  form.name.value;
   var years = eval(test  form.age.value) + 1;
   document.open();
   document.writeln("<html>  <body>");
   document.writeln("Hello  " + person + ".<br>");
   document.writeln("Prediction:  next year you will be " + years + ".");
   document.writeln("</body> </html>");
   document.close();
}
</script>
</head>

<body>
<form>
Please enter your name: <input type="text" name="name">
<p>
Please enter your age: <input type="text" name="age">
<p>
<input type="button" value="submit" onclick="response(this.form)">
</form>
</body>
</html>
```

Client-Side Dynamic Web Page Generation (2)

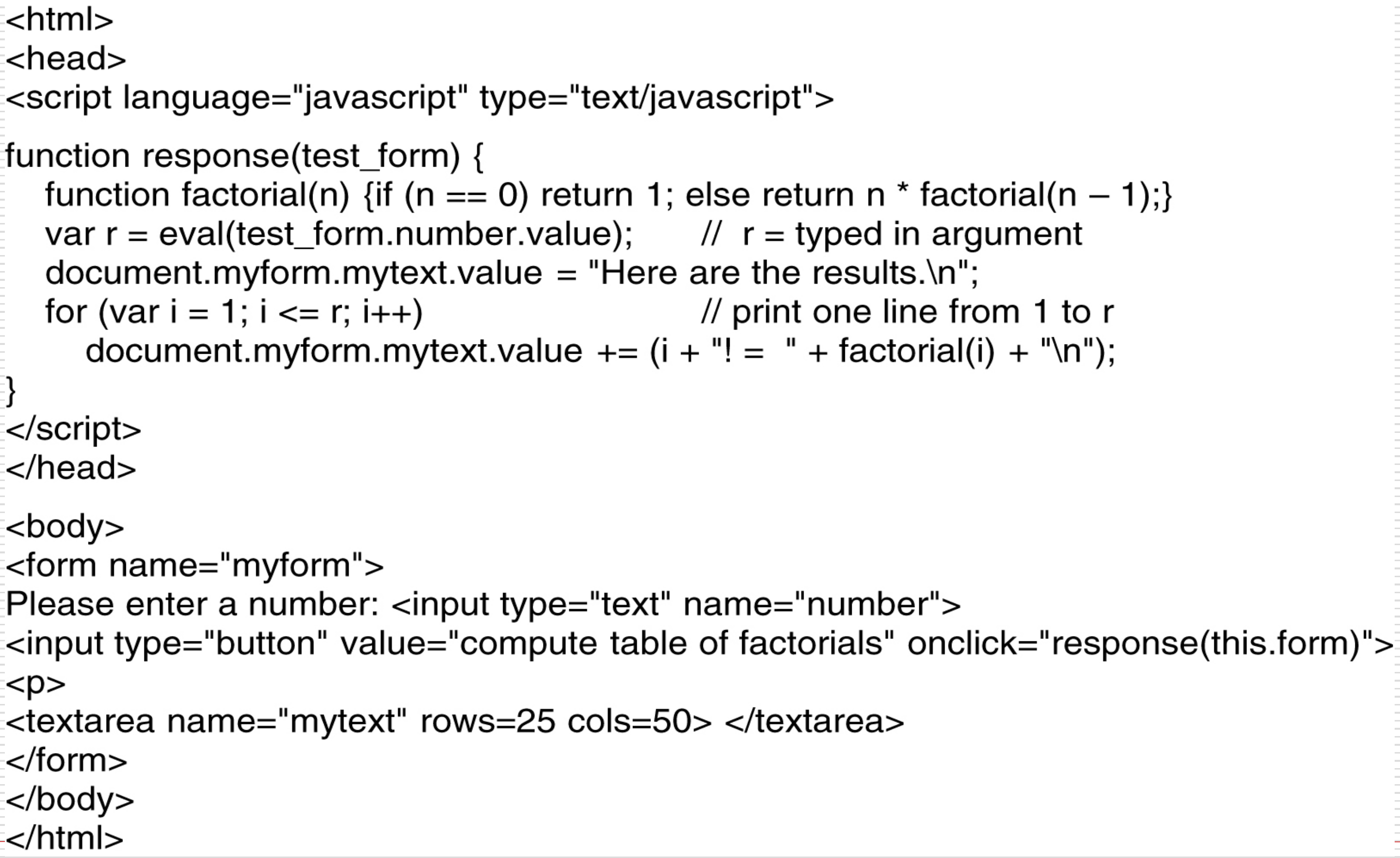
(a) Server-side scripting with PHP.

(b) Client-side scripting with JavaScript.



Client-Side Dynamic Web Page Generation (3)

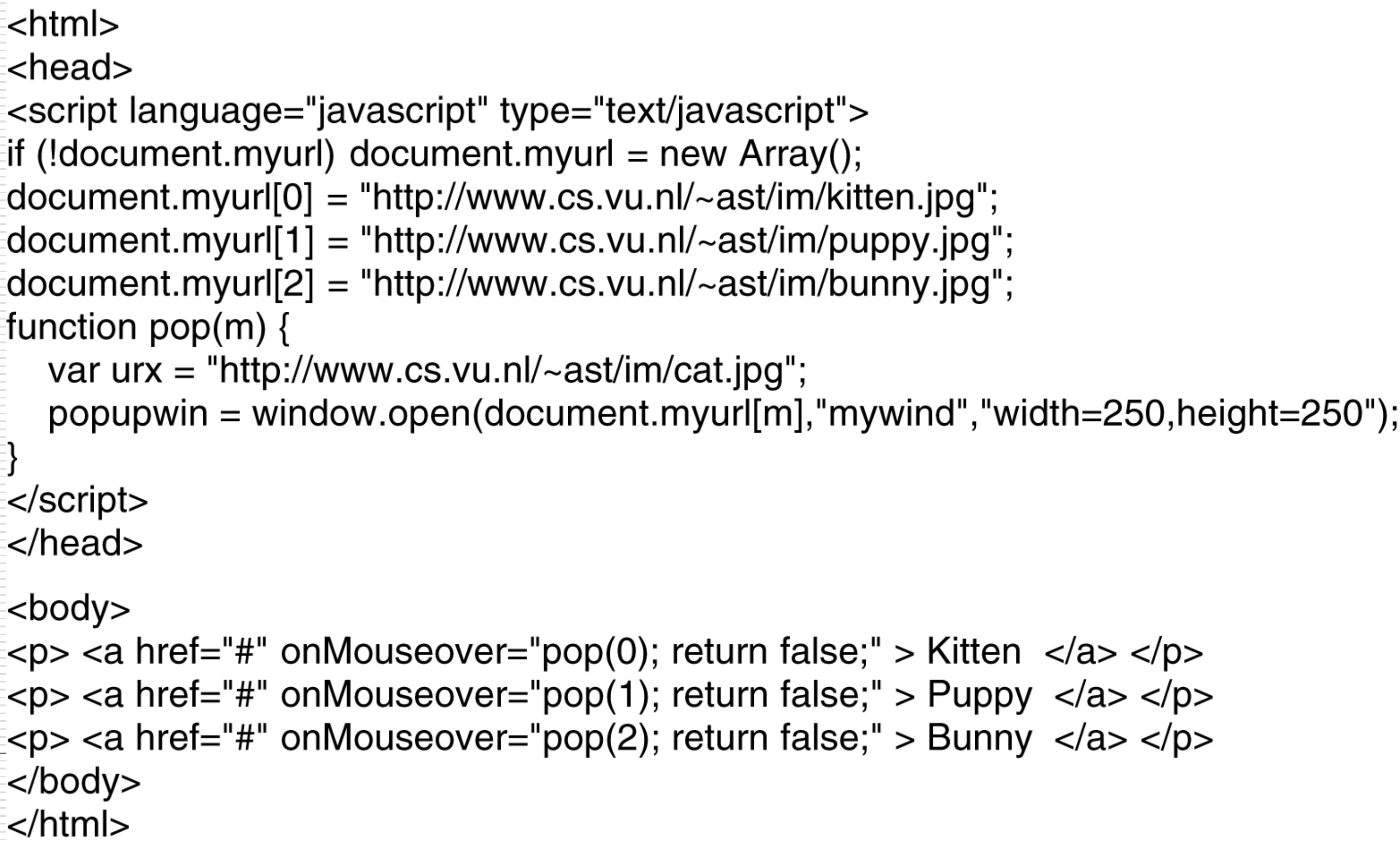
A JavaScript program for computing and printing factorials.



```
<html>
<head>
<script language="javascript" type="text/javascript">
function response(test_form) {
   function factorial(n) {if (n == 0) return 1; else return n * factorial(n – 1);}
   var r = eval(test_form.number.value);      //  r = typed in argument
   document.myform.mytext.value = "Here are the results.\n";
   for (var i = 1; i <= r; i++)                           // print one line from 1 to r
      document.myform.mytext.value += (i + "! =  " + factorial(i) + "\n");
}
</script>
</head>
<body>
<form name="myform">
Please enter a number: <input type="text" name="number">
<input type="button" value="compute table of factorials" onclick="response(this.form)">
<p>
<textarea name="mytext" rows=25 cols=50> </textarea>
</form>
</body>
</html>
```

Client-Side Dynamic Web Page Generation (4)

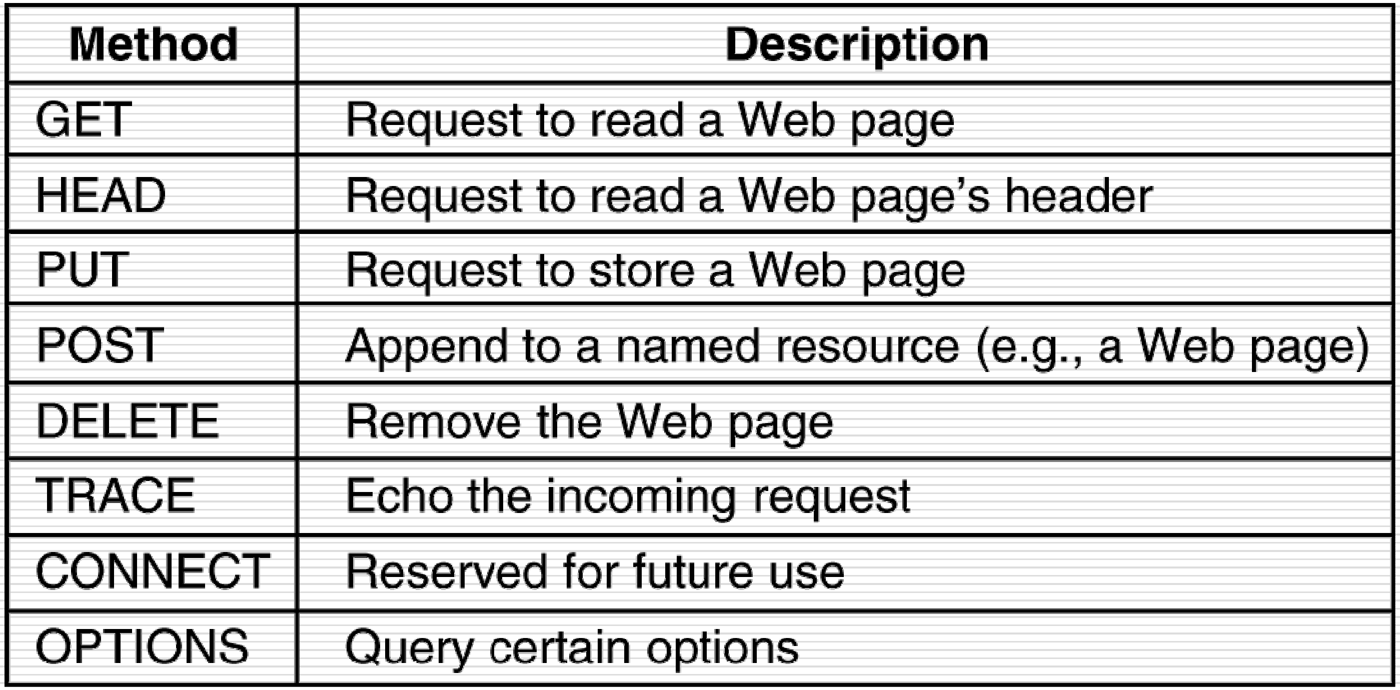
An interactive Web page that responds to mouse movement.



```
<html>
<head>
<script language="javascript" type="text/javascript">
if (!document.myurl) document.myurl = new Array();
document.myurl[0] = "http://www.cs.vu.nl/~ast/im/kitten.jpg";
document.myurl[1] = "http://www.cs.vu.nl/~ast/im/puppy.jpg";
document.myurl[2] = "http://www.cs.vu.nl/~ast/im/bunny.jpg";
function pop(m) {
   var urx = "http://www.cs.vu.nl/~ast/im/cat.jpg";
   popupwin = window.open(document.myurl[m],"mywind","width=250,height=250");
}
</script>
</head>

<body>
<p> <a href="#" onMouseover="pop(0); return false;" > Kitten  </a> </p>
<p> <a href="#" onMouseover="pop(1); return false;" > Puppy  </a> </p>
<p> <a href="#" onMouseover="pop(2); return false;" > Bunny  </a> </p>
</body>
</html>
```

HTTP Methods

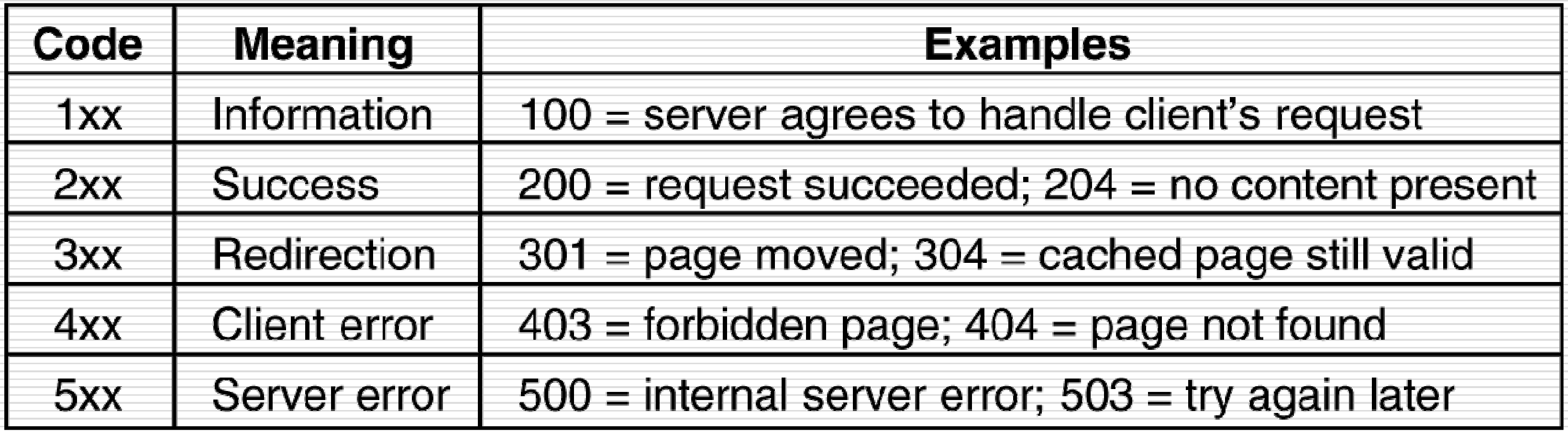
The built-in HTTP request methods.



Method	Description
GET	Request to read a Web page
HEAD	Request to read a Web page's header
PUT	Request to store a Web page
POST	Append to a named resource (e.g., a Web page)
DELETE	Remove the Web page
TRACE	Echo the incoming request
CONNECT	Reserved for future use
OPTIONS	Query certain options

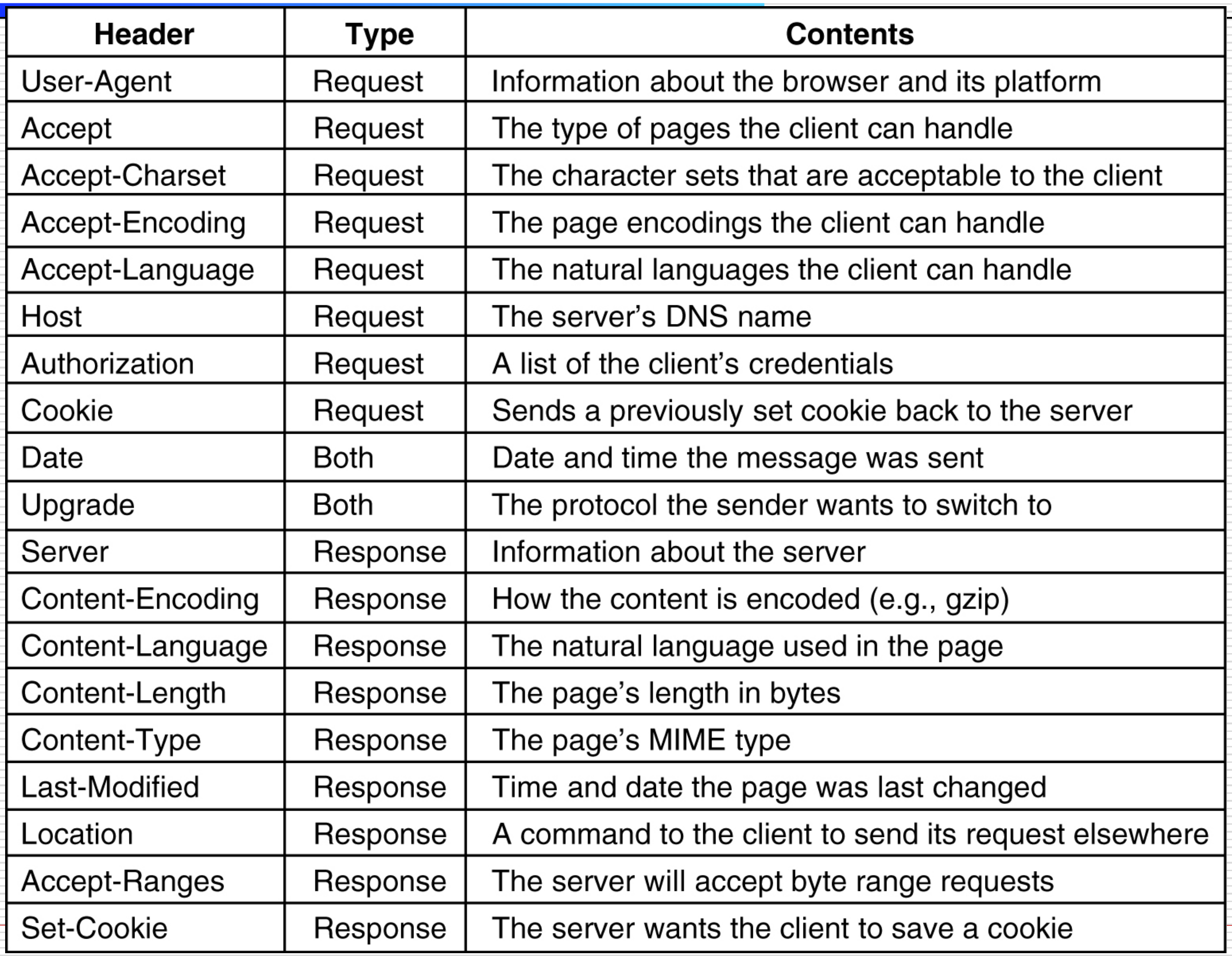
HTTP Methods (2)

The status code response groups.



Code	Meaning	Examples
1xx	Information	100 = server agrees to handle client’s request
2xx	Success	200 = request succeeded; 204 = no content present
3xx	Redirection	301 = page moved; 304 = cached page still valid
4xx	Client error	403 = forbidden page; 404 = page not found
5xx	Server error	500 = internal server error; 503 = try again later

HTTP Message Headers

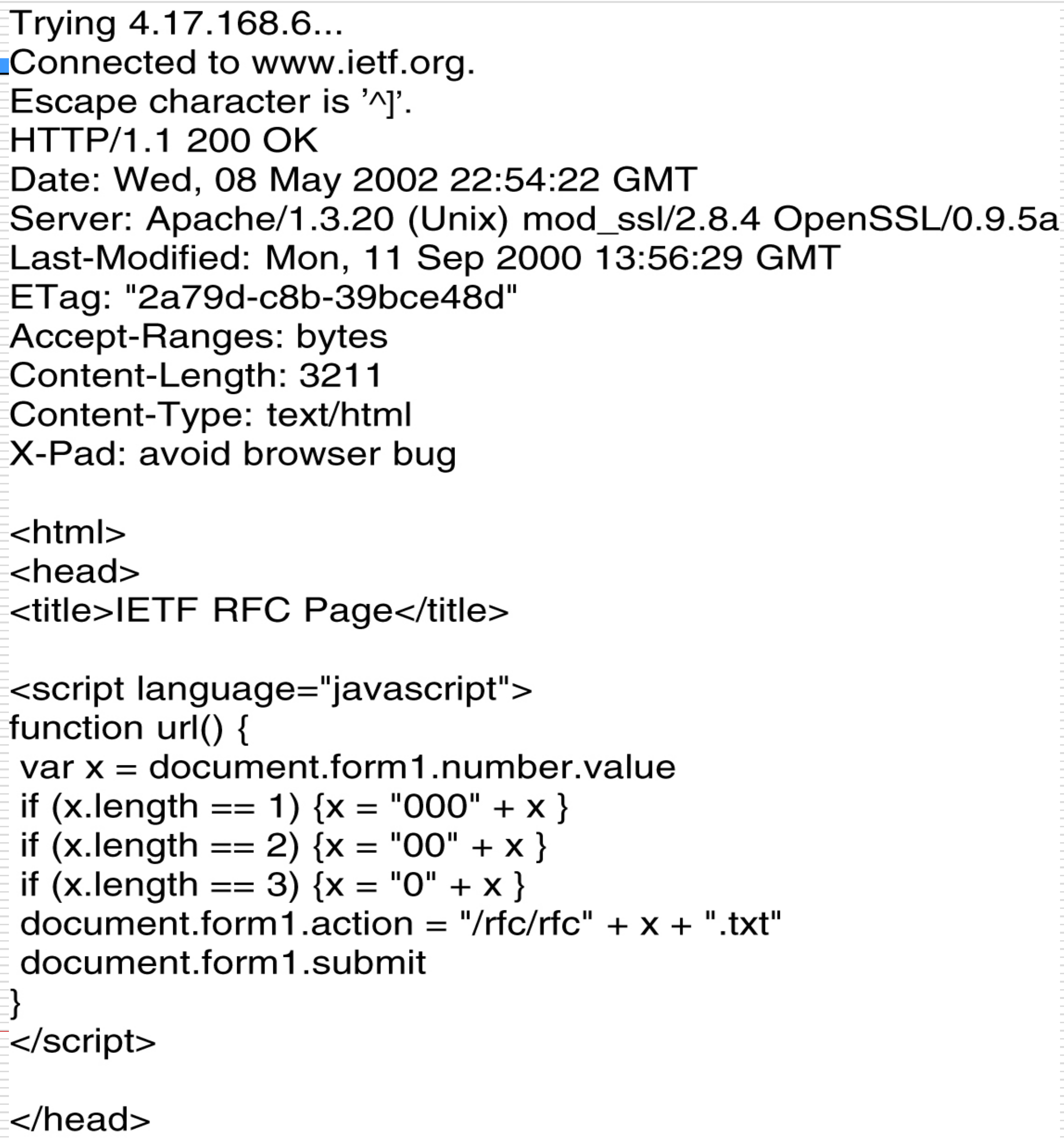


Header	Type	Contents
User-Agent	Request	Information about the browser and its platform
Accept	Request	The type of pages the client can handle
Accept-Charset	Request	The character sets that are acceptable to the client
Accept-Encoding	Request	The page encodings the client can handle
Accept-Language	Request	The natural languages the client can handle
Host	Request	The server's DNS name
Authorization	Request	A list of the client's credentials
Cookie	Request	Sends a previously set cookie back to the server
Date	Both	Date and time the message was sent
Upgrade	Both	The protocol the sender wants to switch to
Server	Response	Information about the server
Content-Encoding	Response	How the content is encoded (e.g., gzip)
Content-Language	Response	The natural language used in the page
Content-Length	Response	The page's length in bytes
Content-Type	Response	The page's MIME type
Last-Modified	Response	Time and date the page was last changed
Location	Response	A command to the client to send its request elsewhere
Accept-Ranges	Response	The server will accept byte range requests
Set-Cookie	Response	The server wants the client to save a cookie

Some HTTP message headers.

Example HTTP Usage

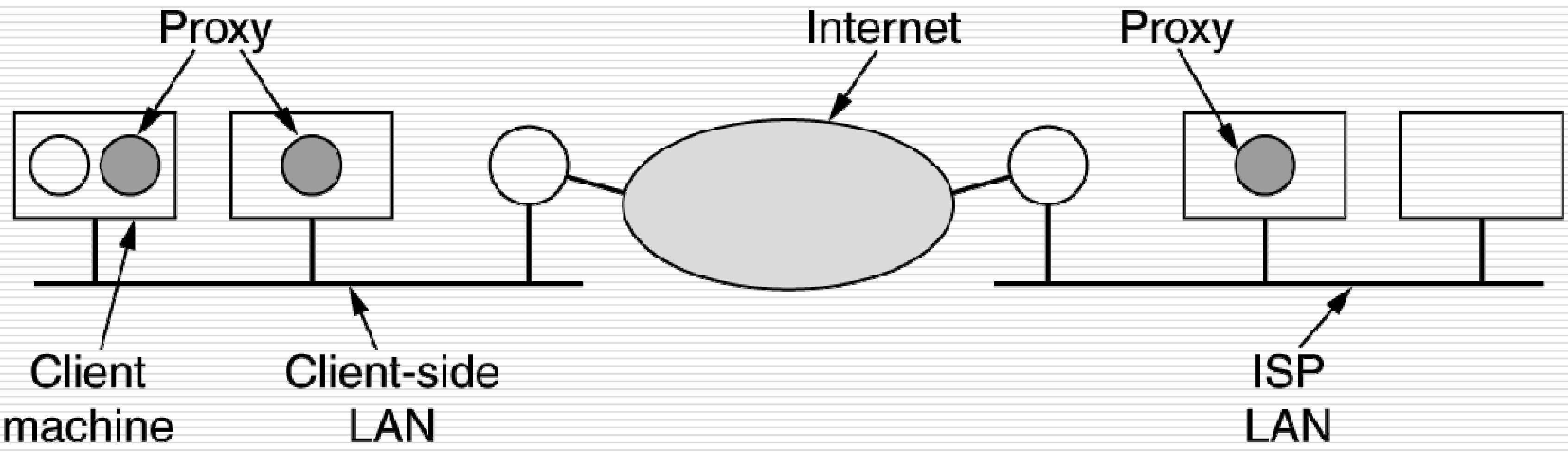
The start of the output of *www.ietf.org/rfc.html*.



```
Trying 4.17.168.6...
Connected to www.ietf.org.
Escape character is '^]'.
HTTP/1.1 200 OK
Date: Wed, 08 May 2002 22:54:22 GMT
Server: Apache/1.3.20 (Unix) mod_ssl/2.8.4 OpenSSL/0.9.5a
Last-Modified: Mon, 11 Sep 2000 13:56:29 GMT
ETag: "2a79d-c8b-39bce48d"
Accept-Ranges: bytes
Content-Length: 3211
Content-Type: text/html
X-Pad: avoid browser bug

<html>
<head>
<title>IETF RFC Page</title>

<script language="javascript">
function url() {
 var x = document.form1.number.value
 if (x.length == 1) {x = "000" + x }
 if (x.length == 2) {x = "00" + x }
 if (x.length == 3) {x = "0" + x }
 document.form1.action = "/rfc/rfc" + x + ".txt"
 document.form1.submit
}
</script>

</head>
```

Caching

Hierarchical caching with three proxies.


Proxy
Internet
Proxy
Client machine
Client-side LAN
ISP LAN