

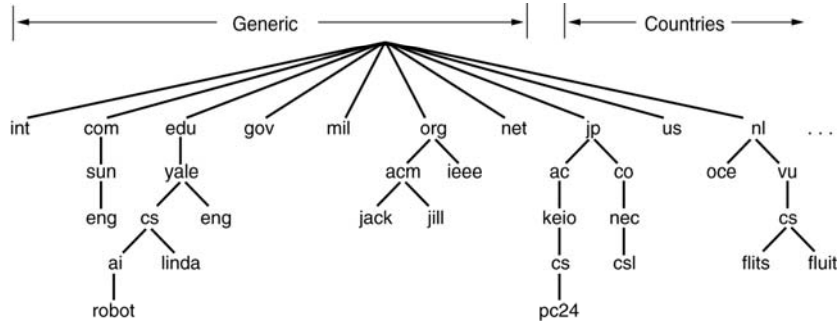
Chapter 7

The Application Layer

DNS – The Domain Name System

- The DNS Name Space
- Resource Records
- Name Servers

The DNS Name Space



A portion of the Internet domain name space.

Resource Records

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

The principal DNS resource records types.

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

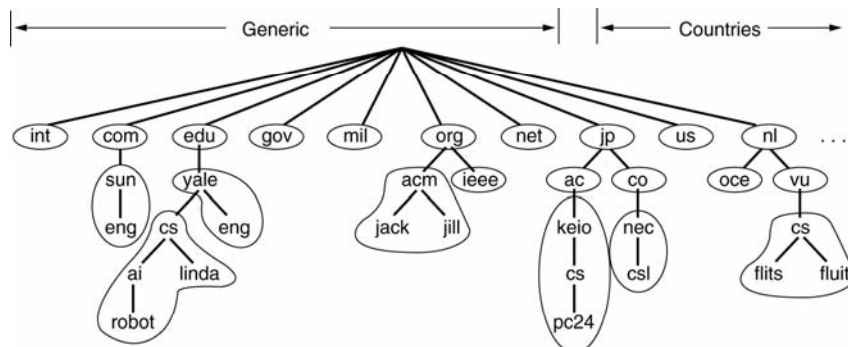
rowboat        IN  A    130.37.56.201
               IN  MX    1 rowboat
               IN  MX    2 zephyr
               IN  HINFO Sun Unix

little-sister  IN  A    130.37.62.23
               IN  HINFO Mac MacOS

laserjet       IN  A    192.31.231.216
               IN  HINFO "HP Laserjet III's" Proprietary
    
```

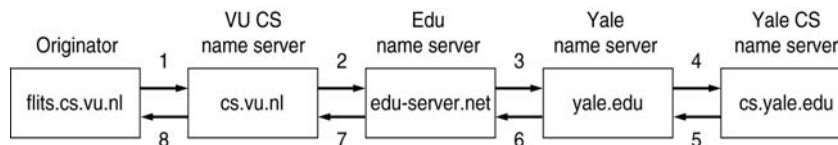
A portion of a possible DNS database for *cs.vu.nl*.

Name Servers



Part of the DNS name space showing the division into zones.

Name Servers (2)



How a resolver looks up a remote name in eight steps.

Electronic Mail

- Architecture and Services
- The User Agent
- Message Formats
- Message Transfer
- Final Delivery

Electronic Mail (2)

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

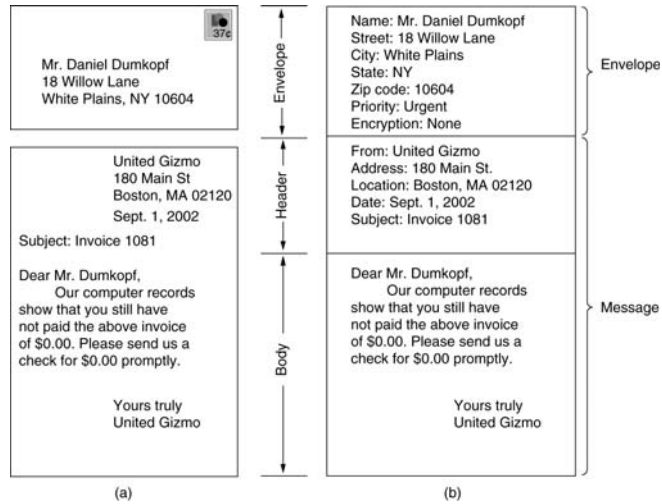
Some smileys. They will not be on the final exam :-).

Architecture and Services

Basic functions

- Composition
- Transfer
- Reporting
- Displaying
- Disposition

The User Agent



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

Reading E-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

An example display of the contents of a mailbox.

Message Formats – RFC 822

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

RFC 822 header fields related to message transport.

Message Formats – RFC 822 (2)

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

Some fields used in the RFC 822 message header.

MIME – Multipurpose Internet Mail Extensions

Problems with international languages:

- 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).

MIME (2)

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

RFC 822 headers added by MIME.

MIME (3)

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

The MIME types and subtypes defined in RFC 2045.

MIME (4)

```
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--
```

A multipart message containing enriched and audio alternatives.

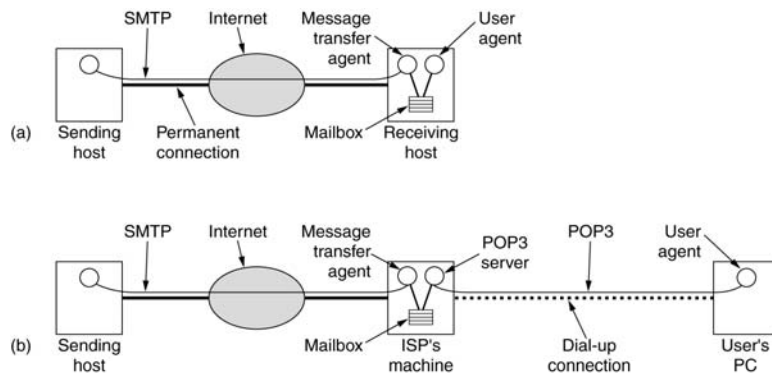
Message Transfer

Transferring a message
from
elinore@abc.com to
carolyn@xyz.com.

```

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

```

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

```

Using POP3 to fetch three messages.

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

A comparison of POP3 and IMAP.

The World Wide Web

- Architectural Overview
- Static Web Documents
- Dynamic Web Documents
- HTTP – The HyperText Transfer Protocol
- Performance Enhancements
- The Wireless Web

Architectural Overview

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

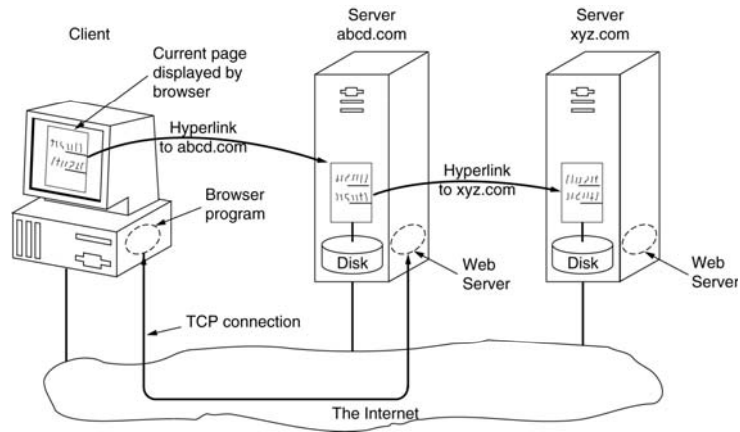
- Information for prospective majors
- Personnel
 - Faculty members
 - Graduate students
 - Nonacademic staff
- Research Projects
- Positions available
- Our most popular courses
 - Dealing with herbivores
 - Horse management
 - Negotiating with your pet
 - User-friendly doghouse construction
- Full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

Webmaster@animalpsyc.eastpodunk.edu

(b)

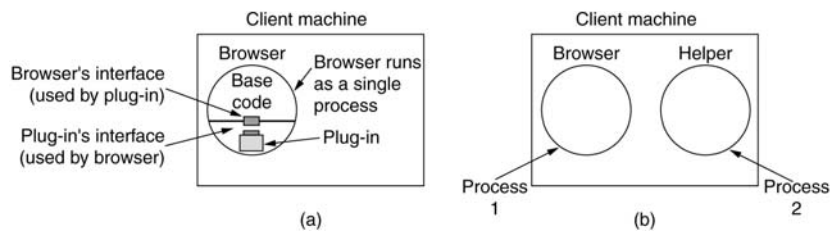
(a) A Web page (b) The page reached by clicking on Department of Animal Psychology.

Architectural Overview (2)



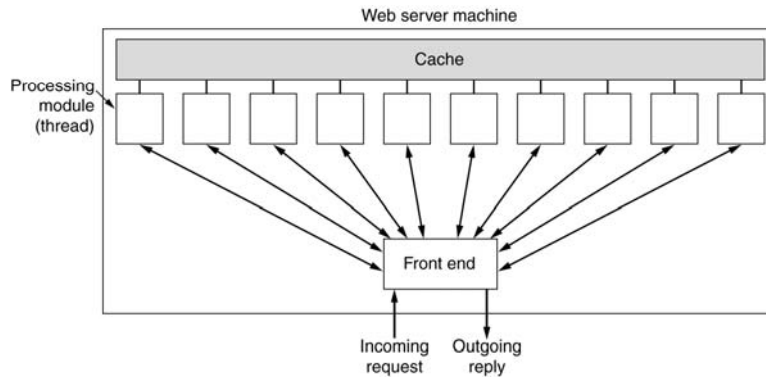
The parts of the Web model.

The Client Side



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

The Server Side



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

URLs – Uniform Resource Locaters

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

Some common URLs.

Statelessness and Cookies

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

Some examples of cookies.

XML and XSL

A simple Web page
in XML.

```
<?xml version="1.0" ?>
<?xml-stylesheet type="text/xsl" href="b5.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>
```

XML and XSL (2)

A style sheet in
XSL.

```
<?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>
```