CONTENT of this CHAPTER

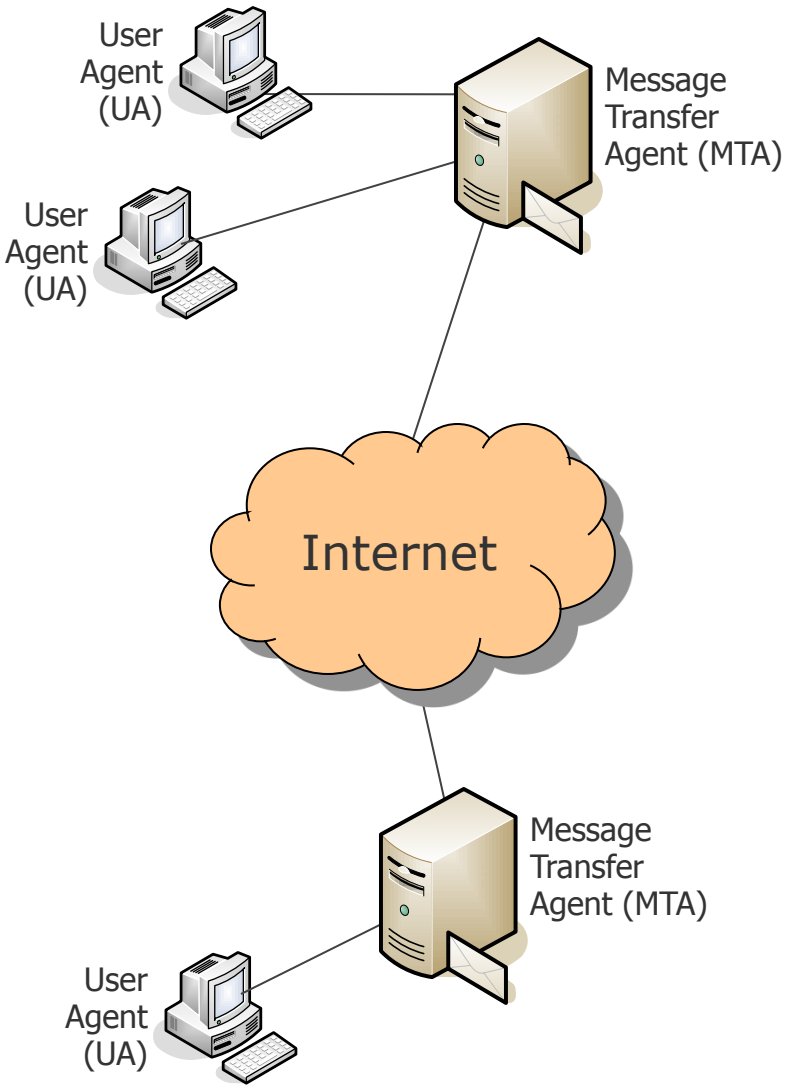
- DNS
- HTTP and WWW
- EMAIL
- SNMP

Electronic Mail (Email)

- The first killer application of the Internet!
- Early systems started in the 1980s
  - Mail via command line of a terminal: simple file transmission took place, with the convention that the first line contains the address of the receiver of the file.
- Rise of webmail in the 1990s
  - Hotmail popularized web-based email access service, launched in 1996
- Rise of mobile email in the 2000s
  - The first killer app for mobile Internet, before the advent of smartphones!
- Merging email/IM/SMS/posts in the 2010s
  - Social networks are currently trying to "swallow" email (and everything else too)

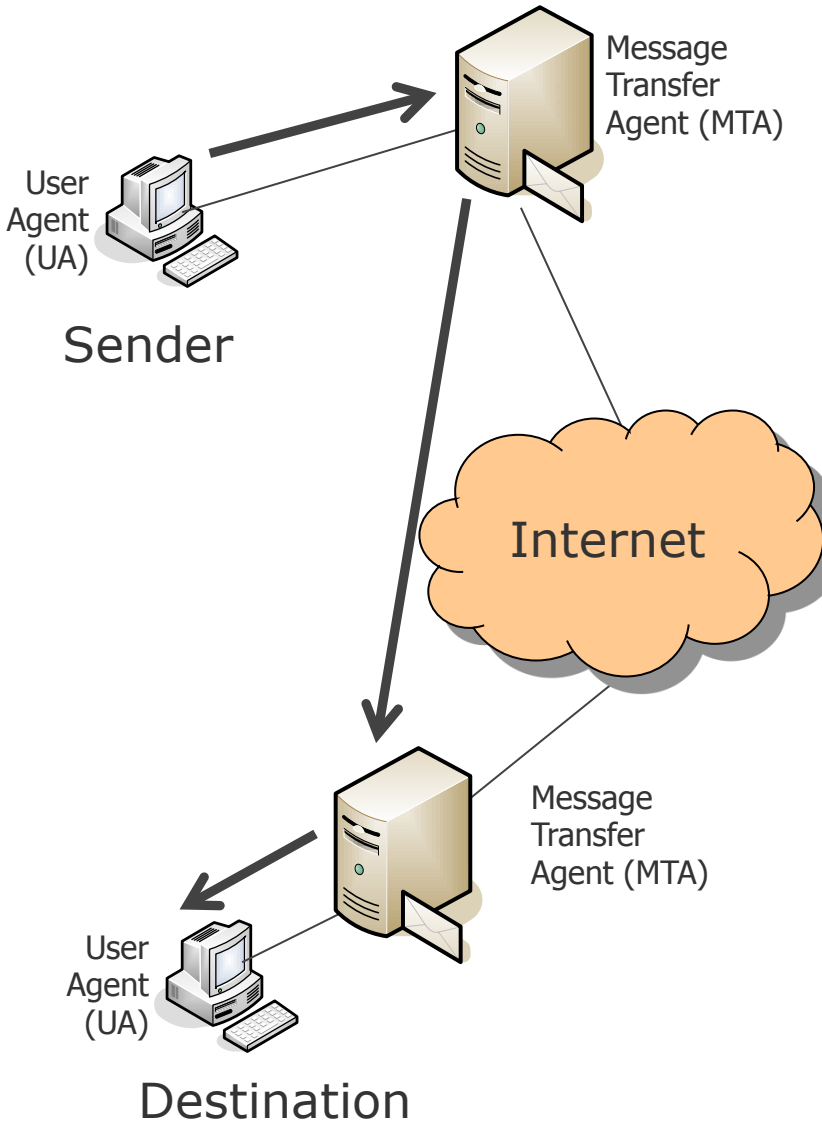
Electronic Mail (Email): Architecture

- User Agent (UA)
  - **Email clients**
  - Runs on the computer of the user
  - Intermittently on
  - Receipt and presentation of email
  - Compose new or answer received email
  - Implementations: Thunderbird, Outlook…
- Message Transfer Agent (MTA)
  - **Email servers**
  - Runs on a remote machine
  - Stores/forwards emails on behalf of Uas
  - Always on, but best-effort service
  - UAs each attach to an MTA
  - Implementations: Microsoft Exchange, Zimbra, Open-Xchange…



Electronic Mail (Email): Architecture

- Phase 1: email transfer
- Phase 2: email access

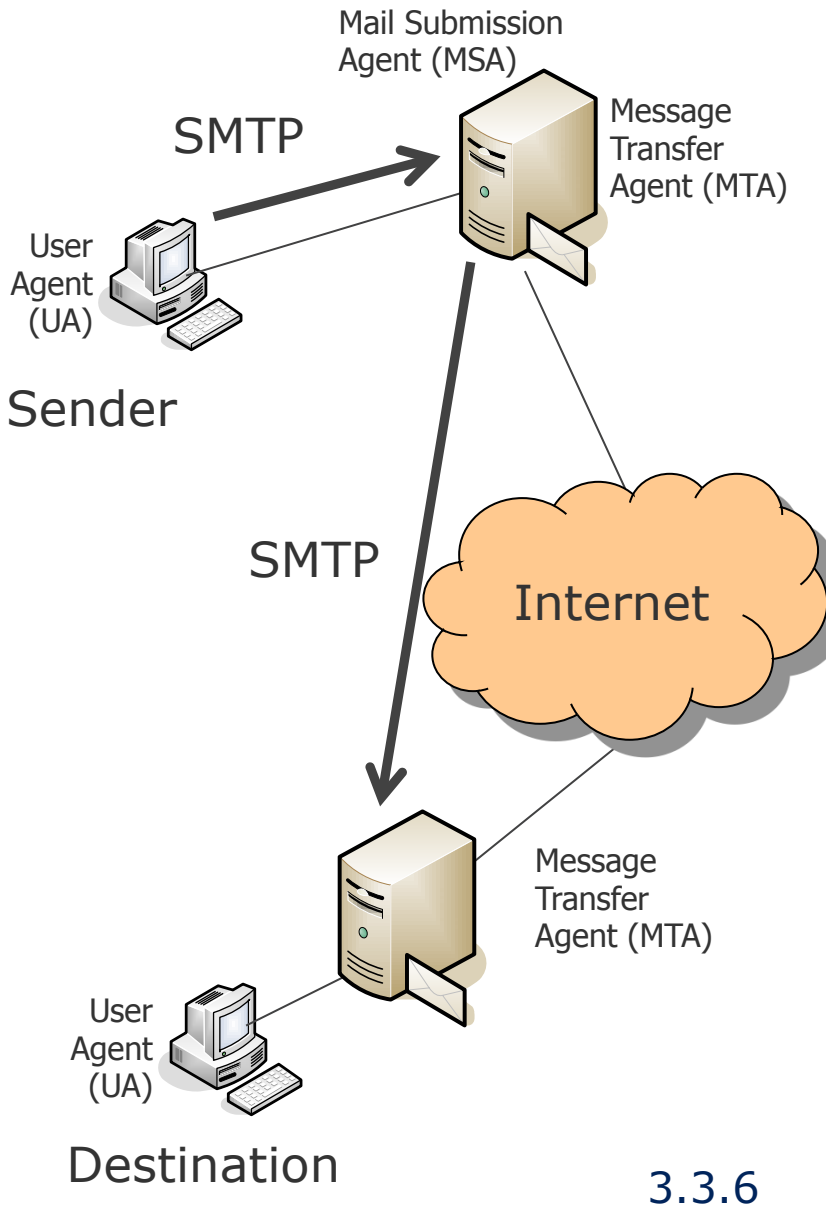


About Electronic Mail (Email)

- Transfer: email push with SMTP protocol
- Access: email pull with POP3, IMAP or HTTP
- Email Format

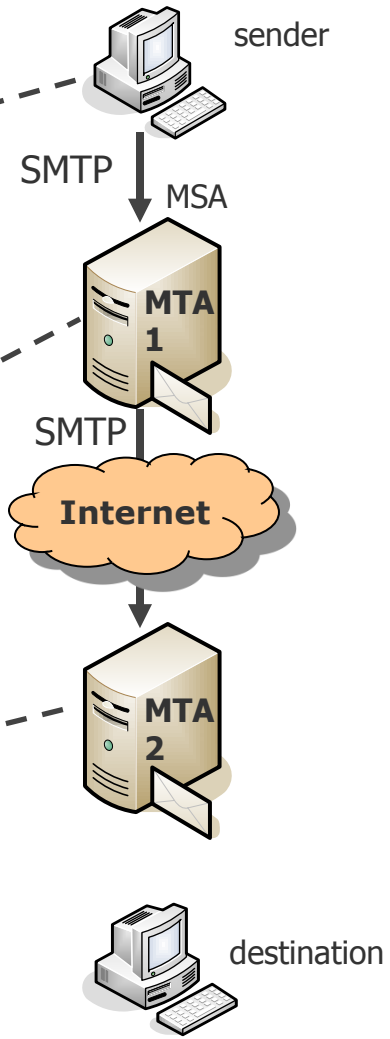
Email Transfer: SMTP

- Simple Mail Transfer Protocol (SMTP)
  - RFC 5321
  - Sends messages through port 25
  - SMTP is a simple ASCII protocol
  - No checksums, no encryption
  - SMTP uses port 587 to reach MSA (RFC 6409), with authentication



Email Transfer with SMTP

- User 1: writes an email
- Client 1 (UA 1): formats the email, produces the receiver list, and sends the email to its mail server (MSA of MTA 1, through port 587)
- Server 1 (MTA 1): Sets up a connection to the destination's SMTP server (MTA 2) on port 25 and sends a copy of the email
- Server (MTA 2): Produces the header of the email and places the email into the destination's mailbox



SMTP Command Sequence between MTAs

Example of communication between two MTAs (from abc.com to beta.edu)
Messages are in ASCII 7 bits.

S: 220 <beta.edu> Service Ready	/* Receiver is ready/*
C: EHLO <abc.com>	/* Identification of the sender/*
S: 250 <beta.edu> OK	/* Server announces itself */
C: MAIL FROM:<bob@abc.com>	/* Sender of the email */
S: 250 OK	/* Sending is permitted */
C: RCPT TO:<alice@beta.edu>	/* Receiver of the email */
S: 250 OK	/* Receiver known */
C: DATA	/* The data is following */
S: 354 Start mail inputs; end with "<crlf>.<crlf>" on a line by itself	
C: Hi dude, let's meet at 8PM.<crlf>.<crlf>	/* Transfer of the whole email, including all headers. */
S: 250 OK	
C: QUIT	
S: 221 <beta.edu> Server Closing	/* Terminating the connection */

S = server, receiving MTA / C = Client, sending MTA

About Electronic Mail (Email)

- Transfer: email push with SMTP protocol
- Access: email pull with POP3, IMAP or HTTP
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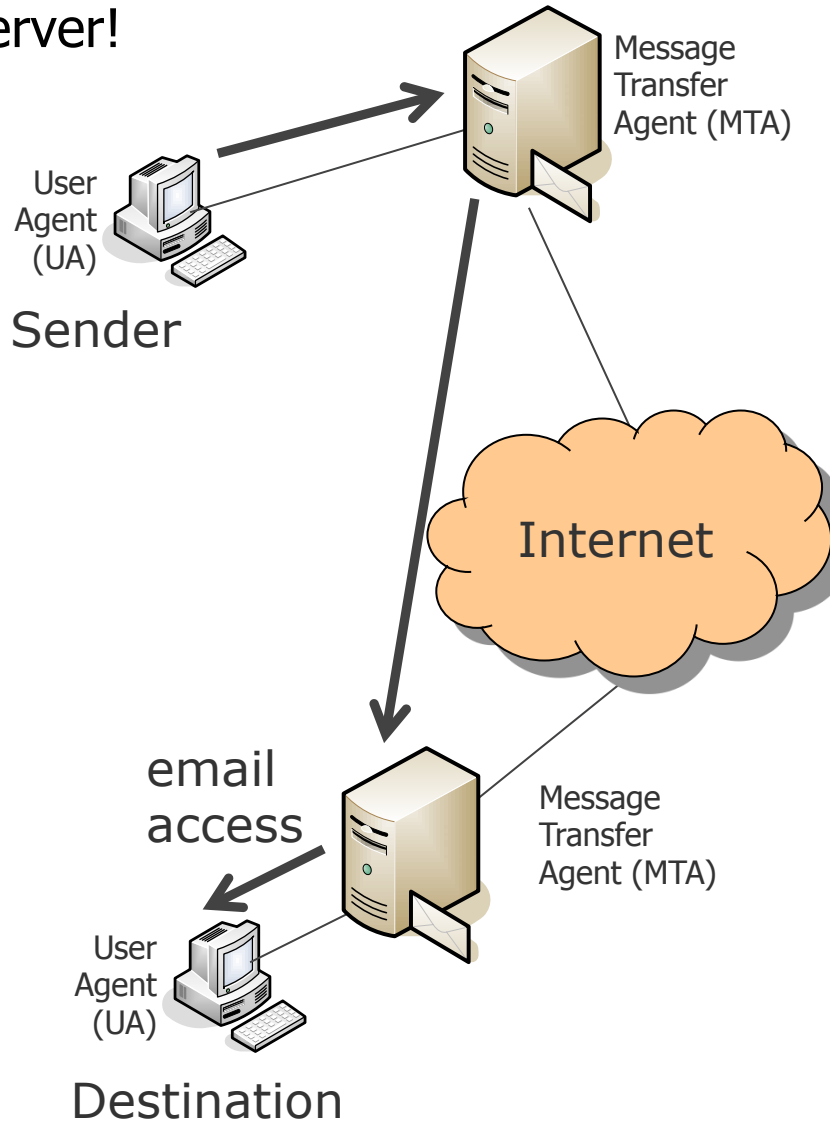
Email Access

- Still needs to pull emails from your mail server!

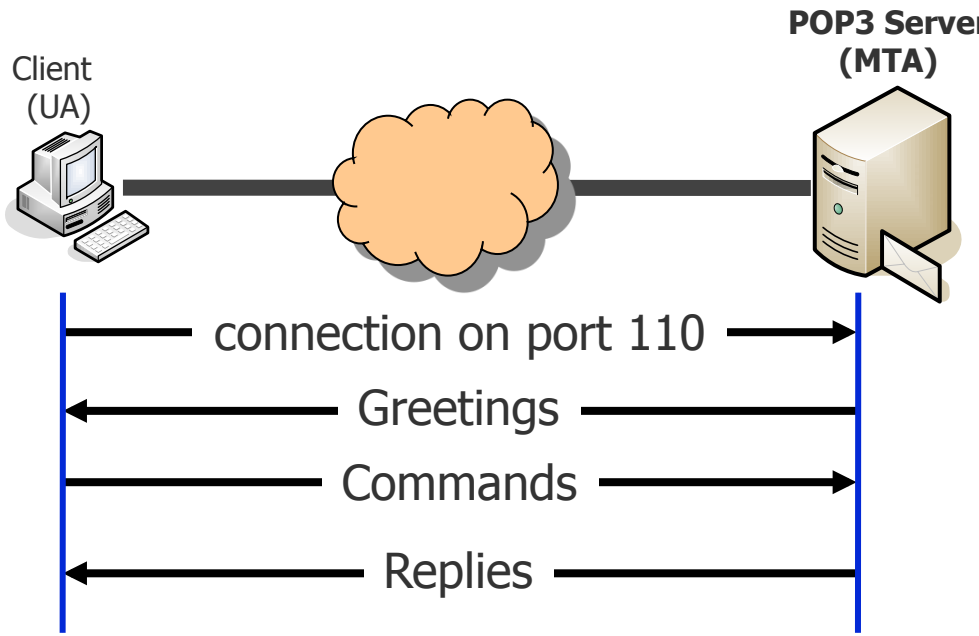


- Email access protocols
  - Post Office Protocol version 3 (POP3)
  - Internet Message Access Protocol (IMAP)
  - HTTP

Accessing Emails with POP3

- Specified in RFC 1939
  - Pull emails from the server over a connection on port 110
  - Text-based (ASCII)
  - Basic functionality. Only:
    - Logging in/out
    - Copy emails to the local computer
    - Deleting emails from the server
- Phase 1: Authorization
  - Commands: USER name, PASS string
- Phase 2: Transaction
  - Commands: LIST [msg], RETR msg, DELE msg, QUIT, NOOP, RSET, STAT

Get emails from the server with POP3



Accessing Emails with POP3: Example

- Authorization phase
  - user identifies the user
  - pass is its password
  - +OK or -ERR are possible server answers

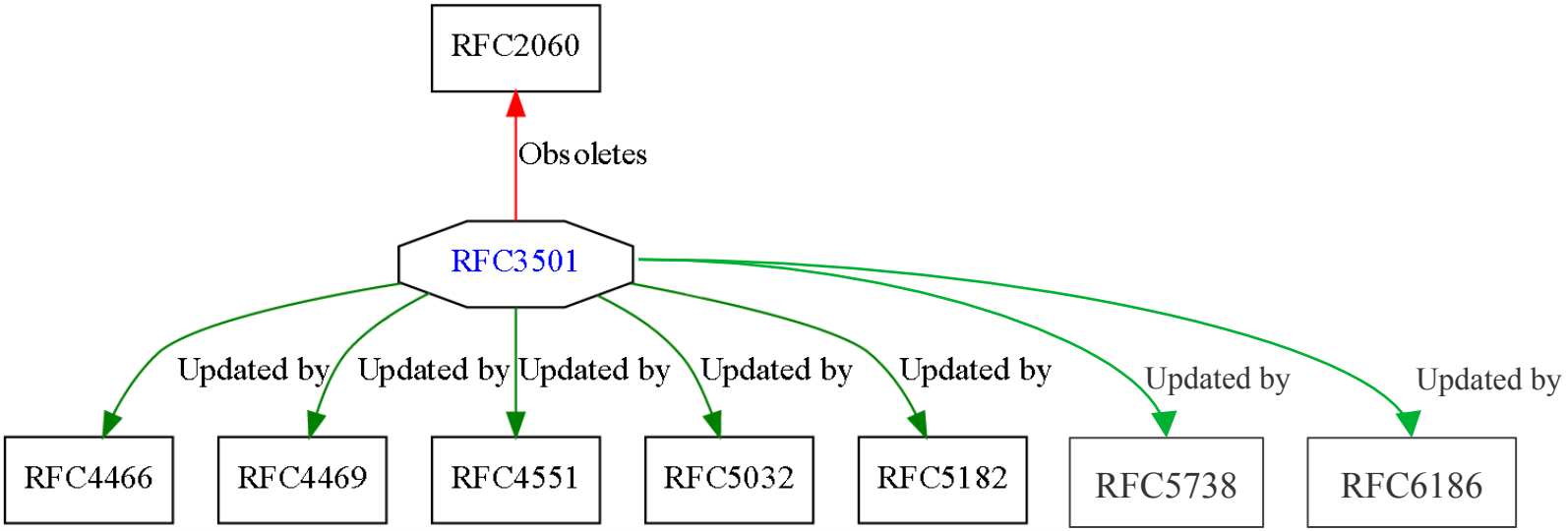
```
S: +OK POP3 server ready
C: user alice
S: +OK
C: pass hungry
S: +OK user successfully logged in
```

- Transaction phase
  - list for the listing of the message numbers and the message sizes
  - retr to requesting a message by its number
  - dele deletes the appropriate message
  - Another retr/dele and then quit

```
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 2 contents>
S: .
C: dele 2
C: quit
S: +OK
```

Accessing Email with IMAP

- Issues with POP3:
  - no encryption,
  - no folders to sort emails,
  - no efficient of access through more than one host…
- Solution: Internet Message Access Protocol (IMAP version 4)
  - RFC 3501



- Most modern email clients implement both POP3 and IMAP

Accessing Email with IMAP

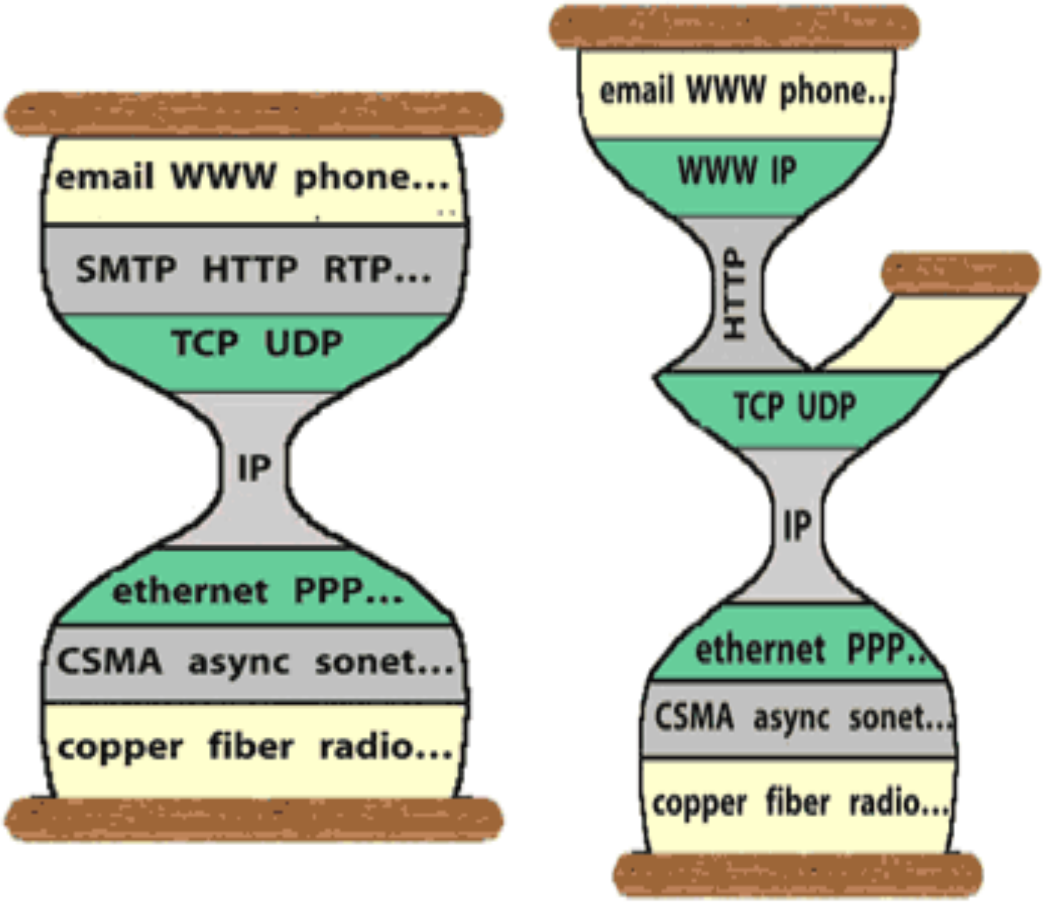
- IMAP protocol details
  - Connection over port 143
  - Emails are not downloaded, but remain on the server
    - The client performs all actions remotely
    - The vast work is shifted to the server (search, change, delete, ...)
  - A user can access the same email environment from different hosts
    - Great for nomadic users
    - Allows multiple clients for same user
  - But IMAP is more complex than POP3
    - Set up and manage remote mailboxes
    - Download only header or parts of an email

Accessing Email with HTTP

- Webmail
  - email clients interaction through your browser
  - HTTP proxy on mail server, used both for mail transfer to MSA and mail access
  - Popular implementations: Yahoo, Gmail, gmx, web.de…
  - VERY popular (Gmail has almost 500 million active users)

Email, and Many Other Things over HTTP

- Email, voice communication, www, video streaming, web services architecture, and even… IP!!
- Why? Proxys, firewalls and NATs which block end-to-end communications, except… HTTP traffic!
- Is HTTP the new slim waist of the hourglass?



From D. Thaler's « Evolution of the IP Model », 2009

About Electronic Mail (Email)

- Transfer: email push with SMTP protocol
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Email Structure: Internet Message Format

- Information needed from the sender of an email:
  - The message itself: usually text + attachments
  - Destination address: generally in the form mailbox@location.com
  - Optional parameters concerning priority, security, etc.

- Internet Message Format (RFC 2822) defines email format as:
  - a simple "envelope"
    - created by the Message Transfer Agent based on the data in the email header
  - a set of header fields
    - each one line ASCII text
  - a blank line
  - the message (Message Body)

Email Structure: MIME

- Problem: RFC 2822 only deals with ASCII text. What about:
  - Emails in languages with special characters, e.g. French, German, Turkish
  - Emails in languages not using the Latin alphabet, e.g. Russian, Arabic
  - Emails in languages not at all using an alphabet, e.g. Japanese, Chinese
  - Emails not completely consisting of pure text, e.g. audio, video, image

- Solution: Multipurpose Internet Mail Extensions (MIME, RFC 2045)
  - extends the RFC 2822 format
  - additional headers in the message body and coding rules for non-ASCII characters.

Header Field	Meaning
MIME-Version:	Used version of MIME is marked
Content-Description:	String which describes the contents of the message
Content-Id:	Clear identifier for the contents
Content-Transfer-Encoding:	Coding which was selected for the contents of the email (some networks understand e.g. only ASCII characters). Examples: base64, quoted-printable
Content-Type:	Type/Subtype regarding RFC 1521, e.g., text/plain, image/jpeg, multi-part/mixed

MIME Content Types

- Content-Type
  - Specifies the type of the body in the format: **type/subtype.** Examples**:**

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

Example Email Header: The Trail of MTAs

Freie Universität Berlin

Microsoft Mail Internet Headers Version 2.0

Received: from mail.math.fu-berlin.de ([160.45.40.10]) by spree.pcpool.mi.fu-berlin.de with Microsoft SMTPSVC(6.0.3790.3959);

Thu, 24 Jan 2008 17:48:26 +0100

Received: (qmail 9044 invoked by alias); 24 Jan 2008 17:48:26 +0100

Delivered-To: schiller@inf.fu-berlin.de

Received: (qmail 9038 invoked from network); 24 Jan 2008 17:48:26 +0100

Received: from lusin.mi.fu-berlin.de (HELO mi.fu-berlin.de) (160.45.117.141)
by leibniz.math.fu-berlin.de with SMTP; 24 Jan 2008 17:48:26 +0100

Received: (qmail 8626 invoked by uid 9804); 24 Jan 2008 17:48:26 +0100

Received: from localhost (HELO mi.fu-berlin.de) (127.0.0.1)
by localhost with SMTP; 24 Jan 2008 17:48:06 +0100

Received: (qmail 23135 invoked by uid 9804); 24 Jan 2008 17:15:01 +0100

Received: from leibniz.math.fu-berlin.de (HELO math.fu-berlin.de) (160.45.40.10)
by lusin.mi.fu-berlin.de with SMTP; 24 Jan 2008 17:15:01 +0100

Received: (qmail 152 invoked from network); 24 Jan 2008 17:15:01 +0100

Received: from sigma.informatik.hu-berlin.de (HELO mailslv1.informatik.hu-berlin.de) (141.20.20.51)
by leibniz.math.fu-berlin.de with (DHE-RSA-AES256-SHA encrypted) SMTP; 24 Jan 2008 16:15:01 -0000

MTA used by email recipient

Loop! Spam filter running on lusin probably ?

from Math server to MI server

from HU to FU

Example Email Header: Continued

Source email server

Virus scan information

Received: from ex.sar.informatik.hu-berlin.de (sar.informatik.hu-berlin.de [141.20.23.63])
by mailslv1.informatik.hu-berlin.de (8.13.8+Sun/8.13.8/INF-2.0-MA-SOLARIS-2.10-25) with ESMTP id m0OGEabt015579 for <schiller@inf.fu-berlin.de>; Thu, 24 Jan 2008 17:14:36 +0100 (CET)
X-Envelope-Sender: mm@informatik.hu-berlin.de
X-Virus-Scanned: by AMaViS 0.3.12pre7-L41+ClamAV[8175](NAI-uvscan@mi.fu-berlin.de)
X-Remote-IP: 141.20.20.51
Content-class: urn:content-classes:message
MIME-Version: 1.0
Content-Type: multipart/alternative;
boundary="----_=_NextPart_001_01C85EA4.35AB5B2E"
Subject: RE: Frohes neues Jahr
X-MimeOLE: Produced By Microsoft Exchange V6.5
Date: Thu, 24 Jan 2008 17:14:33 +0100
Message-ID: <BD8398D4C88E2C458083D1D2B04C4DA3207F4A@ex.sar.informatik.hu-berlin.de>
In-Reply-To: <6FE71171187F564EA019A177D00043B230418A@spree.pcpool.mi.fu-berlin.de>
X-MS-Has-Attach:
X-MS-TNEF-Correlator:
Thread-Topic: Frohes neues Jahr

Subject and Date

Example Email Header: Continued

Thread-Index: AchNIy4Op6zY/HruSXS/HroQsbGWmgBgaQBwApbvmuABYRONYAAGTKOgAAF20KA=

References: <6FE71171187F564EA019A177D00043B2304027@spree.pcpool.mi.fu-berlin.de>
<BD8398D4C88E2C458083D1D2B04C4DA3207E49@ex.sar.informatik.hu-berlin.de>
<6FE71171187F564EA019A177D00043B2304108@spree.pcpool.mi.fu-berlin.de>
<BD8398D4C88E2C458083D1D2B04C4DA3207F47@ex.sar.informatik.hu-berlin.de>
<6FE71171187F564EA019A177D00043B230418A@spree.pcpool.mi.fu-berlin.de>

From: "Max Mustermann" <mm@informatik.hu-berlin.de>

To: "Jochen Schiller" <schiller@inf.fu-berlin.de>

From and To

X-Greylist: Sender IP whitelisted, not delayed by milter-greylist-3.0 (mailslv1.informatik.hu-berlin.de [141.20.20.51]); Thu, 24 Jan 2008 17:14:36 +0100 (CET)

X-Virus-Status: No (sigma)

Return-Path: mm@informatik.hu-berlin.de

X-OriginalArrivalTime: 24 Jan 2008 16:48:26.0547 (UTC) FILETIME=[F0AD6030:01C85EA8]

------_=_NextPart_001_01C85EA4.35AB5B2E

Content-Type: text/plain; charset="iso-8859-1"

Content-Transfer-Encoding: quoted-printable

------_=_NextPart_001_01C85EA4.35AB5B2E

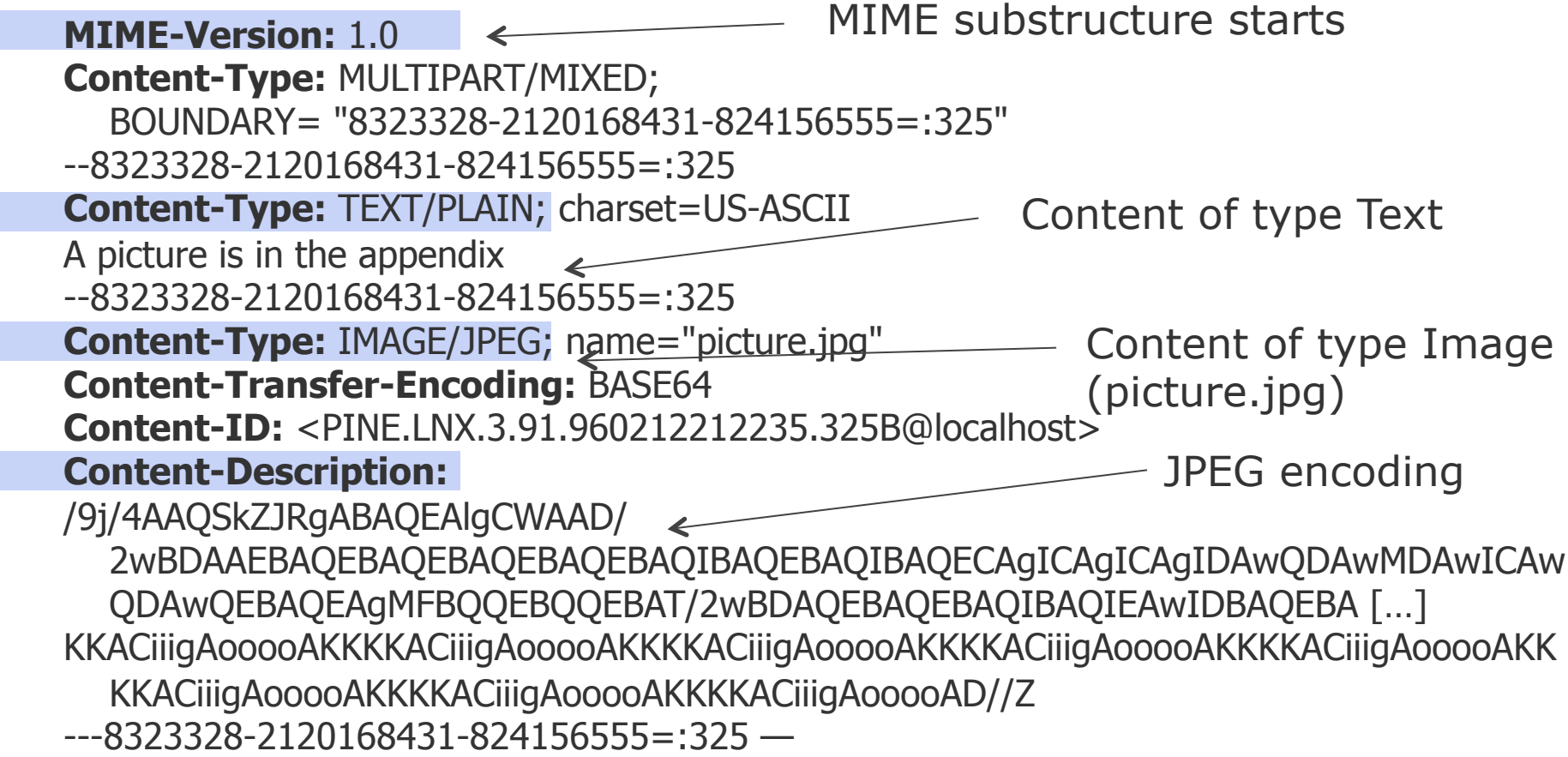
Content-Type: text/html; charset="iso-8859-1"

Content-Transfer-Encoding: quoted-printable

------_=_NextPart_001_01C85EA4.35AB5B2E--

2 parts to follow:
- a plain text part
- an HTML part

Example Email Header: MIME Parts



Advantage: emails can feature more varied content, multimedia etc.
Drawback: complexity w.r.t. command line mechanism from the 80s