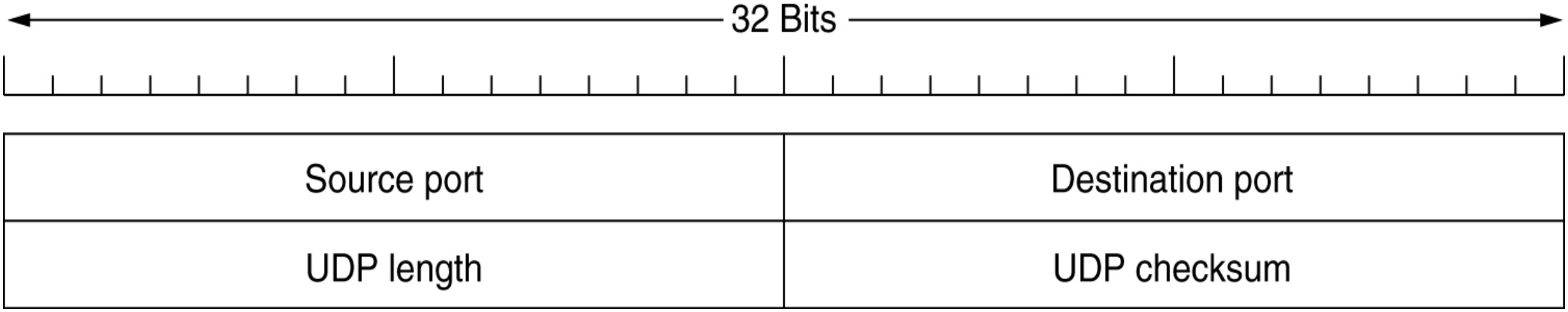
UNIT – V

The Internet Transport Protocols & The Application Layer

The Internet Transport Protocols: UDP

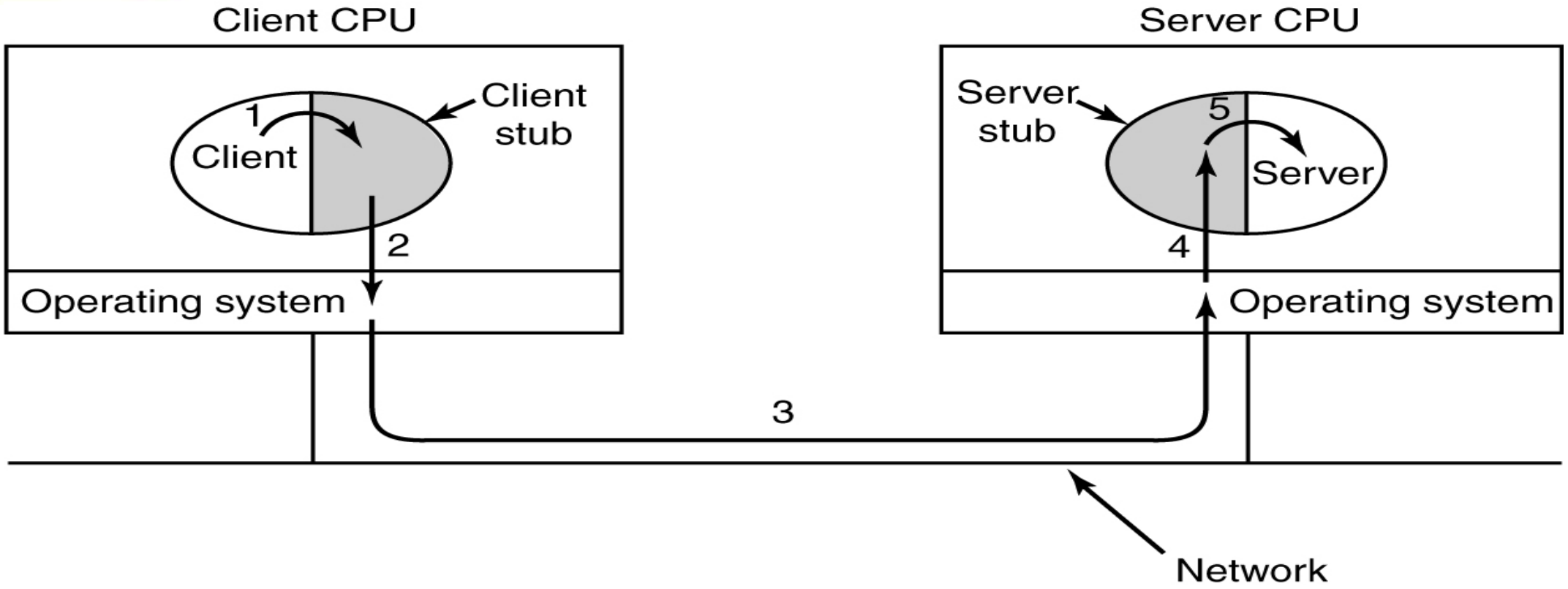
- Introduction to UDP
- Remote Procedure Call
- The Real-Time Transport Protocol

Introduction to UDP



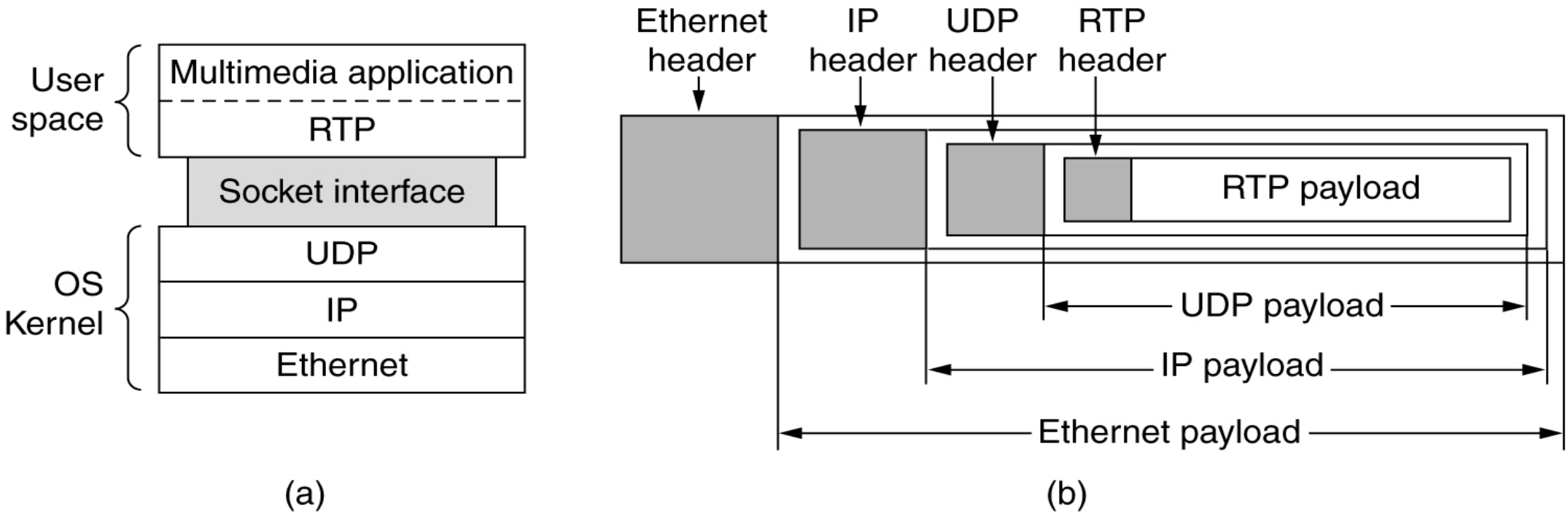
The UDP header.

Remote Procedure Call



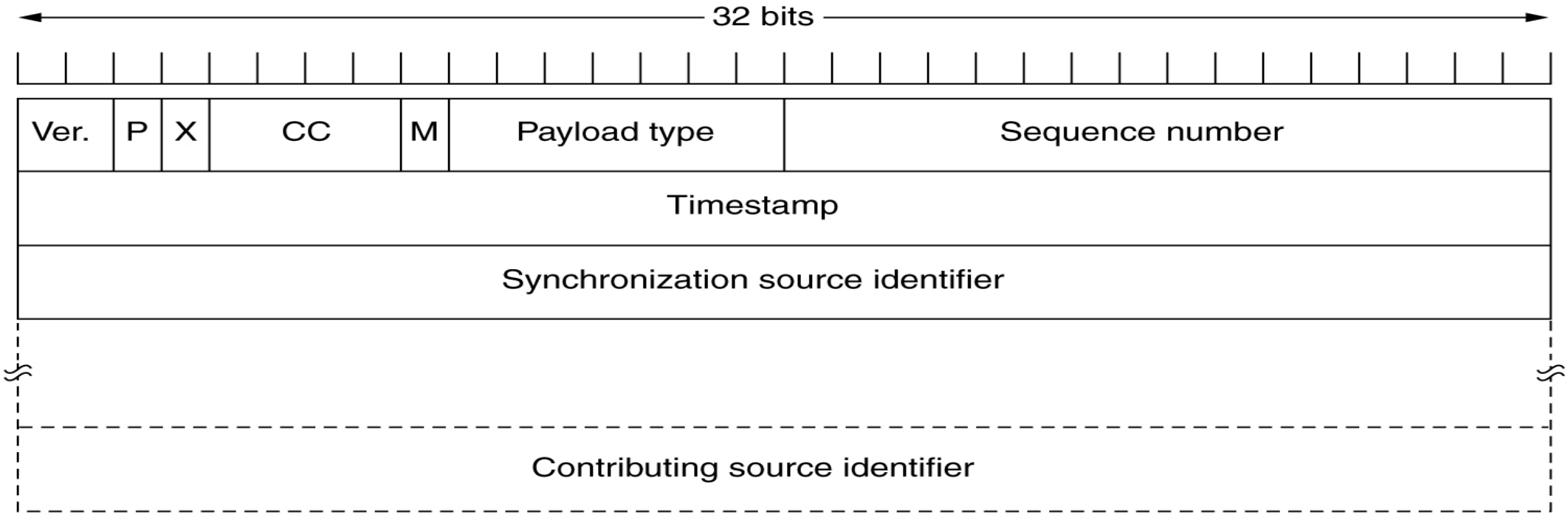
Steps in making a remote procedure call. The stubs are shaded.

The Real-Time Transport Protocol



(a) The position of RTP in the protocol stack. (b) Packet nesting.

The Real-Time Transport Protocol (2)



The RTP header.

The Internet Transport Protocols: TCP

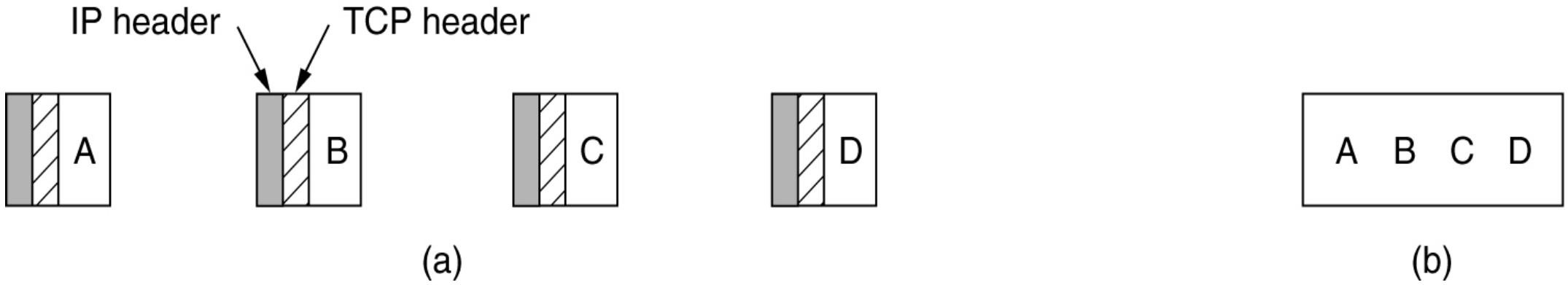
- Introduction to TCP
- The TCP Service Model
- The TCP Segment Header

The TCP Service Model

Port	Protocol	Use
21	FTP	File transfer
23	Telnet	Remote login
25	SMTP	E-mail
69	TFTP	Trivial File Transfer Protocol
79	Finger	Lookup info about a user
80	HTTP	World Wide Web
110	POP-3	Remote e-mail access
119	NNTP	USENET news

Some Assigned Ports.

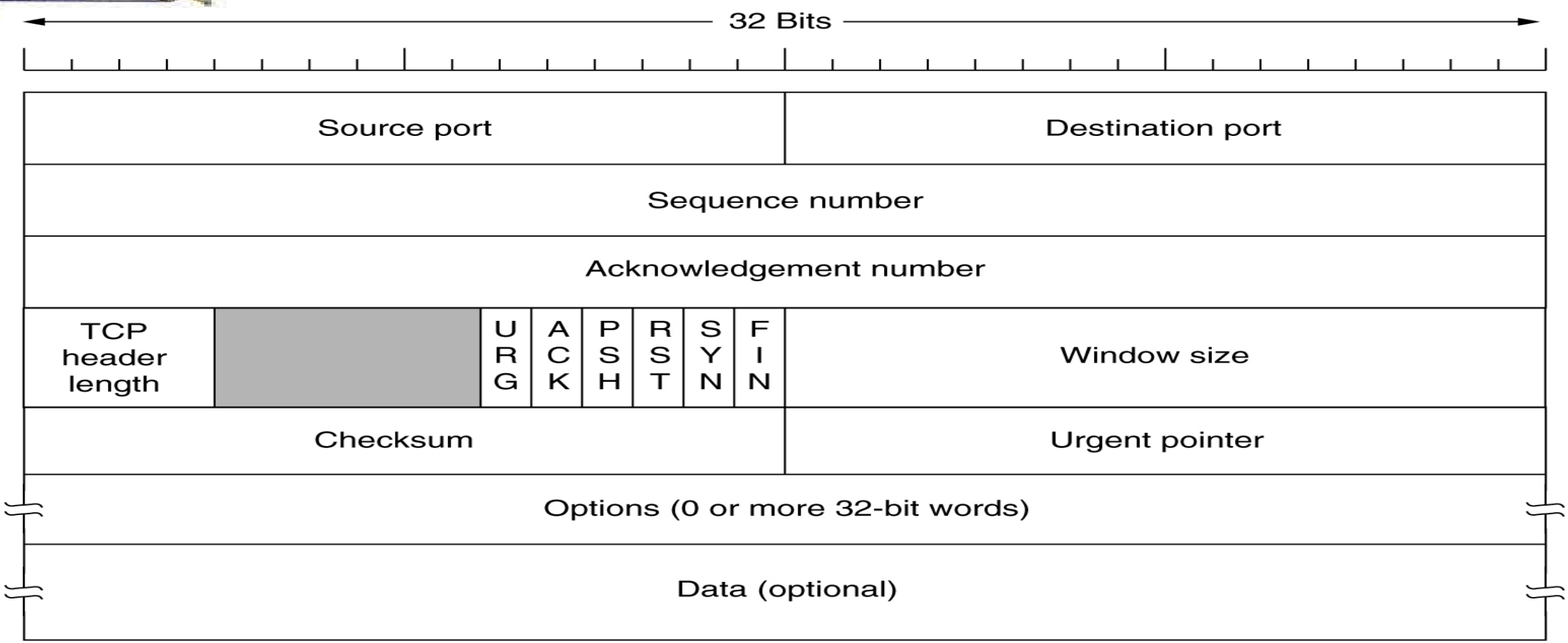
The TCP Service Model (2)



(a) Four 512-byte segments sent as separate IP Datagrams.

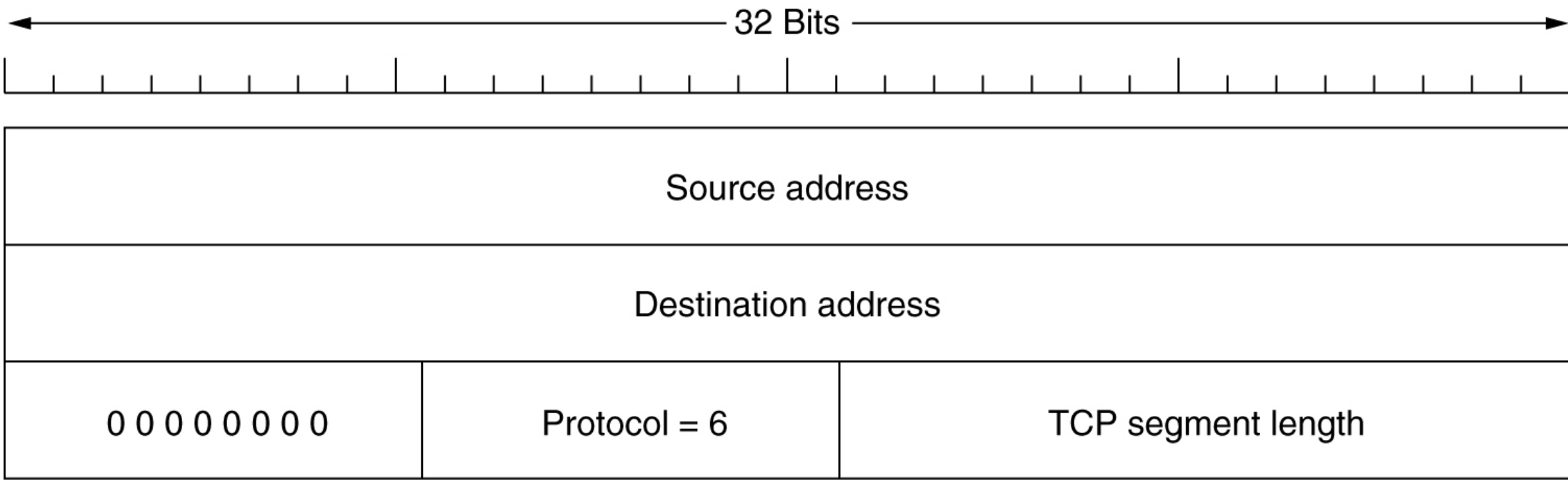
(b) The 2048 bytes of data delivered to the application in a single READ CALL.

The TCP Segment Header



TCP Header.

The TCP Segment Header (2)



The Pseudo-header included in the TCP checksum.

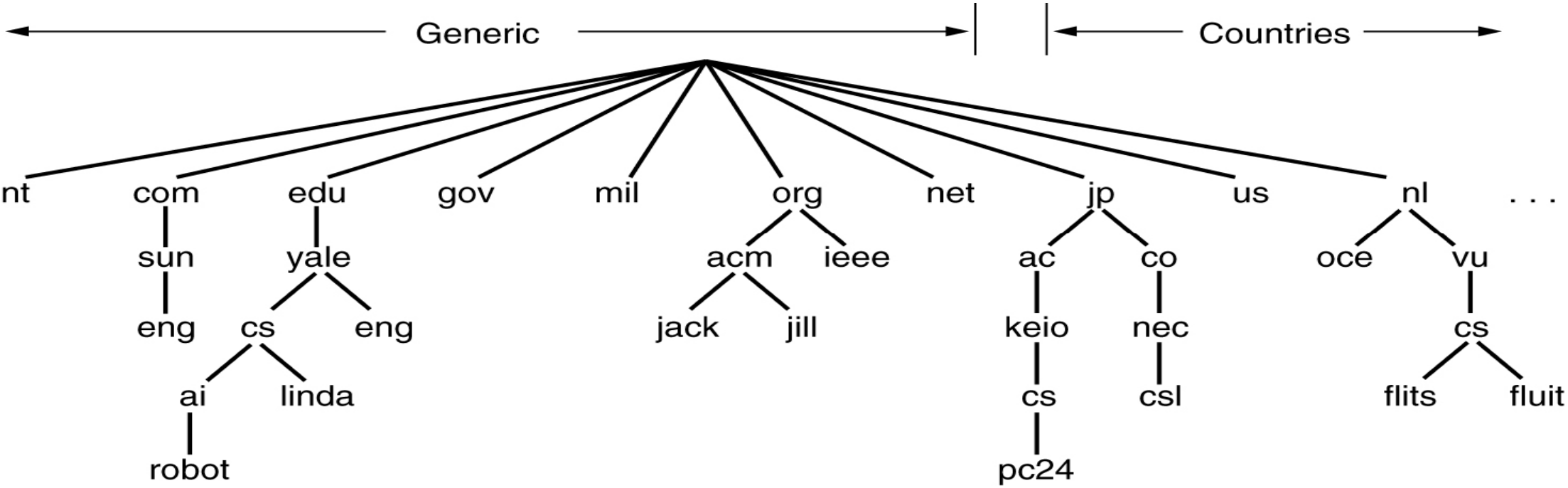
Topics

- Domain name system,
- Electronic mail
  - Architecture and services
  - SMTP
- World Wide Web
  - Architecture overview

DNS – The Domain Name System

- The DNS Name Space
- Resource Records
- Name Servers

The DNS Name Space



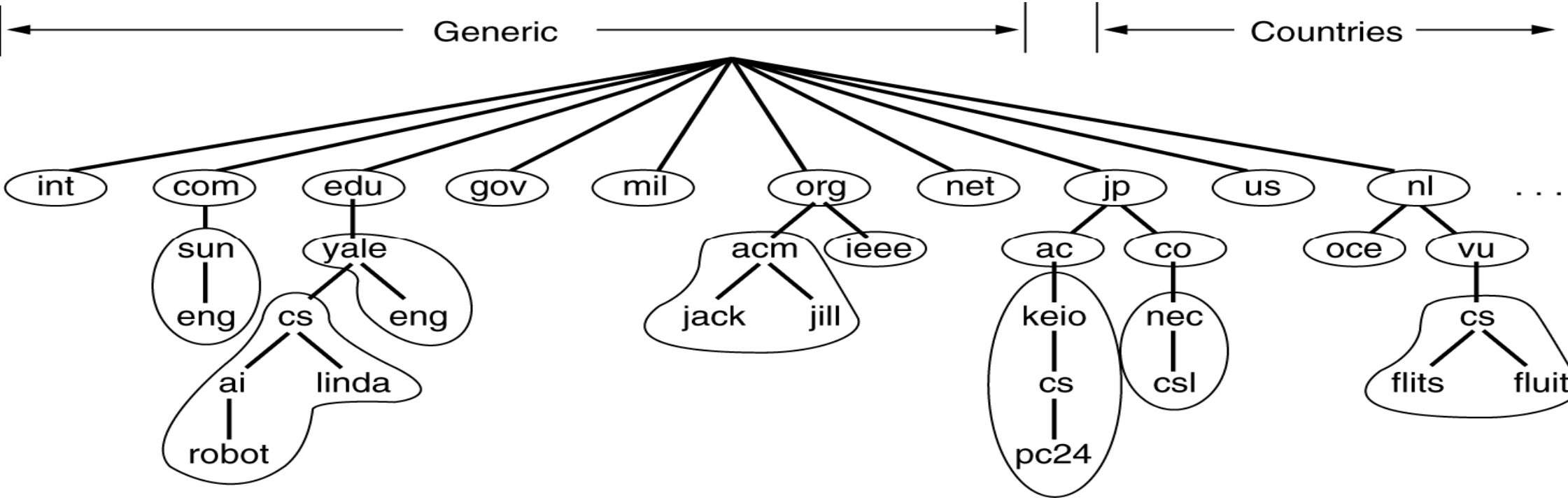
A portion of the Internet domain name space.

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

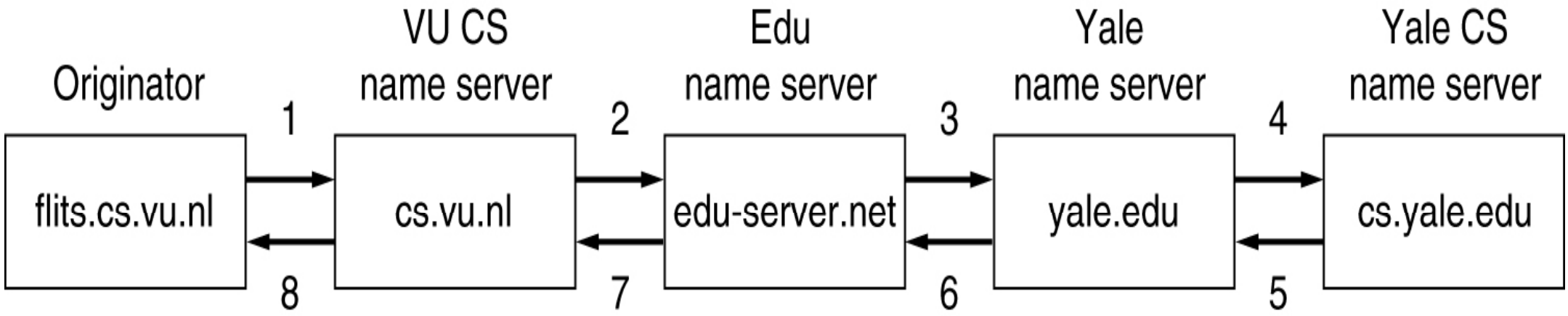
The principal DNS resource records types.

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

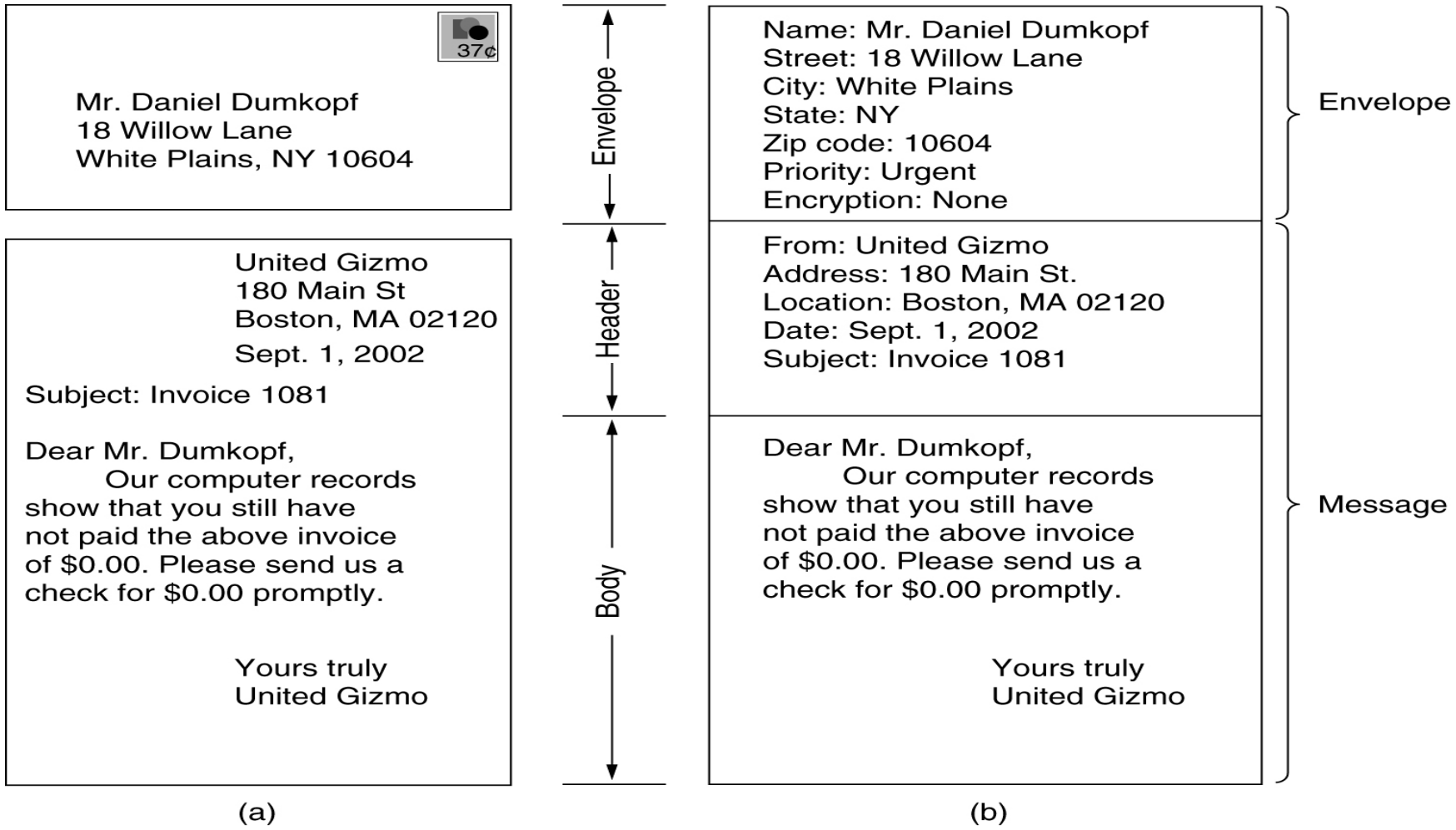
- Architecture and Services
- The User Agent
- Message Formats
- Message Transfer
- Final Delivery

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

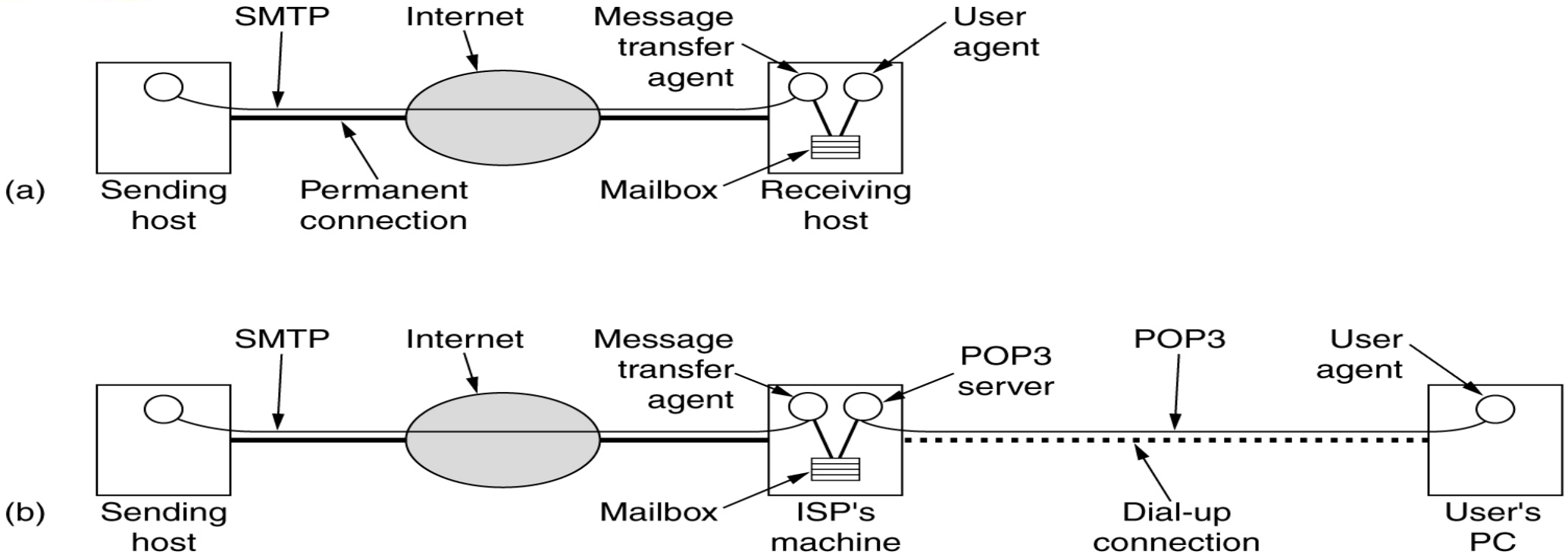
Some fields used in the RFC 822 message header.

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).

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 (Internet Message Access Protoco

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 Hyper Text Transfer Protocol
- Performance Ehnancements
- 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

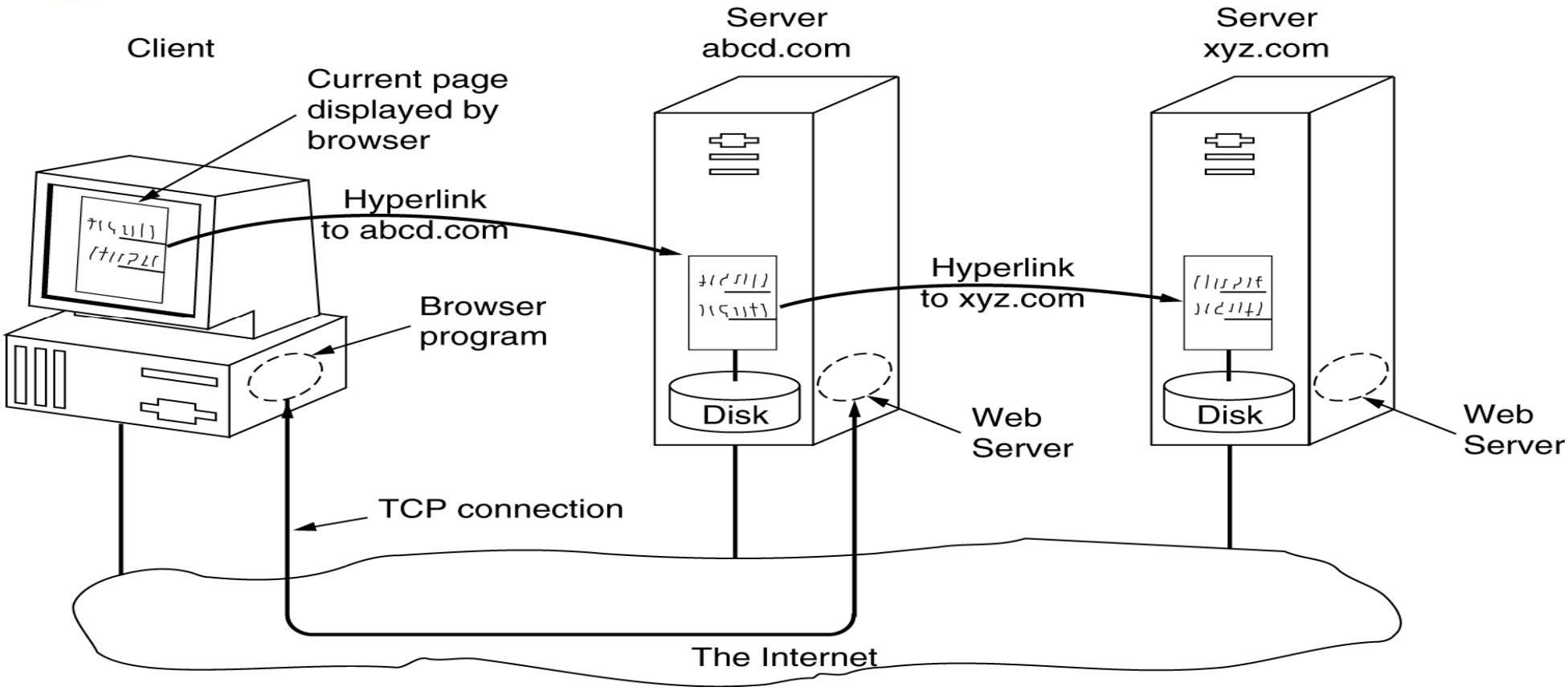
- Information for prospective majors
- Personnel
  - Faculty members
  - Graduate students
  - Nonacademic staff
- Research Projects
- Positions available
- Our most popular courses
  - Dealing with herbivores
  - Horse management
  - Negotiating with your pet
  - User-friendly doghouse construction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

Webmaster@animalpsyc.eastpodunk.edu

(b)

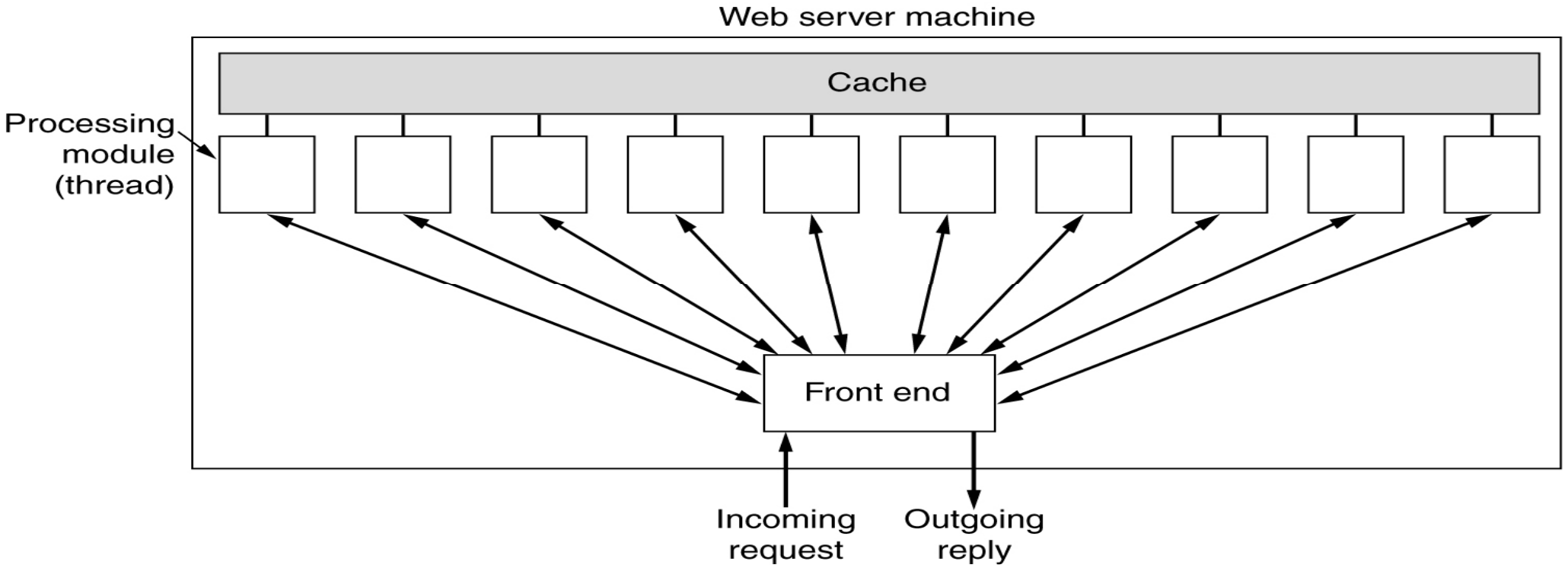
(a) A Web page (b) The page reached by clicking on Department of Animal Psychology

Architectural Overview (2)



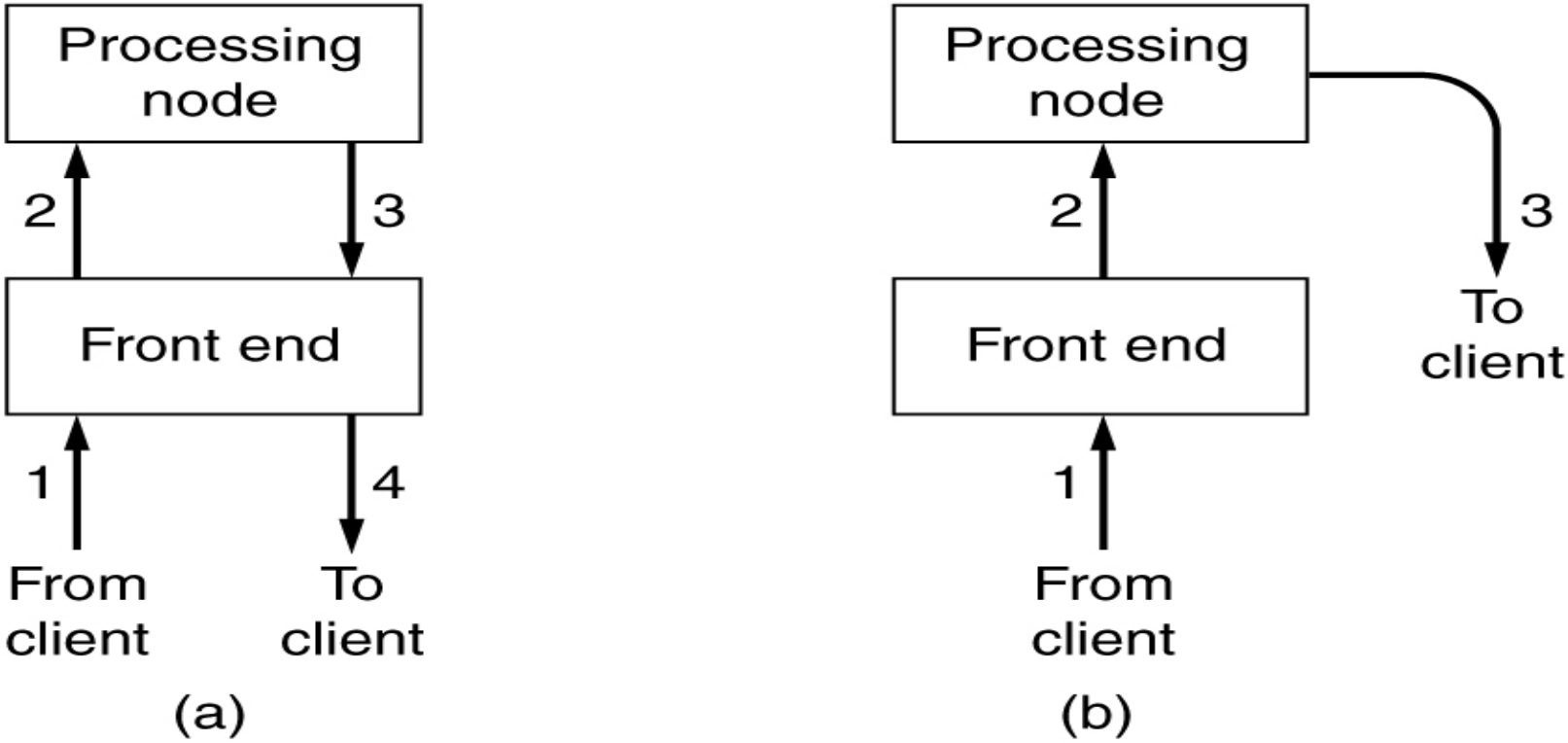
The parts of the Web model.

The Server Side



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

The Server Side (2)



(a) Normal request-reply message sequence.

(b) Sequence when TCP handoff is used.

URLs – Uniform Resource Locaters

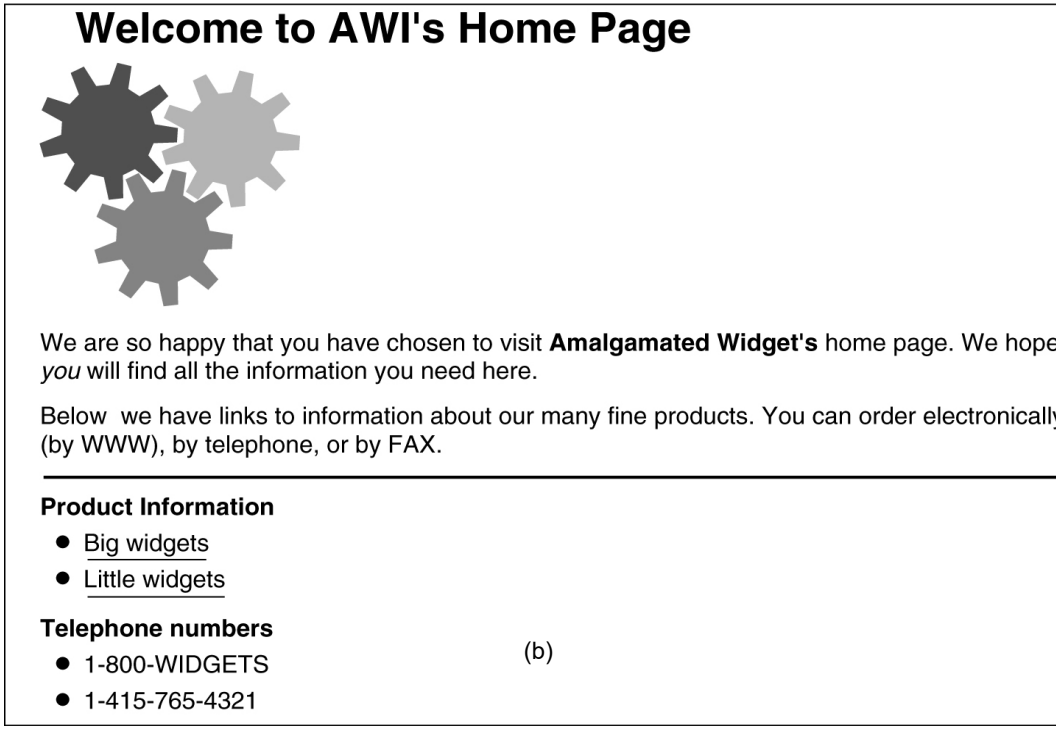
Name	Used for	Example
http	Hypertext (HTML)	http://www.cs.vu.nl/~ast/
ftp	FTP	ftp://ftp.cs.vu.nl/pub/minix/README
file	Local file	file:///usr/suzanne/prog.c
news	Newsgroup	news:comp.os.minix
news	News article	news:AA0134223112@cs.utah.edu
gopher	Gopher	gopher://gopher.tc.umn.edu/11/Libraries
mailto	Sending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

Some common URLs.

HTML – Hyper Text Markup Language

```
<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)



(b)

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

HTML (2)

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
...	Set ... in boldface
...	Set ... in italics
...	Center ... on the page horizontally
...	Brackets an unordered (bulleted) list
...	Brackets a numbered list
	Starts a list item (there is no)
 	Forces a line break here
<p>	Starts a paragraph
<hr>	Inserts a Horizontal rule
<img src="...">	Displays an image here
 ... 	Defines a hyperlink

A selection of common HTML tags. some can have additional parameters.

Forms

```
<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>   <td> x <td> x <td> x </tr>
<tr> <th> Forms <td>   <td> x <td> x <td> x </tr>
<tr> <th> Equations <td>   <td>   <td> x <td> x </tr>
<tr> <th> Toolbars <td>   <td>   <td> x <td> x </tr>
<tr> <th> Tables <td>   <td>   <td> x <td> x </tr>
<tr> <th> Accessibility features <td>   <td>   <td>   <td> x </tr>
<tr> <th> Object embedding <td>   <td>   <td>   <td> x </tr>
<tr> <th> Scripting <td>   <td>   <td>   <td> x </tr>
</table>
</body>
</html>
```

(a)

a) An HTML table.

b) A possible rendition of this table.

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)

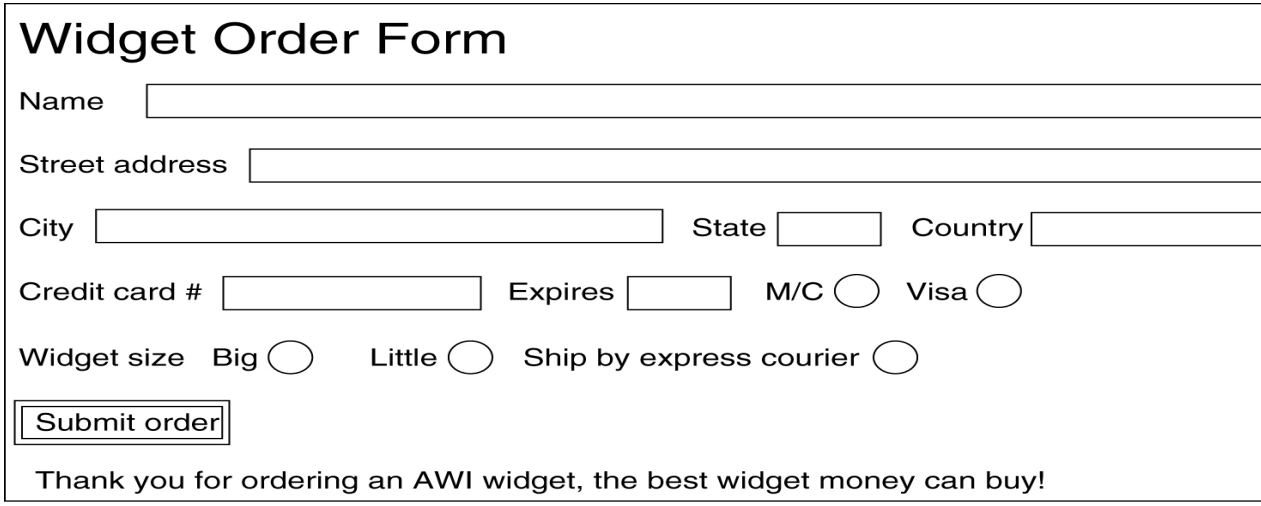
Forms (2)

(a) The HTML for an order form.

(b) The formatted page.

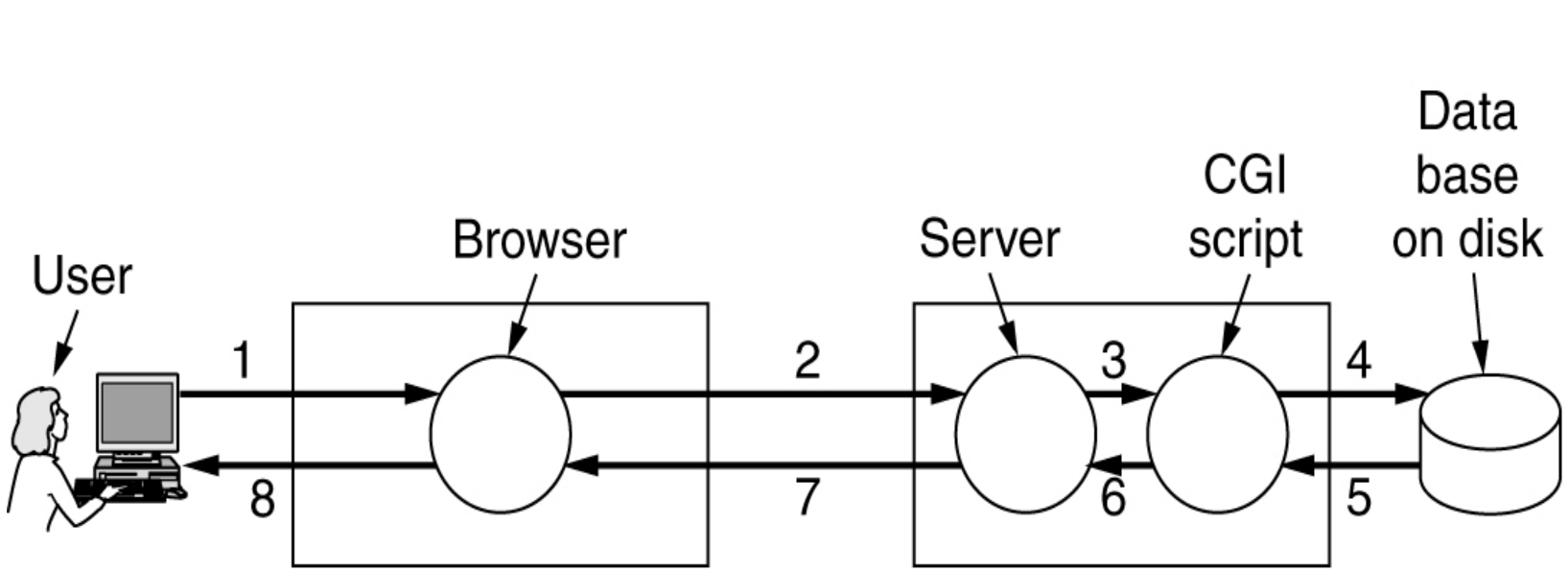
```
<html>
<head> <title> AWI CUSTOMER ORDERING FORM </title> </head>
<body>
<h1> Widget Order Form </h1>
<form ACTION="http://widget.com/cgi-bin/widgetorder" method=POST>
<p> Name <input name="customer" size=46> </p>
<p> Street Address <input name="address" size=40> </p>
<p> City <input name="city" 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)



(b)

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.

HTTP 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

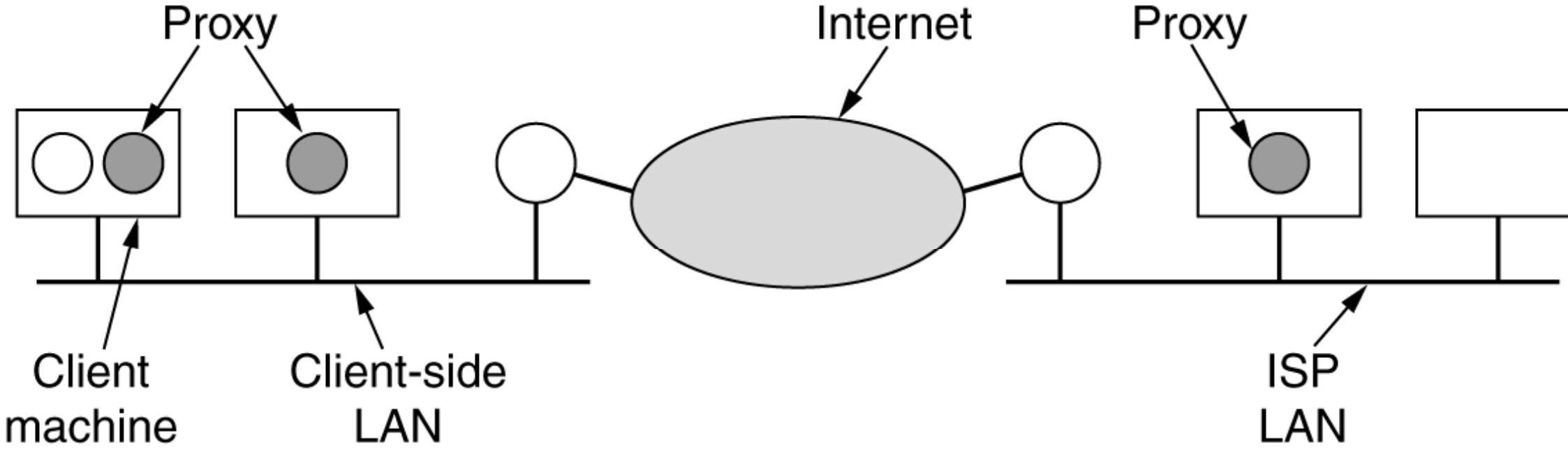
The built-in HTTP request methods.

HTTP Methods (2)

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

The status code response groups.

Caching



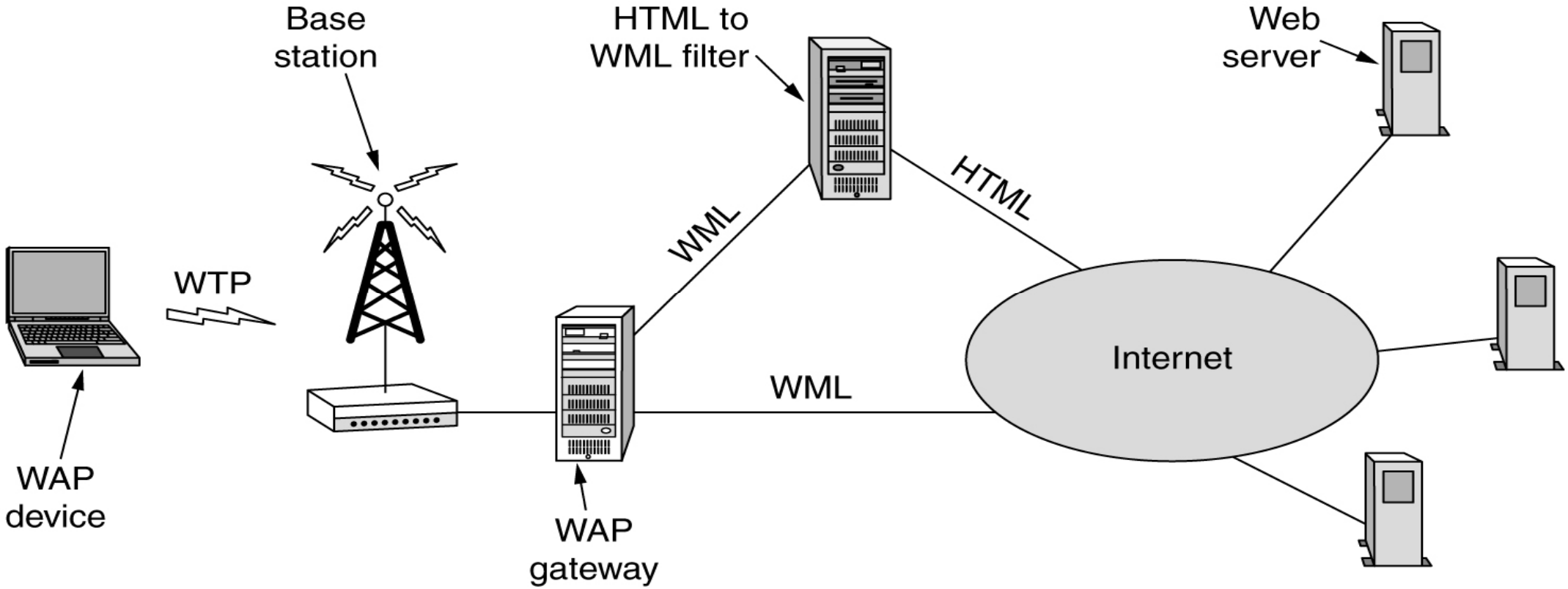
Hierarchical caching with three proxies.

WAP – The Wireless Application Protocol

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.)

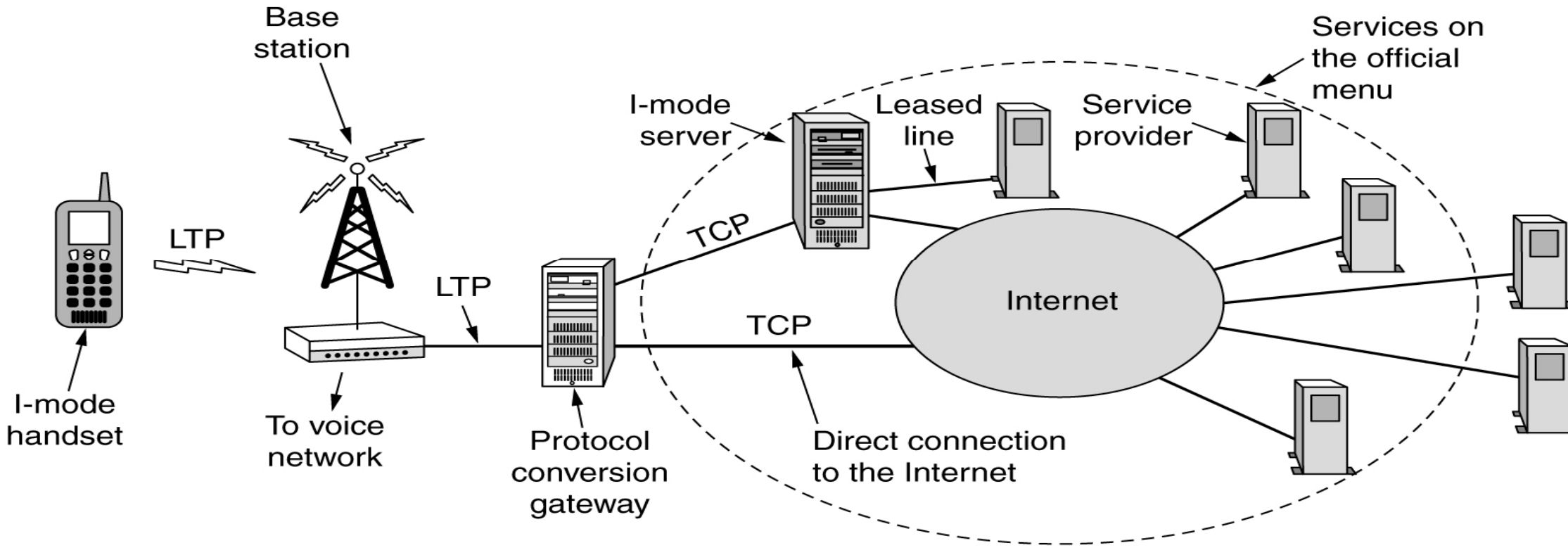
The WAP protocol stack.

WAP (2)



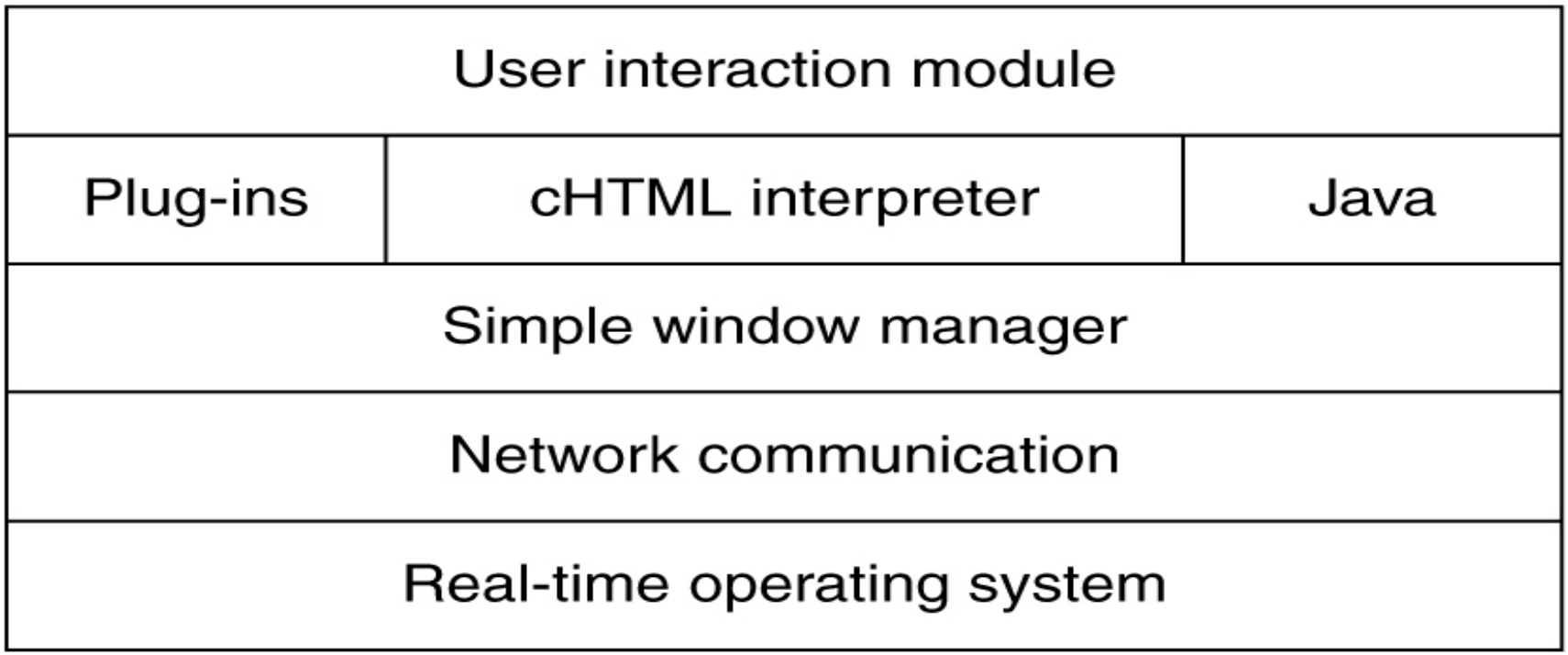
The WAP architecture.

I-Mode



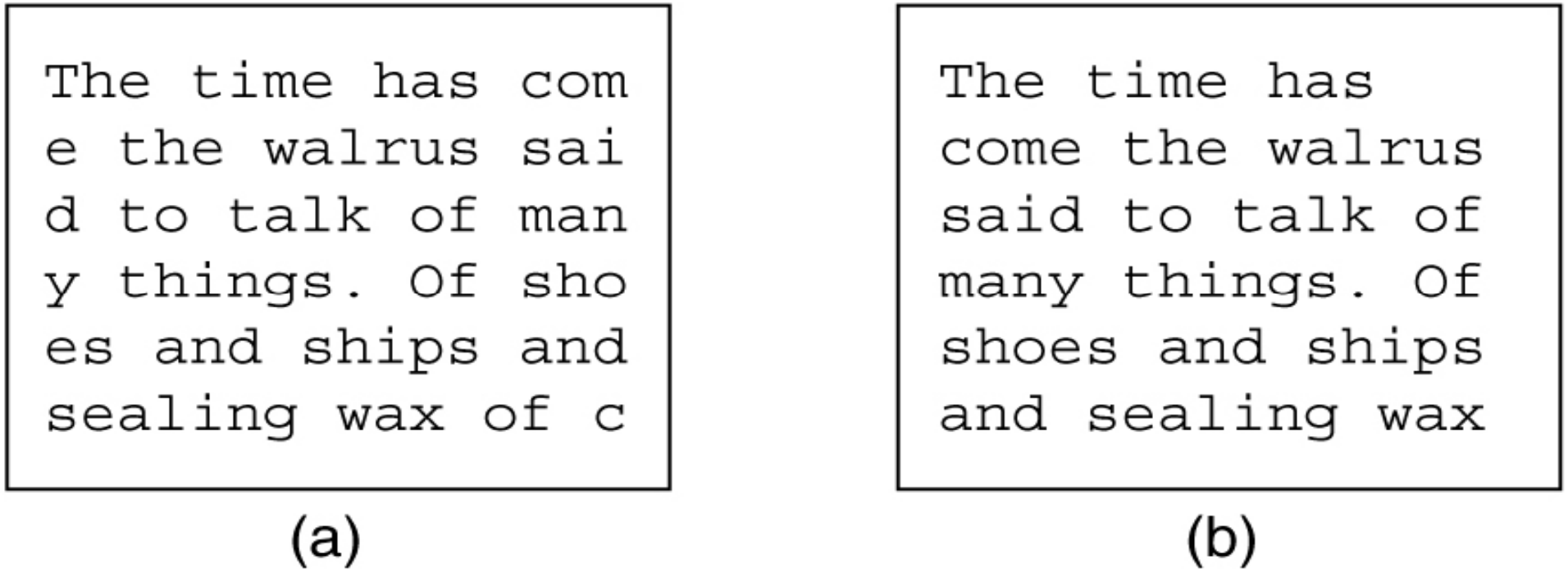
Structure of the i-mode data network showing the transport protocols.

I-Mode (2)



Structure of the i-mode software.

I-Mode (3)



Lewis Carroll meets a 16 x 16 screen.

Second-Generation Wireless Web

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

A comparison of first-generation WAP and i-mode.

Second-Generation Wireless Web (2)

New features of WAP 2.0.

- Push model as well as pull model.
- Support for integrating telephony into apps.
- Multimedia messaging.
- Inclusion of 264 pictograms.
- Interface to a storage device.
- Support for plug-ins in the browser.

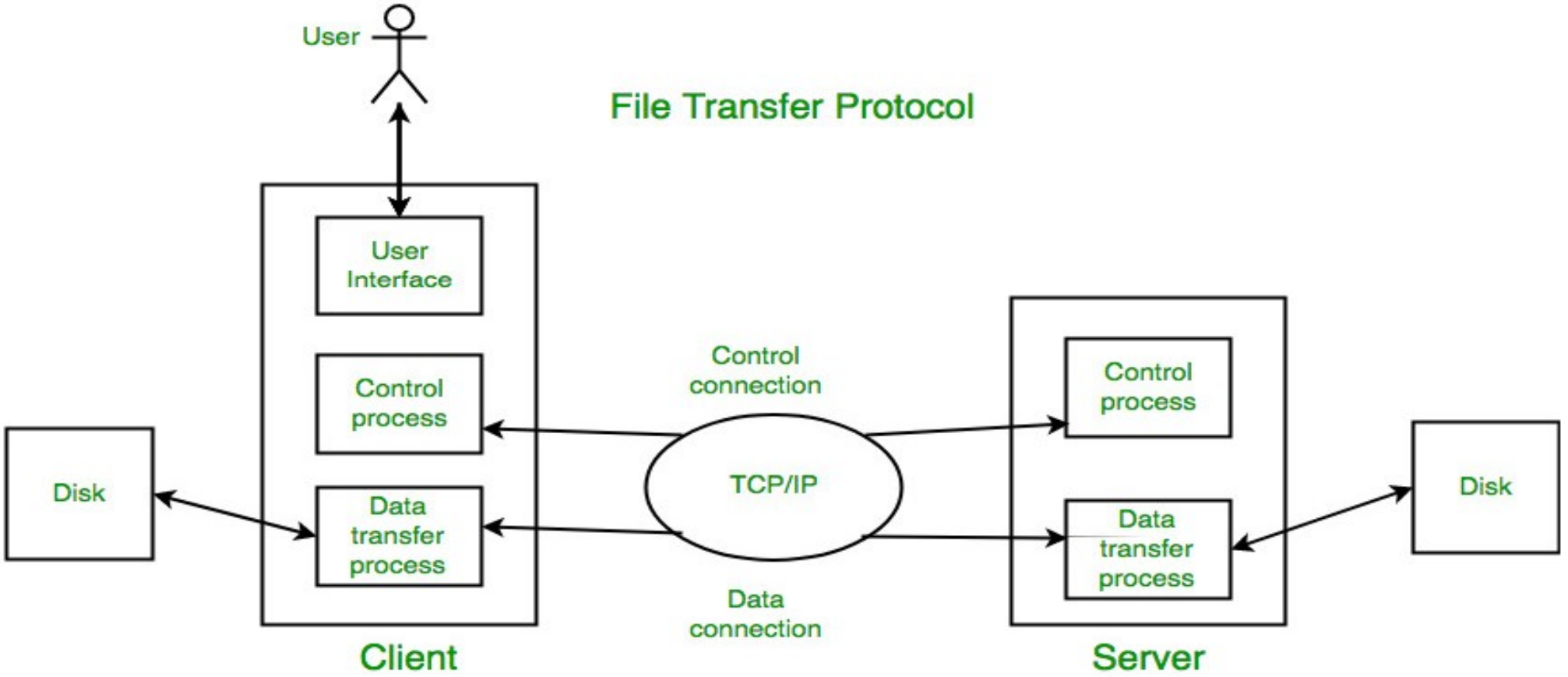
FTP

- File Transfer Protocol(FTP) is an application layer protocol that moves files between local and remote file systems. It runs on the top of TCP, like HTTP. To transfer a file, 2 TCP connections are used by FTP in parallel: control connection and data connection.
- **What is a control connection?**
  For sending control information like user identification, password, commands to change the remote directory, commands to retrieve and store files, etc., FTP makes use of a control connection. The control connection is initiated on port number 21.
- **What is a data connection?**
  For sending the actual file, FTP makes use of a data connection. A data connection is initiated on port number 20.

FTP Session

- When an FTP session is started between a client and a server, the client initiates a control TCP connection with the server-side. The client sends control information over this. When the server receives this, it initiates a data connection to the client-side. Only one file can be sent over one data connection. But the control connection remains active throughout the user session. As we know HTTP is stateless i.e. it does not have to keep track of any user state. But FTP needs to maintain a state about its user throughout the session.

FTP Session


User
File Transfer Protocol
User Interface
Control process
Data transfer process
Disk
Client
Control connection
TCP/IP
Data connection
Control process
Data transfer process
Disk
Server

FTP Commands

- *USER* – This command sends the user identification to the server.
- *PASS* – This command sends the user password to the server.
- *CWD* – This command allows the user to work with a different directory or dataset for file storage or retrieval without altering his login or accounting information.
- *RMD* – This command causes the directory specified in the path name to be removed as a directory.
- *MKD* – This command causes the directory specified in the pathname to be created as a directory.
- *PWD* – This command causes the name of the current working directory to be returned in the reply.

FTP Commands

- *RETR* – This command causes the remote host to initiate a data connection and to send the requested file over the data connection.
- *STOR* – This command causes to store of a file into the current directory of the remote host.
- *LIST* – Sends a request to display the list of all the files present in the directory.
- *ABOR* – This command tells the server to abort the previous FTP service command and any associated transfer of data.
- *QUIT* – This command terminates a USER and if file transfer is not in progress, the server closes the control connection.

FTP Replies

- 200 Command okay.
- 530 Not logged in.
- 331 User name okay, need a password.
- 225 Data connection open; no transfer in progress.
- 221 Service closing control connection.
- 551 Requested action aborted: page type unknown.
- 502 Command not implemented.
- 503 Bad sequence of commands.
- 504 Command not implemented for that parameter

Advantages of FTP

- Speed is one of the advantages of FTP(File Transfer Protocol).
- File sharing also comes in the category of advantages of FTP in this between two machines files can be shared on the network.
- Efficiency is more in FTP.

Disadvantages of FTP

- File size limit is the drawback of FTP only 2 GB size files can be transferred.
- Multiple receivers are not supported by the FTP.
- FTP does not encrypt the data this is one of the biggest drawbacks of FTP.
- FTP is unsecured we use login IDs and passwords making it secure but they can be attacked by hackers.

Anonymous FTP

- Anonymous FTP is enabled on some sites whose files are available for public access. A user can access these files without having any username or password. Instead, the username is set to anonymous and the password to the guest by default. Here, user access is very limited. For example, the user can be allowed to copy the files but not to navigate through directories.

Network Management System

- We can define network management as monitoring, testing, configuring, and troubleshooting network components to meet a set of requirements defined by an organization.
- We can say that the functions performed by a network management system can be divided into five broad categories:
  - Configuration management,
  - Fault management,
  - Performance management,
  - Security management, and
  - Accounting management.

Configuration Management

- The **configuration management system must know, at any time, the** status of each entity and its relation to other entities. Configuration management can be divided into two subsystems: reconfiguration and documentation.
- **Reconfiguration:** There are three types of reconfiguration: hardware reconfiguration, software reconfiguration, and user-account reconfiguration.
- **Documentation:** The original network configuration and each subsequent change must be recorded meticulously. This means that there must be documentation for hardware, software, and user accounts.

Fault Management

- An effective fault management system has two subsystems: reactive fault management and proactive fault management.
- **Reactive Fault Management:** A reactive fault management system is responsible for detecting, isolating, correcting, and recording faults. It handles short-term solutions to faults. (Locate, Isolate, Document).
- **Proactive Fault Management:** Proactive fault management tries to prevent faults from occurring. Although this is not always possible, some types of failures can be predicted and prevented.

Performance Management

- Performance management, which is closely related to fault management, tries to monitor and control the network to ensure that it is running as efficiently as possible. Performance management tries to quantify performance by using some measurable quantity such as:
  - Capacity,
  - Traffic,
  - Throughput, and
  - Response time.

Security Management

- Security management is responsible for controlling access to the network based on the predefined policy.

Accounting Management

- Accounting management is the control of users' access to network resources through charges.
- Under accounting management, individual users, departments, divisions, or even projects are charged for the services they receive from the network.

Structure of Management Information (SMI)

- The Structure of Management Information, version 2 (SMIv2) is a component for network management.
- Its functions are
  - 1. To name objects
  - 2. To define the type of data that can be stored in an object
  - 3. To show how to encode data for transmission over the network
- SMI is a guideline for SNMP. It emphasizes three attributes to handle an object: name, data type, and encoding method

Management Information Base (MIB)

- The Management Information Base, version 2 (MIB2) is the second component used in network management. Each agent has its own MIB2, which is a collection of all the objects that the manager can manage. The objects in MIB2 are categorized under 10 different groups:
  - system, interface, address translation, IP, ICMP, TCP, UDP, EGP, transmission, and SNMP.
- These groups are under the mib-2 object in the object identifier

Simple Network Management Protocol (SNMP)

- SNMP is an application-level protocol in which few manager stations control a set of agents. The protocol is designed at the application level so that it can monitor devices made by different manufacturers and installed on different physical networks.
- **Manager:** A management station, called a manager, is a host that runs the SNMP client program.
- **Agent:** A managed station, called an agent, is a router (or a host) that runs the SNMP server program.
- Management is achieved through simple interaction between a manager and an agent.
- The agent keeps performance information in a database. The manager has access to the values in the database.

SNMP

- Agents can also contribute to the management process. The server program running on the agent can check the environment, and if it notices something unusual, it can send a warning message, called a trap, to the manager.
- To do management tasks, SNMP uses two other protocols:
  - Structure of Management Information (SMI) and
  - Management Information Base (MIB).
- In other words, management on the Internet is done through the cooperation of the three protocols SNMP, SMI, and MIB.
- SNMP uses the services of UDP on two well-known ports, 161 and 162. The well-known port 161 is used by the server (agent), and the well-known port 162 is used by the client (manager).

SNMP

- SNMP uses both SMI and MIB in Internet network management. It is an application program that allows
  - 1. A manager to retrieve the value of an object defined in an agent
  - 2. A manager to store a value in an object defined in an agent
  - 3. An agent to send an alarm message about an abnormal situation to the manager
- SNMPv3 defines eight types of packets (or PDUs):
  - GetRequest, GetNextRequest, GetBulkRequest, SetRequest, Response, Trap, InformRequest, and Report

SNMP

- **GetRequest:** The GetRequest PDU is sent from the manager (client) to the agent (server) to retrieve the value of a variable or a set of variables.
- **GetNextRequest:** The GetNextRequest PDU is sent from the manager to the agent to retrieve the value of a variable. The retrieved value is the value of the object following the defined Objectid.
- **GetBulkRequest:** The GetBulkRequest PDU is sent from the manager to the agent to retrieve a large amount of data. It can be used instead of multiple GetRequest and GetNextRequest PDUs.
- **SetRequest:** The SetRequest PDU is sent from the manager to the agent to set (store) a value in a variable.

SNMP

- **Response:** The Response PDD is sent from an agent to a manager in response to GetRequest or GetNextRequest. It contains the value(s) of the variable(s) requested by the manager.
- **Trap:** The Trap PDU is sent from the agent to the manager to report an event. For example, if the agent is rebooted, it informs the manager and reports the time of rebooting.
- **InformRequest:** The InfonnRequest PDU is sent from one manager to another remote manager to get the value of some variables from agents under the control of the remote manager.
- **Report:** The Report PDU is designed to report some types of errors between managers. It is not yet in use.