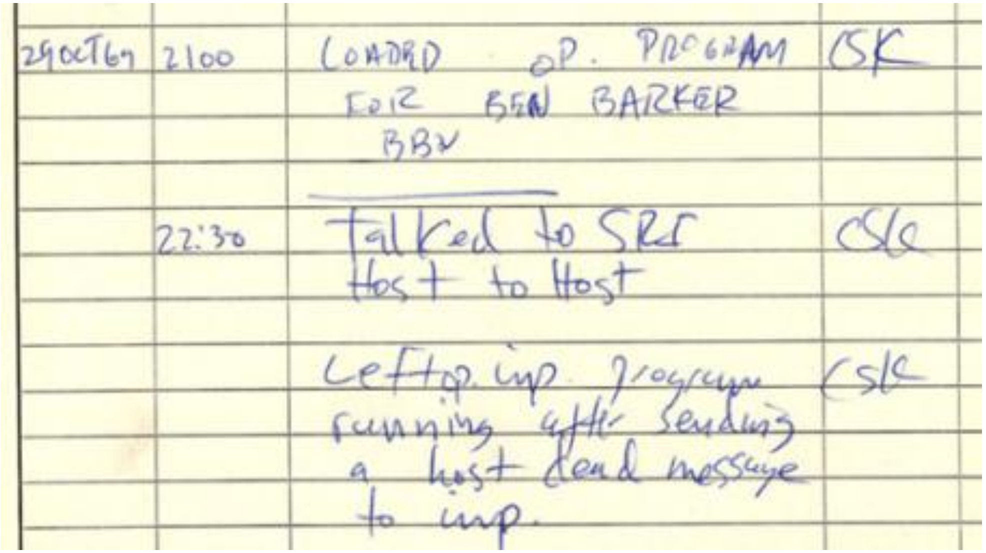
Electronic Mail

Overview

- Electronic mail
    - History
    - Format of email
        - RFC 822, MIME, email addresses
    - Sending email
        - SMTP, DNS
    - Retrieving email
        - POP, IMAP, Web-based

Flashback to the 70s

- ARPANET just recently came alive



29OCT69	2100	LOADED OP. PROGRAM FOR BEN BARKER BBN	CSK
	22:30	talked to SRI Host to Host	CSK
		Left op. imp program running after sending a host dead message to imp.	CSK

October 29, 1969:

First message sent on the ARPANET between UCLA and Stanford.

Attempted to type "login", crashed after "lo".

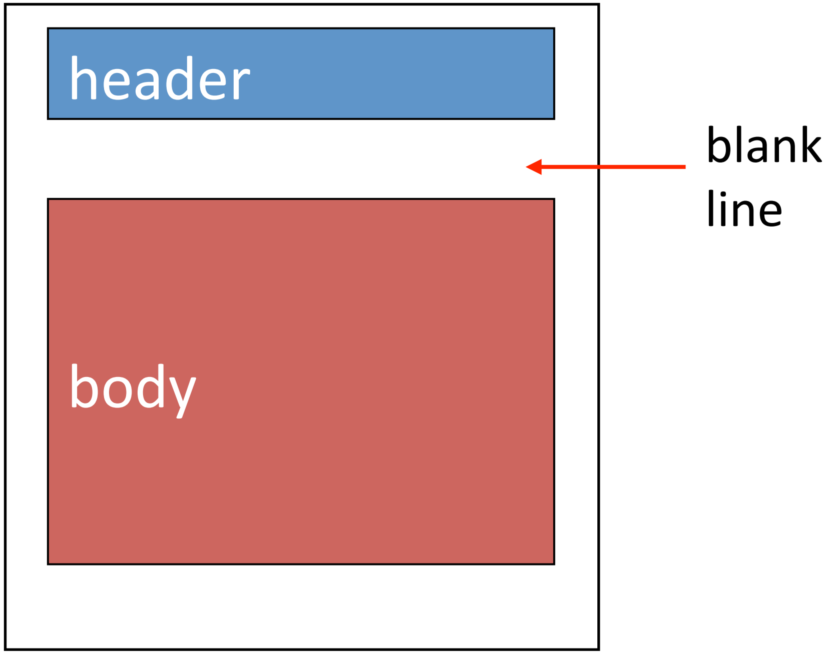
- July 1971, RFC-196: A Mail Box Protocol
  - Send documents to teletype printers
- Late 1971, Ray Tomlinson
  - Let the user decide whether to print or not

First email

- Sent between two TENEX systems
  - Each machine had a MAILBOX file in a user's directory
  - Sender specified address of recipient
    - @ sign between user account name and the host name
  - If on remote system, opened a connection
  - Message appended to MAILBOX file
- Email client:
  - To read email: TYPE MAILBOX
  - To delete email: delete lines from MAILBOX

Email format

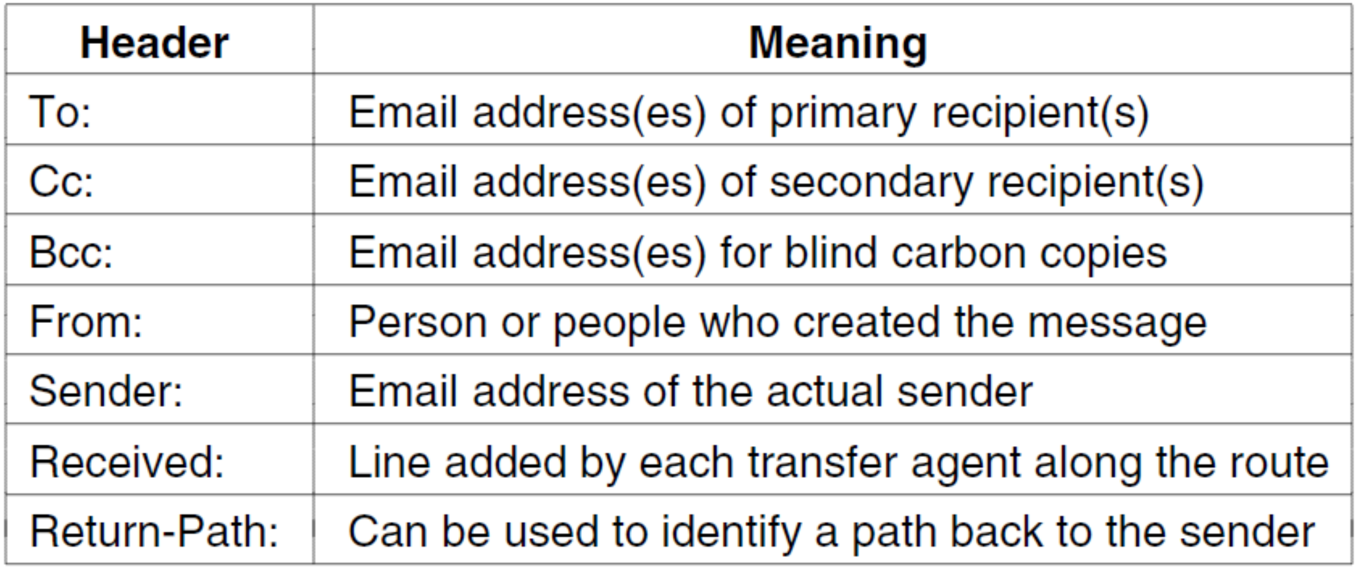
- Email format
  - Defined in RFC 822, Revised in RFC 5322, MIME
  - Made up of two parts: header and body
  - Everything in 7-bit ASCII text
- Header
  - Lines with "type: value" pairs
  - "To: user@mtech.edu"
  - "Subject: meeting"
- Body
  - The text of the message
  - No particular structure



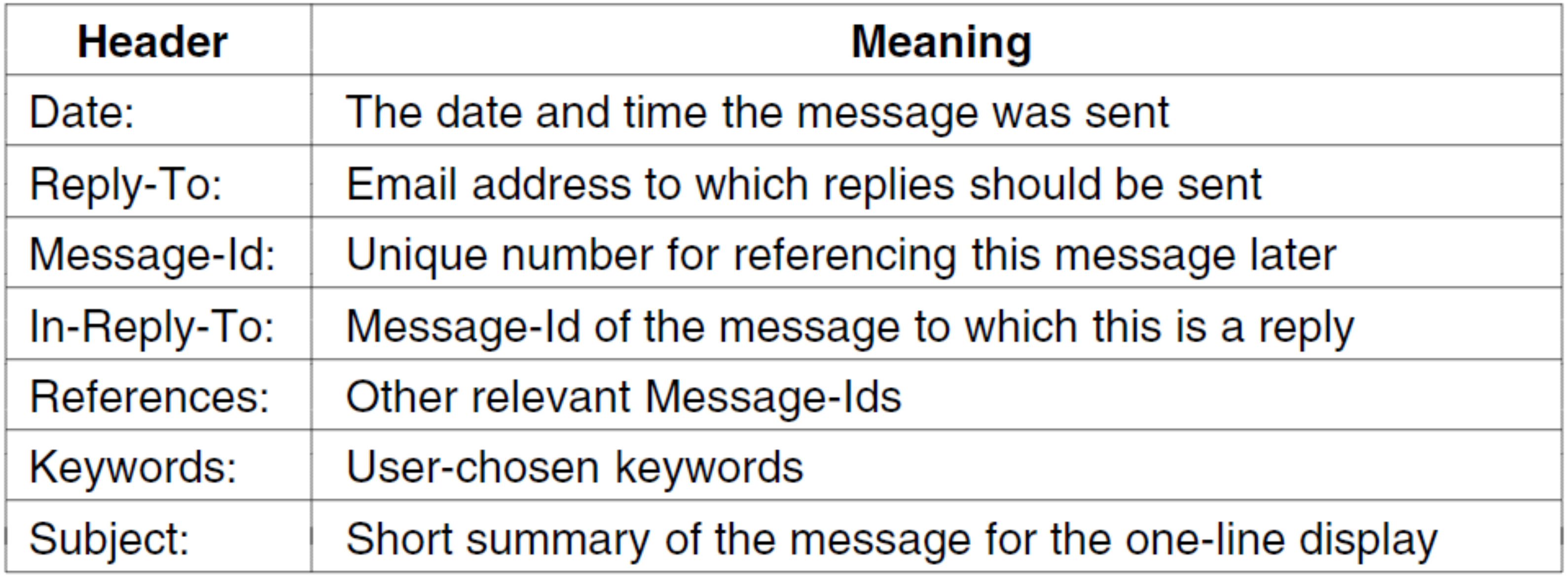
Example email

```
Received: from mtmail8b.butte.campus ([10.34.34.212]) by mtmail8a.butte.campus
 ([10.34.34.211]) with mapi; Wed, 9 Nov 2011 15:53:59 -0700
From: "Evenson, Shaela" <SEvenson@mtech.edu>
To: All Faculty <all_faculty_users@mtech.edu>
Date: Wed, 9 Nov 2011 15:51:22 -0700
Subject: Volleyball Excuse List
Thread-Topic: Volleyball Excuse List
Thread-Index: AQHMnzJ3kOLNFJy+q0SZzTt4MMegZg==
Message-ID:
 <AEC2139945463246967DF069BB2FA52153C220898F@mtmail8b.butte.campus>
Accept-Language: en-US
Content-Language: en-US
X-MS-Exchange-Organization-AuthAs: Internal
X-MS-Exchange-Organization-AuthMechanism: 04
X-MS-Exchange-Organization-AuthSource: mtmail8a.butte.campus
Content-Type: text/plain; charset="us-ascii"
Content-Transfer-Encoding: quoted-printable
MIME-Version: 1.0

Please excuse the following student athletes from class this Thursday, Nove=
mber 10th at 3:00pm and all day Friday, November 11th.
…
```

Some RFC 5322 header fields



Header	Meaning
To:	Email address(es) of primary recipient(s)
Cc:	Email address(es) of secondary recipient(s)
Bcc:	Email address(es) for blind carbon copies
From:	Person or people who created the message
Sender:	Email 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



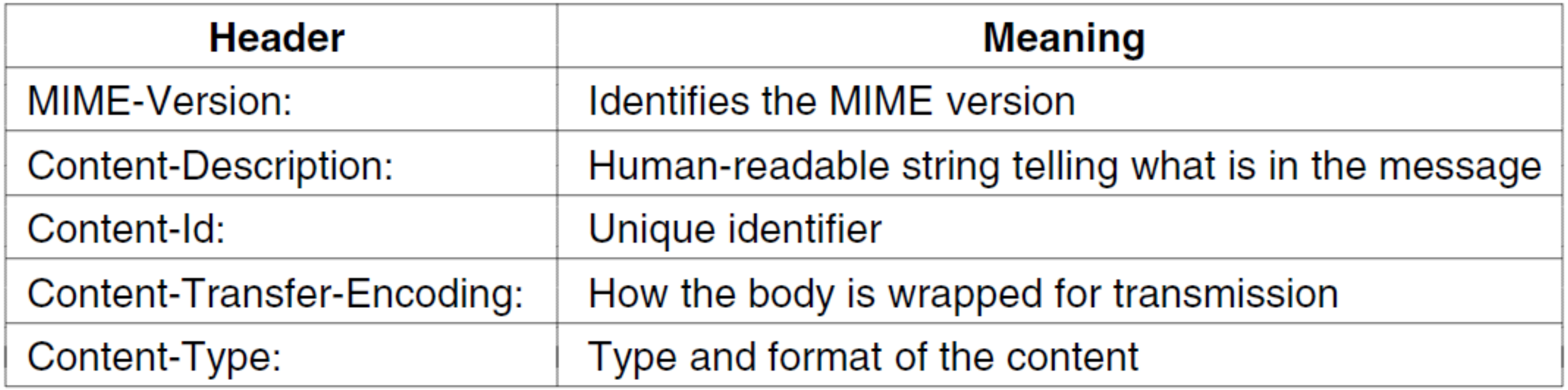
Header	Meaning
Date:	The date and time the message was sent
Reply-To:	Email address to which replies should be sent
Message-Id:	Unique number for referencing this message later
In-Reply-To:	Message-Id of the message to which this is a reply
References:	Other relevant Message-Ids
Keywords:	User-chosen keywords
Subject:	Short summary of the message for the one-line display

Sending more complex things

- Users often want to send multiple things
  - A message plus multiple attachments
  - A message in different forms: plaintext and HTML version
  - A mailing list digest, messages from a bunch of people
- Users may want to send non-ASCII
  - ¿Qué pasa si usted quiere hablar español?
  - Binary files
- Message body can contain anything
  - Use some sort of known separator between parts
  - Need a standard to ensure interoperability

MIME

- Multipurpose Internet Mail Extensions (MIME)
  - A series of RFCs, 2045-2047, 4288, 4289, 2049
- Addresses a number of issues:
  - Sending non-ASCII data
    - Other languages
    - Binary files, e.g. images, PDFs, videos
  - Sending multiple parts

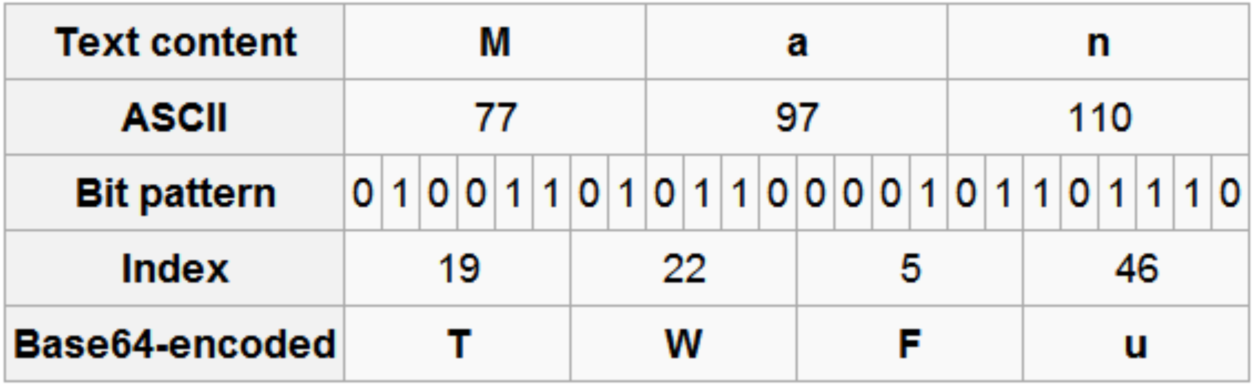


Header	Meaning
MIME-Version:	Identifies the MIME version
Content-Description:	Human-readable string telling what is in the message
Content-Id:	Unique identifier
Content-Transfer-Encoding:	How the body is wrapped for transmission
Content-Type:	Type and format of the content

Additional message headers defined by MIME.

Sending non-text data

- Problem: Email body, 7-bit US ASCII
- Solution: Convert non-ASCII to ASCII
- Base64 encoding (uuencode):
  - Group data in blocks of three bytes
  - Split each block into four 6-bit chunks
  - 0->A, 1->B, …, 51->z, 52->0, 53->1, …, 62->+, 63->/
  - If needed, pad last block with = signs to make four chunks



Text content	**M**								**a**								**n**							
ASCII	77								97								110							
Bit pattern	0	1	0	0	1	1	0	1	0	1	1	0	0	0	0	1	0	1	1	0	1	1	1	0
Index	19						22						5						46					
Base64-encoded	**T**						**W**						**F**						**u**					

Example base64 email

```
From: Keith Vertanen <kvertanen@mtech.edu>
To: "Vertanen, Keith" <KVertanen@mtech.edu>
Date: Tue, 29 Nov 2011 08:49:57 -0700
Subject: image
Message-ID: <4ED4FF25.9010309@mtech.edu>
Content-Type: multipart/mixed; boundary="_002_4ED4FF25
MIME-Version: 1.0

--_002_4ED4FF259010309mtechedu_
Content-Type: image/png; name="girl.png"
Content-Description: girl.png
Content-Disposition: attachment; filename="girl.png"; size=2
        creation-date="Tue, 29 Nov 2011 15:49:52 GMT";
        modification-date="Tue, 29 Nov 2011 15:49:52 G
Content-Transfer-Encoding: base64
```

iVBORw0KGgoAAAANSUhEUgAAACAAAAAgCAYAAABzenr0AAAABGdBTUEAALGPC/xhBQAAAAFzUkdC
AK7OHOkAAAAgY0hSTQAAeiYAAICEAAD6AAAAgOgAAHUwAADqYAAAOpgAABdwnLpRPAAAAAZiS0dE
....
AAAAJXRFWHRkYXRlOm1vZGlmeQAyMDExLTEwLTMwVDIyOjM1OjM0LTA2OjAwXfqg4wAAAABJRU5E
rkJggg==

```
--_002_4ED4FF259010309mtechedu_--
```

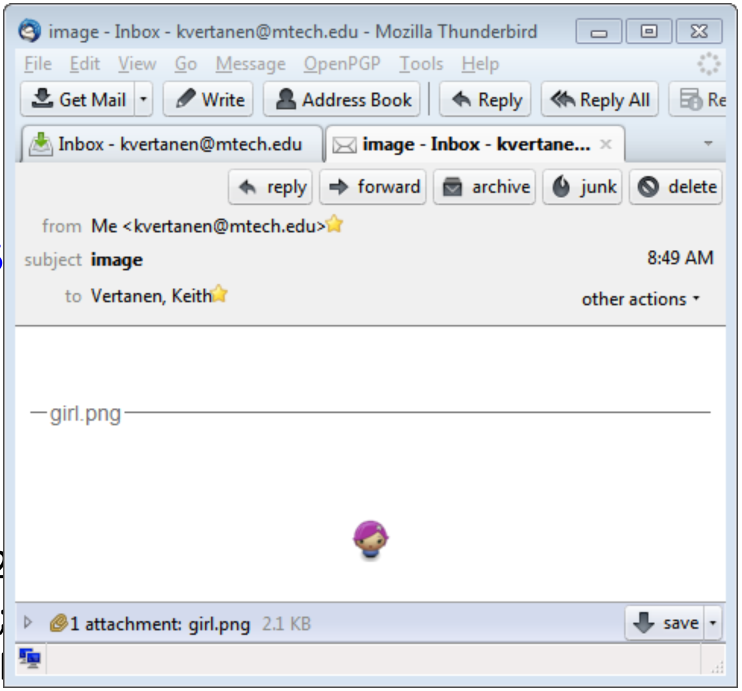


image - Inbox - kvertanen@mtech.edu - Mozilla Thunderbird
File Edit View Go Message OpenPGP Tools Help
Get Mail
Write
Address Book
Reply
Reply All
Re
Inbox - kvertanen@mtech.edu
image - Inbox - kvertane...
reply
forward
archive
junk
delete
other actions
save

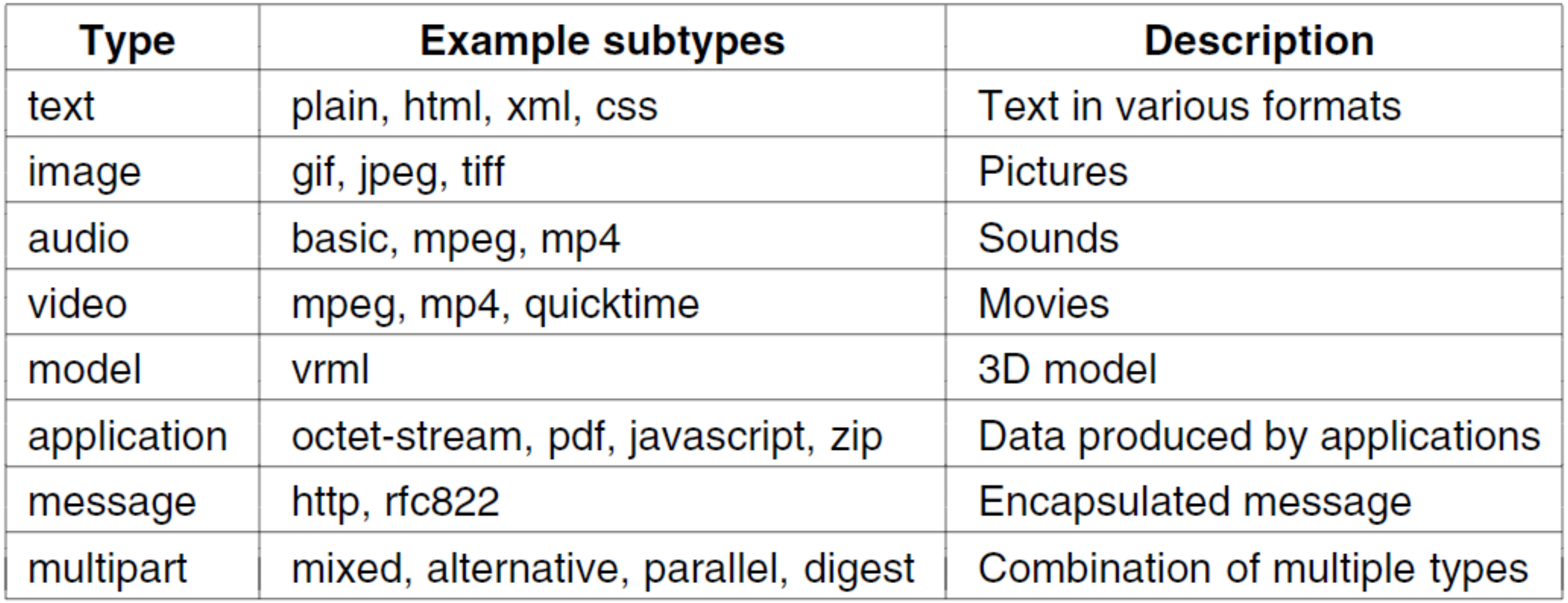
from Me <kvertanen@mtech.edu>
subject image 8:49 AM
to Vertanen, Keith

girl.png

1 attachment: girl.png 2.1 KB

MIME types

- Each part identified by type/subtype
  - Originally 7 types, now 9 with hundreds of subtypes
  - http://www.iana.org/assignments/media-types/index.html

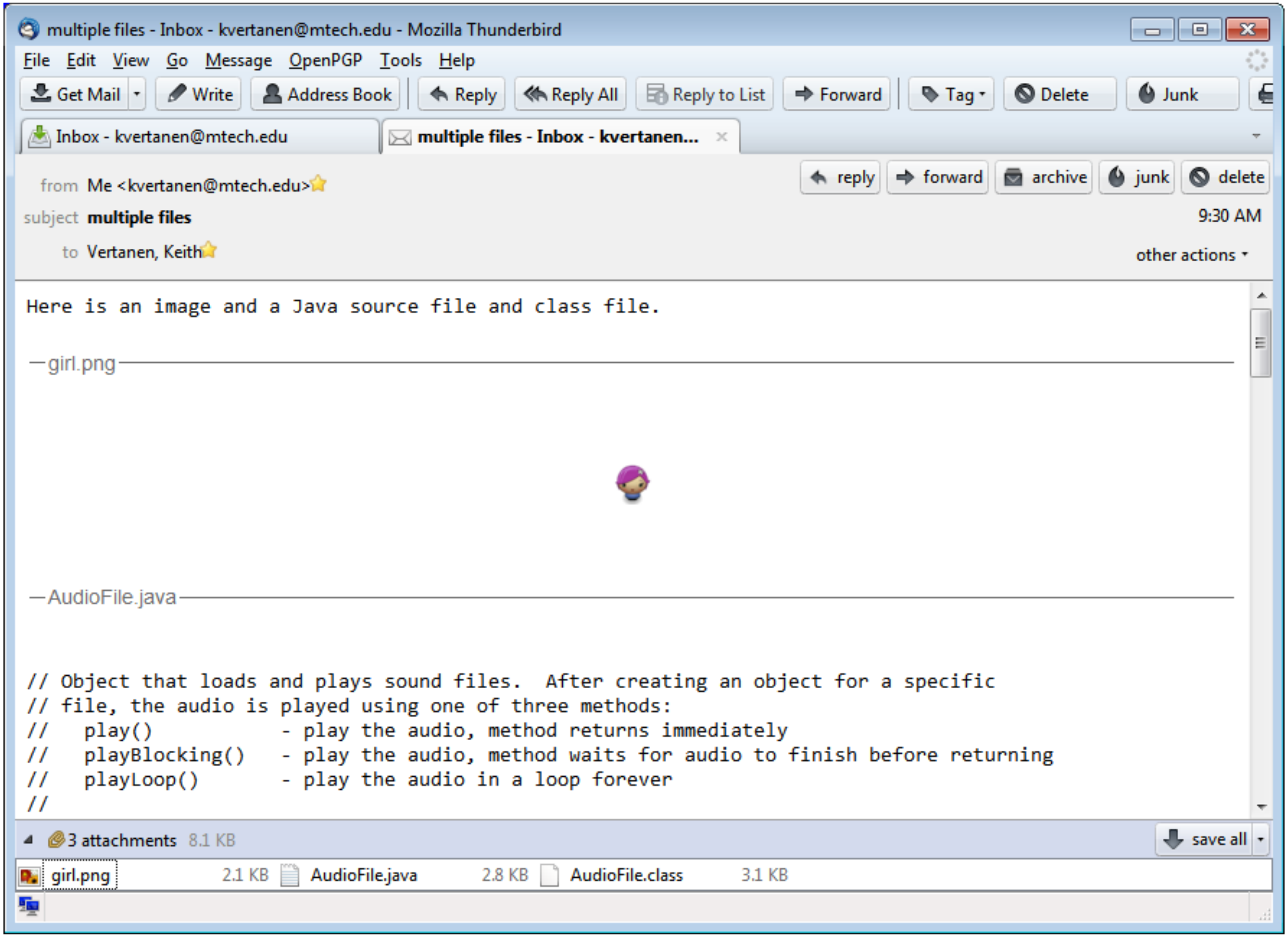


Type	Example subtypes	Description
text	plain, html, xml, css	Text in various formats
image	gif, jpeg, tiff	Pictures
audio	basic, mpeg, mp4	Sounds
video	mpeg, mp4, quicktime	Movies
model	vrml	3D model
application	octet-stream, pdf, javascript, zip	Data produced by applications
message	http, rfc822	Encapsulated message
multipart	mixed, alternative, parallel, digest	Combination of multiple types

MIME content types and some example subtypes.

multipart/mixed

- Each part a different type, e.g. multiple attachments


multiple files - Inbox - kvertanen@mtech.edu - Mozilla Thunderbird
File Edit View Go Message OpenPGP Tools Help
Get Mail
Write
Address Book
Reply
Reply All
Reply to List
Forward
Tag
Delete
Junk
Inbox - kvertanen@mtech.edu
multiple files - Inbox - kvertanen...
reply
forward
archive
junk
delete
other actions
save all

from Me <kvertanen@mtech.edu>

subject **multiple files**

to Vertanen, Keith

9:30 AM

```
Here is an image and a Java source file and class file.
```

girl.png

AudioFile.java

```
// Object that loads and plays sound files.  After creating an object for a specific
// file, the audio is played using one of three methods:
//   play()           - play the audio, method returns immediately
//   playBlocking()   - play the audio, method waits for audio to finish before returning
//   playLoop()       - play the audio in a loop forever
//
```

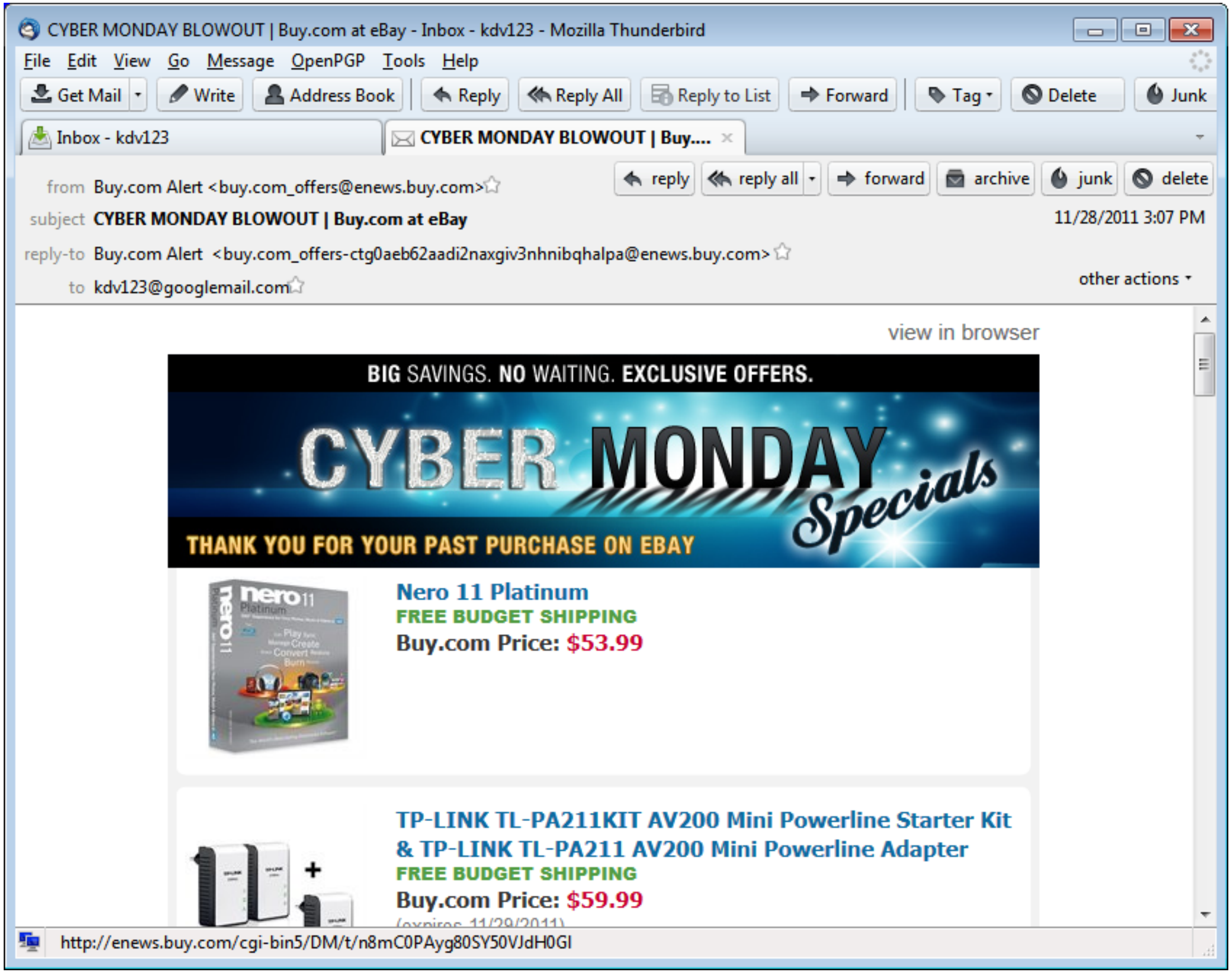
3 attachments 8.1 KB

girl.png	2.1 KB	AudioFile.java	2.8 KB	AudioFile.class	3.1 KB

```
…
Content-Type: multipart/mixed; boundary="_004_4ED508B68000103mtechedu_"
MIME-Version: 1.0

--_004_4ED508B68000103mtechedu_
Content-Type: text/plain; charset="iso-8859-1"
Content-Transfer-Encoding: quoted-printable

Here is an image and a Java source file and class file.

--_004_4ED508B68000103mtechedu_
Content-Type: image/png; name="girl.png"
Content-Description: girl.png
Content-Disposition: attachment; filename="girl.png"; size=2234;
Content-Transfer-Encoding: base64

iVBORw0KGgoAAAANSUhEUgAAACrkJggg==

--_004_4ED508B68000103mtechedu_
Content-Type: text/plain; name="AudioFile.java"
Content-Description: AudioFile.java
Content-Disposition: attachment; filename="AudioFile.java"; size=2968;
Content-Transfer-Encoding: base64

Ly8gT2JqZWN0IHRoYXQgbG9hZHMgYW5kIHBsYXlzIHNvdW5kIGZpbGVzLiAgQWZ0ZXIgY3JlYXRp
…
```

multipart/alternative

- Parts are different forms of the same content


CYBER MONDAY BLOWOUT | Buy.com at eBay - Inbox - kdv123 - Mozilla Thunderbird
File Edit View Go Message OpenPGP Tools Help
Get Mail
Write
Address Book
Reply
Reply All
Reply to List
Forward
Tag
Delete
Junk
Inbox - kdv123
CYBER MONDAY BLOWOUT | Buy....
reply
reply all
forward
archive
junk
delete
other actions
view in browser

from Buy.com Alert <buy.com_offers@enews.buy.com>

subject **CYBER MONDAY BLOWOUT | Buy.com at eBay**

11/28/2011 3:07 PM

reply-to Buy.com Alert <buy.com_offers-ctg0aeb62aadi2naxgiv3nhnibqhalpa@enews.buy.com>

to kdv123@googlemail.com

BIG SAVINGS. NO WAITING. EXCLUSIVE OFFERS.
CYBER MONDAY Specials
THANK YOU FOR YOUR PAST PURCHASE ON EBAY

Nero 11 Platinum
FREE BUDGET SHIPPING
Buy.com Price: $53.99

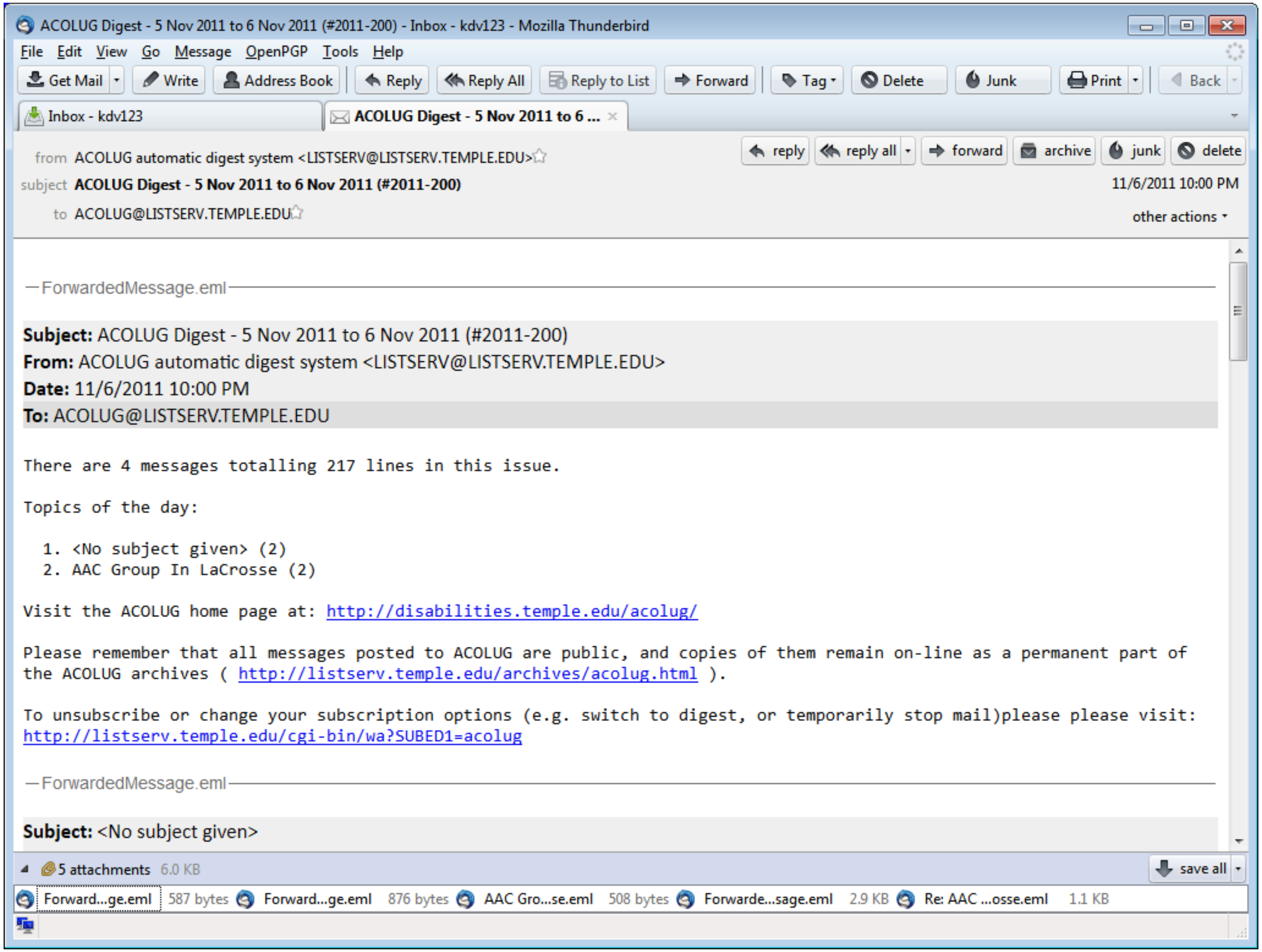
TP-LINK TL-PA211KIT AV200 Mini Powerline Starter Kit & TP-LINK TL-PA211 AV200 Mini Powerline Adapter
FREE BUDGET SHIPPING
Buy.com Price: $59.99
(expires 11/29/2011)

http://enews.buy.com/cgi-bin5/DM/t/n8mC0PAyg80SY50VJdH0GI

```
…
Subject: CYBER MONDAY BLOWOUT | Buy.com at eBay
MIME-Version: 1.0
Content-Type: multipart/alternative; boundary="----000000000000000000000000000000"

------ 000000000000000000000000000000
Content-Type: text/plain; charset="utf-8"
Content-Transfer-Encoding: 8bit

Join us on:

View In Browser
http://enews.buy.com/cgi-bin5/DM/t/m8mC0PAyg80SY50VJdG0Hl

------ 000000000000000000000000000000
Content-Type: text/html; charset="utf-8"
Content-Transfer-Encoding: 8bit

<HTML><HEAD><TITLE></TITLE><STYLE type=text/css>
   <!--
   a:link {text-decoration: none}
…
```

multipart/digest

- Combine messages in a mailing list


ACOLUG Digest - 5 Nov 2011 to 6 Nov 2011 (#2011-200) - Inbox - kdv123 - Mozilla Thunderbird
File Edit View Go Message OpenPGP Tools Help
Get Mail
Write
Address Book
Reply
Reply All
Reply to List
Forward
Tag
Delete
Junk
Print
Back
Inbox - kdv123
ACOLUG Digest - 5 Nov 2011 to 6 ...
reply
reply all
forward
archive
junk
delete
other actions
5 attachments 6.0 KB
save all
Forward...ge.eml 587 bytes
Forward...ge.eml 876 bytes
AAC Gro...se.eml 508 bytes
Forwarde...sage.eml 2.9 KB
Re: AAC ...osse.eml 1.1 KB

from ACOLUG automatic digest system <LISTSERV@LISTSERV.TEMPLE.EDU>
subject **ACOLUG Digest - 5 Nov 2011 to 6 Nov 2011 (#2011-200)**
to ACOLUG@LISTSERV.TEMPLE.EDU

11/6/2011 10:00 PM

—ForwardedMessage.eml—

Subject: ACOLUG Digest - 5 Nov 2011 to 6 Nov 2011 (#2011-200)
From: ACOLUG automatic digest system <LISTSERV@LISTSERV.TEMPLE.EDU>
Date: 11/6/2011 10:00 PM
To: ACOLUG@LISTSERV.TEMPLE.EDU

```
There are 4 messages totalling 217 lines in this issue.

Topics of the day:

  1. <No subject given> (2)
  2. AAC Group In LaCrosse (2)

Visit the ACOLUG home page at: http://disabilities.temple.edu/acolug/

Please remember that all messages posted to ACOLUG are public, and copies of them remain on-line as a permanent part of
the ACOLUG archives ( http://listserv.temple.edu/archives/acolug.html ).

To unsubscribe or change your subscription options (e.g. switch to digest, or temporarily stop mail)please please visit:
http://listserv.temple.edu/cgi-bin/wa?SUBED1=acolug
```

—ForwardedMessage.eml—

Subject: <No subject given>

```
...
MIME-Version: 1.0
Content-Type: multipart/digest; boundary="LZQGCUJHLICPcMVULTPFREXCMLdADY"

--LZQGCUJHLICPcMVULTPFREXCMLdADY

Date:     Mon, 7 Nov 2011 00:00:28 -0500
From:     ACOLUG automatic digest system <LISTSERV@LISTSERV.TEMPLE.EDU>
Subject: ACOLUG Digest - 5 Nov 2011 to 6 Nov 2011 (#2011-200)
To:       ACOLUG@LISTSERV.TEMPLE.EDU
Message-ID: <ACOLUG%201111070000287422.2EEF@LISTSERV.TEMPLE.EDU>
List-Unsubscribe: <mailto:ACOLUG-unsubscribe-request@LISTSERV.TEMPLE.EDU>
List-Subscribe: <mailto:ACOLUG-subscribe-request@LISTSERV.TEMPLE.EDU>

There are 4 messages totalling 217 lines in this issue.

  1. <No subject given> (2)
  2. AAC Group In LaCrosse (2)

--LZQGCUJHLICPcMVULTPFREXCMLdADY

Date:    Sun, 6 Nov 2011 14:41:10 -0500
...
```

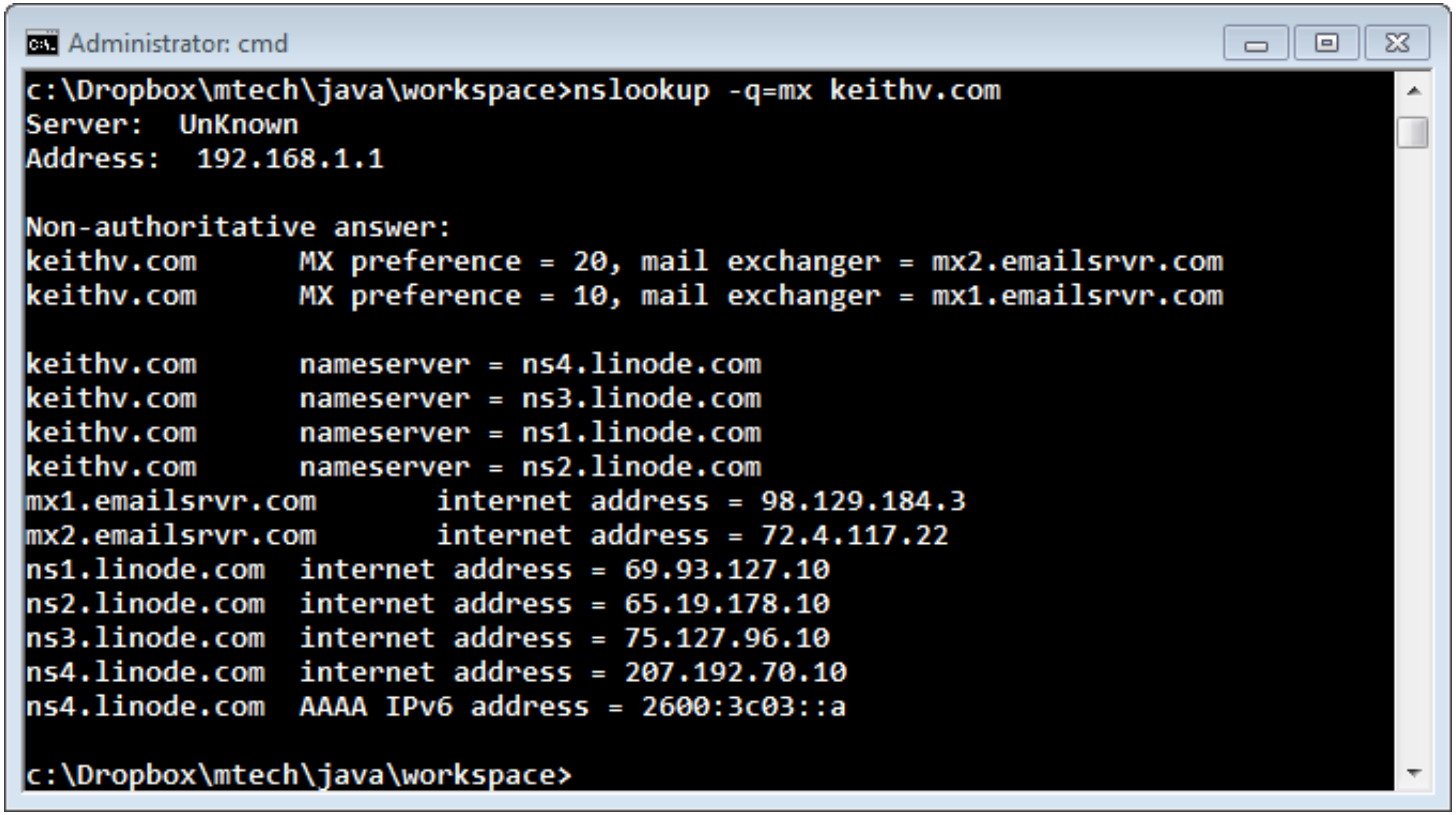
Email addresses

- username@company.tld
  - Local mailbox on the left of @
  - Domain name on the right of @
- Domain name not necessarily same as mail server
  - Mail may live on different server than say web server
  - Multiple mail servers for failover

valid email	invalid email
niceandsimple@example.com	Abc.example.com
a.little.unusual@example.com	A@b@c@example.com
much."more\ unusual"@example.com	"(),:;<>[\]@example.com
very.unusual."@".unusual.com@example.com	just"not"right@example.com
very."(),:;<>[]".VERY."very\\\ \@ \"very".unusual@strange.example.com	this\ is\"really\"not\\allowed@example.com

Email addresses

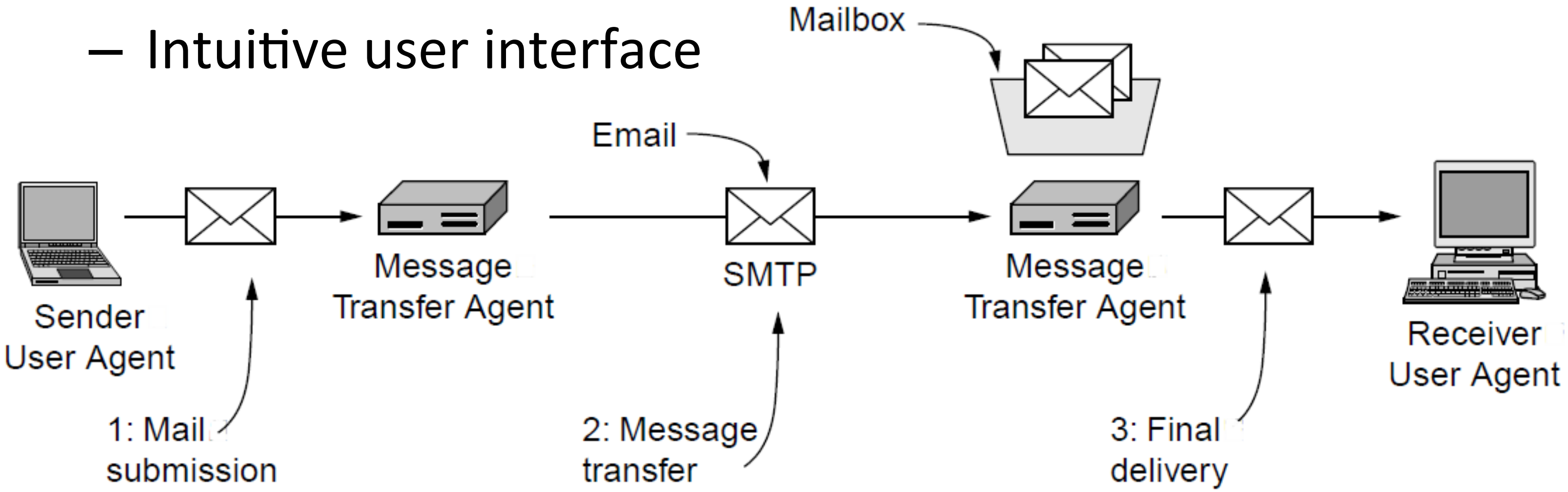
- Mapping domain to mail server
  - Make DNS query for MX record (Mail eXchange)
    - e.g. nslookup -q=mx keithv.com



```
c:\Dropbox\mtech\java\workspace>nslookup -q=mx keithv.com
Server:  UnKnown
Address:  192.168.1.1

Non-authoritative answer:
keithv.com      MX preference = 20, mail exchanger = mx2.emailsrvr.com
keithv.com      MX preference = 10, mail exchanger = mx1.emailsrvr.com

keithv.com      nameserver = ns4.linode.com
keithv.com      nameserver = ns3.linode.com
keithv.com      nameserver = ns1.linode.com
keithv.com      nameserver = ns2.linode.com
mx1.emailsrvr.com       internet address = 98.129.184.3
mx2.emailsrvr.com       internet address = 72.4.117.22
ns1.linode.com  internet address = 69.93.127.10
ns2.linode.com  internet address = 65.19.178.10
ns3.linode.com  internet address = 75.127.96.10
ns4.linode.com  internet address = 207.192.70.10
ns4.linode.com  AAAA IPv6 address = 2600:3c03::a

c:\Dropbox\mtech\java\workspace>
```

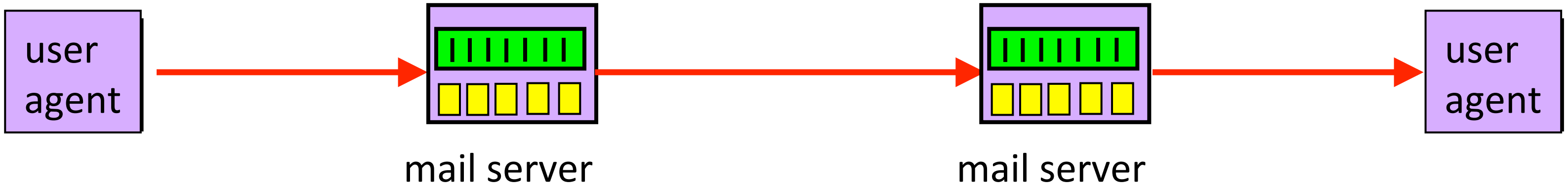
Mail servers and user agents

- Mail servers
  - Mail Transfer Agent (MTA), mail daemon
  - Always on
  - Transfer email to and from other servers
- User agents
  - Sometimes on
  - Intuitive user interface



SMTP

- Simple Mail Transfer Protocol (SMTP)
  - Used to exchange email messages
  - Plaintext protocol running over TCP typically on port 25
  - Store-and-forward protocol
    - Messages sent through a series of servers
    - Servers queue messages and will retry on failure
    - Each hop adds its identity to the message "Received:" header



Email with received header

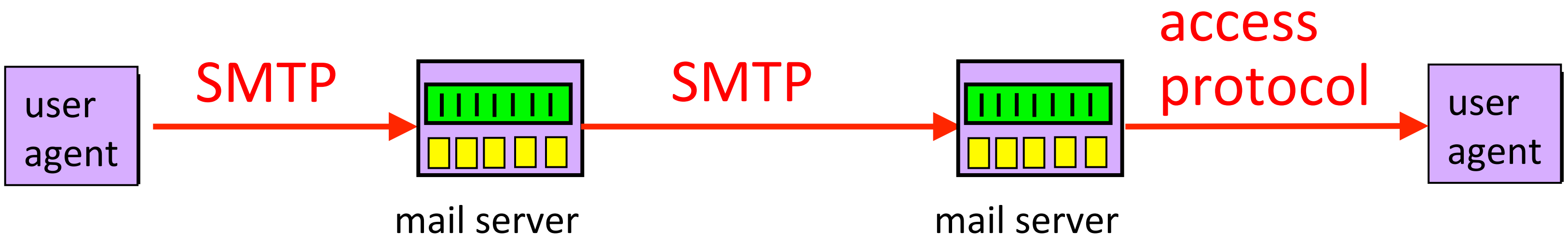
```
Received: from hermes.umt.edu (10.10.7.32) by mtmail8e.butte.campus
 (10.34.34.215) with Microsoft SMTP Server id 8.3.137.0; Mon, 28 Nov 2011
 14:43:39 -0700
Received: from umont01.umt.edu (umont01.umt.edu [10.249.8.16]) by
 hermes.umt.edu (8.13.8/8.13.8) with ESMTP id pASLhdt9003244 for
 <kvertanen@mtech.edu>; Mon, 28 Nov 2011 14:43:39 -0700
Received: from precisionconference.com ([204.232.241.168])  by umont01.umt.edu
 with ESMTP; 28 Nov 2011 14:43:39 -0700
Received: by precisionconference.com (Postfix, from userid 48) id
 58ED92DF80AC; Mon, 28 Nov 2011 16:43:38 -0500 (EST)
From: "do_not_reply@precisionconference.com"
                <do_not_reply@precisionconference.com>
To: "Vertanen, Keith" <KVertanen@mtech.edu>
Date: Mon, 28 Nov 2011 14:43:38 -0700
Subject: [IUI 2012 Short and Long Papers #319] Additional references
```

Multiple server hops

- Usually at least two server hops
  - Sending and receiving mail servers
- But sometimes more. Why?
  - Separate mail servers for different functions
    - e.g. Spam filtering, virus scanning
  - Servers may redirect message
    - e.g. Forwarding old email address to a new one
  - Electronic mailing lists
    - Mail delivered to a mailing list's server
    - Sent off to all the subscribers of the list

SMTP protocol

- Client-server protocol
  - Client is the sending machine
  - Server is the receiving machine
- Reliable data transfer
  - ASCII protocol running over TCP (port 25)
- Push protocol
  - Sending machine pushes the data to the receiver
  - Instead of having receiver periodically poll for data



SMTP

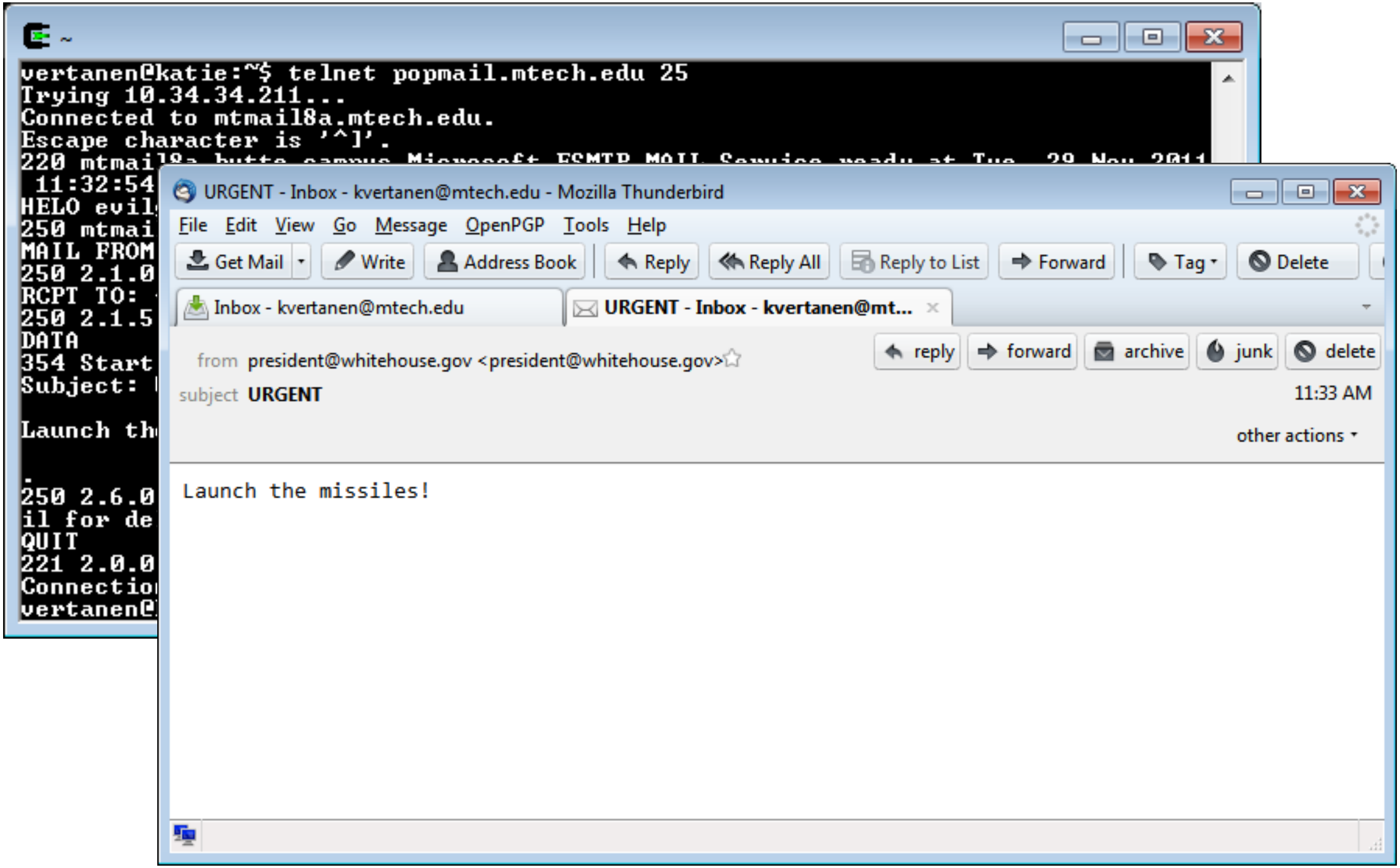
- Command/response protocol
  - Commands are 4-letter ASCII commands and usually some argument
  - Response is numeric code plus freeform human text
- Synchronous
  - Sender fire command and then waits for response
  - Pipelining added later (RFC 2920)
- Process:
  - Handshake
  - Transfer message(s)
  - Close connection

```
S: 220 smtp.example.com ESMTP Postfix
C: HELO relay.example.org
S: 250 Hello relay.example.org, I am glad to meet you
C: MAIL FROM:<bob@example.org>
S: 250 Ok
C: RCPT TO:<alice@example.com>
S: 250 Ok
C: RCPT TO:<theboss@example.com>
S: 250 Ok
C: DATA
S: 354 End data with <CR><LF>.<CR><LF>
C: From: "Bob Example" <bob@example.org>
C: To: "Alice Example" <alice@example.com>
C: Cc: theboss@example.com
C: Date: Tue, 15 Jan 2008 16:02:43 -0500
C: Subject: Test message
C:
C: This is a test message.
C: .
S: 250 Ok: queued as 12345
C: QUIT
S: 221 Bye
```

Trying SMTP for yourself

- Running SMTP
  - "telnet popmail.mtech.edu 25" at UNIX prompt
  - You'll get 220 reply from server
  - Enter HELO, MAIL FROM, RECPT TO, DATA commands
- Spoofing?
  - Yes, put whatever you like in "MAIL FROM"
  - Original SMTP didn't include authentication of senders
  - Caused big spam issues in the 90s
    - Now AUTH extension to SMTP
  - 9 out of 10 email messages are spam (McAfee 2010)

Manually sending an email



```
vertanen@katie:~$ telnet popmail.mtech.edu 25
Trying 10.34.34.211...
Connected to mtmail8a.mtech.edu.
Escape character is '^]'.
220 mtmail8a.butte.campus Microsoft ESMTP MAIL Service ready at Tue, 29 Nov 2011
 11:32:54
HELO evil
250 mtmai
MAIL FROM
250 2.1.0
RCPT TO:
250 2.1.5
DATA
354 Start
Subject:

Launch th

.
250 2.6.0
il for de
QUIT
221 2.0.0
Connectio
vertanen@
```

URGENT - Inbox - kvertanen@mtech.edu - Mozilla Thunderbird

from president@whitehouse.gov <president@whitehouse.gov>

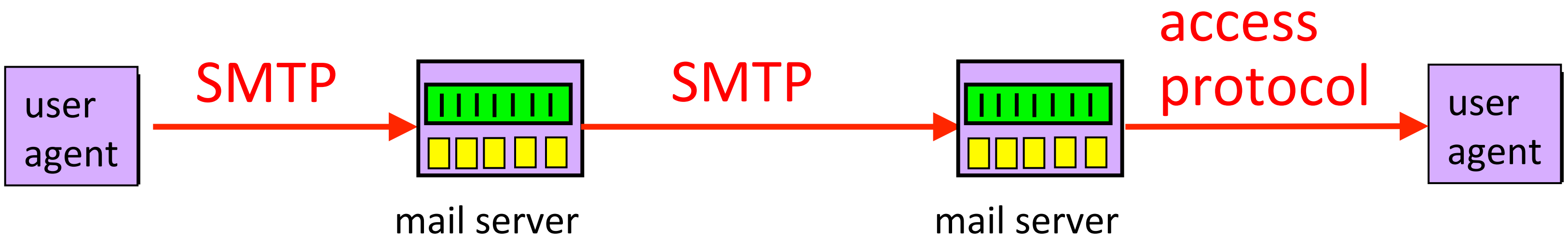
subject **URGENT**

11:33 AM

Launch the missiles!

Retrieving your email

- Mail server stores email by mailbox
  - Based on the "From:" field in the message
- User agent needs to retrieve
  - At some later point, not when message was sent
  - View the message, reply, organize and store
- In the olden days:
  - Telnet to main machine at work
  - Mail client read the mailbox directly

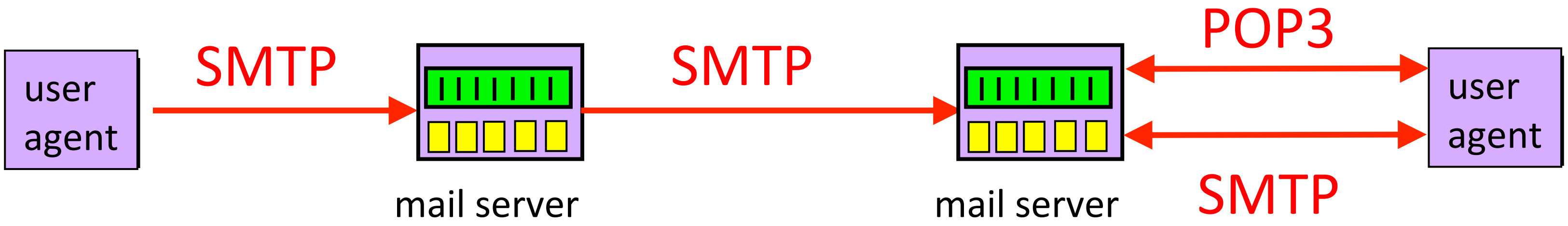


Modern email retrieval

- People access same email account from:
  - Desktop at work
  - Laptop at home
  - Smart phone
- Problems:
  - No single device
  - Devices are not always-on
- Led to the Post Office Protocol (POP)
  - Retrieve email from server when connected to network
  - Allow users to view/manipulate messages offline
  - TCP on port 110

Post Office Protocol (POP)

- Typical POP interaction:
  - Connect to server
  - Retrieve all email messages
  - Store messages on user's machine as new messages
  - Delete all the messages from the server
  - Disconnect from server
- User agent still uses SMTP to send messages



POP3 example

Authorization phase

- Client commands:
  - **user:** declare username
  - **pass:** password
- Server responses
  - **+OK**
  - **-ERR**

Transaction phase

- **list:** list message numbers
- **retr:** retrieve message by number
- **dele:** delete
- **quit**

```
S: +OK POP3 server ready
C: user bob
S: +OK
C: pass hungry
S: +OK user successfully logged on
```

```
C: list
S: 1 498
S: 2 912
S: .
C: retr 1
S: <message 1 contents>
S: .
C: dele 1
C: retr 2
S: <message 1 contents>
S: .
C: dele 2
C: quit
S: +OK POP3 server signing off
```

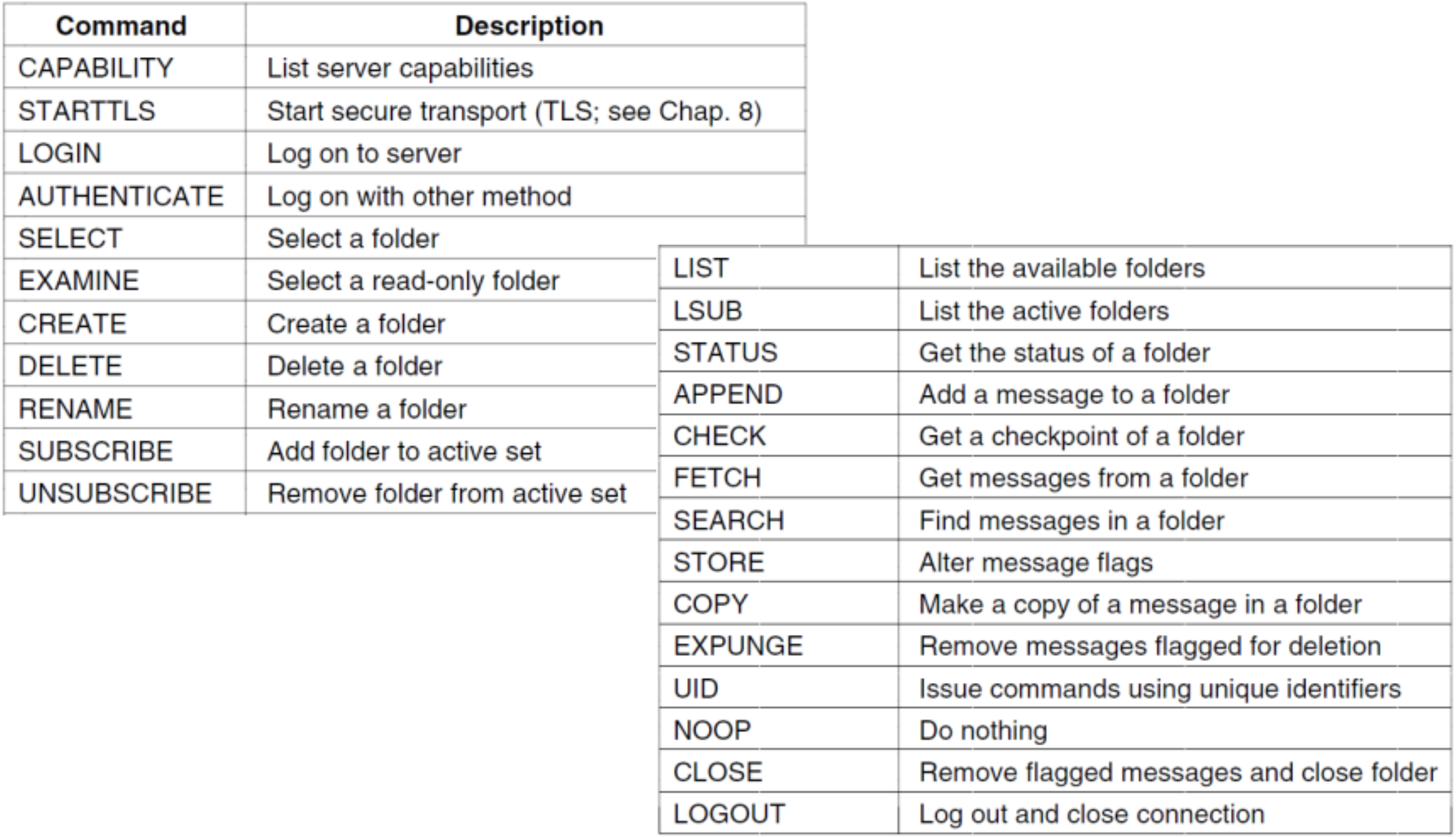
POP3 problems

- Not designed to keep messages on server
  - No way to track "read" state of messages across multiple client mail programs
- Does not handle multiple folders
  - Everything in one folder
- High bandwidth required
  - You can list message IDs and size
  - No search ability
  - Download entire message
  - TOP to view certain number of lines at top of message

IMAP

- Internet Message Access Protocol (IMAP)
  - Plaintext protocol, TCP port 143
- Multiple client programs can connect at once
  - Server tracks message state (read, replied to, deleted)
  - Server can synch changes between clients
- Access to MIME parts and partial fetch
  - Retrieve only parts of a message
  - e.g. Get the message but not any attachments
- Support for creating, renaming and deleting folders
- Search messages on server-side

IMAP commands



Command	Description
CAPABILITY	List server capabilities
STARTTLS	Start secure transport (TLS; see Chap. 8)
LOGIN	Log on to server
AUTHENTICATE	Log on with other method
SELECT	Select a folder
EXAMINE	Select a read-only folder
CREATE	Create a folder
DELETE	Delete a folder
RENAME	Rename a folder
SUBSCRIBE	Add folder to active set
UNSUBSCRIBE	Remove folder from active set
LIST	List the available folders
LSUB	List the active folders
STATUS	Get the status of a folder
APPEND	Add a message to a folder
CHECK	Get a checkpoint of a folder
FETCH	Get messages from a folder
SEARCH	Find messages in a folder
STORE	Alter message flags
COPY	Make a copy of a message in a folder
EXPUNGE	Remove messages flagged for deletion
UID	Issue commands using unique identifiers
NOOP	Do nothing
CLOSE	Remove flagged messages and close folder
LOGOUT	Log out and close connection

telnet popmail.mtech.edu 143

```
S: * OK The Microsoft Exchange IMAP4 service is ready.
C: ? CAPABILITY
S: * CAPABILITY IMAP4 IMAP4rev1 AUTH=NTLM AUTH=GSSAPI AUTH=PLAIN STARTTLS
IDLE NAMESPACE LITERAL+
C: ? list "" "*"
S: * LIST (\HasNoChildren) "/" "Deleted Items"
S: * LIST (\HasNoChildren) "/" Drafts
S: * LIST (\Marked \HasNoChildren) "/" INBOX
S: * LIST (\HasNoChildren) "/" Sent
C: ? SELECT INBOX
S: * 1251 EXISTS
S: * 0 RECENT
S: * FLAGS (\Seen \Answered \Flagged \Deleted \Draft $MDNSent)
S: * OK [PERMANENTFLAGS (\Seen \Answered \Flagged \Deleted \Draft $MDNSent)]
Permanent flags
S: * OK [UIDVALIDITY 535045] UIDVALIDITY value
S: * OK [UIDNEXT 1422] The next unique identifier value
```

telnet popmail.mtech.edu 143

```
C: ? FETCH 1250:1251 flags
S: * 1250 FETCH (FLAGS (\Seen \Deleted))
S: * 1251 FETCH (FLAGS (\Seen))
C: ? FETCH 1251 rfc822.header
S: * 1251 FETCH (RFC822.HEADER {736}
S: MIME-Version: 1.0
S: Received: from evilgenius.com (10.33.73.166) by mtmail8a.butte.campus
 (10.34.34.211) with Microsoft SMTP Server id 8.3.137.0; Tue, 29 Nov 2011
 11:33:32 -0700
S: From: "president@whitehouse.gov" <president@whitehouse.gov>
S: Date: Tue, 29 Nov 2011 11:33:32 -0700
S: Subject: URGENT
S: Content-Type: text/plain; charset="iso-8859-1"
S: Content-Transfer-Encoding: quoted-printable
C: ? FETCH 1251 rfc822.header
S: * 1251 FETCH (RFC822.TEXT {24}
S: Launch the missiles!
S: FLAGS (\Seen))
C: ? LOGOUT
S: * BYE Microsoft Exchange Server 2007 IMAP4 server signing off.
```

Web-based email

- User agent is a web browser
  - Network protocol is HTTP
  - e.g. Gmail, Yahoo mail, Hotmail
- Reading email
  - Web page displays folders and messages
  - HTTP "GET" request to retrieve pages
- Sending email
  - Web form that does a "POST" to submit message
  - Webmail provider sends message via SMTP

Summary

- Application protocols we've seen so far:
  - Finding IP addresses: DNS
  - Web: HTTP
  - Email: SMTP, POP3, IMAP4
- Electronic email
  - Format of messages specified originally by RFC 822
  - MIME allows multiple parts, binary data
  - SMTP for sending email
  - POP3, IMAP4, or HTTP for retrieving to mail