Introduction to Network Security

Chapter 9

Email

Email Topics

- SMTP
- POP & IMAP
  - Protocol
  - Vulnerabilities and countermeasures
- MIME
  - Vulnerabilities and countermeasures
- General Email Countermeasures

Email

Simple Mail Transfer Protocol:

First we will look at Electronic Mail systems in general and then we will look at SMTP. A basic electronic mail system performs four functions:

Creation: A user creates and edits a message, generally using a rudimentary editing capability. Most systems also allow the user to create a message using the system editor or a word processor, and then incorporate the resulting file as the body of the message.

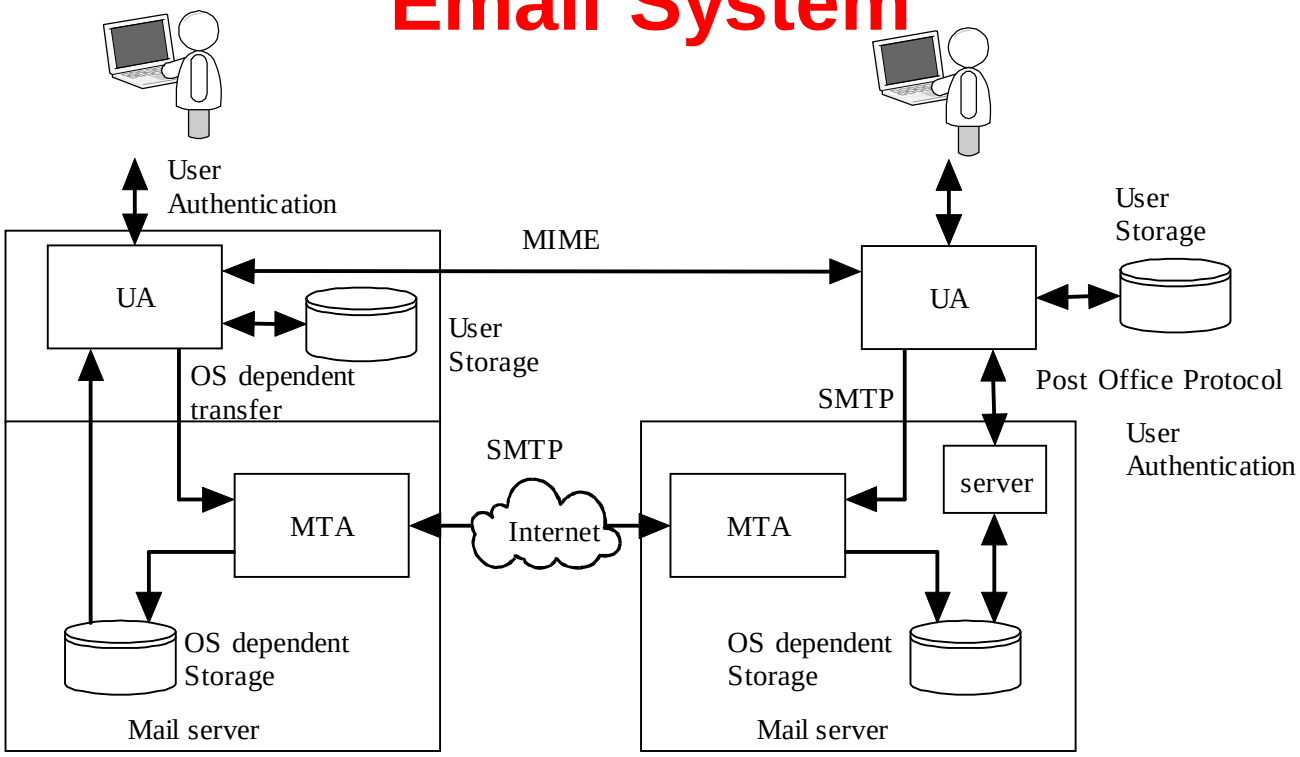
Email

Sending: The user designates the recipient (or recipients) of the message, and the facility stores the message in the appropriate mailbox(es)

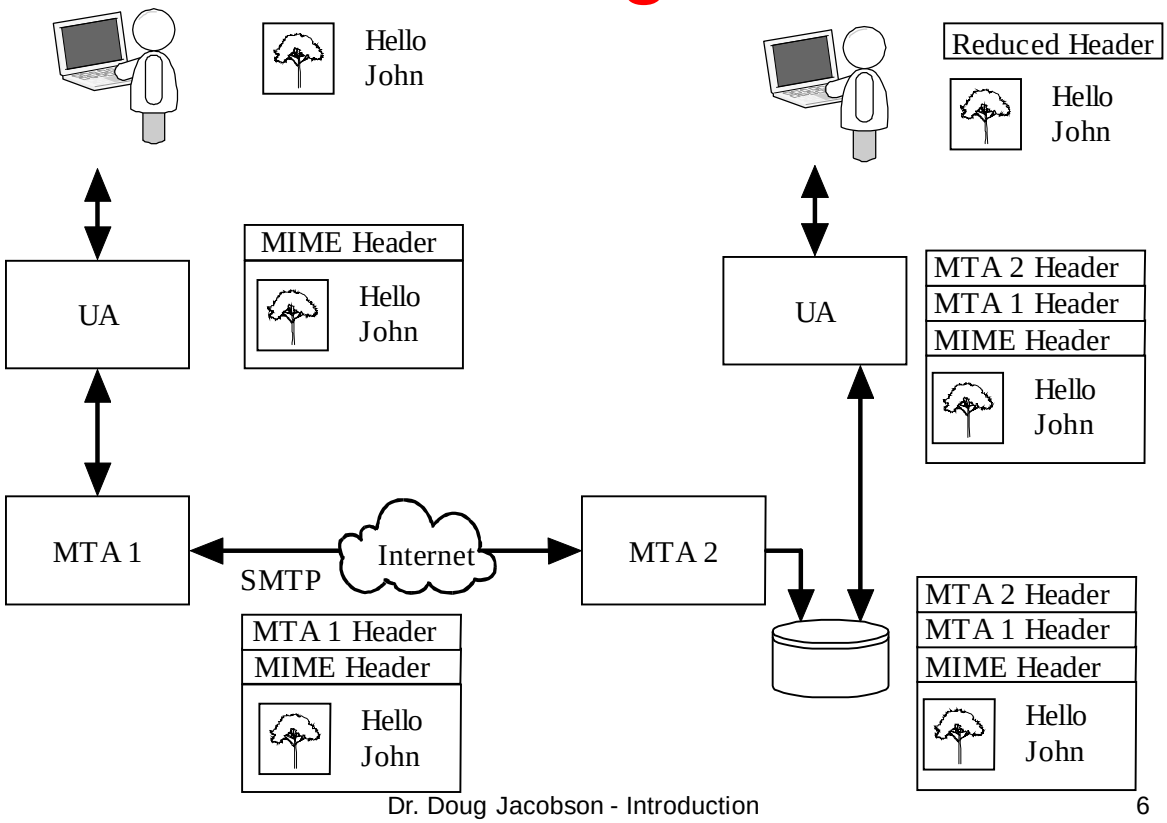
Reception: The intended recipient may invoke the electronic mail facility to access and read the delivered mail

Storage: Both sender and recipient may chose to save the message in a file for permanent storage

Email System



Email Message Format



Email

The SMTP protocol is the standard protocol for transferring mail between hosts. The protocol was defined in RFC 821 and later formalized as MIL-STD-1781.

SMTP is not concerned with the format or content of the messages themselves, with two minor exceptions.

SMTP requires a 7 bit ASCII character set.

SMTP adds logging information to message that indicates the path the message took.

Email

The SMTP protocol attempts to provide reliable operation, but does not guarantee to recover from hosts that lose files. No end-to-end acknowledgment is returned to a message's originator when a message is successfully delivered, and errors are not guaranteed to be returned either. However, the mail system is sufficiently reliable that this is not an issue.

In most cases mail goes directly from the mail originator's machine to the destination machine. However, mail will occasionally go through intermediate systems.

The SMTP protocol is made up of a set of simple commands.

Email

SMTP has 14 commands.

Command syntax is a set of 4 letter commands with parameters
Not all commands need to be implemented

The commands are:

CMD Syntax	Action
HELO <domain>	Used by the sending system to identify itself (HELO eeclass.ee.iastate.edu)

Email

CMD Syntax	Action
MAIL FROM: <path>	Identifies who the message is from. (MAIL FROM doug@iastate,edu) error messages have a NULL from field to prevent answers.
RCPT TO: <forward path>	Identifies who the message should be mailed to. There is separate RCPT for each recipient.

Email

CMD Syntax	Action
DATA	Indicates that the next transmission contains the message text. Terminated with a line containing <CR LF>.<CR LF>
RSET	Terminate current transaction
SEND FROM: <path>	Used instead of MAIL if message should be displayed on user's terminal.

Email

CMD Syntax	Action
SOML FROM: <path>	(Send or Mail) Used instead of MAIL if message should be mailed or displayed on user's terminal.
SAML FROM: <path>	(Send And Mail) Used instead of MAIL if message should be mailed and displayed on user's terminal.
VRFY <string>	Returns to the sender the full name of the user specified in the parameter
EXPN <string>	Returns to the sender a list of mailboxes corresponding to the alias provided

Email

CMD	Syntax	Action
NOOP		Performs no actions: returns a "250 OK" for debugging
QUIT		Sent after completion of transfer, prior to closing TCP connection.
TURN		Reverses the role of SMTP sender and receiver.

A reply code is returned for each command sent. The next slide shows the reply code format.

Email

The reply codes are designed to make implementation of SMTP easier. Each digit of the three digit code has a unique purpose.

First digit specifies whether the response was good, bad, or or incomplete.

The second digit specifies what type of error occurred.

The third digit details specific failures.

The values for the codes are given on the next slide.

Email

1XX Positive Preliminary Reply - The command has been accepted, but the receiver requires more information. (not used by SMTP, used by other protocols)

2XX Positive Completion Reply - The requested action has been successfully completed. A new request may be initiated.

3XX Positive Intermediate Reply - The command has been accepted, but action is being held, pending receipt of further information. The SMTP sender should send another command specifying this information.

Email

4XX Transient Negative Completion Reply - The command was not accepted, however, the error condition is temporary

5XX Permanent Negative Completion Reply - The command was not accepted.

Email

X0X Syntax Error or unimplemented commands

X1X Information: reply to requests for information

X2X Connections - reply to the request for connection

X3X Unspecified

X4X Unspecified

X5X Mail System - indicates the status of the receiver during, for example, a transfer.

The next slide has come common reply codes.

Email

211 System status or system help reply
214 help message
220 service ready
221 Service closing transmission channel
250 Requested mail action okay, completed
251 User not local; will forward to <forward path>
354 Start mail input
421 Service not available; closing channel
450 Mail box busy
451 requested action terminated; local error in processing
452 Requested action not taken; insufficient system storage

Email

500 Syntax Error, command unrecognized

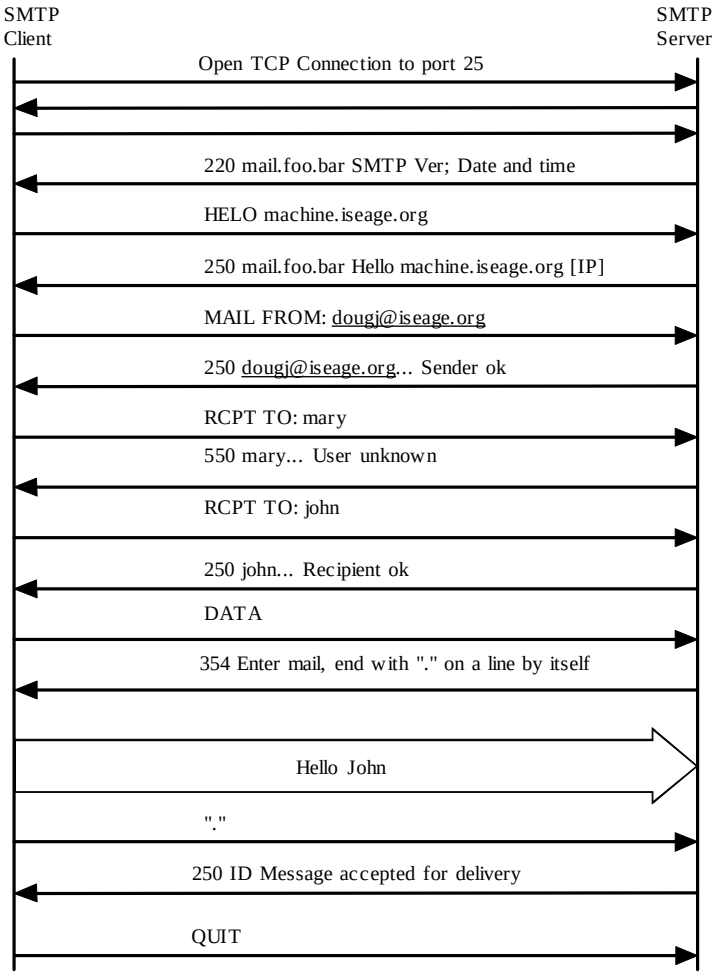
501 Syntax Error in parameters or arguments

502 Command not implemented

550 mailbox not found

551 user not local; please try <forward path>

554 transaction failed



SMTP

Header based

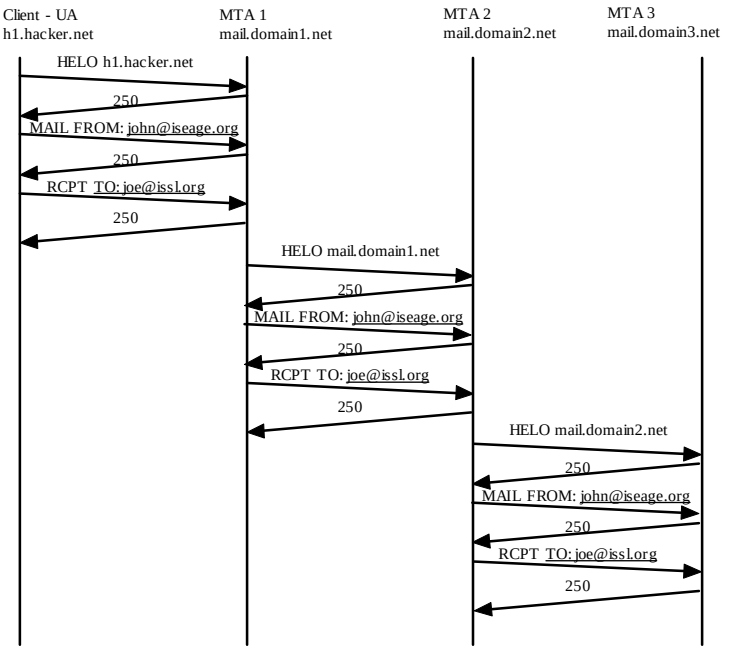
- Not common
- Some buffer overflow issues in old implementations

Protocol Based

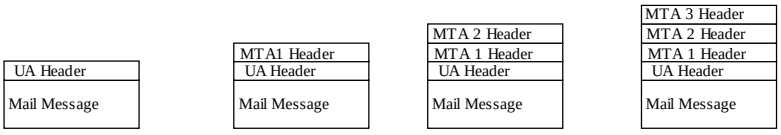
- Not common in command/response protocols
- Out of order commands are reported back as errors
- Multiple open connections could limit access to the email server.

Authentication Based

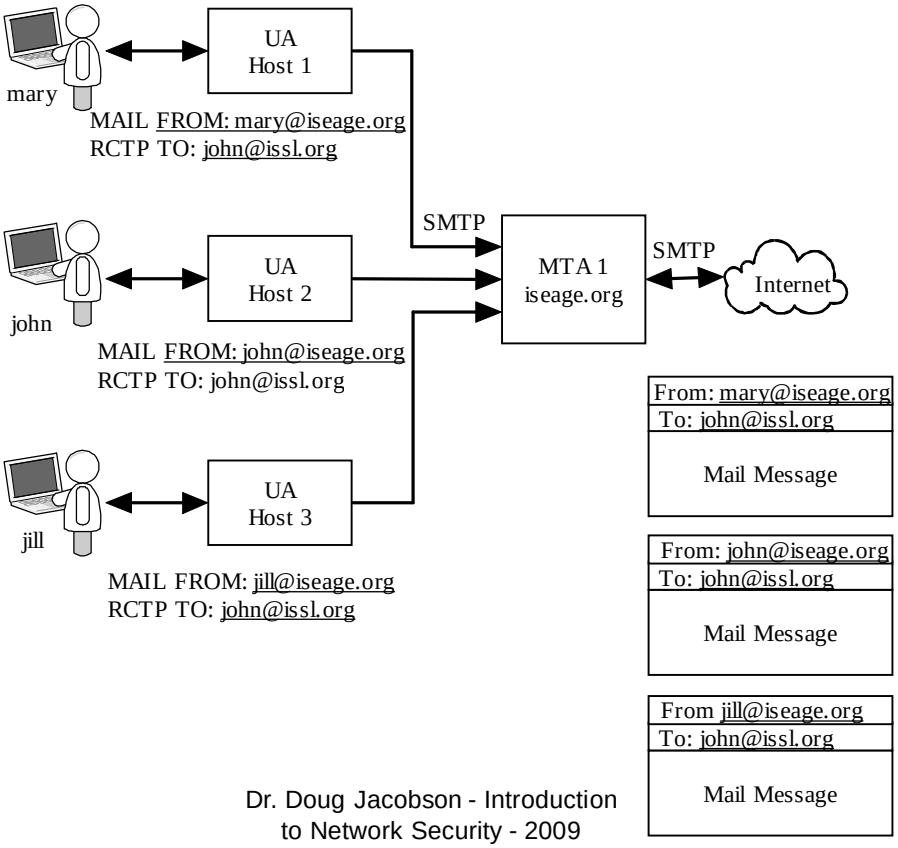
- Most common attack
- No authentication in SMTP
- Sender tells MTA the name of the sender
- Spam and phishing attacks
- Sometimes we want to spoof the senders address (email relay)



Email Address Propagation



Email Relay



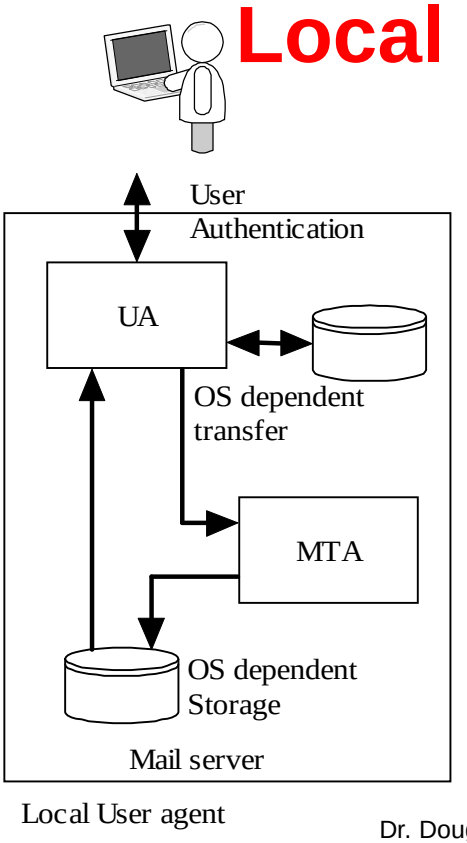
Traffic Based

- Flooding of the email server
  - Too many messages
  - Messages are too large
  - Sending email to B from A with C as the return address could cause an attack on C
- Sniffing

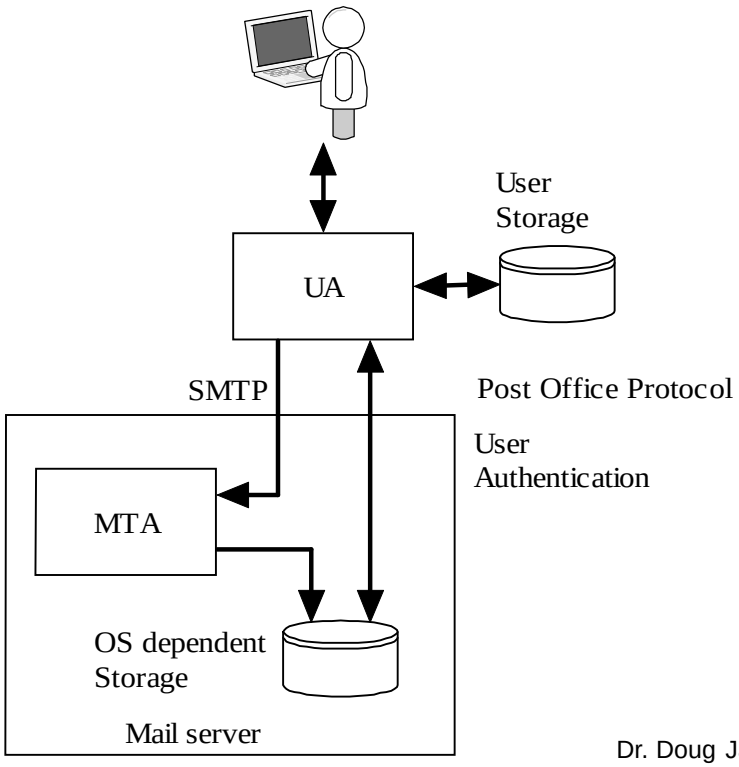
General Countermeasures

- STARTTLS cause SMTP to use transport layer security (encrypted traffic)
- AUTH provides a method for users to authenticate with the MTA.
- Typically used for remote access to MTA for relaying
- Being discussed as a method to reduce spam

Local User Agent

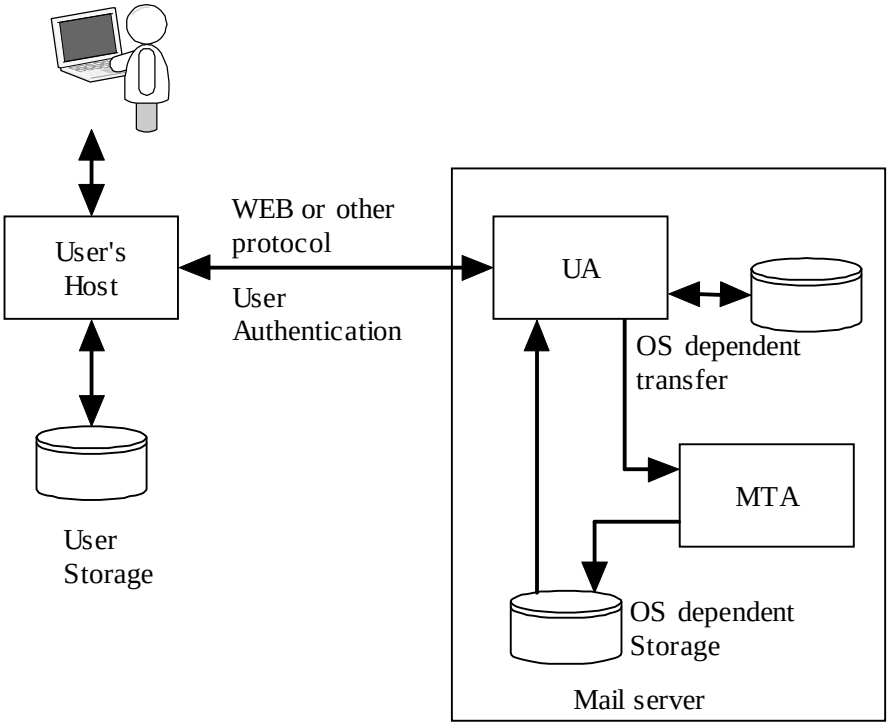


Remote User Agent



Remote User Agent

Remote access to local UA



Remote Access to Local User agent

POP

Post Office Protocol

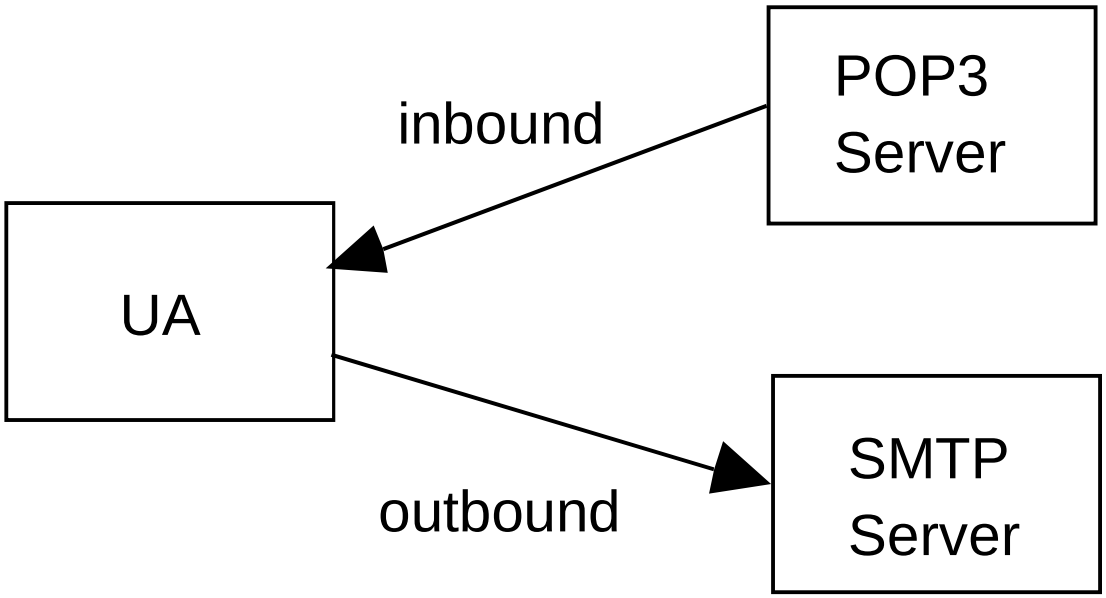
Used to transfer mail between the mail server and a PC

Provides user Authentication

POP3 protocol

- POP3 client “logs in” to a POP3 server (TCP port 110)
- Login name and password in clear text
- User can configure how often mail is checked
  - this means the login and password can be sent many times a day
  - easy to capture since when there is no mail there are only a few packets exchanged.

POP3 block diagram



POP3 Commands

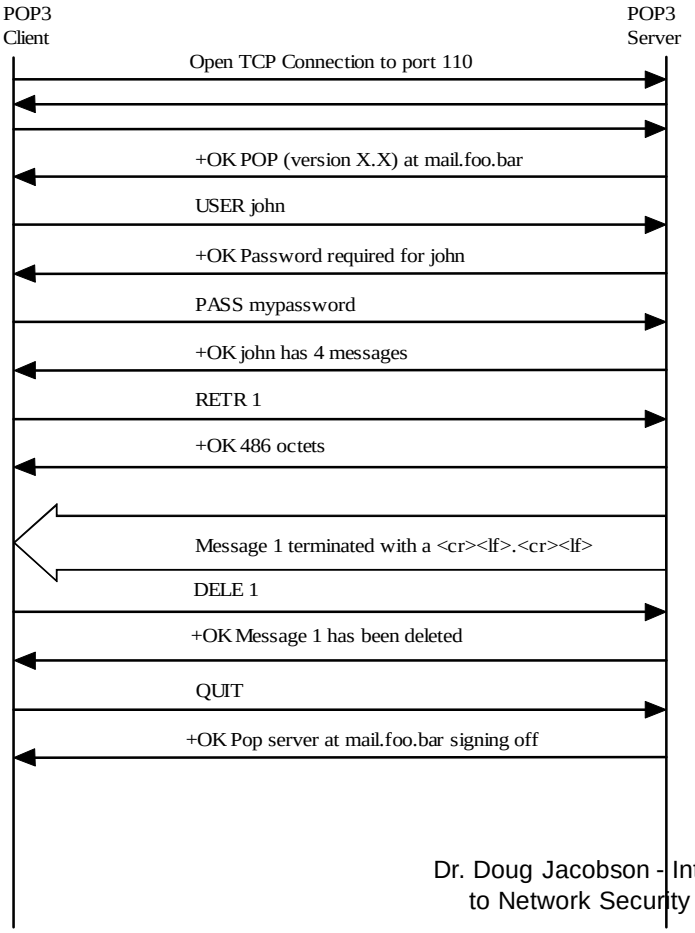
- USER name — Login name
- PASS string — User password
- STAT — returns number of messages
- LIST [msg] — returns the size of msg or all messages if [msg] is not supplied
- RETR msg — send client the full message [msg]
- DELE msg — Delete message from server
- NOOP — No operation
- RSET — Reset deletion indicators

POP3 Commands

- Quit — Quit the session
- APOP name digest — Optional authentication
- TOP msg n — return first n lines of message
- UIDL — returns a unique ID string for the requested message, does not change during session. Message ID can used to request message.

POP3 Responses

- Two response codes
  - -ERR message
  - +OK message

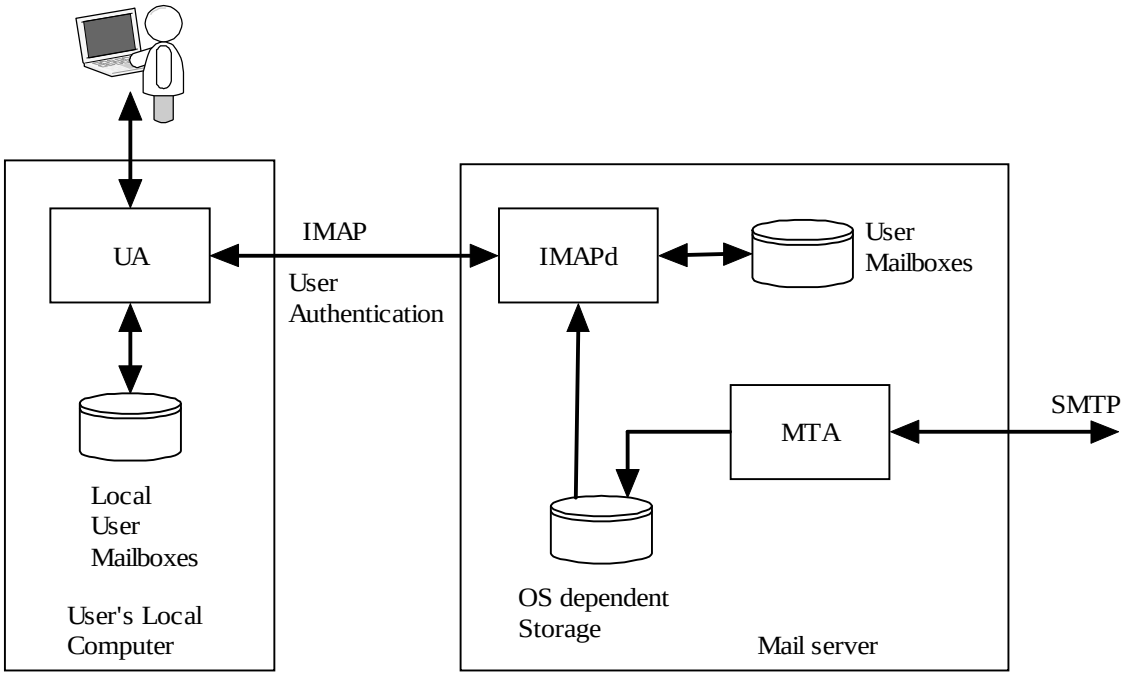


POP3 Protocol

IMAP

- Supports message retrieval
- Support message filing
- POP, does not work well in a multiple client configuration since mail is deleted after it is read.
- IMAP can keep messages on the server and an be used by multiple clients.

IMAP Mail Boxes



Remote Access to Local User agent

IMAP Commands

- CAPABILITY List server capabilities
- NOOP No operation
- LOGOUT
- AUTHENTICATE type
- LOGIN name passwd
- SELECT mailbox
- EXAMINE mailbox read only version of select
- CREATE mailbox
- DETELE mailbox

IMAP COMMANDS

- RENAME current-name new-name rename mailbox
- SUBCRIBE mailbox add mailbox to servers list of active mailboxes
- UNSUBSCRIBE mailbox
- LIST ref mailbox provide a list of mailboxes
- LSUB provide a list based on subscribe
- APPEND mailbox mess Append the message to the mailbox
- CHECK Flush mailboxes to disk
- CLOSE Close mailbox, all messages marked as deleted are removed

IMAP Commands

- EXPUNGE Remove messages marked as deleted
- SEARCH criteria Search the mailbox for messages that match
- FETCH message-set get message
- PARTIAL message len get partial message
- STORE
- COPY message-set Mailbox copy a message to another mailbox
- UID gets unique ID for messages

Header & Protocol based

- Very few header or protocol based attacks

Authentication Based

- User authentication over the network
- Password guessing using POP or IMAP
- Every attempt can be logged
- Restrict POP and IMAP authentication to know IP addresses
- Use web client for remote access

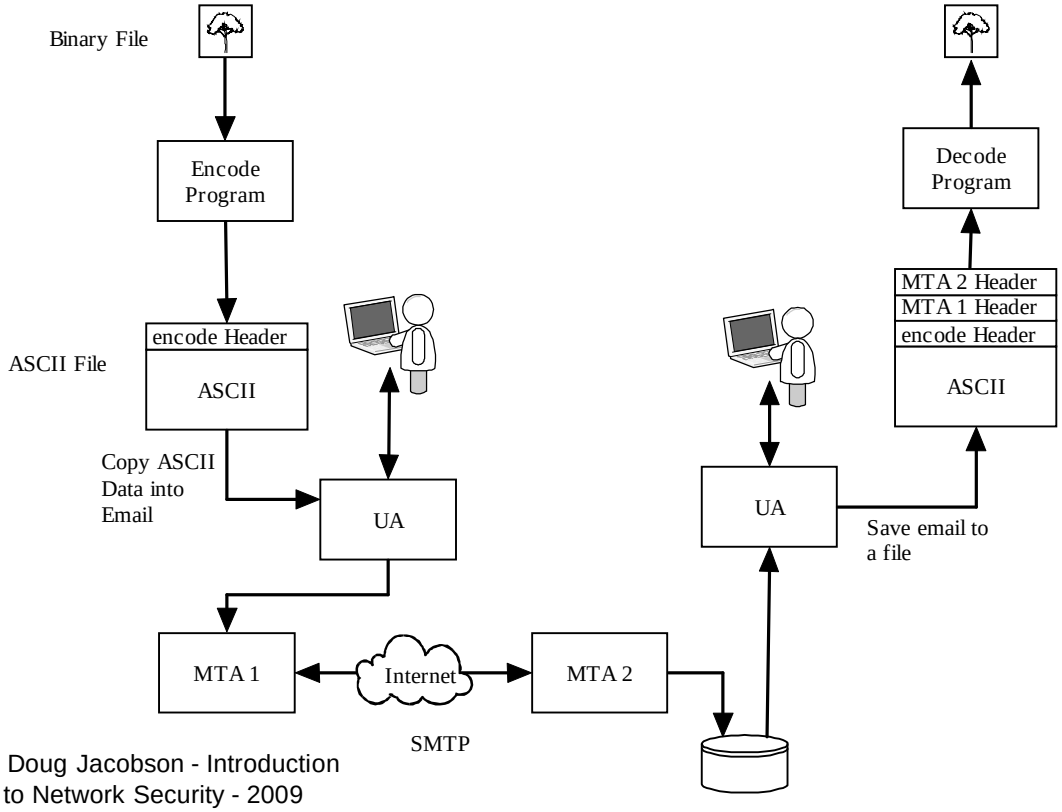
Traffic Based

- Flooding is not much of an issue
- Sniffing is an issue
  - There are encrypted versions of both IMAP and POP, but they are not widely used.

MIME

- Multipurpose Internet Mail Extensions
- Email message format
  - Embedded pictures
  - Embedded code
  - Attachments

Encode and Decode



MIME Structure

SMTP Headers
MIME Version
MIME Headers
Email Object
MIME Headers
Email Object
MIME Headers
Email Object
MIME Headers
Email Object

MIME Headers

MIME Header	Function
MIME-Version:	Indicates a MIME message. The current version is 1.1
Content-Type:	Indicates the type of content contained in the message
Content-Transfer-Encoding:	Indicates how the content is encoded
Content-Id:	Optional Identifier used for multiple messages
Content-Description:	Optional description of the object that can be displayed by the user agent
Content-Disposition:	Optional description of the method to use to display the object in receiving the user agent

Content-Type

Type	Subtype	Description
	Plain	Unformatted text
Text	Html	Text in HTML format
Multipart	Mixed	Multiple ordered objects
	Parallel	Multiple object, not ordered
	Digest	Multiple ordered RFC822 objects
	Alternative	Alternate methods of representing the same object
Message	RFC822	Encapsulated message
	Partial	Part of a larger message
	External-Body	Object is a reference to an external message
Image	JPEG	JPEG Image
	GIF	GIF Image
Video	MPEG	MPEG movie
Audio	Basic	Audio object
Application	Postscript	Adobe Postscript object
	Octet-stream	8 bit binary object

Multipart MIME

- Next three slides show a multipart MIME message


```
Email Header
MIME-Version: 1.0
UA Header
Content-Type: multipart/mixed;
 boundary="------------090603080000040609050705"

This is a multi-part message in MIME format.
```

```
----------090603080000040609050705
Content-Type: multipart/alternative;
 boundary="------------000407030803000901080005"

  --------------000407030803000901080005
  Content-Type: text/plain; charset=ISO-8859-1;
  format=flowed
  Content-Transfer-Encoding: 7bit

  ASCII text message

  --------------000407030803000901080005

  Content-Type: multipart/related;
   boundary="------------080803090003030603090002"


  --------------080803090003030603090002
  Content-Type: text/html; charset=ISO-8859-1
  Content-Transfer-Encoding: 7bit

  HTML Text
   <img src="cid:part1.09040604.05020804@iastate.edu"
  alt=""><br>
  HTML Text

  --------------080803090003030603090002
  Content-Type: image/gif;
   name="logo.gif"
  Content-Transfer-Encoding: base64
  Content-ID: <part1.09040604.05020804@iastate.edu>
  Content-Disposition: inline;
   filename="logo.gif"

  GIF File in base64

  --------------080803090003030603090002--
  --------------000407030803000901080005--
```


OR

```
--------------090603080000040609050705
Content-Type: image/gif;
 name="logo.gif"
Content-Transfer-Encoding: base64
Content-Disposition: inline;
 filename="logo.gif"

GIF File in base64

--------------090603080000040609050705--
```

Content-Description
Content-Disposition

- Content-Description: <description>
  - Lets user “tell” the User Agent what type of file is attached
  - Allows malicious code to look like something else
- Content-Disposition: (Inline, Attachments)
  - Allows inline documents which will be displayed by the user agent
  - Allows malicious code be open automatically

Header based

- Headers can be used to hide actual content type
- HTML documents with hyperlinks where the text is different than the link
- Countermeasures:
  - User education

Protocol Based

- Different that normal protocols (no message exchange)
- Attachments can be malicious (viruses, worms, Trojan horses.
- Some can be auto opened (inline)
- Countermeasures:
  - Disable UA functions
  - Scanners, filters
  - Education

Authentication Based

- MIME does not support authentication
- Can support email monitoring
  - "Web Bugs"
    - 1x1 pixel picture stored on a web site
    - When email is read the file is downloaded
    - Web server will log access to the file and information about the machine that accessed it.
- Countermeasures:
  - Disable User Agent function to auto display pictures

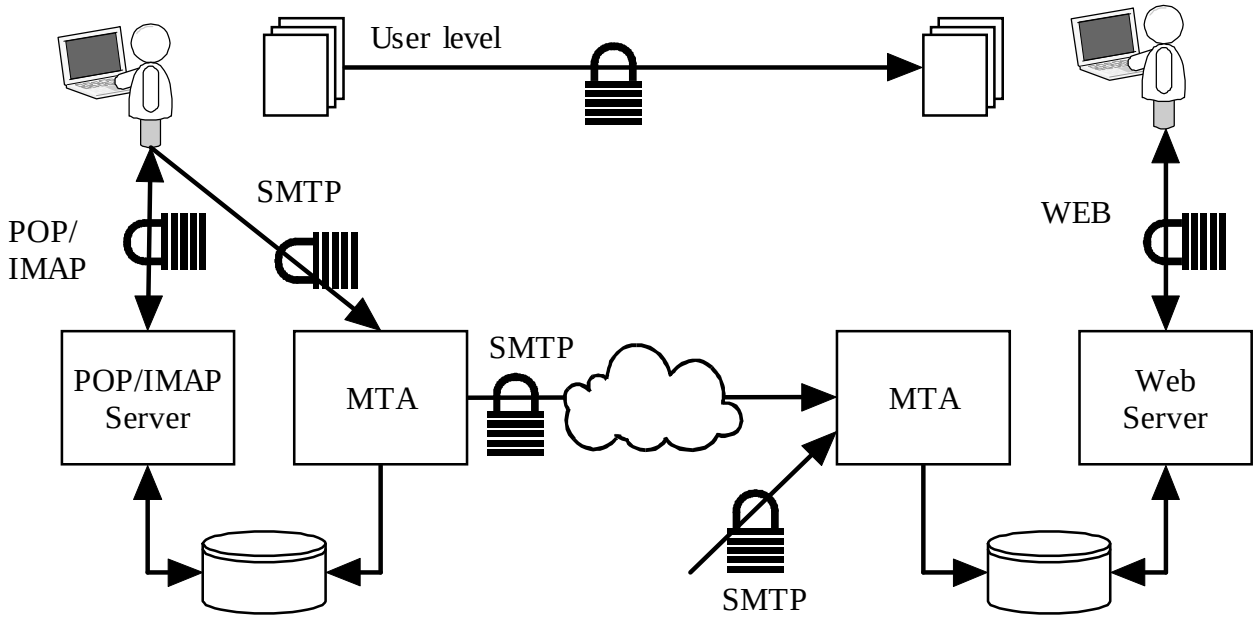
Traffic Based

- Enables flooding of the email server
  - Large messages
- Sniffing

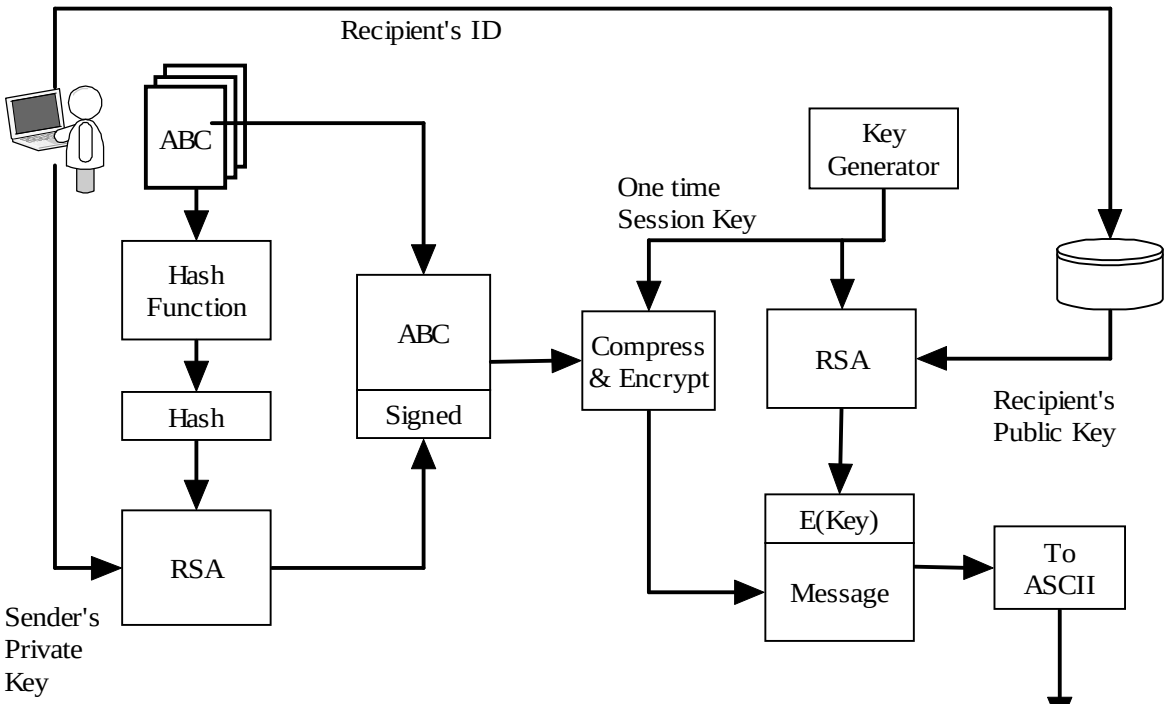
General Email Countermeasures

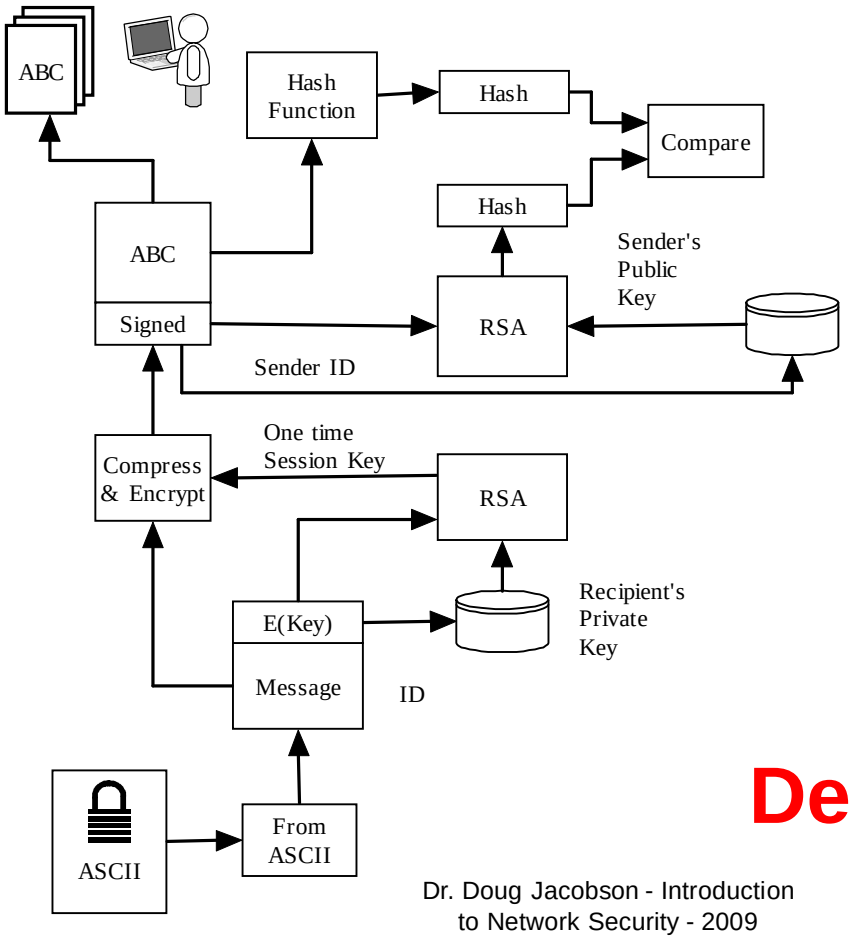
- Encryption & authentication
- Email filtering
- Content Filtering
- Email Forensics

Encryption & Authentication



PGP Encryption



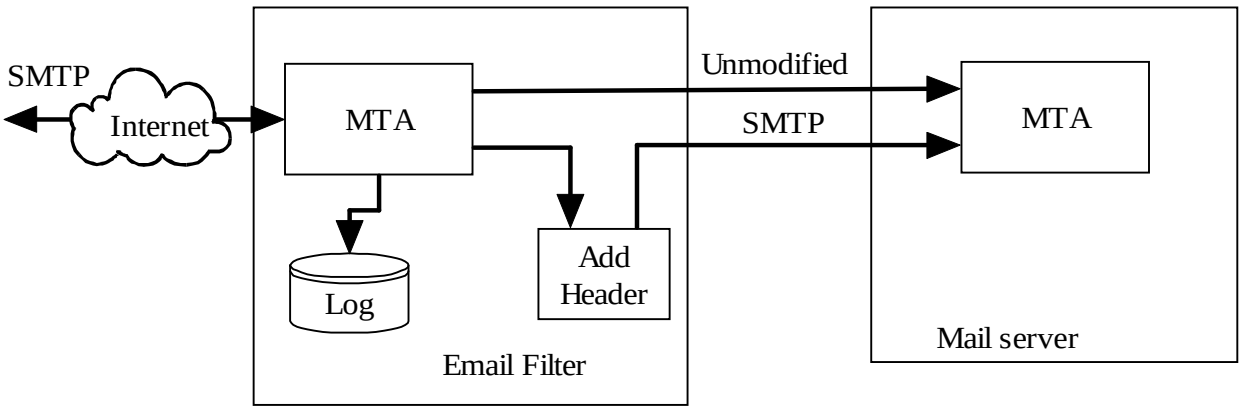


PGP Decryption

Email Filtering

- Check email
  - Based on email addresses
  - Based on domain address
  - Based on malicious payload
- Either Block, pass, or modify the email

Email Filtering



Spam Filter

- Uses learning to decide what content is spam.
- System is “trained” to know is spam
- Spam filter will mark the message as spam.
- Some User agents support spam detection and will move spam email into a spam folder

Bypassing a Spam Filter

- Keyword loading
- Misspelled keywords
- Picture only
- Picture with background words

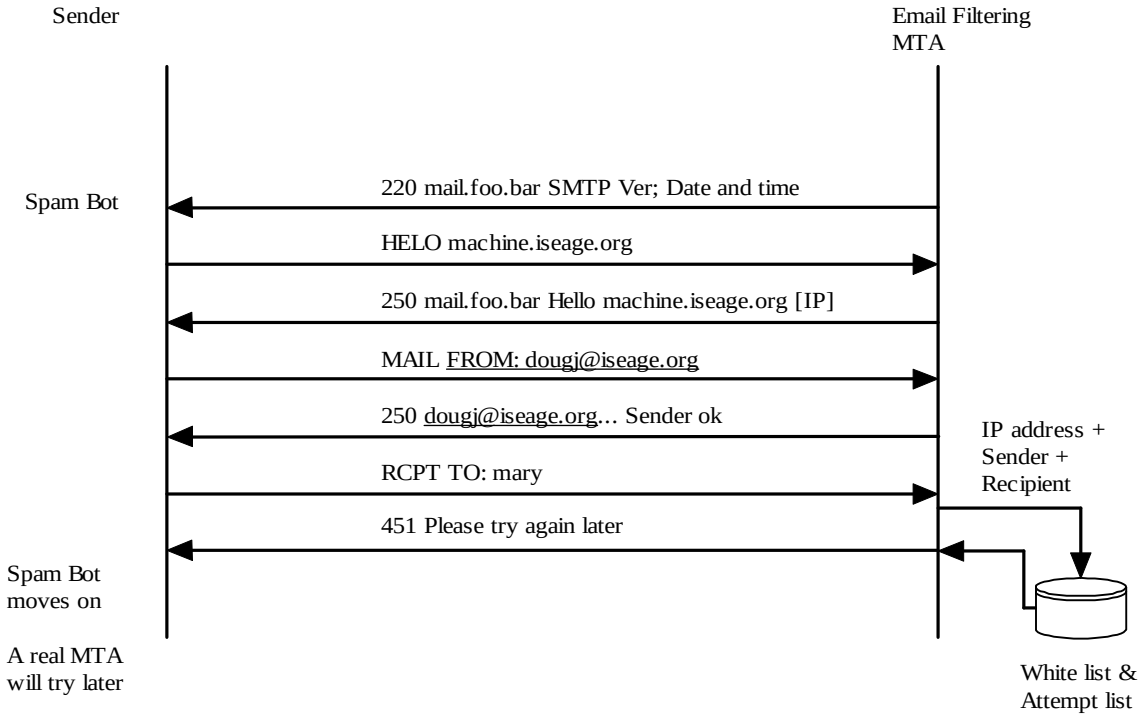
Filtering list

- Blacklist
  - A list of bad users & domains
  - Spammers just change domains
- Whitelist
  - A list of good users and domains
  - Very restrictive

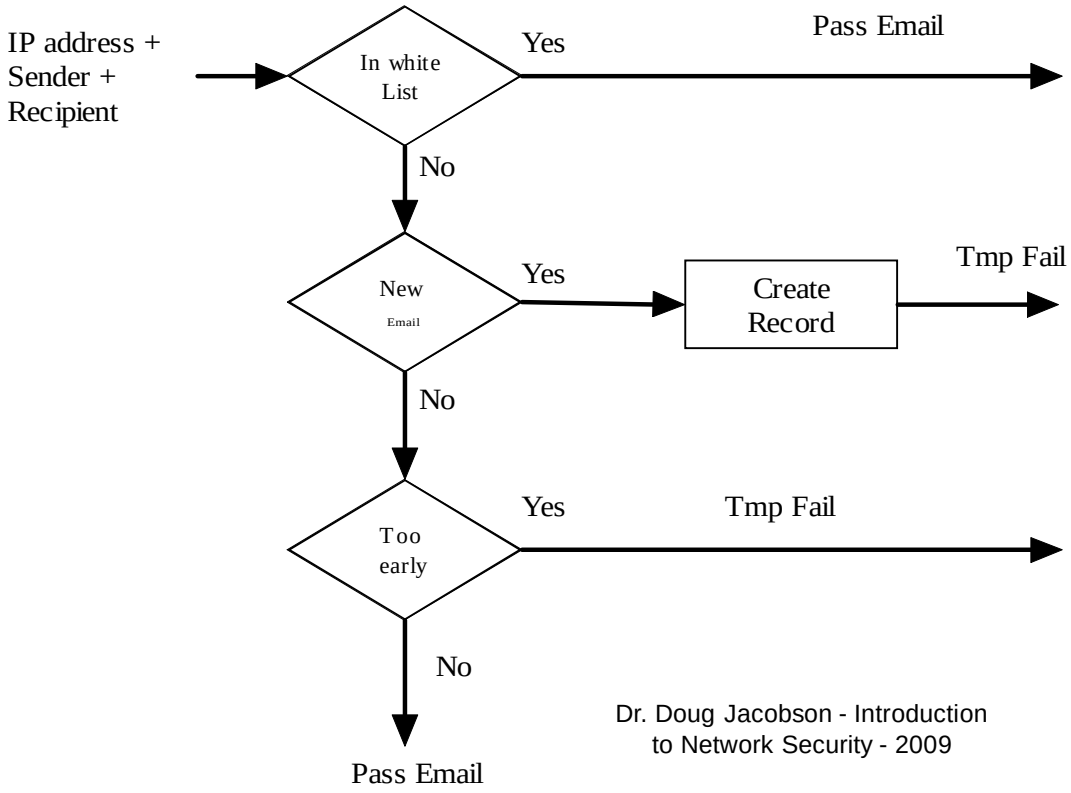
Greylist

- Reject all email with a temp reject
- Maintain a whitelist that is not subject to filtering
- Add machines to the grey list when they resend the email

Greylist



Greylist



Bypassing a grey list

- Use real MTA to send email

Content filter

- Examine the payload for:
  - Viruses
  - Worms
  - Trojan horses
- Often based on a signature
- Requires constant update of signatures

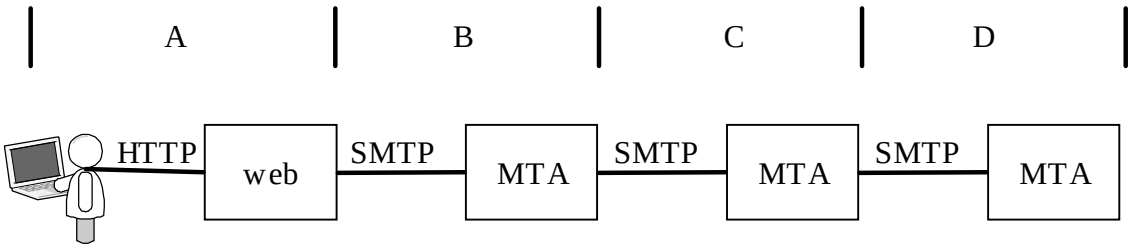
Outbound content filtering

- Used to keep private information from leaving
  - SS Numbers
  - Account Numbers
  - Medical records
- Will either log, stop, or encrypt violating emails

Bypassing a content filter

- Encryption
  - There are encrypted viruses
- Compression

Email Forensics



10.70.63.2 9/5/2006 8:34:31 PDT	10.65.237.1 9/5/2006 8:34:31 PDT	nf-out-0910.email.mta 9/5/2006 8:34:32 PDT	vulcan.ece.mail.spam 9/5/2006 10:36:59 CDT From: 192.168.182.188

Email Forensics

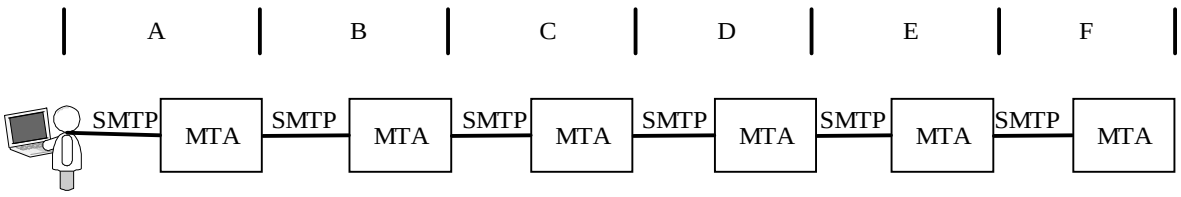
D
```
Received: from nf-out-0910.email.mta (nf-out-0910.email.mta
[192.168.182.188])
        by vulcan.ece.mail.spam (8.12.8/8.9.3) with ESMTP id
k85FaxBT1486661
        for <john@ee.mail.spam>; Tue, 5 Sep 2006 10:36:59  -0500 (CDT)
```

C
```
Received: by nf-out-0910.email.mta with SMTP  id p77so1381355nfc
        for <john@ee.mail.spam>; Tue, 05 Sep 2006 08:34:32  -0700 (PDT)
DomainKey-Signature: a=rsa-sha1; q=dns; c=nofws;
        s=beta; d=spammer.fake;
        h=received:message-id:date:from:to:subject:mime-
version:content-type;
b=BD9tHbNaozYZj9gNQqXmkrnHNA3N8+3W4NApcFJkKsKyX8DdOTS7Dp1VNunGx66SLcU5r
YiDxCnY6SuVCktWq73DDH7MYEfWgaOtYdl/hILBIRVNcbLxGtyCoIT7I8use4F4RgCzZWc3
Oc6fjqNzgGLe5s3RFQ9eVPhS+HxW+DA=
```

B
```
Received: by 10.65.237.1 with SMTP id o1mr4809264qbr;
        Tue, 05 Sep 2006 08: 34:31 -0700 (PDT)
```

A
```
Received: by 10.70.63.2 with HTTP; Tue, 5 Sep 2006 08:34:31  -0700 (PDT)
Message-ID:
<ab156e9f0609050834v528b5b2eld9204458fe6409a1@mail.spammer.fake>
Date: Tue, 5 Sep 2006 10:34:31  -0500
From: "Harry Mudd" <Harry6502@spammer.fake>
To: john@ee.mail.spam
Subject: mail trace 2
MIME-Version: 1.0
```


Email Forensics



vulcan.ece.mail.spam
9/5/2006
10:45:06 CDT
from 172.21.4.7

despam-3.mail.spam
9/5/2006
10:42:55 CDT
from: 192.168.16.211

pop-5.mail.spam
9/5/2006
10:42:55 CDT
from: 172.16.7.10

babylon4.ece.mail.spam

magellan.sender.mta
9/5/2006
10:42:40 CDT

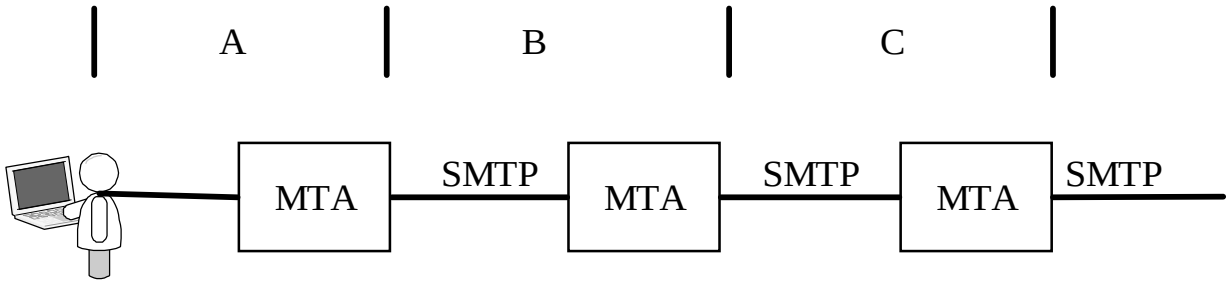
devirus-2.mail.spam
9/5/2006
10:38:34 CDT
from: 172.16.7.5

vulcan.ece.mail.spam
9/5/2006
10:45:28 CDT
From: 192.168.182.188

Email Forensics

F
```
Received: from pop-5.mail.spam (pop-5.mail.spam [172.16.7.12])
        by vulcan.ece.mail.spam (8.12.8/8.9.3) with ESMTP id
k85FjSBT1508024
        for <john@EE.MAIL.SPAM>; Tue, 5 Sep 2006 10:45:28  -0500 (CDT)
```
E
```
Received: from devirus-2.mail.spam (devirus-2.mail.spam [172.16.7.10])
        by pop-5.mail.spam (8.12.11.20060614/8.12.11) with SMTP id
k85Fgt28016542
        for <john@mail.spam>; Tue, 5 Sep 2006 10:42:55  -0500
```
D
```
Received: from (despam-3.mail.spam [172.16.7.5]) by devirus-2.mail.spam
with smtp
         id 0df9_ae8af2c2_3cca_11db_969a_001372537fef;
        Tue, 05 Sep 2006 10:38:34 +0000
```
C
```
Received: from magellan.sender.mta (magellan.sender.mta
[192.168.16.211])
        by despam-3.mail.spam (8.12.11.20060614/8.12.4) with ESMTP id
k85FgttT020053
        for <john@mail.spam>; Tue, 5 Sep 2006 10:42:55  -0500
```
B
```
Received: from vulcan.ece.mail.spam (vulcan.ece.mail.spam [ 172.20.5.6])
        by magellan.sender.mta (8.13.6/8.13.6) with ESMTP id
k85Fgemo030599
        for <dwj@sender.mta>; Tue, 5 Sep 2006 10:42:40  -0500 (CDT)
        (envelope-from john@mail.spam)
```
A
```
Received: from [172.21.4.7] (babylon4.ece.mail.spam [172.21.4.7])
        by vulcan.ece.mail.spam (8.12.8/8.9.3) with ESMTP id
k85Fj6BT1501144
        for <dwj@sender.mta>; Tue, 5 Sep 2006 10:45:06  -0500 (CDT)
Message-ID:  <44FD9AEC.4040103@mail.spam>
Date: Tue, 05 Sep 2006 10:42:36  -0500
From: Harry Mudd <Harry@mail.spam>
Organization: ISU Information Assurance Center
User-Agent: Mozilla Thunderbird 1.0.7 (Windows/20050923)
X-Accept-Language: en-us, en
MIME-Version: 1.0
To: Dave Johnson <dwj@sender.mta>
Subject: test 4
Content-Type: text/plain; charset=ISO-8859-1; format=flowed
Content-Transfer-Encoding: 7bit
```
Spam Filters
```
X-Filter-MailScanner-Information: Please contact the ISP for more
information
X-Filter-MailScanner: Found to be clean
X-Filter-MailScanner-SpamCheck: not spam, SpamAssassin (score= -2.6,
        required 6, autolearn=not spam, BAYES_00  -2.60, SPF_PASS -0.00)
X-Filter-MailScanner-From: john@mail.spam
X-PMX-Version: 5.2.0.264296, Antispam-Engine: 2.4.0.264935, Antispam-
Data: 2006.9.5.82442
X-Perlmx-Spam: Gauge=IIIIIII, Probability=7%, Report='__C230066_ P5 0,
__CP_URI_IN_BODY 0, __CT 0, __CTE 0, __CT_TEXT_PLAIN 0, __HAS_MSGID 0,
__MIME_TEXT_ONLY 0, __MIME_VERSION 0, __SANE_MSGID 0, __USER_AGENT 0'
```


Email Forensics



Logged into MTA	ns09.egujarat.net 9/9/2006 22:29:41	ns09.egujarat.net 9/9/2006 22:29:41 from 127.0.0.1	despam-2.mail.spam 9/9/2006 15:18:28 CDT from: 202.149.46.162

Email Forensics

```
(Removed local headers)
Received: from ns09.egujarat.net (202 -149-46-162.static.exatt.net
[202.149.46.162] (may be forged))
        by despam-2.iastate.edu (8.12.11.20060614/8.12.4) with ESMTP id
k89KIRCr017274
        for <dougj@iastate.edu>; Sat, 9 Sep 2006 15:18:28  -0500
Received: from ns09.egujarat.net (localhost.localdomain [127.0.0.1])
        by ns09.egujarat.net (8.13.5/8.13.5) with ESMTP id
k89H5sYI007263
        for <dougj@iastate.edu>; Sat, 9 Sep 2006 22:37:19 +0530
Received: (from administrator@localhost)
        by ns09.egujarat.net (8.13.5/8.13.5/Submit) id k89Gxf4q006335;
        Sat, 9 Sep 2006 22:29:41 +0530
Date: Sat, 9 Sep 2006 22:29:41 +0530
Message-Id: <200609091659.k89Gxf4q006335@ns09.egujarat.net>
To: dougj@iastate.edu
Subject: Password change required!
From: "eBay Inc." <admin@eBay.com>
Content-Type: text/html
X-egujarat-MailScanner-Information: Please contact the ISP for more
information
X-egujarat-MailScanner: Found to be clean
X-MailScanner-From: administrator@ns09.egujarat.net
X-PMX-Version: 5.2.0.264296, Antispam-Engine: 2.4.0.264935, Antispam-
Data: 2006.9.9.124943
X-Perlmx-Spam: Gauge=XXXXXXXXXIIIIIIIII, Probability=99%,

<p><img src="http://pics.ebaystatic.com/aw/pics/navbar/eBayLogoTM.gif "
width="150" height="70"></p>
<BR>
                Dear sir, <BR>
                <BR>
                We recently have determined that different computers
have logged onto your eBay  account, and multiple
password failures were present before the logons. We strongly advice
CHANGE YOUR PASSWORD. <BR>
                <BR>
                If this is not completed by <STRONG>September 15,
2006</STRONG>, we will be forced to suspend your
account indefinitely, as it may have been used for fraudulent purposes.
Thank you for your cooperation. <BR>
                <BR>
<A
href="http://linux.net zero.idv.tw/~ming/.change/index.php?MfcISAPIComma
nd=ChangeFPP"
target=_blank>Click here to Change Your Password</A></TD>
```

D — Received: from ns09.egujarat.net (202 -149-46-162.static.exatt.net [202.149.46.162] (may be forged)) by despam-2.iastate.edu (8.12.11.20060614/8.12.4) with ESMTP id k89KIRCr017274 for <dougj@iastate.edu>; Sat, 9 Sep 2006 15:18:28 -0500

C — Received: from ns09.egujarat.net (localhost.localdomain [127.0.0.1]) by ns09.egujarat.net (8.13.5/8.13.5) with ESMTP id k89H5sYI007263 for <dougj@iastate.edu>; Sat, 9 Sep 2006 22:37:19 +0530

B — Received: (from administrator@localhost) by ns09.egujarat.net (8.13.5/8.13.5/Submit) id k89Gxf4q006335; Sat, 9 Sep 2006 22:29:41 +0530

A — Date: Sat, 9 Sep 2006 22:29:41 +0530; Message-Id: <200609091659.k89Gxf4q006335@ns09.egujarat.net>; To: dougj@iastate.edu; Subject: Password change required!; From: "eBay Inc." <admin@eBay.com>; Content-Type: text/html

Spam Filter 2 — X-egujarat-MailScanner-Information: Please contact the ISP for more information; X-egujarat-MailScanner: Found to be clean; X-MailScanner-From: administrator@ns09.egujarat.net

Spam Filter 1 — X-PMX-Version: 5.2.0.264296, Antispam-Engine: 2.4.0.264935, Antispam-Data: 2006.9.9.124943; X-Perlmx-Spam: Gauge=XXXXXXXXXIIIIIIIII, Probability=99%,

Logo — <img src="http://pics.ebaystatic.com/aw/pics/navbar/eBayLogoTM.gif " width="150" height="70">

Phishing Site — <A href="http://linux.net zero.idv.tw/~ming/.change/index.php?MfcISAPICommand=ChangeFPP" target=_blank>Click here to Change Your Password</A></TD>