

EEC-682/782 Computer Networks I

Lecture 19

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(Lecture notes are based on materials supplied by
Dr. Louise Moser at UCSB and Prentice-Hall)

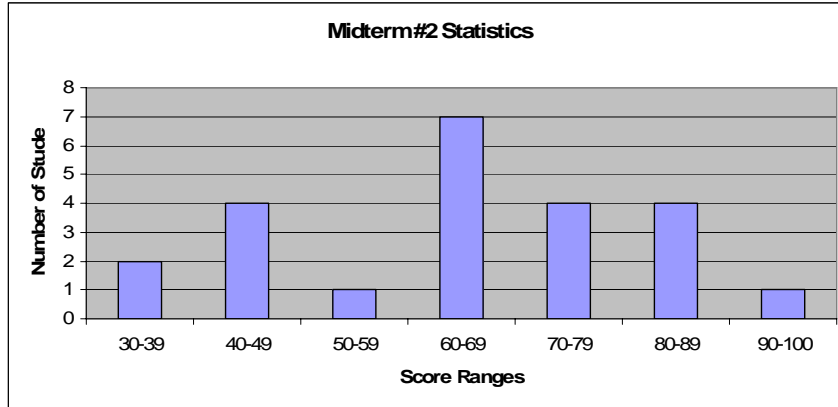


Outline

- # Midterm #2
- # The application layer
 - Domain name systems
 - Electronic mail

Midterm #2 Statistics

Max: 93.5, min: 31.5, average: 64.2

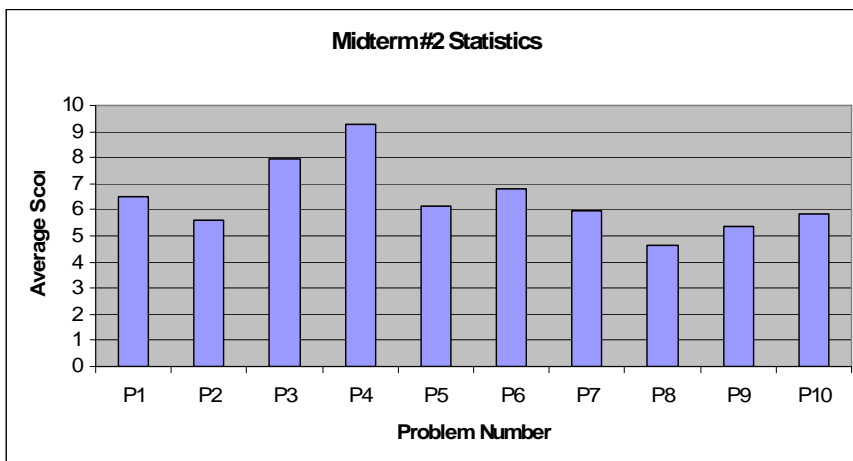


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3

Midterm #2 Statistics



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4

Midterm #1 and Midterm #2

M#1	M#2	Total	GPA	M#1	M#2	Total	GPA
99	93.5	43.45	A	63	60	27.75	B
90	74.5	37.4	A	71	49.5	27.65	B
76	84.5	35.9	A	74	44.5	27.4	B
79	76	34.95	A	55.5	66	27.075	B
65.5	86	33.575	A-	66	41	24.7	B-
70	80	33.5	A-	60.5	38.5	22.825	B-
70	75	32.5	A-	65	31.5	22.55	B-
65	80.5	32.35	A-	44	56.5	22.3	B-
72	69	31.8	B+	34	65	21.5	B-
76	61.5	31.3	B+	43.5	41.5	19.175	C+
68	61.5	29.3	B+				
61	68.5	28.95	B+				
54	77	28.9	B+				

DNS - The Domain Name System

- # Hierarchical domain-based naming scheme and distributed database system for implementing it
- # Maps ASCII strings to network addresses, i.e., maps hostnames and email addresses to IP addresses
- # Application program calls library procedure
 - Resolver whose input is name, output is IP address
 - Resolver sends UDP packet to local DNS server
 - Local DNS server looks up name, returns IP address to resolver
 - Resolver returns IP address to caller

DNS - The Domain Name System

- # The DNS Name Space
- # Resource Records
- # Name Servers

The DNS Name Space

- # Internet divided into several hundred top-level domains
- # Domains correspond to organizational boundaries, not physical networks
- # Domains partitioned into subdomains, etc.
- # To create new domain, need permission from manager above in tree

The DNS Name Space

- # Generic names:
 - com - commercial
 - edu - education
 - gov - US government
 - int - certain international organizations
 - mil - US military
 - net - network providers
 - org - nonprofit organizations
- # Domain is named by path, e.g., eng.sun.com
- # Domain names can be absolute (end with period), or relative, and they are case insensitive
- # Component names ≤ 63 chars
- # Full path names ≤ 255 chars

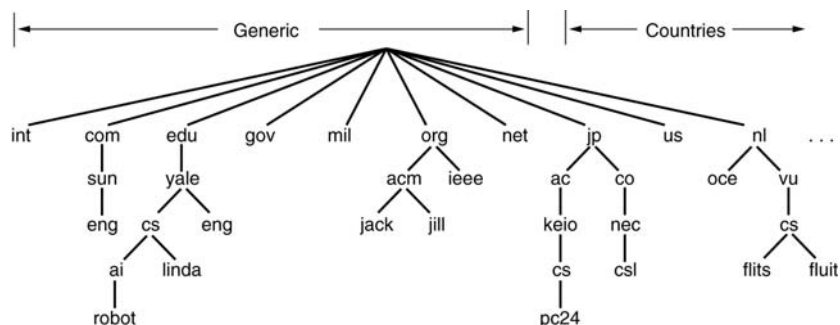
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9

The DNS Name Space

- # A portion of the Internet domain name space.



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Resource Records

- # Every domain has set of resource records associated with it
- # Resolver actually returns set of resource record
- # Record:
 - Domain-name
 - Time_to_live - how stable (1 day, 1 min, etc.)
 - Type - what kind of record
 - Class - IN for Internet
 - Value - number, domain name, ASCII string

Resource Records

- # 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

```

; 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

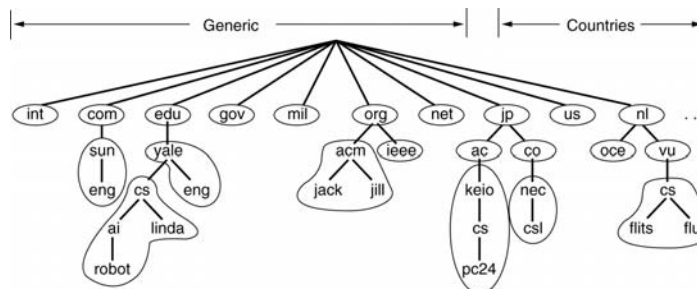
little-sister   IN  A    130.37.62.23
                IN  HINFO Mac MacOS

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*

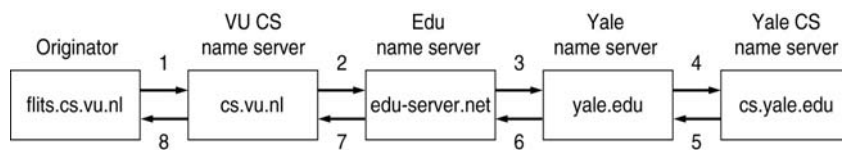
Name Servers

- # DNS name space divided into non-overlapping zones
- # Each zone contains
 - Part of tree and
 - Name server holding info about zone
 - One primary name server gets its info off disk
 - One or more non-primary name servers get info from primary name server



Name Servers

- # When resolver has query about domain names, it passes query to one of local name servers
- # If domain is in jurisdiction of name server, it returns resource record
- # If domain is remote, name server sends query message to top-level name server for domain requested using recursive query



Electronic Mail

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

Electronic Mail

Two subsystems

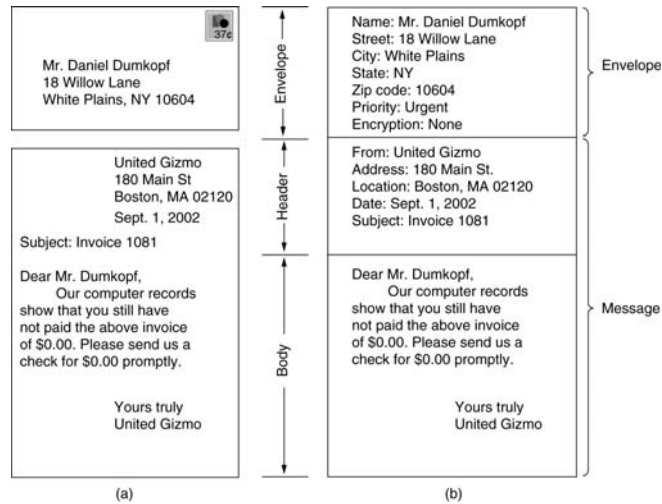
- User agents - allow users to read and send email.
 - They are local programs that provide command-based, menu-based, or graphics for interacting with email system
 - User agent builds message, passes it to message transfer agent, which uses header fields to construct envelop
- Message transfer agents - move messages from source to destination
 - They are system daemons (software that runs in background) that move email through systems

Architecture and Services

Five basic functions

- Composition - creating and replying to messages
- Transfer - moving messages from source to destination
 - Establish connection to destination
 - Output the message
 - Release connection
- Reporting - telling source what happened to messages, e.g., sent, rejected, etc.
- Displaying incoming messages so user can read them
- Disposition - what destination does with message after receiving, e.g., throw away, save, etc.

The User Agent



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

Reading E-mail

An example display of the contents of a mailbox

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

Message Formats - RFC 822

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 - RFC 822

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

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)

Solutions

- Add structure to message body
- Define encoding rules for non-ASCII messages

MIME

RFC 822 headers added by MIME

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

MIME

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

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25

MIME

A multipart message containing enriched and audio alternatives

```
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--
```

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26

Message Transfer System

- # Establishes transport connection from source machine to destination machine and transfers the message
- # SMTP - Simple Mail Transfer Protocol

Message Transfer System

- # SMTP - Simple Mail Transfer Protocol
 - Source machine (client) establishes TCP connection to port 25 of destination machine
 - Email daemon listens to this port, accepts incoming connections, copies messages from them into appropriate mailboxes
 - Error report returned to sender if message can't be delivered
 - Source machine waits for destination machine to reply
 - Destination machine (server) sends line of text, giving its identity and telling whether or not it can receive mail
 - If not, client releases connection and tries again later. If so, client announces users at source and destination machines. If user exists at destination machine, server tells client to send message
 - Client sends, server acks
 - Connection is released

Message Transfer

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

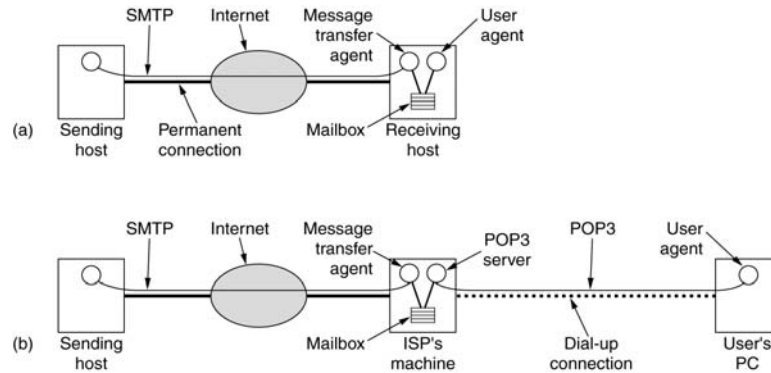
```
S: 220 xyz.com SMTP service ready
C: HELO abcd.com
S: 250 xyz.com says hello to abcd.com
C: MAIL FROM: <elinor@abcd.com>
S: 250 sender ok
C: RCPT TO: <carolyn@xyz.com>
S: 250 recipient ok
C: DATA
S: 354 Send mail; end with "." on a line by itself
C: From: elinor@abcd.com
C: To: carolyn@xyz.com
C: 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
```

Email Gateways

- # Required when two machines use different transport protocols or different message formats
- # Gateway does conversion

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

✦ POP3 - Post Office Protocol

- Fetch email from remote mailbox, store in user's local machine to be read later

✦ 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

IMAP - Interactive Mail Access Protocol

- For users who use multiple machines
- Email server maintains central repository that can be accessed from any machine
- Unlike POP3, IMAP does not copy email to user's machines

IMAP

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

Email Spoofing

- # Email spoofing: the forgery of an e-mail header so that the message appears to have originated from someone or somewhere other than the actual source
- # E-mail spoofing is possible because Simple Mail Transfer Protocol does not include an authentication mechanism
 - To send spoofed e-mail, senders insert commands in headers that will alter message information.
 - It is possible to send a message that appears to be from anyone, anywhere, saying whatever the sender wants it to say

Open Relay Problem

- # An open relay is an SMTP email server that allows third-party relay of e-mail messages.
- # By processing mail that is neither for nor from a local user, an open relay makes it possible for an unscrupulous sender to route large volumes of spam

