7

THE APPLICATION LAYER

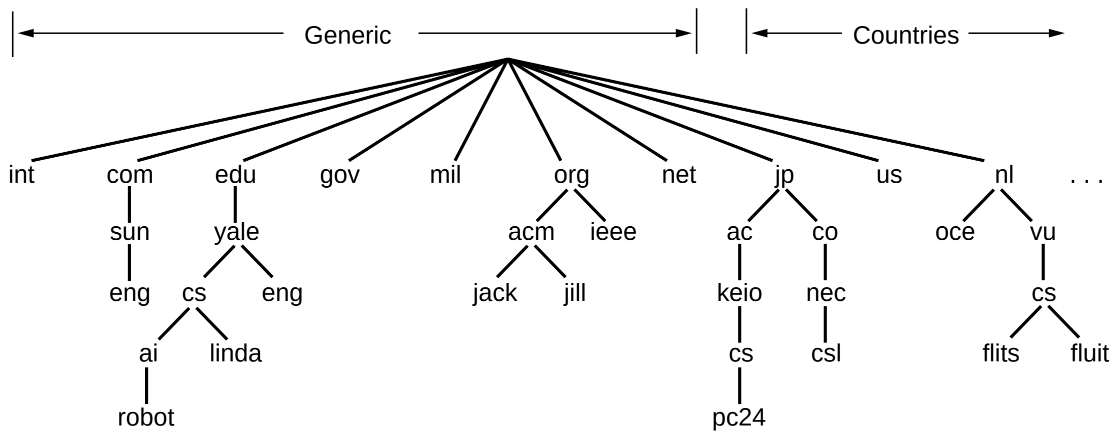


Fig. 7-1. A portion of the Internet domain name space.

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

Fig. 7-2. The principal DNS resource record types for IPv4.

```
; Authoritative data for cs.vu.nl
cs.vu.nl.        86400   IN  SOA      star boss (9527,7200,7200,241920,86400)
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
```

Fig. 7-3. A portion of a possible DNS database for *cs.vu.nl*

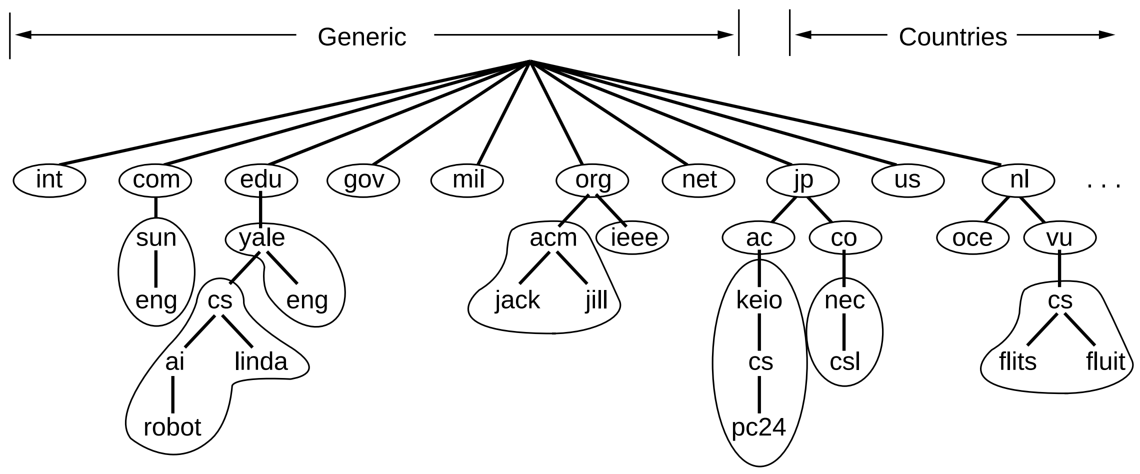


Fig. 7-4. Part of the DNS name space showing the division into zones.

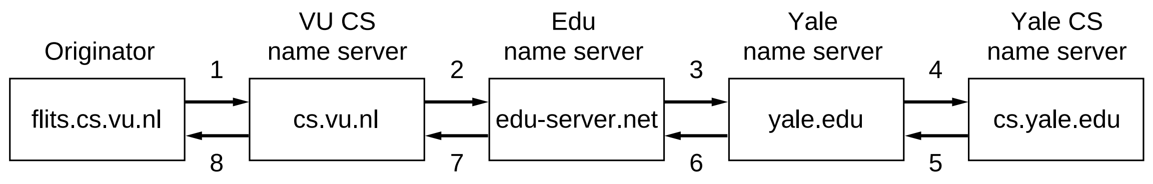


Fig. 7-5. How a resolver looks up a remote name in eight steps.

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

Fig. 7-6. Some smileys. They will not be on the final exam :-)

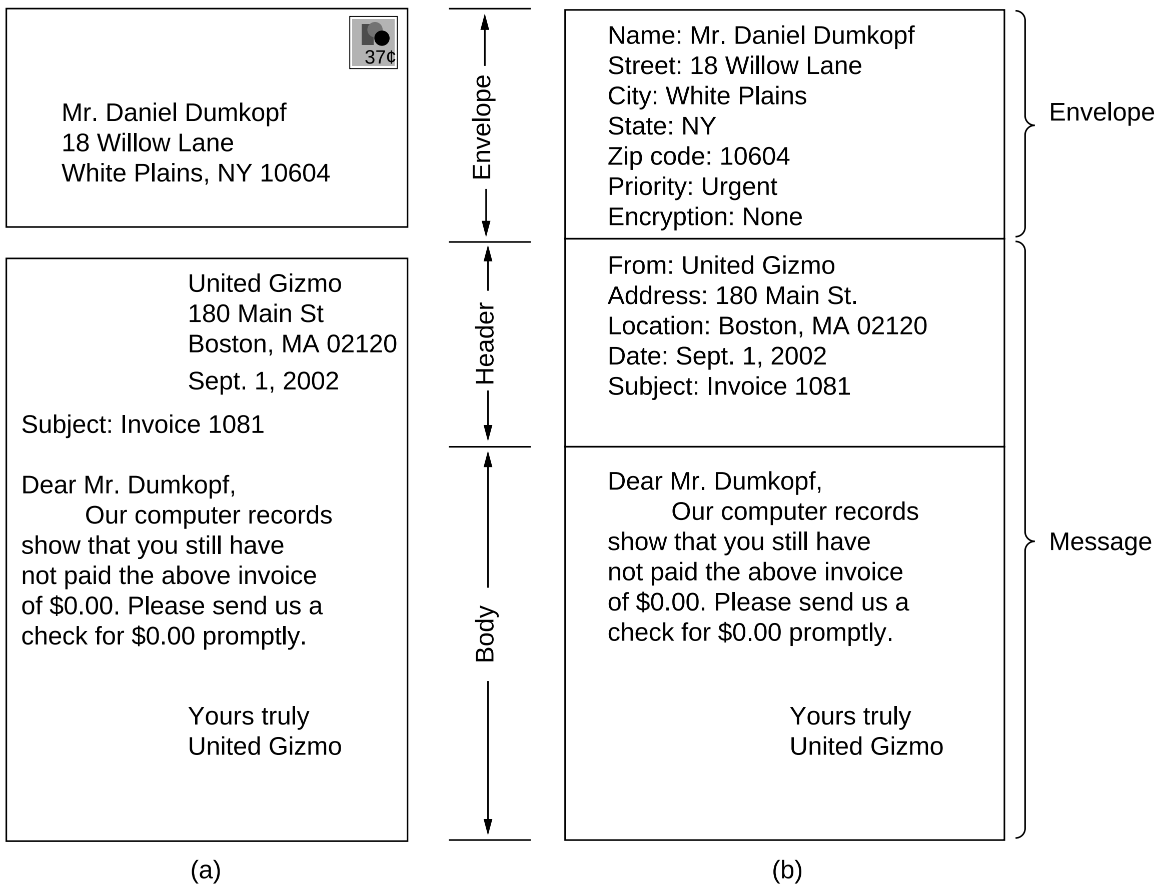


Fig. 7-7. Envelopes and messages. (a) Paper mail. (b) Electronic mail.

#	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

Fig. 7-8. An example display of the contents of a mailbox.

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

Fig. 7-9. RFC 822 header fields related to message transport.

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

Fig. 7-10. Some fields used in the RFC 822 message header.

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

Fig. 7-11. RFC 822 headers added by MIME.

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

Fig. 7-12. The MIME types and subtypes defined in RFC 2045.

```
From: elinor@abcd.com
To: carolyn@xyz.com
MIME-Version: 1.0
Message-Id: <0704760941.AA00747@abcd.com>
Content-Type: multipart/alternative; boundary=qwertyuiopasdfghjklzxcvbnm
Subject: Earth orbits sun integral number of times

This is the preamble. The user agent ignores it. Have a nice day.

--qwertyuiopasdfghjklzxcvbnm
Content-Type: text/enriched

Happy birthday to you
Happy birthday to you
Happy birthday dear <bold> Carolyn </bold>
Happy birthday to you

--qwertyuiopasdfghjklzxcvbnm
Content-Type: message/external-body;
        access-type="anon-ftp";
        site="bicycle.abcd.com";
        directory="pub";
        name="birthday.snd"

content-type: audio/basic
content-transfer-encoding: base64
--qwertyuiopasdfghjklzxcvbnm--
```

Fig. 7-13. A multipart message containing enriched and audio alternatives.

```
                    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
```

Fig. 7-14. Transferring a message from *elinor@abcd.com* to *carolyn@xyz.com*.

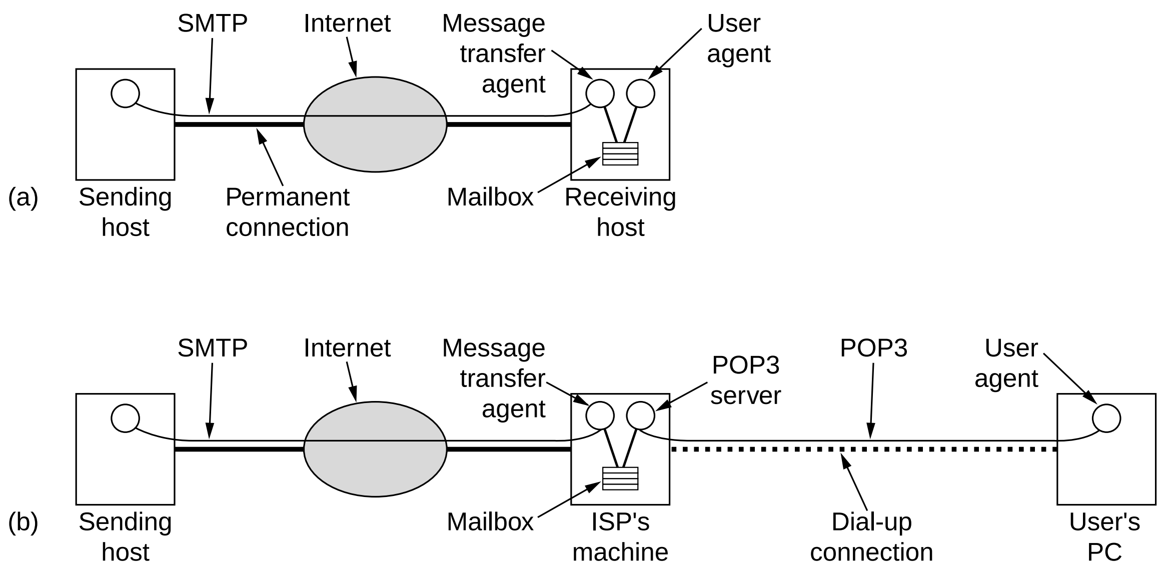


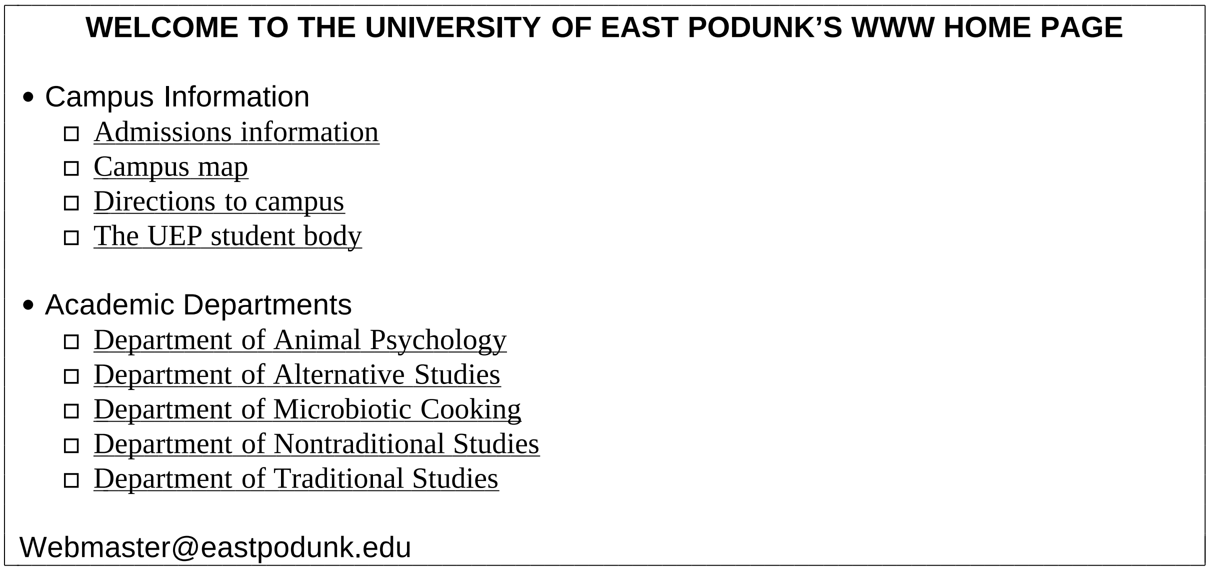
Fig. 7-15. (a) Sending and reading mail when the receiver has a permanent Internet connection and the user agent runs on the same machine as the message transfer agent. (b) Reading e-mail when the receiver has a dial-up connection to an ISP.

```
                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
```

Fig. 7-16. Using POP3 to fetch three messages.

Feature	POP3	IMAP
Where is protocol defined	RFC 1939	RFC 2060
TCP port 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

Fig. 7-17. A comparison of POP3 and IMAP.



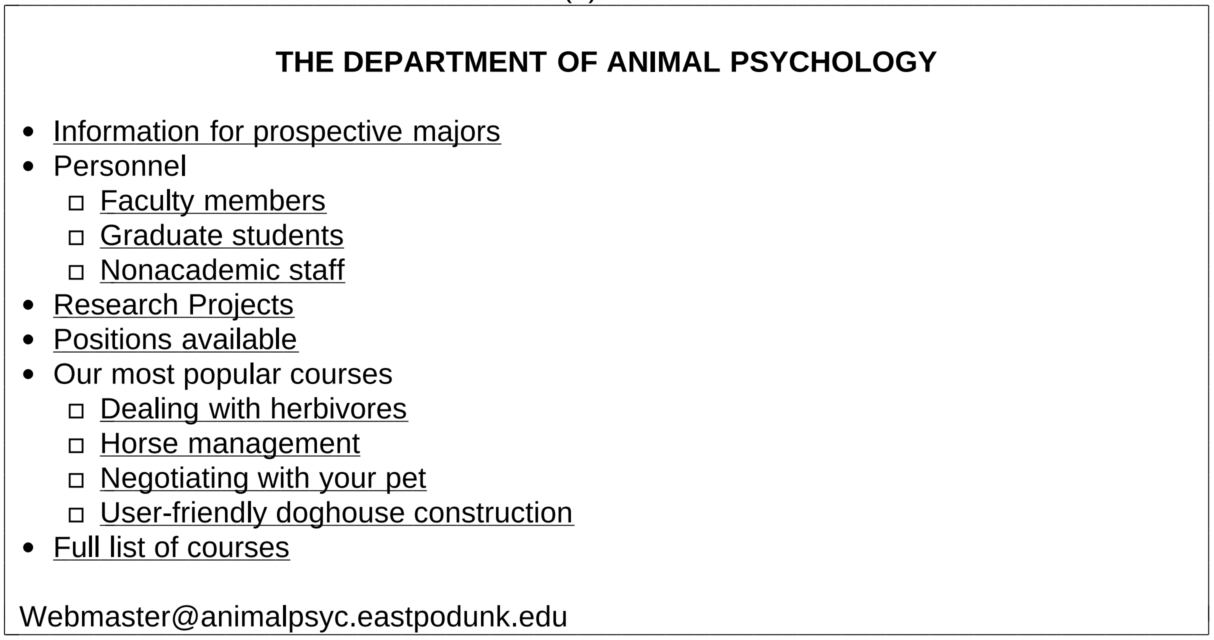
WELCOME TO THE UNIVERSITY OF EAST PODUNK'S WWW HOME PAGE

- Campus Information
  - Admissions information
  - Campus map
  - Directions to campus
  - The UEP student body

- Academic Departments
  - Department of Animal Psychology
  - Department of Alternative Studies
  - Department of Microbiotic Cooking
  - Department of Nontraditional Studies
  - Department of Traditional Studies

Webmaster@eastpodunk.edu

(a)



THE DEPARTMENT OF ANIMAL PSYCHOLOGY

- Information for prospective majors
- Personnel
  - Faculty members
  - Graduate students
  - Nonacademic staff
- Research Projects
- Positions available
- Our most popular courses
  - Dealing with herbivores
  - Horse management
  - Negotiating with your pet
  - User-friendly doghouse construction
- Full list of courses

Webmaster@animalpsyc.eastpodunk.edu

(b)

Fig. 7-18. (a) A Web page. (b) The page reached by clicking on Department of Animal Psychology.

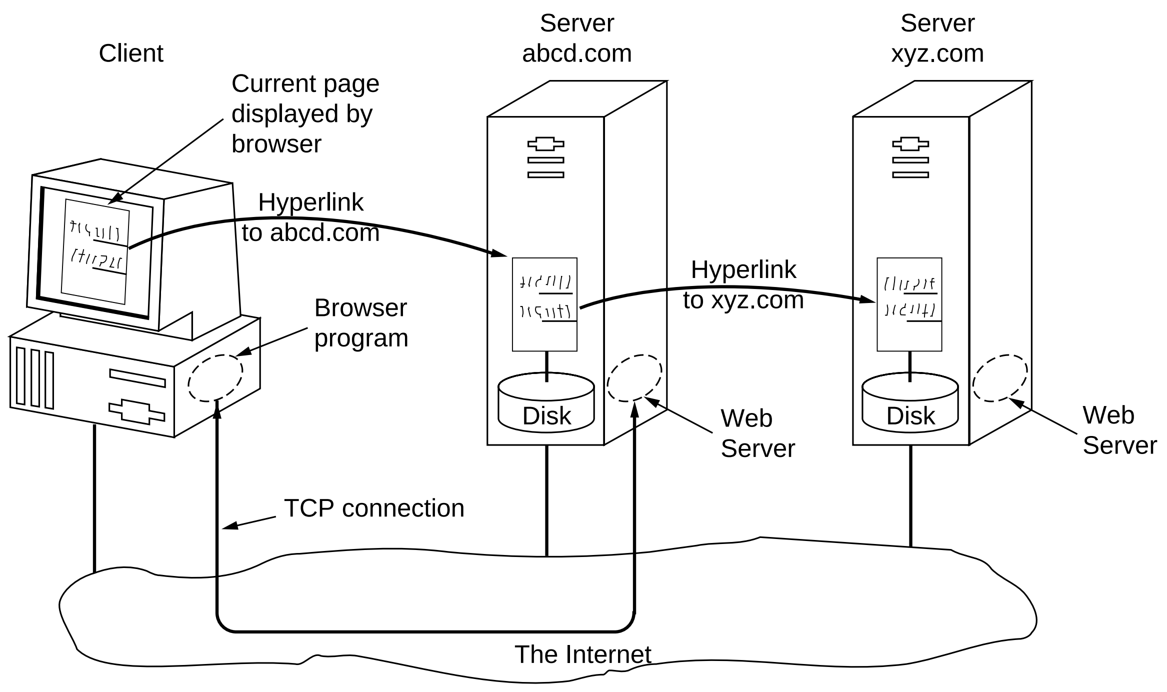


Fig. 7-19. The parts of the Web model.

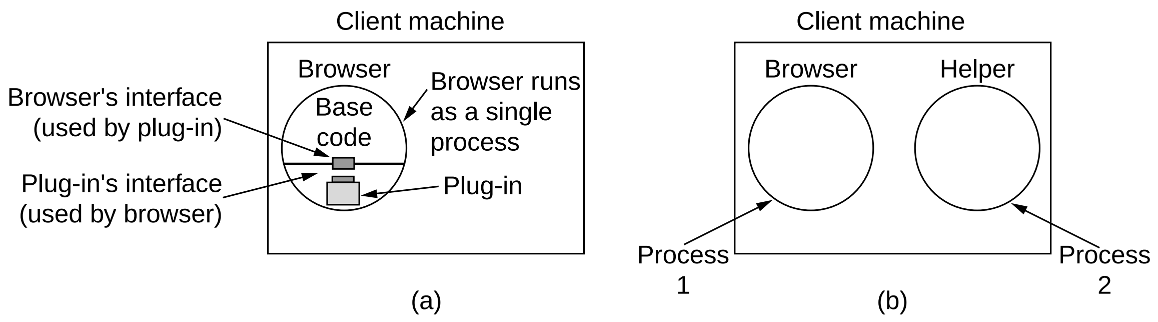

Client machine
Browser
Base code
Browser runs as a single process
Browser's interface (used by plug-in)
Plug-in's interface (used by browser)
Plug-in
(a)
Client machine
Browser
Helper
Process 1
Process 2
(b)

Fig. 7-20. (a) A browser plug-in. (b) A helper application.

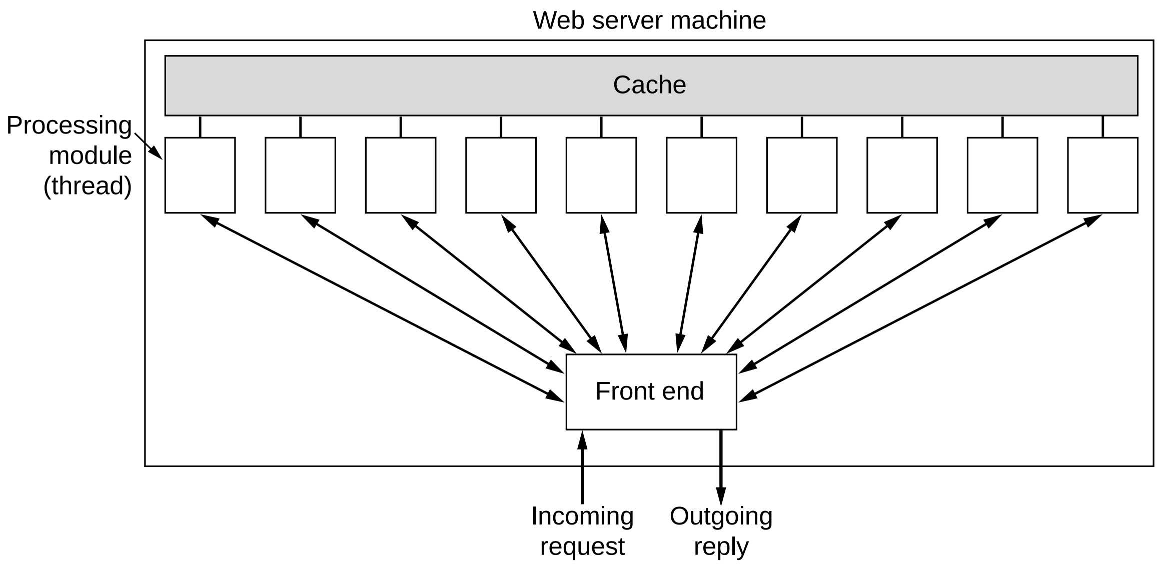


Fig. 7-21. A multithreaded Web server with a front end and processing modules.

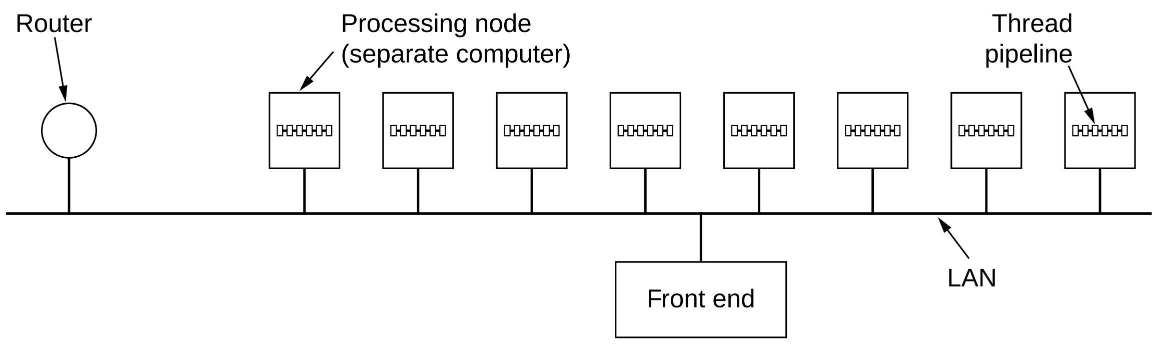


Fig. 7-22. A server farm.

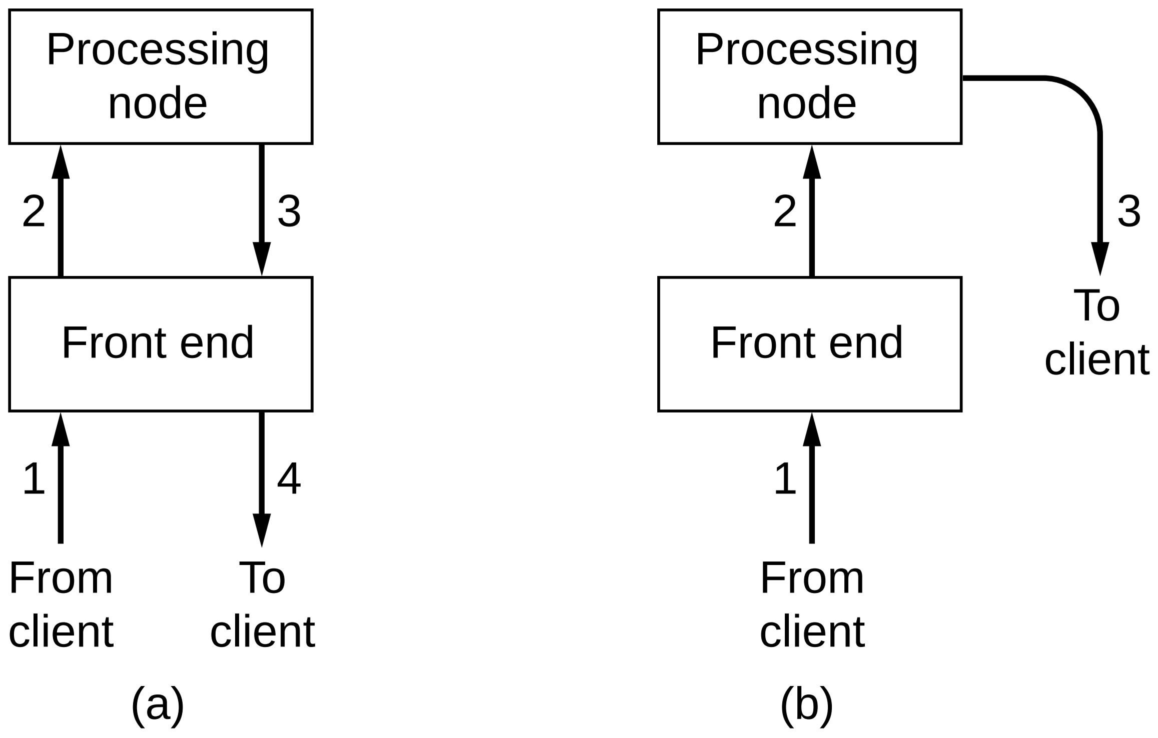


Fig. 7-23. (a) Normal request-reply message sequence. (b) Sequence when TCP handoff is used.

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

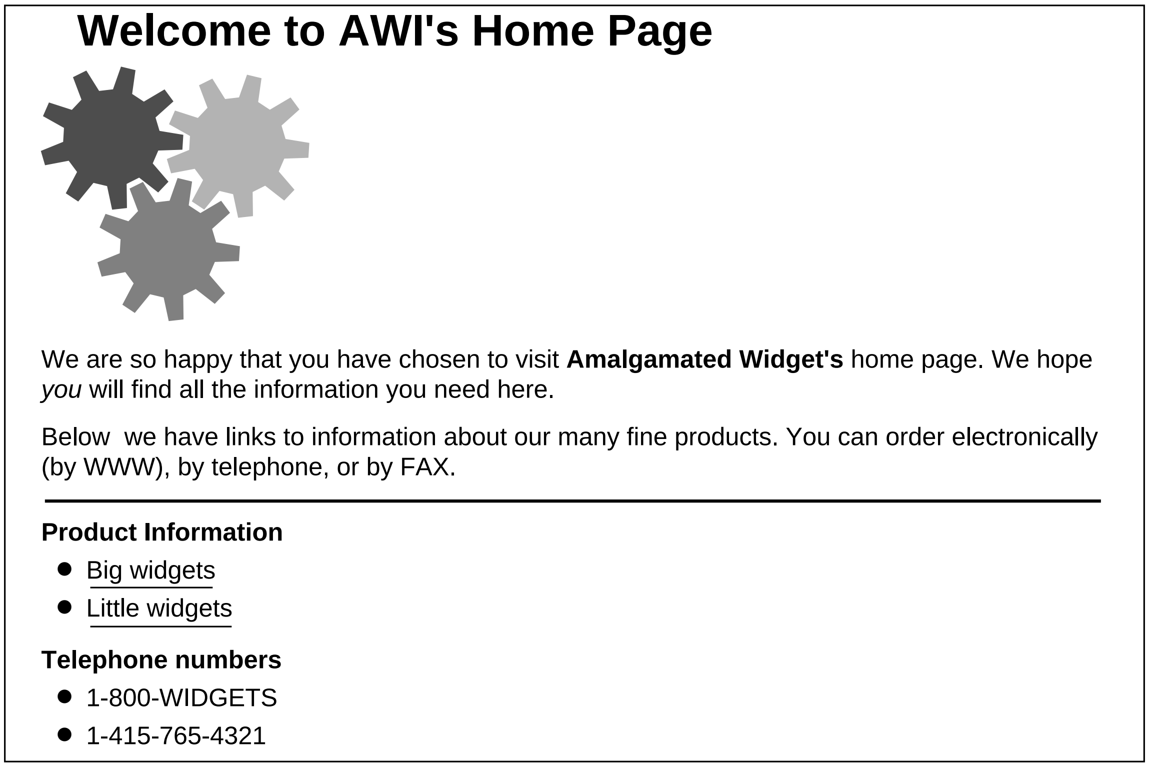
Fig. 7-24. Some common URLs.

Domain	**Path**	**Content**	**Expires**	**Secure**
toms-casino.com	/	CustomerID=497793521	15-10-02 17:00	Yes
joes-store.com	/	Cart=1-00501;1-07031;2-13721	11-10-02 14:22	No
aportal.com	/	Prefs=Stk:SUNW+ORCL;Spt:Jets	31-12-10 23:59	No
sneaky.com	/	UserID=3627239101	31-12-12 23:59	No

Fig. 7-25. Some examples of cookies.

```html
<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.

Product Information

- Big widgets
- Little widgets

Telephone numbers

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

(b)

Fig. 7-26. (a) The HTML for a sample Web page. (b) The formatted page.

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> ... </li>	Brackets an item in an ordered or numbered list
<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

Fig. 7-27. A selection of common HTML tags. Some can have additional parameters.

```
<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)

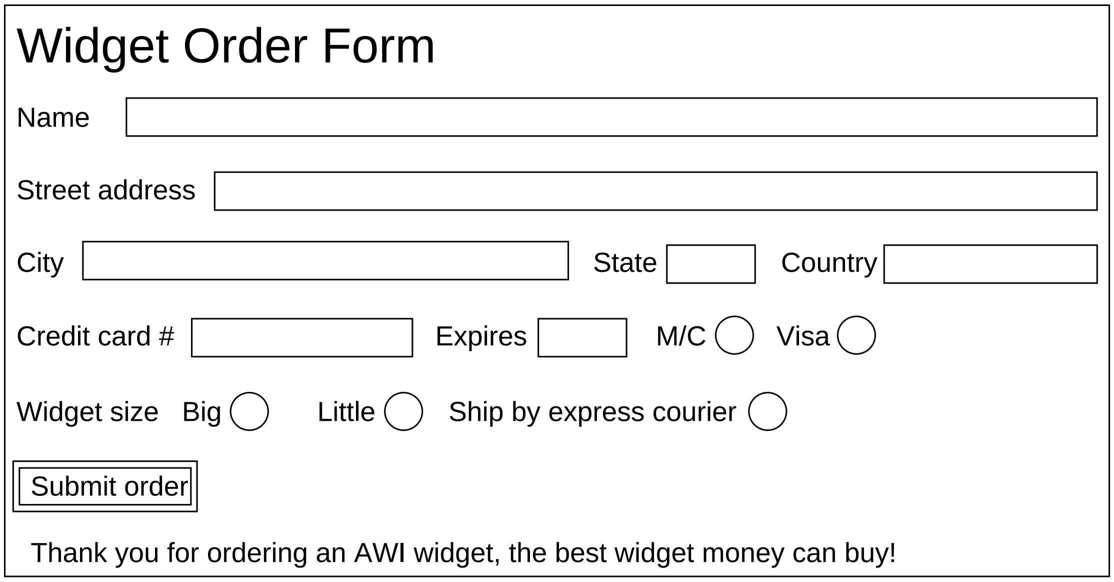
Some Differences between HTML Versions

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

Fig. 7-28. (a) An HTML table. (b) A possible rendition of this table.

```
<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)

Fig. 7-29. (a) The HTML for an order form. (b) The formatted page.

```
customer=John+Doe&address=100+Main+St.&city=White+Plains&
state=NY&country=USA&cardno=1234567890&expires=6/98&cc=mastercard&
product=cheap&express=on
```

Fig. 7-30. A possible response from the browser to the server with information filled in by the user.

```
<?xml version="1.0" ?>
<?xml-stylesheet type="text/xsl" href="book_list.xsl"?>

<book_list>

<book>
   <title> Computer Networks, 4/e </title>
   <author> Andrew S. Tanenbaum </author>
   <year> 2003 </year>
</book>

<book>
   <title> Modern Operating Systems, 2/e </title>
   <author> Andrew S. Tanenbaum </author>
   <year> 2001 </year>
</book>

<book>
   <title> Structured Computer Organization, 4/e </title>
   <author> Andrew S. Tanenbaum </author>
   <year> 1999 </year>
</book>

</book_list>
```

Fig. 7-31. A simple Web page in XML.

```
<?xml version='1.0'?>
<xsl:stylesheet xmlns:xsl="http://www.w3.org/1999/XSL/Transform" version="1.0">
<xsl:template match="/">

<html>
<body>

<table border="2">
   <tr>
       <th> Title</th>
       <th> Author</th>
       <th> Year </th>
   </tr>

   <xsl:for-each select="book_list/book">
   <tr>
       <td> <xsl:value-of select="title"/> </td>
       <td> <xsl:value-of select="author"/> </td>
       <td> <xsl:value-of select="year"/> </td>
  </tr>
  </xsl:for-each>
</table>

</body>
</html>
</xsl:template>
</xsl:stylesheet>
```

Fig. 7-32. A style sheet in XSL.

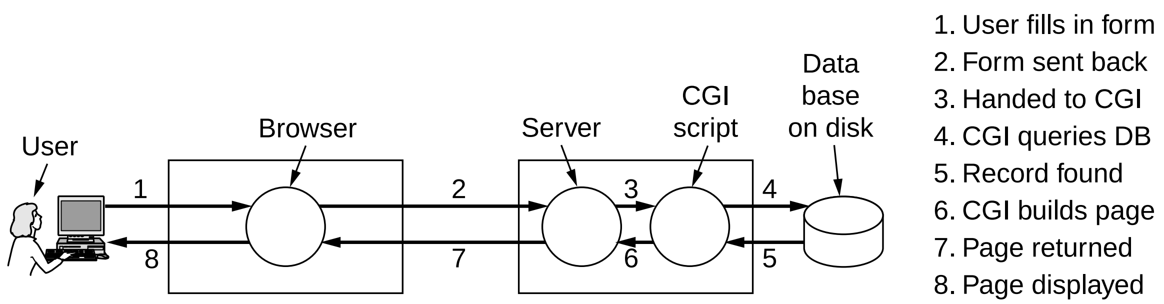


Fig. 7-33. Steps in processing the information from an HTML form.

```
<html>
<body>

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

</body>
</html>
```

Fig. 7-34. A sample HTML page with embedded PHP.

```
<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)

Fig. 7-35. (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>
<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>
```

Fig. 7-36. Use of JavaScript for processing a form.

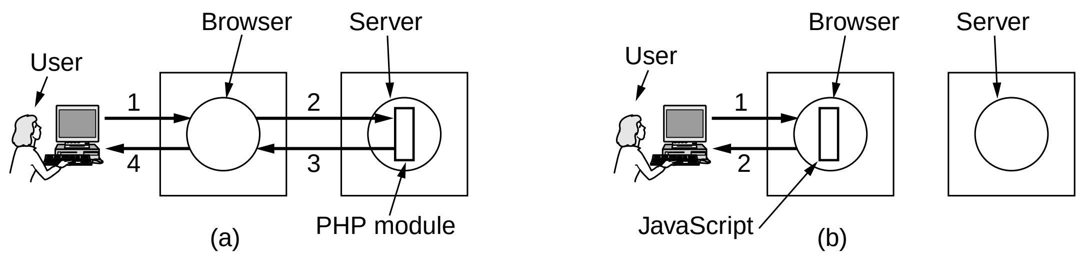


Fig. 7-37. (a) Server-side scripting with PHP. (b) Client-side scripting with JavaScript.

```
<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>
```

Fig. 7-38. A JavaScript program for computing and printing factorials.

```
<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>
```

Fig. 7-39. An interactive Web page that responds to mouse movement.

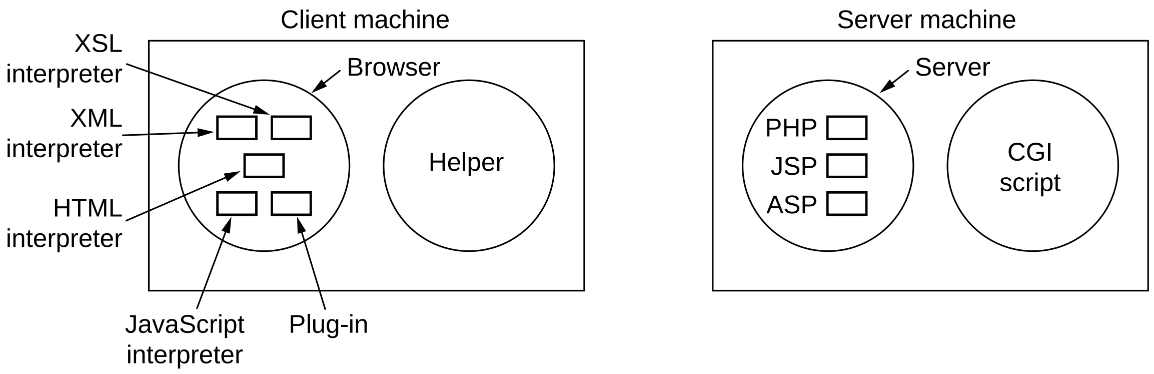


Fig. 7-40. The various ways to generate and display content.

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

Fig. 7-41. The built-in HTTP request methods.

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

Fig. 7-42. The status code response groups.

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

Fig. 7-43. Some HTTP message headers.

```
Trying 4.17.168.6...
Connected to www.ietf.org.
Escape character is ’ˆ]’.
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>
```

Fig. 7-44. The start of the output of *www.ietf.org/rfc.html*.

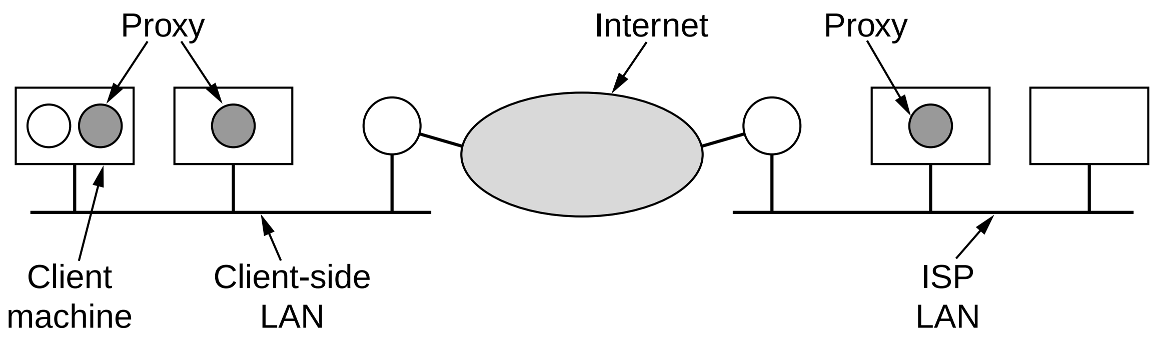


Fig. 7-45. Hierarchical caching with three proxies.

```
<html>
<head> <title> Furry Video </title> </head>
<body>
<h1> Furry Video's Product List </h1>
<p> Click below for free samples. </p>

<a href="bears.mpg"> Bears Today </a> <br>
<a href="bunnies.mpg"> Funny Bunnies </a> <br>
<a href="mice.mpg"> Nice Mice </a> <br>
</body>
</html>
```

(a)

```
<html>
<head> <title> Furry Video </title> </head>
<body>
<h1> Furry Video's Product List </h1>
<p> Click below for free samples. </p>

<a href="http://cdn-server.com/furryvideo/bears.mpg"> Bears Today </a> <br>
<a href="http://cdn-server.com/furryvideo/bunnies.mpg"> Funny Bunnies </a> <br>
<a href="http://cdn-server.com/furryvideo/mice.mpg"> Nice Mice </a> <br>
</body>
</html>
```

(b)

Fig. 7-46. (a) Original Web page. (b) Same page after transformation.

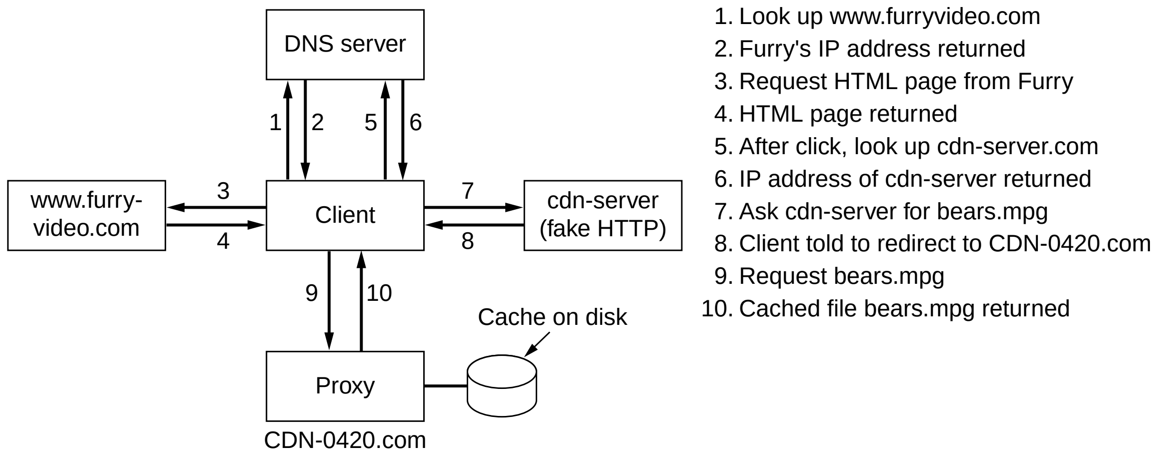

DNS server
1
2
5
6
www.furry-video.com
3
4
Client
7
8
cdn-server (fake HTTP)
9
10
Cache on disk
Proxy
CDN-0420.com
1. Look up www.furryvideo.com
2. Furry's IP address returned
3. Request HTML page from Furry
4. HTML page returned
5. After click, look up cdn-server.com
6. IP address of cdn-server returned
7. Ask cdn-server for bears.mpg
8. Client told to redirect to CDN-0420.com
9. Request bears.mpg
10. Cached file bears.mpg returned

Fig. 7-47. Steps in looking up a URL when a CDN is used.

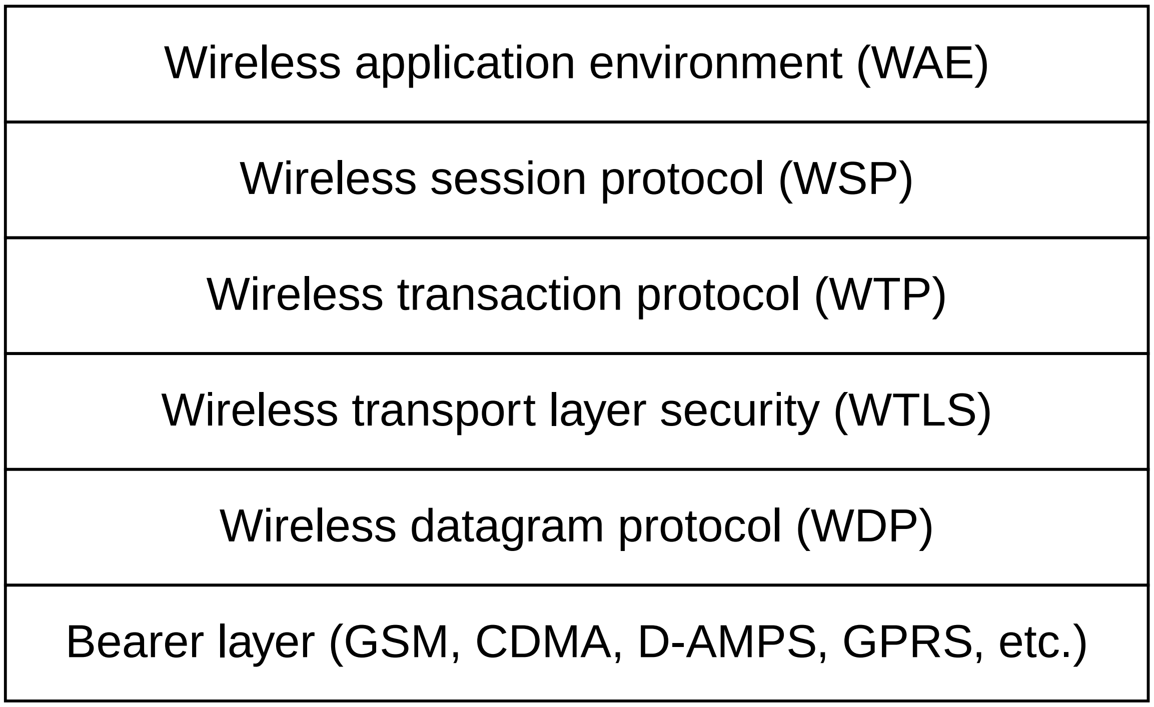

Wireless application environment (WAE)
Wireless session protocol (WSP)
Wireless transaction protocol (WTP)
Wireless transport layer security (WTLS)
Wireless datagram protocol (WDP)
Bearer layer (GSM, CDMA, D-AMPS, GPRS, etc.)

Fig. 7-48. The WAP protocol stack.

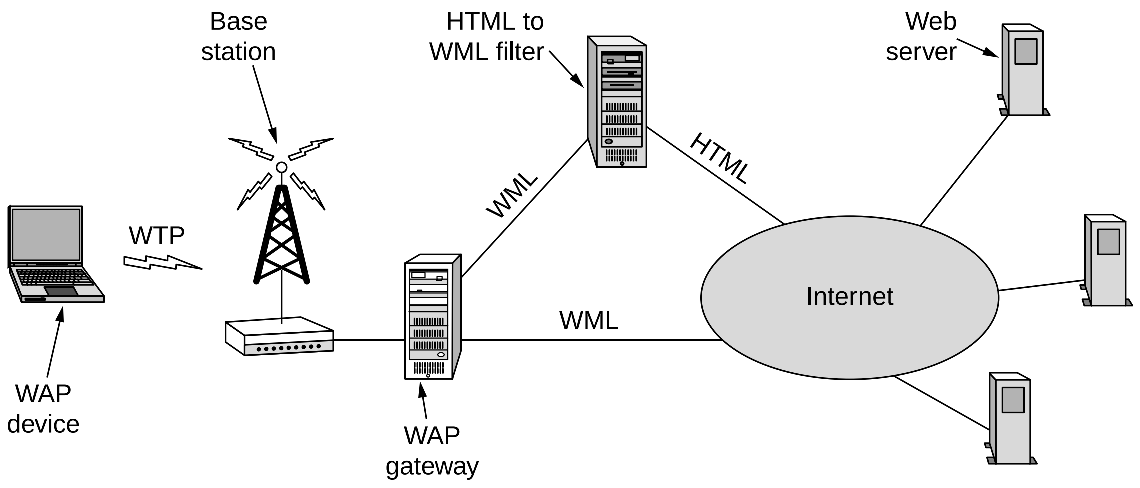


Fig. 7-49. The WAP architecture.

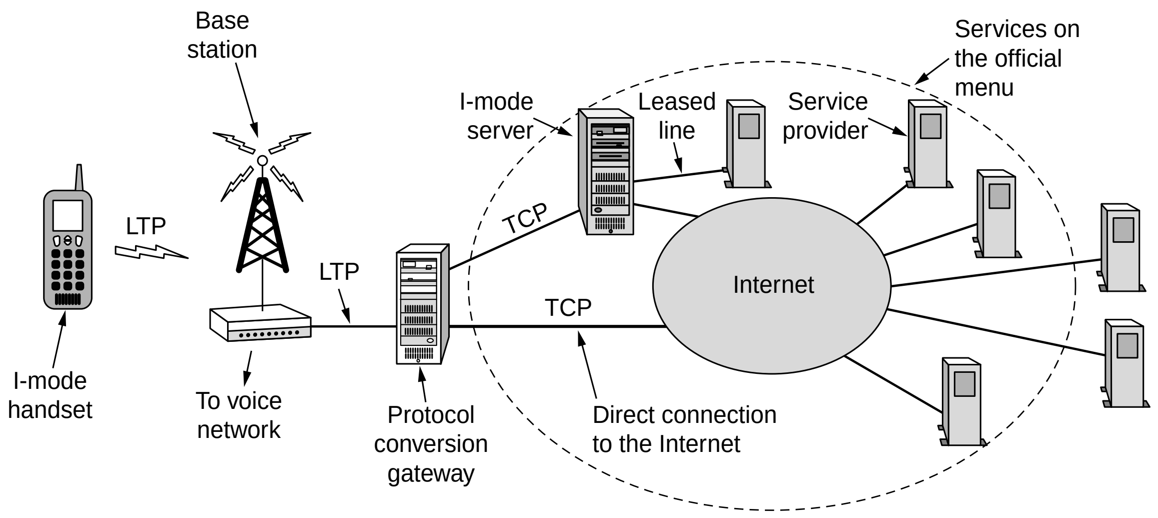


Fig. 7-50. Structure of the i-mode data network showing the transport protocols.

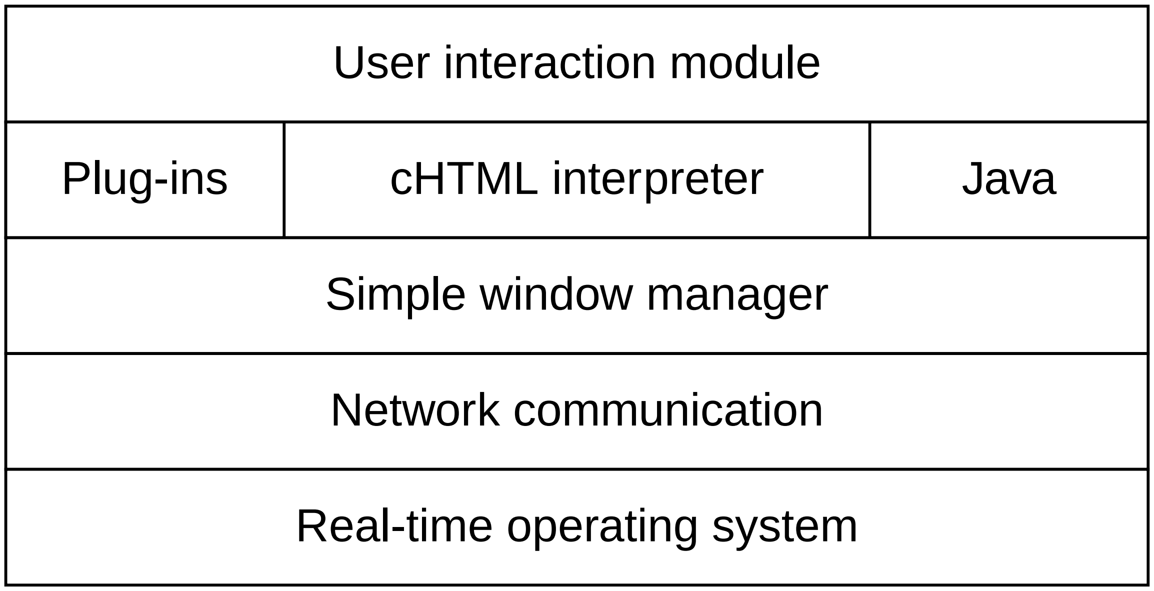
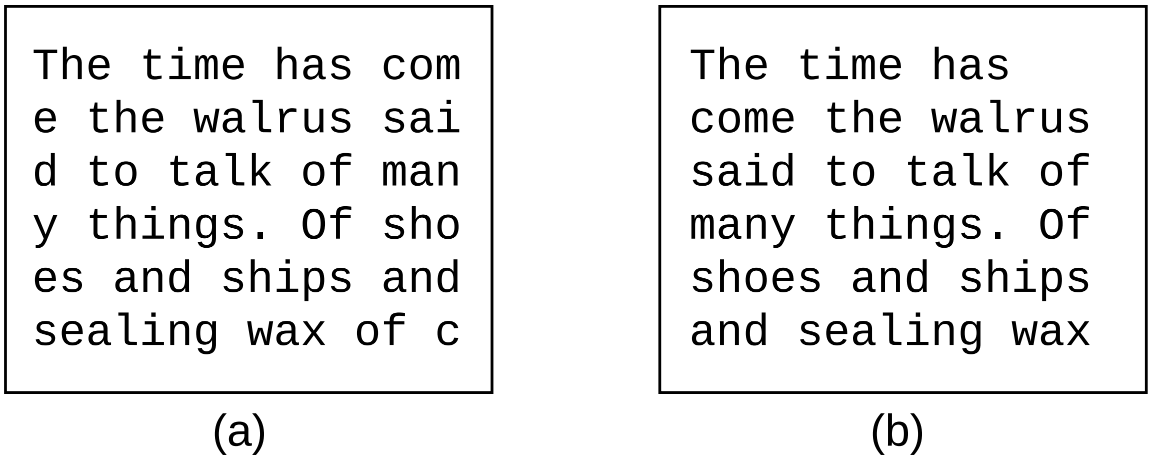


Fig. 7-51. Structure of the i-mode software.



```
The time has com
e the walrus sai
d to talk of man
y things. Of sho
es and ships and
sealing wax of c
```

```
The time has
come the walrus
said to talk of
many things. Of
shoes and ships
and sealing wax
```

Fig. 7-52. Lewis Carroll meets a 16 $\times$ 6 screen.

```
<html>
<body>
<h1> Select an option </h1>
<a href="messages.chtml" accesskey="1"> Check voicemail </a> <br>
<a href="mail.chtml" accesskey="2"> Check e-mail </a> <br>
<a href="games.chtml" accesskey="3"> Play a game </a>
</body>
</html>
```

Fig. 7-53. An example cHTML file.

Feature	**WAP**	**I-mode**
What it is	Protocol stack	Service
Device	Handset, PDA, notebook	Handset
Access	Dial up	Always on
Underlying network	Circuit-switched	Two: circuit + packet
Data rate	9600 bps	9600 bps
Screen	Monochrome	Color
Markup language	WML (XML application)	cHTML
Scripting language	WMLscript	None
Usage charges	Per minute	Per packet
Pay for shopping	Credit card	Phone bill
Pictograms	No	Yes
Standardization	WAP forum open standard	NTT DoCoMo proprietary
Where used	Europe, Japan	Japan
Typical user	Businessman	Young woman

Fig. 7-54. A comparison of first-generation WAP and i-mode.

XHTML	
WSP	HTTP
WTP	TLS
WTLS	TCP
WDP	IP
Bearer layer	Bearer layer
WAP 1.0 protocol stack	WAP 2.0 protocol stack

Fig. 7-55. WAP 2.0 supports two protocol stacks.

Module	Req.?	Function	Example tags
Structure	Yes	Doc. structure	body, head, html, title
Text	Yes	Information	br, code, dfn, em, h*n*, kbd, p, strong
Hypertext	Yes	Hyperlinks	a
List	Yes	Itemized lists	dl, dt, dd, ol, ul, li
Forms	No	Fill-in forms	form, input, label, option, textarea
Tables	No	Rectangular tables	caption, table, td, th, tr
Image	No	Pictures	img
Object	No	Applets, maps, etc.	object, param
Meta-information	No	Extra info	meta
Link	No	Similar to <a>	link
Base	No	URL starting point	base

Fig. 7-56. The XHTML Basic modules and tags.

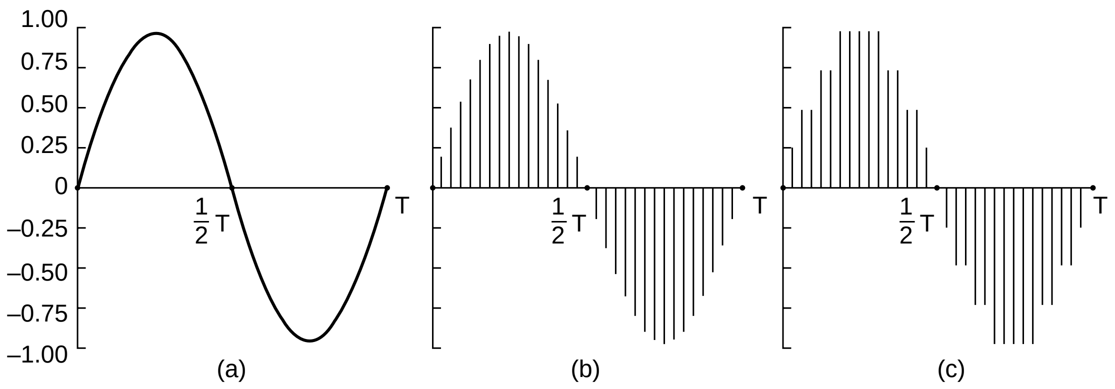


Fig. 7-57. (a) A sine wave. (b) Sampling the sine wave. (c) Quantizing the samples to 4 bits.

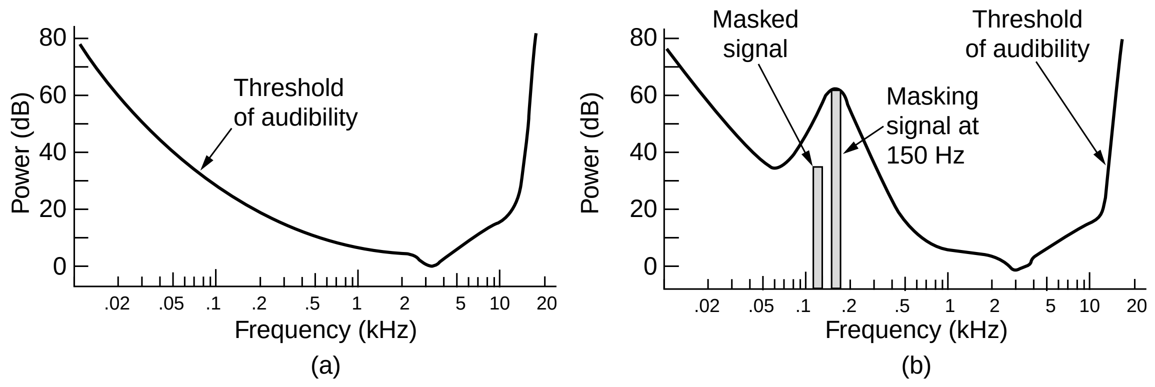


Fig. 7-58. (a) The threshold of audibility as a function of frequency. (b) The masking effect.

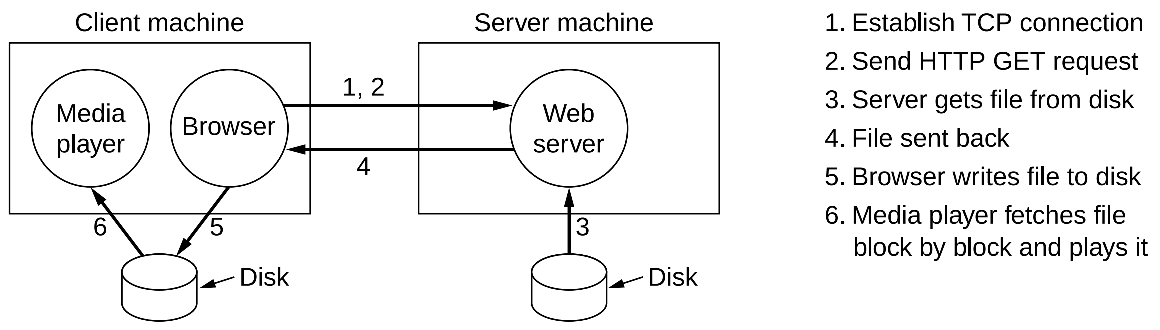

Client machine
Server machine
Media player
Browser
Web server
1, 2
4
6
5
3
Disk
Disk
1. Establish TCP connection
2. Send HTTP GET request
3. Server gets file from disk
4. File sent back
5. Browser writes file to disk
6. Media player fetches file block by block and plays it

Fig. 7-59. A straightforward way to implement clickable music on a Web page.

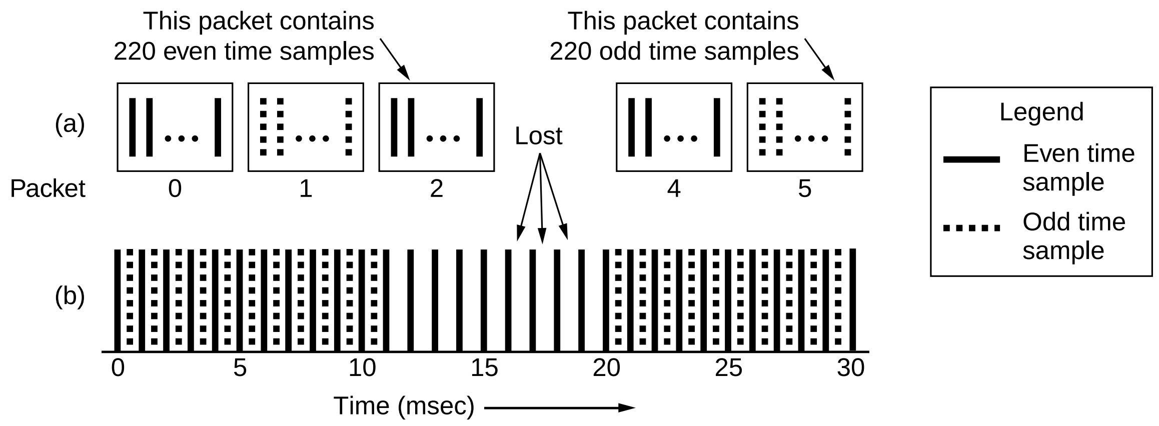

This packet contains 220 even time samples
This packet contains 220 odd time samples
(a)
Packet
0
1
2
4
5
Lost
(b)
0
5
10
15
20
25
30
Time (msec)
Legend
Even time sample
Odd time sample

Fig. 7-60. When packets carry alternate samples, the loss of a packet reduces the temporal resolution rather than creating a gap in time.

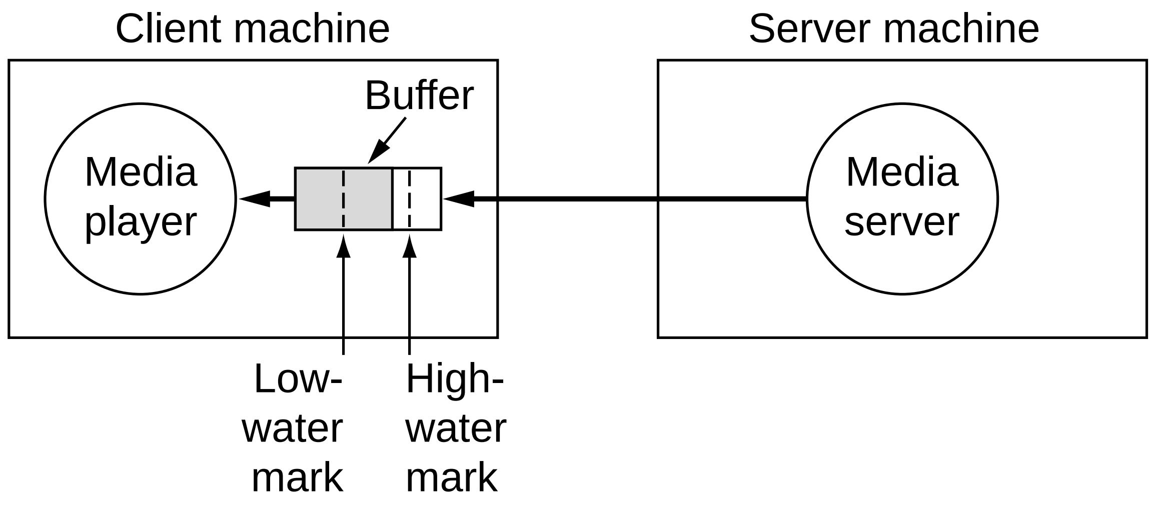


Fig. 7-61. The media player buffers input from the media server and plays from the buffer rather than directly from the network.

Command	**Server action**
DESCRIBE	List media parameters
SETUP	Establish a logical channel between the player and the server
PLAY	Start sending data to the client
RECORD	Start accepting data from the client
PAUSE	Temporarily stop sending data
TEARDOWN	Release the logical channel

Fig. 7-62. RTSP commands from the player to the server.

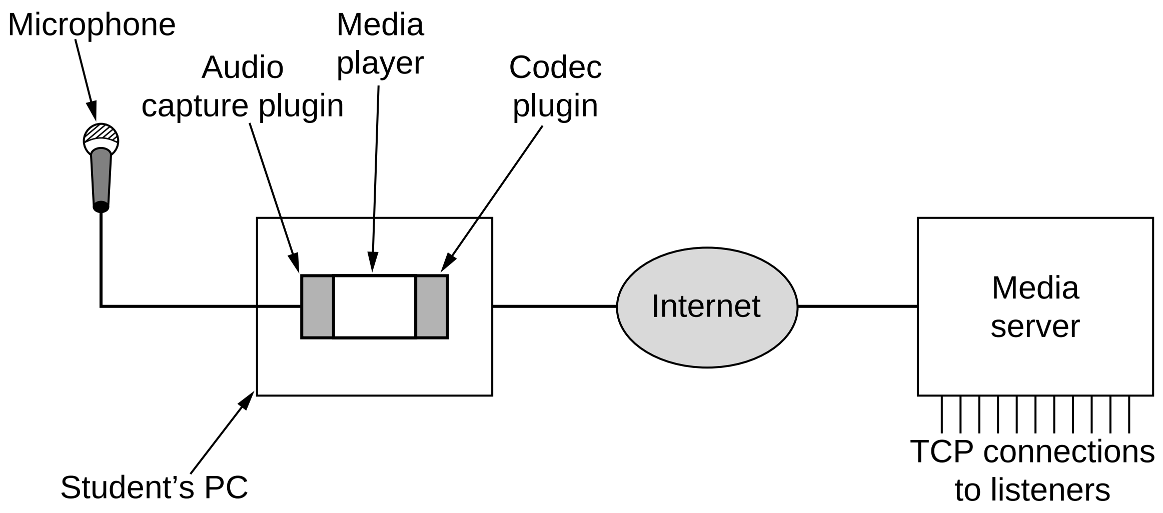


Fig. 7-63. A student radio station.

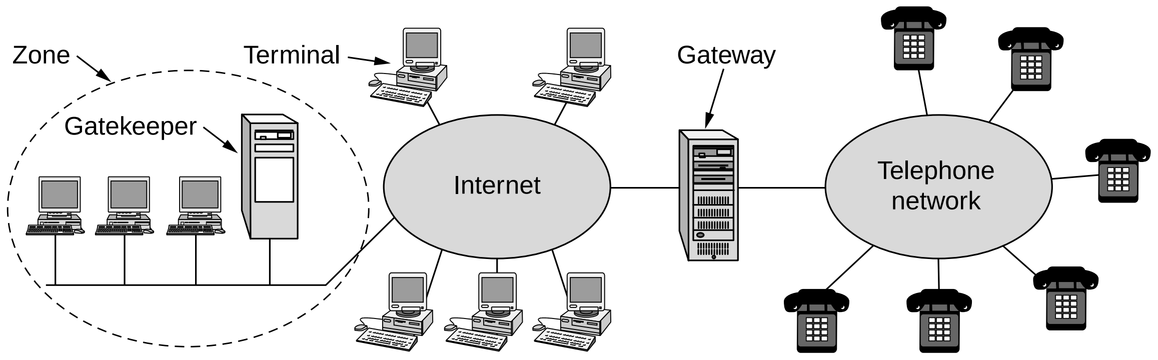


Fig. 7-64. The H.323 architectural model for Internet telephony.

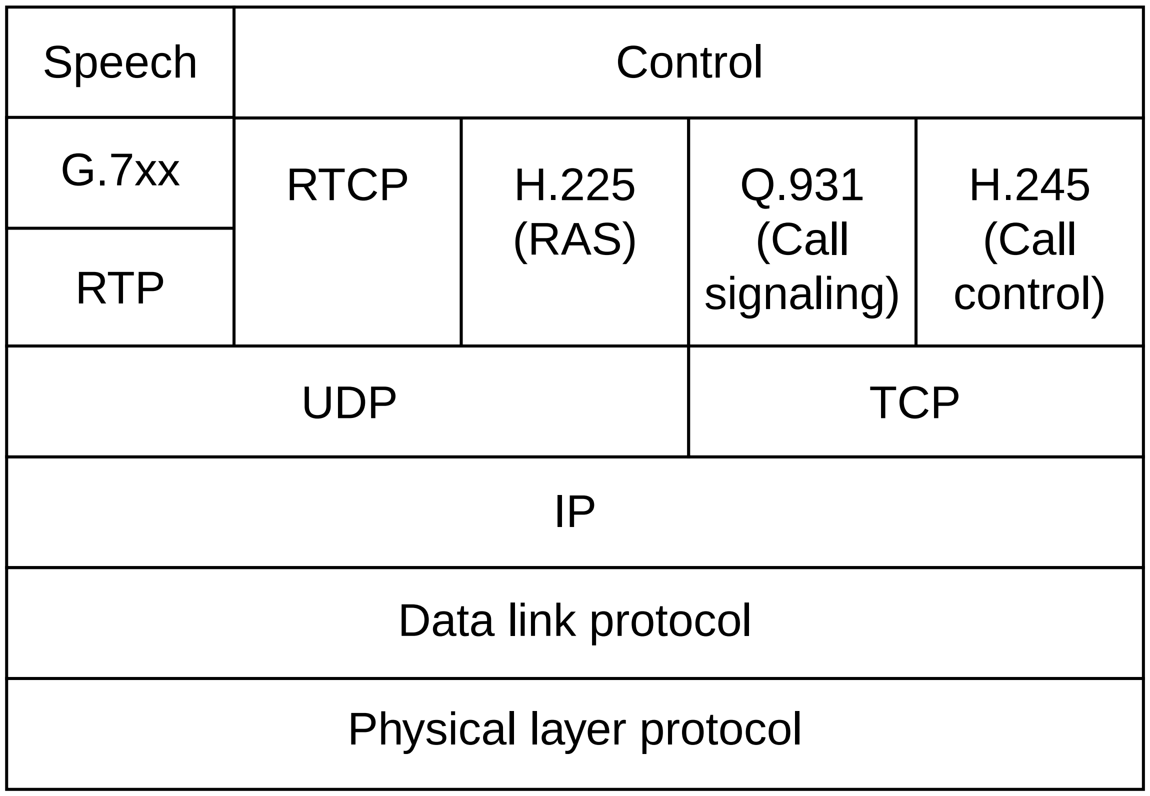


Fig. 7-65. The H.323 protocol stack.

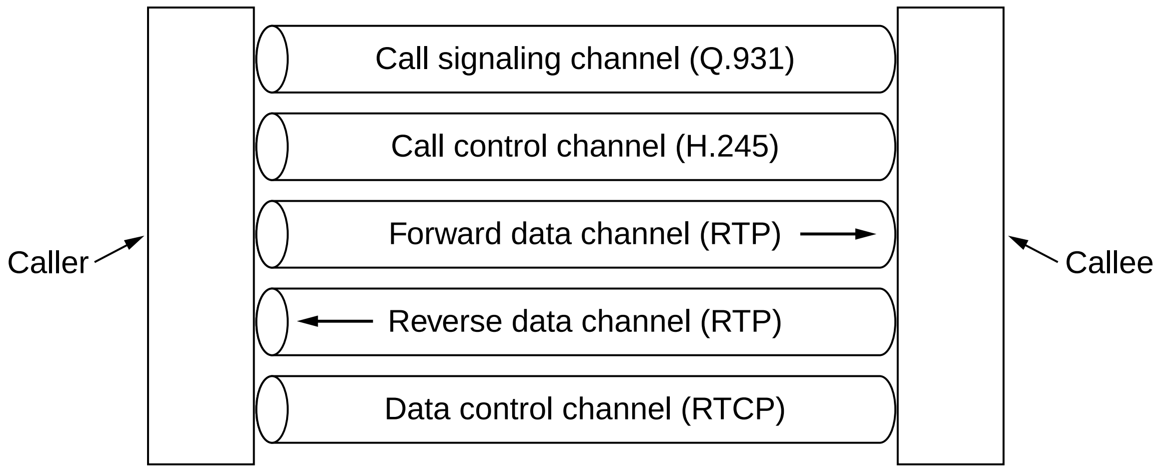

Call signaling channel (Q.931)
Call control channel (H.245)
Forward data channel (RTP)
Caller
Callee
Reverse data channel (RTP)
Data control channel (RTCP)

Fig. 7-66. Logical channels between the caller and callee during a call.

Method	**Description**
INVITE	Request initiation of a session
ACK	Confirm that a session has been initiated
BYE	Request termination of a session
OPTIONS	Query a host about its capabilities
CANCEL	Cancel a pending request
REGISTER	Inform a redirection server about the user’s current location

Fig. 7-67. The SIP methods defined in the core specification.

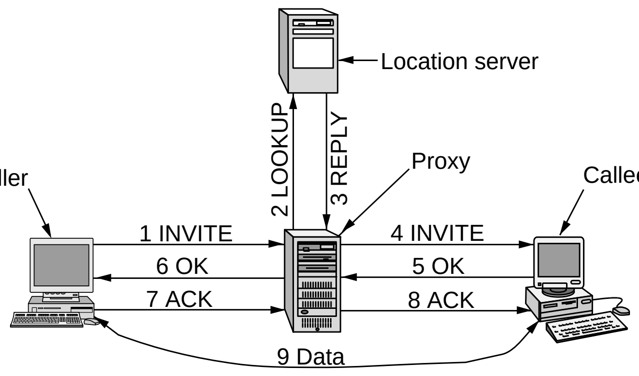


Fig. 7-68. Use a proxy and redirection servers with SIP.

Item	**H.323**	**SIP**
Designed by	ITU	IETF
Compatibility with PSTN	Yes	Largely
Compatibility with Internet	No	Yes
Architecture	Monolithic	Modular
Completeness	Full protocol stack	SIP just handles setup
Parameter negotiation	Yes	Yes
Call signaling	Q.931 over TCP	SIP over TCP or UDP
Message format	Binary	ASCII
Media transport	RTP/RTCP	RTP/RTCP
Multiparty calls	Yes	Yes
Multimedia conferences	Yes	No
Addressing	Host or telephone number	URL
Call termination	Explicit or TCP release	Explicit or timeout
Instant messaging	No	Yes
Encryption	Yes	Yes
Size of standards	1400 pages	250 pages
Implementation	Large and complex	Moderate
Status	Widely deployed	Up and coming

Fig. 7-69. Comparison of H.323 and SIP

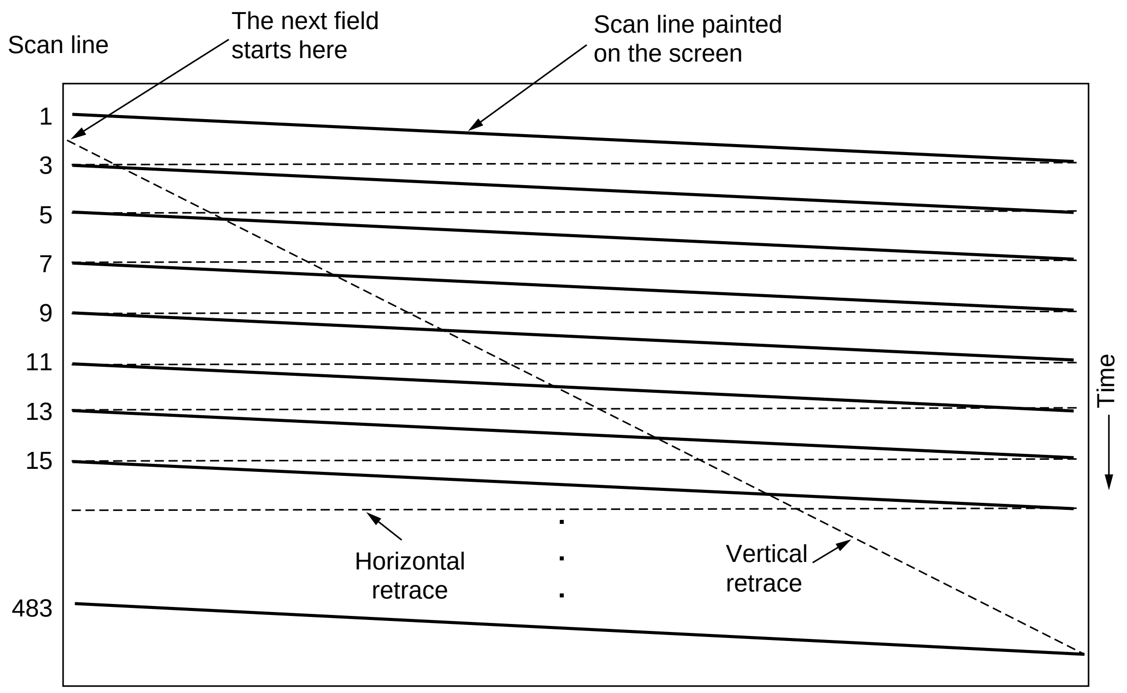


Fig. 7-70. The scanning pattern used for NTSC video and television.

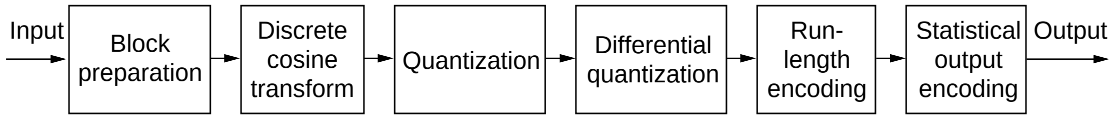

Input
Block preparation
Discrete cosine transform
Quantization
Differential quantization
Run-length encoding
Statistical output encoding
Output

Fig. 7-71. The operation of JPEG in lossy sequential mode.

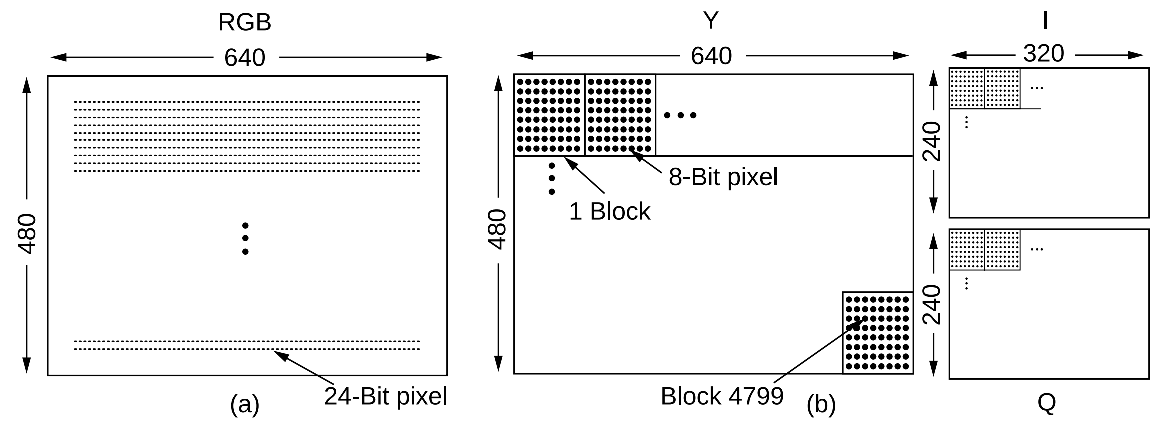


Fig. 7-72. (a) RGB input data. (b) After block preparation.

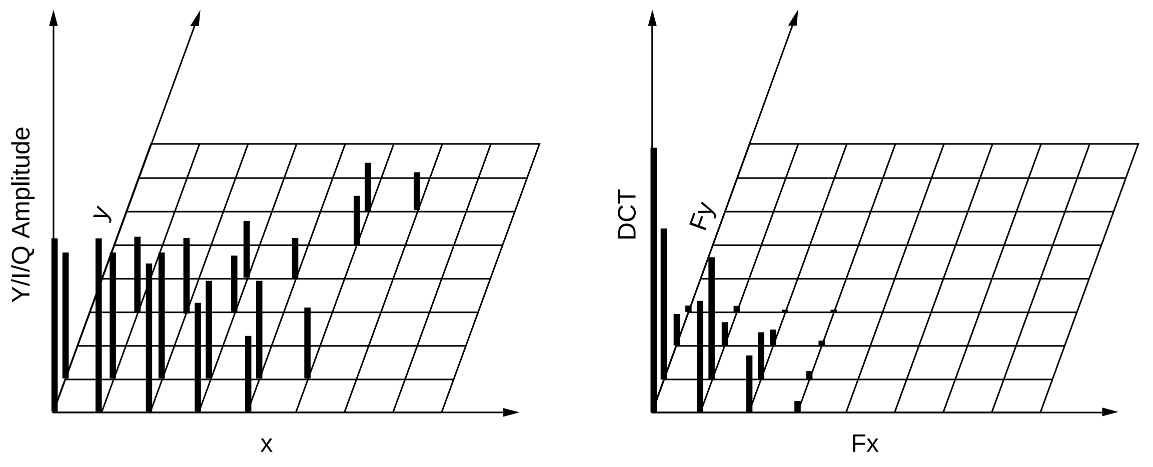


Fig. 7-73. (a) One block of the *Y* matrix. (b) The DCT coefficients.

DCT Coefficients

150	80	40	14	4	2	1	0
92	75	36	10	6	1	0	0
52	38	26	8	7	4	0	0
12	8	6	4	2	1	0	0
4	3	2	0	0	0	0	0
2	2	1	1	0	0	0	0
1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0

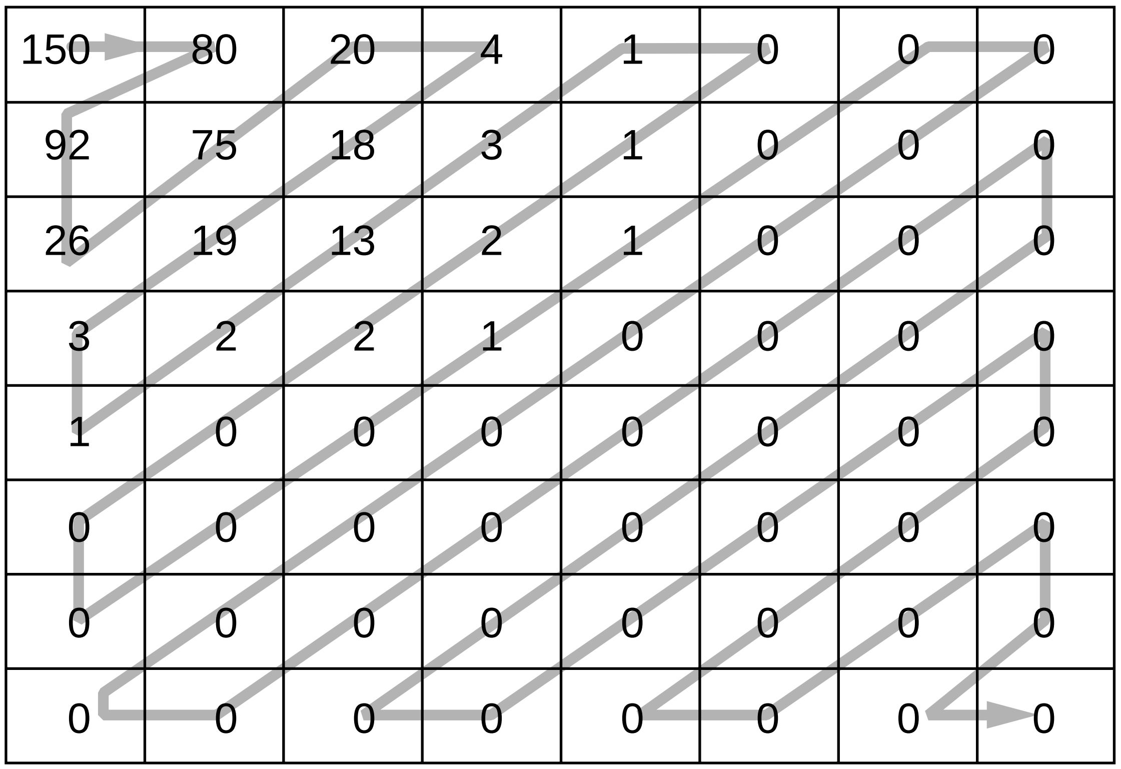
Quantization table

1	1	2	4	8	16	32	64
1	1	2	4	8	16	32	64
2	2	2	4	8	16	32	64
4	4	4	4	8	16	32	64
8	8	8	8	8	16	32	64
16	16	16	16	16	16	32	64
32	32	32	32	32	32	32	64
64	64	64	64	64	64	64	64

Quantized coefficients

150	80	20	4	1	0	0	0
92	75	18	3	1	0	0	0
26	19	13	2	1	0	0	0
3	2	2	1	0	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Fig. 7-74. Computation of the quantized DCT coefficients.



150	80	20	4	1	0	0	0
92	75	18	3	1	0	0	0
26	19	13	2	1	0	0	0
3	2	2	1	0	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Fig. 7-75. The order in which the quantized values are transmitted.

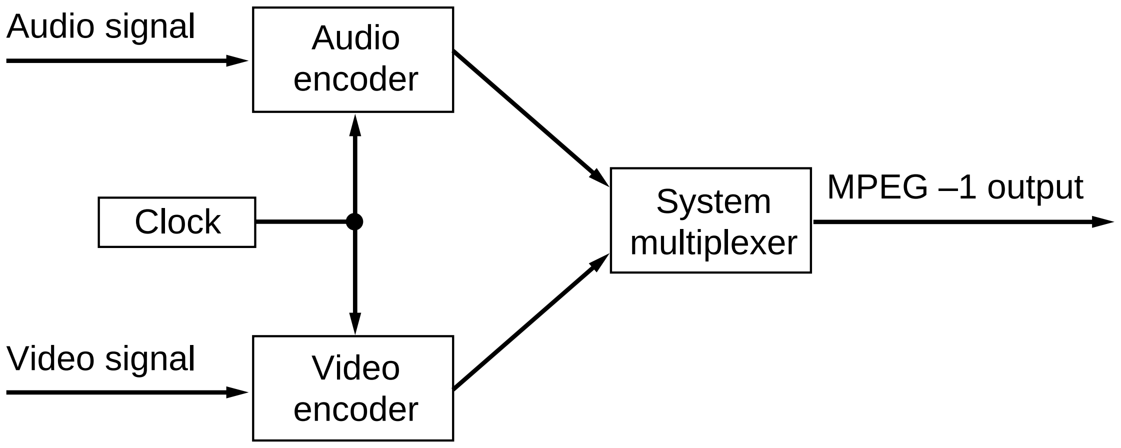


Fig. 7-76. Synchronization of the audio and video streams in MPEG-1.

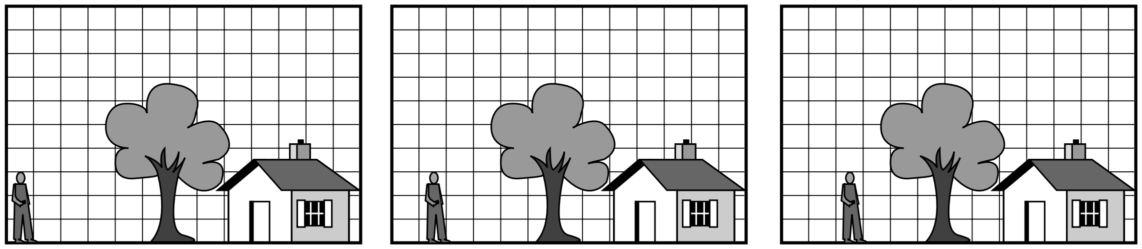


Fig. 7-77. Three consecutive frames.

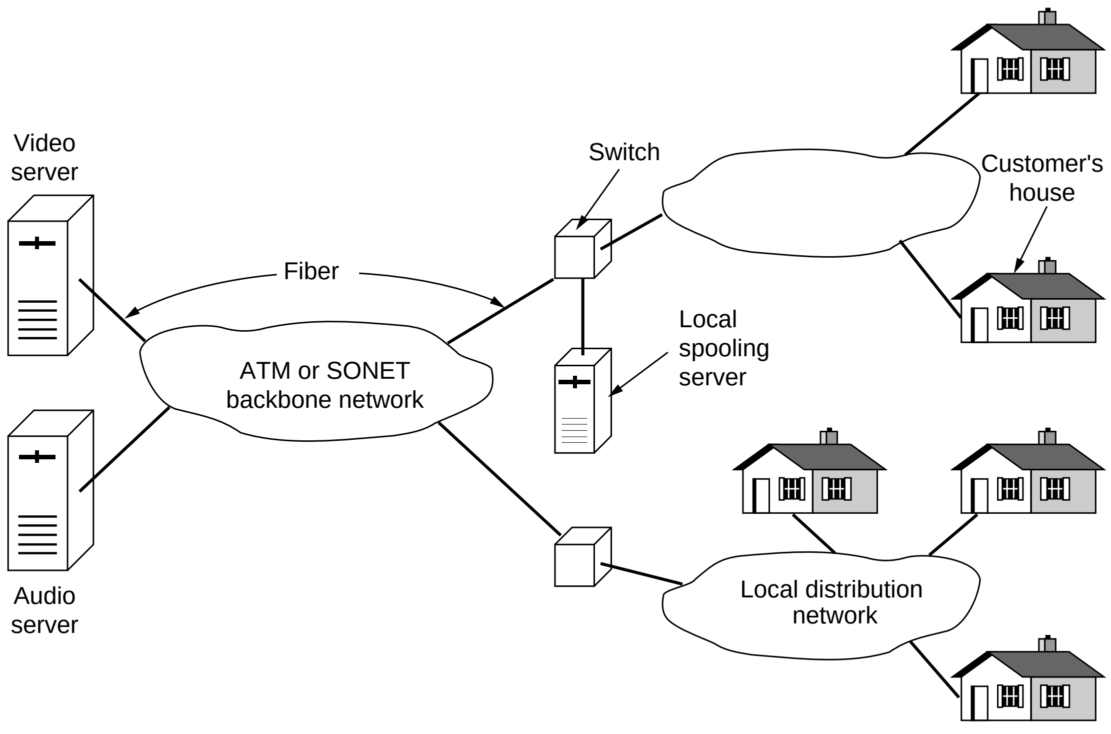


Fig. 7-78. Overview of a video-on-demand system.

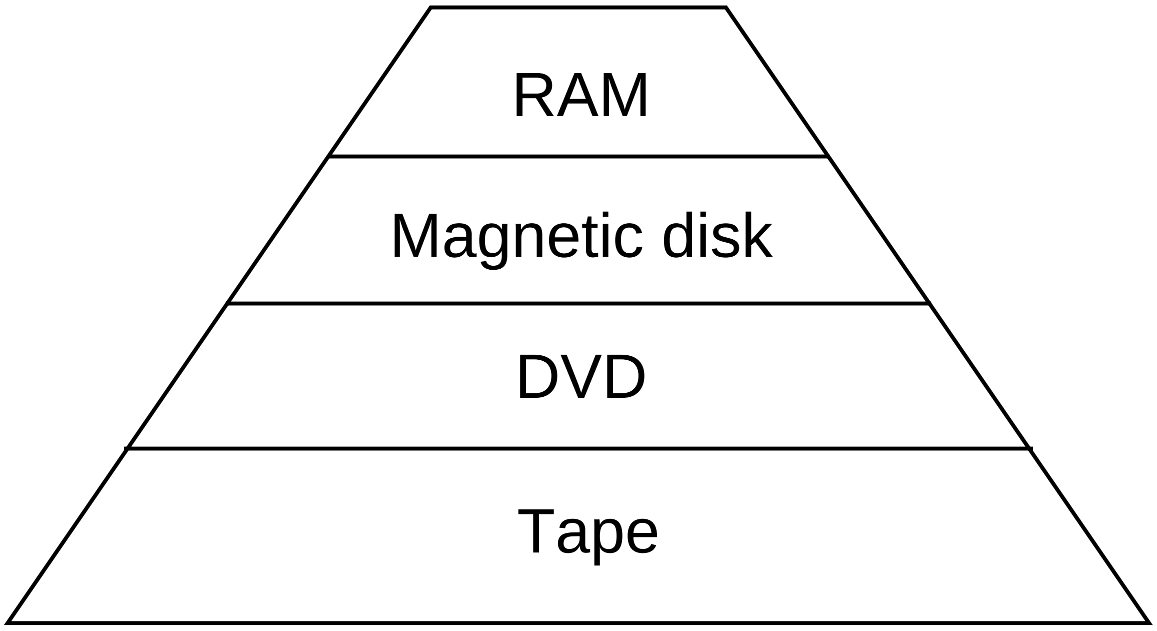


Fig. 7-79. A video server storage hierarchy.

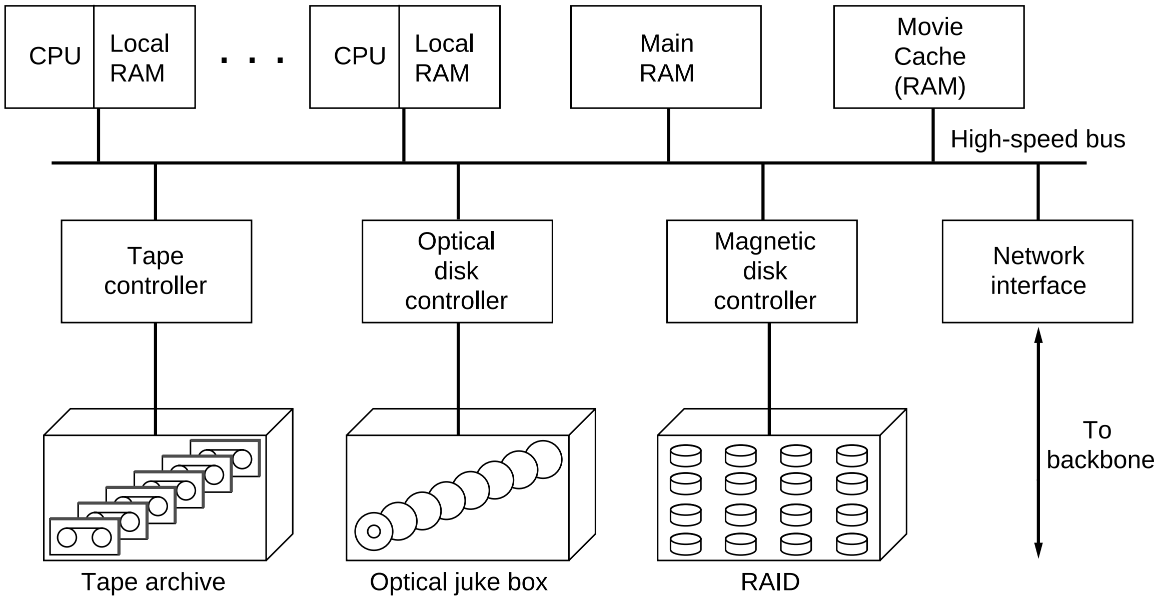


Fig. 7-80. The hardware architecture of a typical video server.

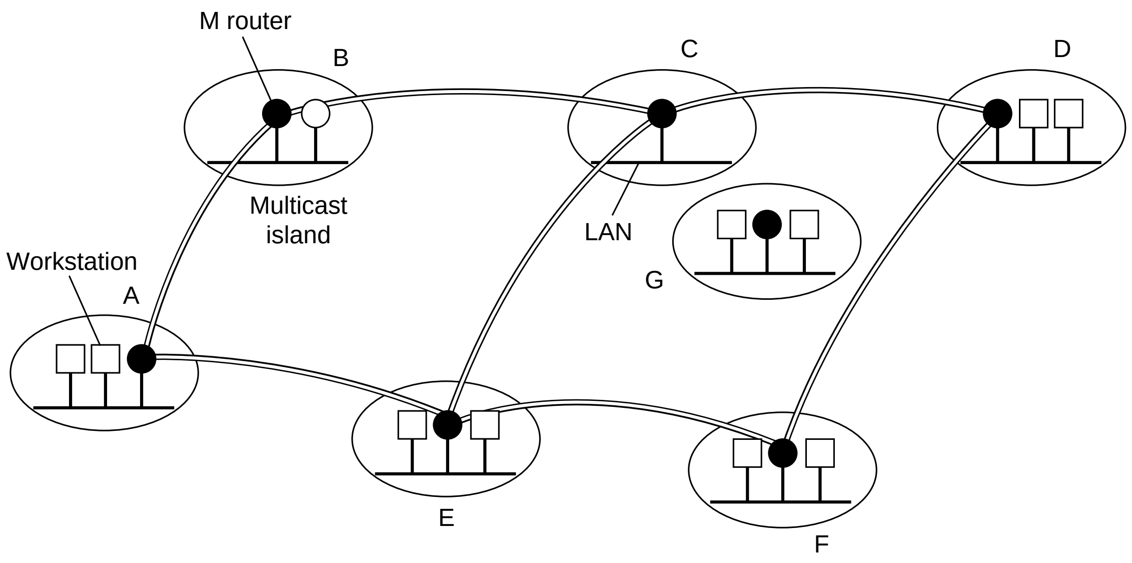


Fig. 7-81. MBone consists of multicast islands connected by tunnels.