Computer Network 1

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Chapter 10:
Application Layer

Advanced Principal Concepts

Samples and Techniques

Foundation Summary

Question and Answer

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Outline

- ## Application Layer

  - There is a need for support protocols, to allow the applications to function

- ## Some network applications

  - DNS: handles naming within the Internet

  - POP – IMAP – SMTP: handle electronic mail

  - FTP: File Transfer over the Internet

  - WWW – HTTP: Web world

  - Multimedia

Part 1: DNS and Email

Advanced Principal Concepts

Samples and Techniques

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Outline

- Where our applications are running?

- Using services provided by layers below that provide reliable transport

- We will look at:

    - Domain Name System

    - Email

Domain Name System - DNS

- IP addresses can be used to identify a host machine on the Internet

    - As those machines move around, the addresses need to be changed accordingly as well

- ASCII names have been used to decouple host names and their IPs to provide more flexibility

- The network itself still understands only numerical addresses

- The DNS was invented to manage and resolve host names into IP addresses

DNS: Characteristics

- A file *host.txt* listed all the hosts and their IP addresses, but issue some problems:

    - File size, load and latency

    - Host name conflict

- Essence of DNS:

    - Hierarchical

    - Domain-based naming scheme

    - A distributed database system

DNS: A Brief

- To map a name onto an IP address, an application program:
    - Calls a library procedure called the *resolver*, passing it the name as a parameter
    - The resolver sends a UDP packet to a local DNS server
    - DNS server looks up the name and returns the IP address to the resolver
    - Resolver returns it to the application
    - Armed with the IP address, the program can then establish a TCP connection with the destination or send it UDP packets

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DNS Name Space

- A portion of the Internet domain name space
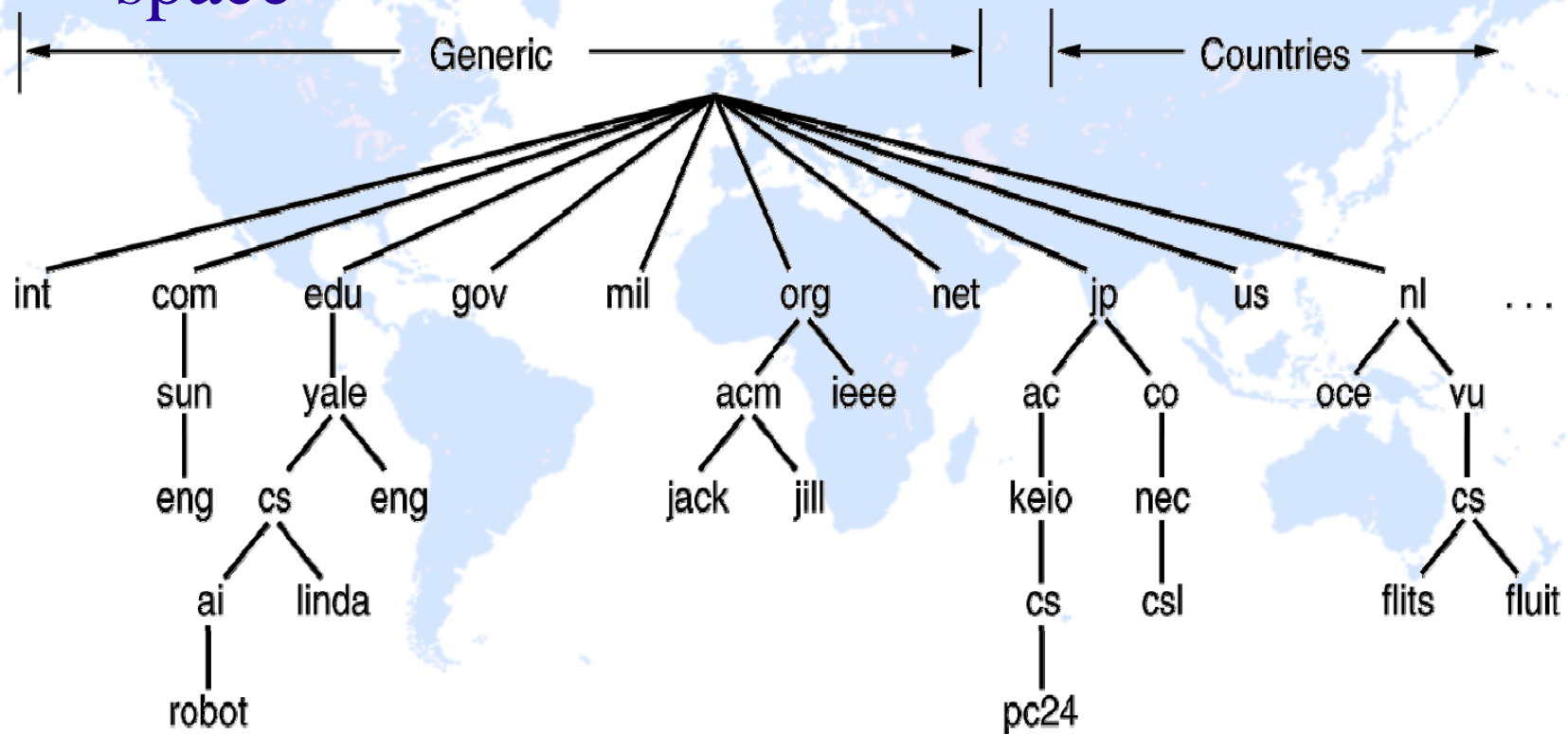
DNS naming

- ✓ Domain names are case insensitive: edu, Edu, EDU have the same meaning

- ✓ Component name can be up to 63 characters

- ✓ Full path names must not exceed 255 characters
  Each domain name server manages its own name space. It can create subdomain names without asking for permission from upper server. Examples: hcmut.edu.vn and cse.hcmut.edu.vn

Resource Records

- Every domain has a set of records associated with it
- 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.*

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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.
```
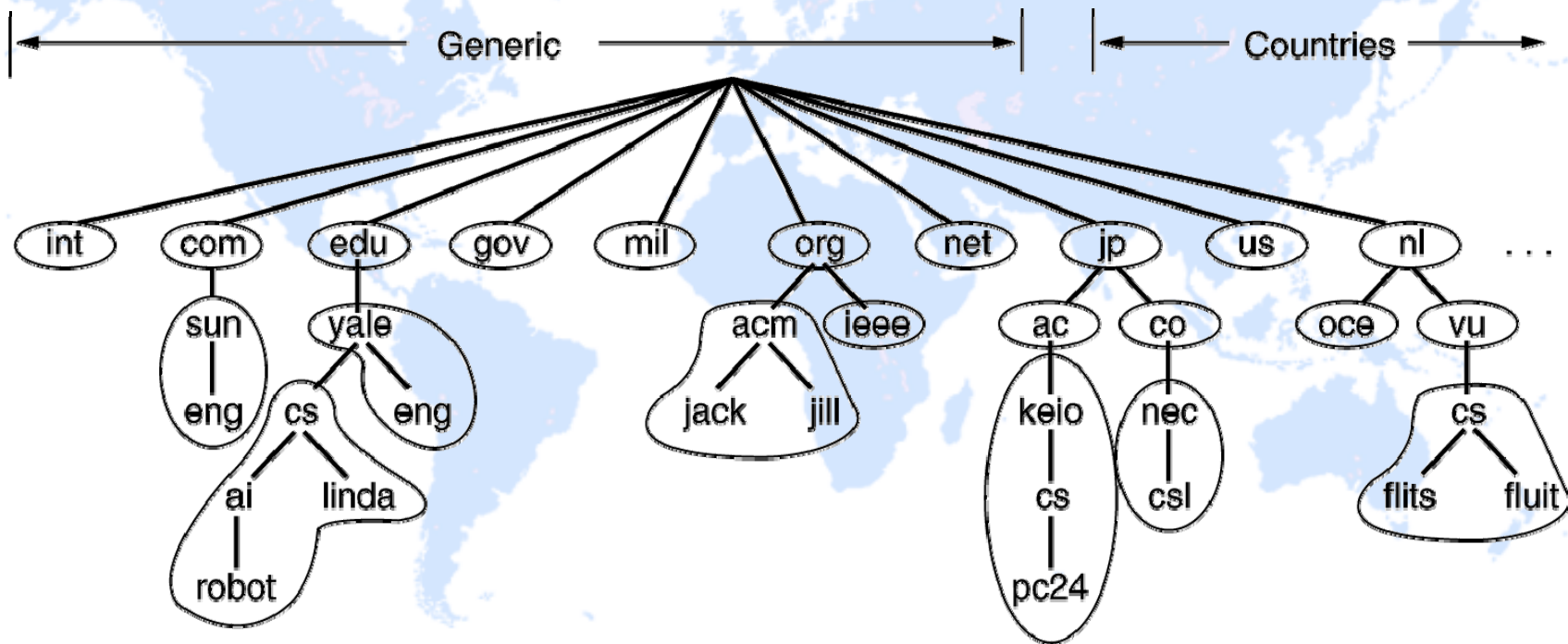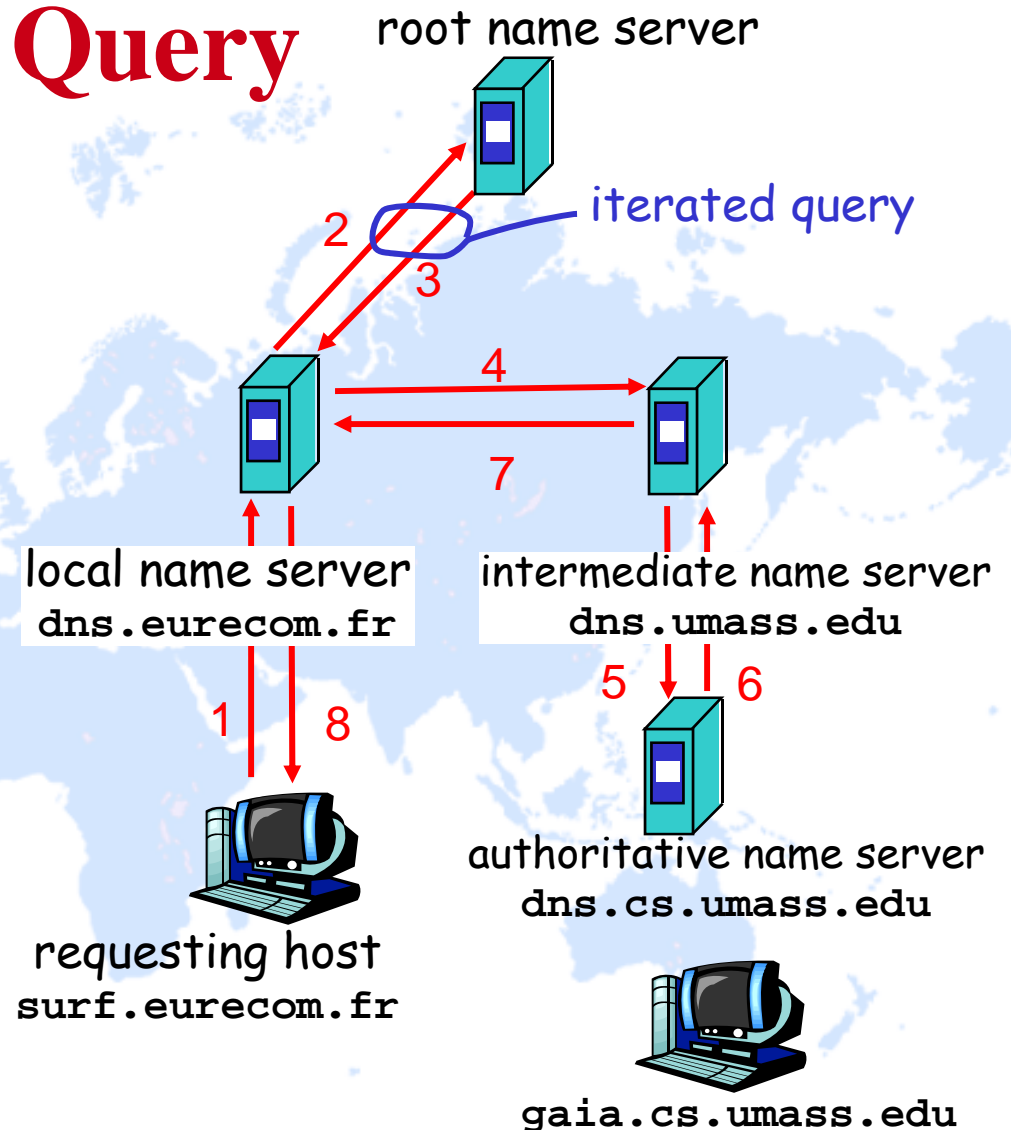
Name Servers

- DNS Name Space is divided into non-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"

root name server

iterated query

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3

4

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local name server
dns.eurecom.fr

intermediate name server
dns.umass.edu

5 6

1 8

authoritative name server
dns.cs.umass.edu

requesting host
surf.eurecom.fr

gaia.cs.umass.edu

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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	=l:-)	Abe Lincoln	:+)	Big nose
:-(	I'm sad/angry	=):-)	Uncle Sam	:-))	Double chin
:-l	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
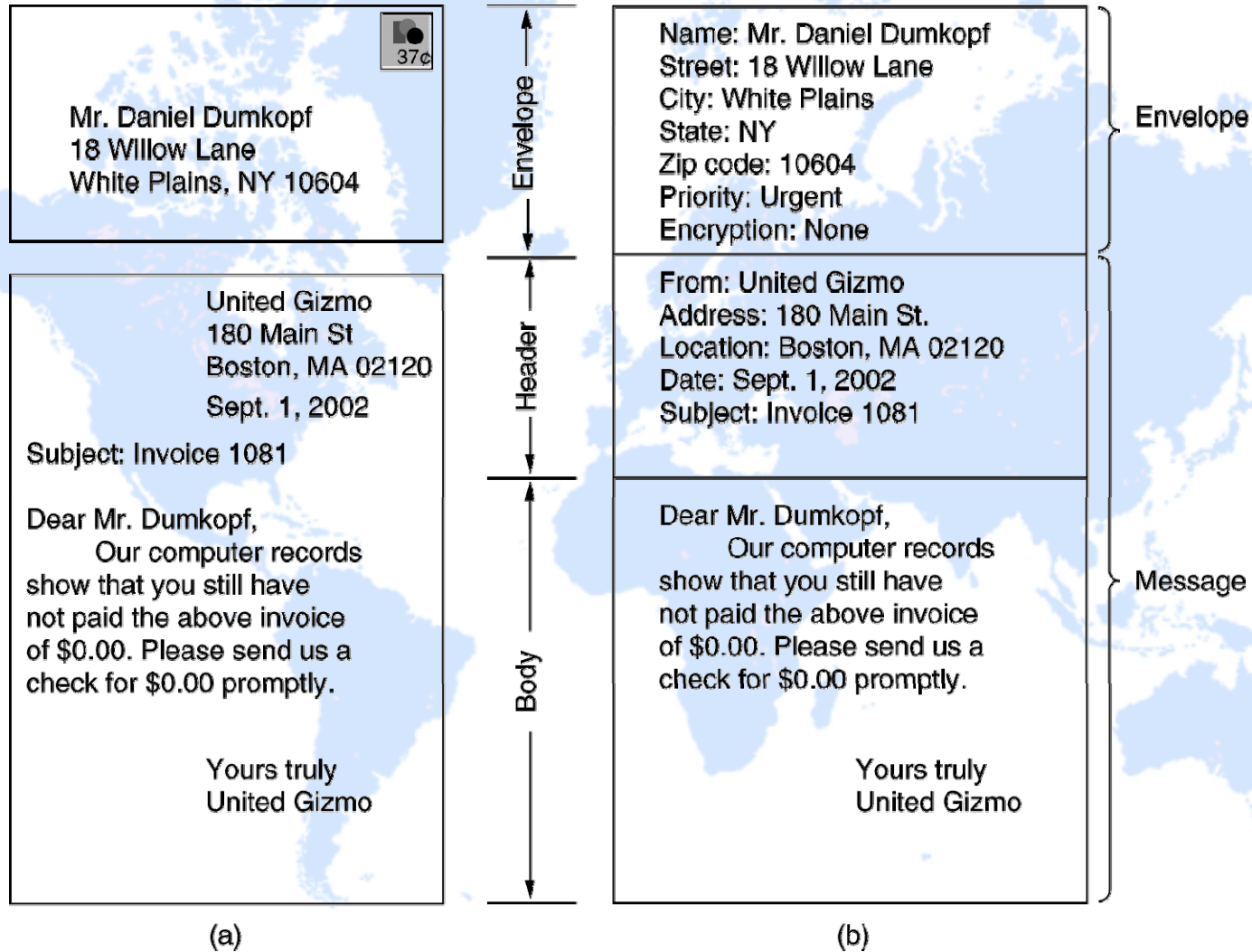- Displaying
- Disposition

Some email terms

mailbox – storage where incoming emails are saved for later processing

mailing list – a representative email address of a group of people. Email sent to this address will be forwarded to all of its participants

CC, BCC ...

Email Message Structure

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

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

Header

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

Body

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

Message

(a)   (b)

Envelopes and messages. (a) Paper mail. (b) Electronic mail.   20

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

Address format: user@dns-address

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

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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

multipart/mixed

```
From: Nathaniel Borenstein <nsb@bellcore.com>
To:  Ned Freed <ned@innosoft.com>
Subject: Sample message
MIME-Version: 1.0
Content-type: multipart/mixed; boundary="simple
boundary"

This is the preamble.  It is to be ignored, though it
is a handy place for mail composers to include an
explanatory note to non-MIME compliant readers.
--simple boundary

This is implicitly typed plain ASCII text.
It does NOT end with a linebreak.
--simple boundary
Content-type: text/plain; charset=us-ascii

This is explicitly typed plain ASCII text.
It DOES end with a linebreak.

--simple boundary--
This is the epilogue.  It is also to be ignored.
```

multipart/alternative

```
From:  Nathaniel Borenstein <nsb@bellcore.com>
To: Ned Freed <ned@innosoft.com>
Subject: Formatted text mail
MIME-Version: 1.0
Content-Type: multipart/alternative; boundary=boundary42


--boundary42
Content-Type: text/plain; charset=us-ascii

...plain text version of message goes here....

--boundary42
Content-Type: text/richtext

.... richtext version of same message goes here ...
--boundary42
Content-Type: text/x-whatever

.... fanciest formatted version of same  message  goes  here
...
--boundary42--
```

multipart/digest

```
From: Moderator-Address
MIME-Version: 1.0
Subject:  Internet Digest, volume 42
Content-Type: multipart/digest;
       boundary="---- next message ----"


------ next message ----

From: someone-else
Subject: my opinion

...body goes here ...

------ next message ----

From: someone-else-again
Subject: my different opinion

... another body goes here...

------ next 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
```

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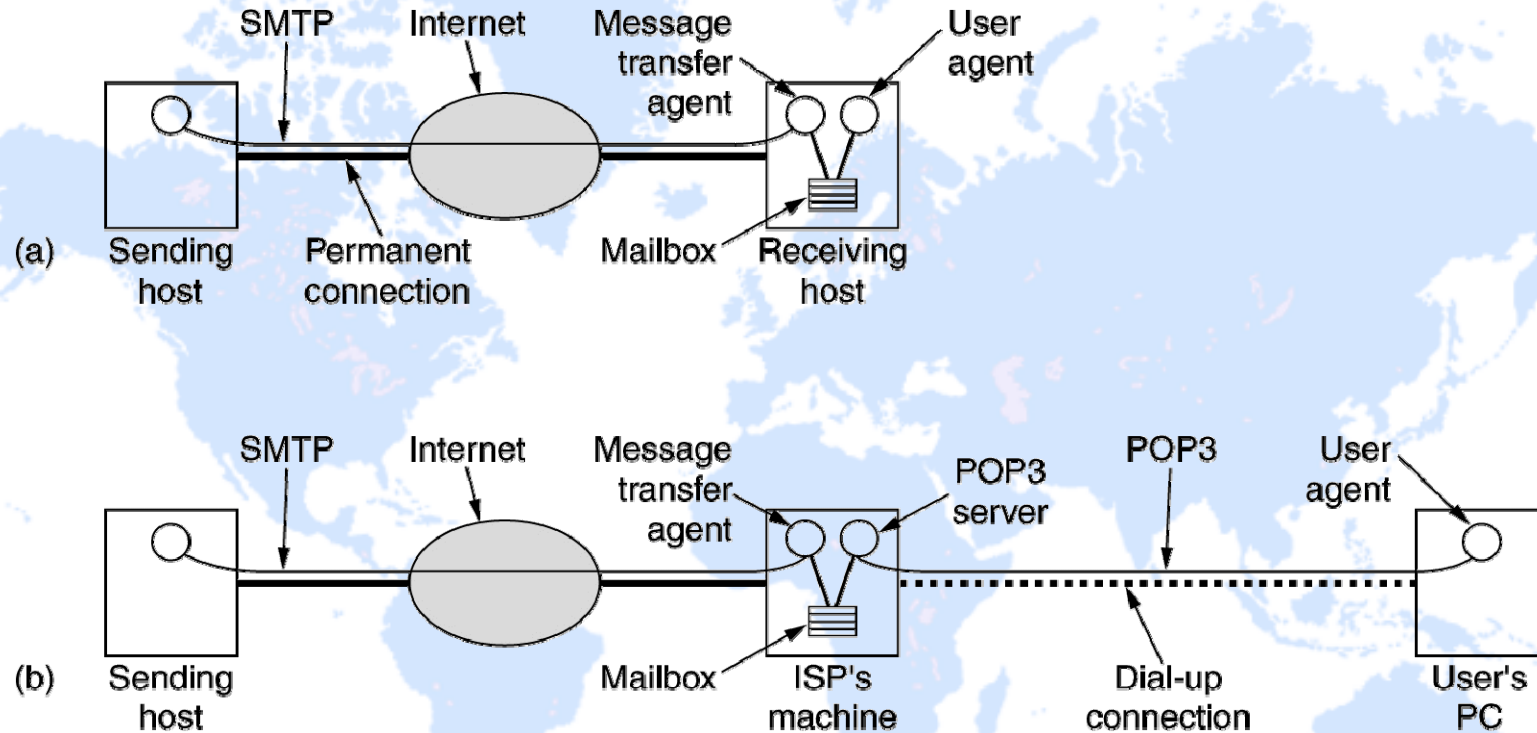
(a) Sending and reading mail when the receiver has a permanent Internet connection and the user agent runs on the same machine as the message transfer agent. (b) Reading e-mail when the receiver has a dial-up connection to an ISP.

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
```
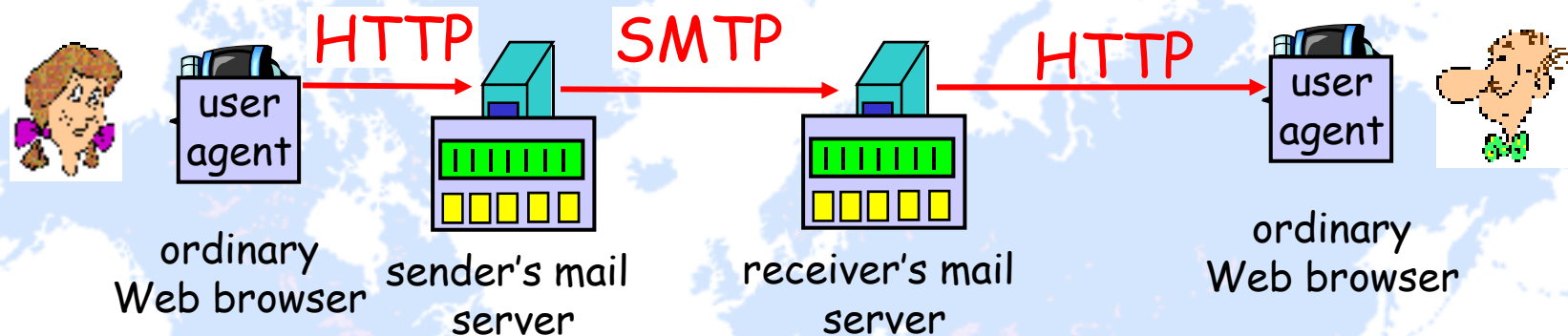
IMAP (Internet Message Access Protocol)

- 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

HTTP SMTP HTTP

user agent — ordinary Web browser

sender's mail server

receiver's mail server

user agent — ordinary Web browser

- 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