# E-Mail System

tsaimh (2024-2025, CC-BY)
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? (?-2019)

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# Components of an E-Mail (1)

- You can really see …
  - Headers, which can be forged, altered, etc.
  - Body

| | |
|---|---|
| The Header => | Date: Thu, 30 Mar 2023 09:15:04 +0800 (CST)<br>From: NCTU CSCC Help <help@cs.nctu.edu.tw><br>To: tsaimh@cs.nctu.edu.tw<br>Subject: [CSCC] Test Mail |
| Blank Line => | |
| The Body => | This is a test mail. |

# Components of an E-Mail (2)

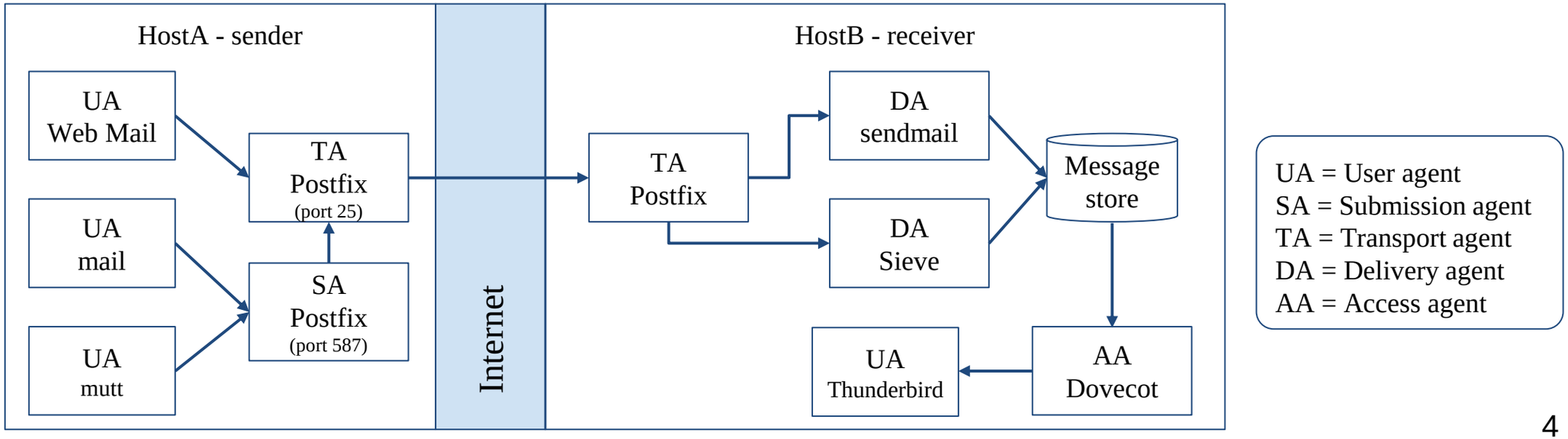
- Three major components
  - The envelope
    - Invisible to users
    - Determine where the message should be delivered, or to whom it should be returned
  - The headers
    - Information about the messages, defined in RFC2822
      - Date, From, To, Content-Type, charset
      - Content-Length, MessageID, …
      - No checking consistent "To" in envelope and header
  - The message body
    - Text, attachments, ...


Mail systems rely on this


Can be anything!

# Mail System

- Major components
  - Mail User Agent (MUA)
    - Help user read and compose mails
  - Submission Agent (SA)
    - Route mails to local MTA
  - Mail Transport Agent (MTA)
    - Route mails among machines
  - Delivery Agent (DA)
    - Place mails in users' mailboxes
  - Access Agent (AA)
    - Connect the user agents to the mailboxes using POP3 or IMAP protocols

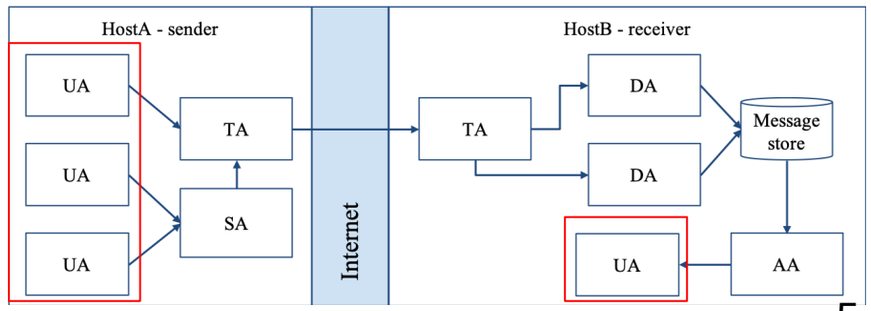


# Mail System – The User Agent

- Help user read and compose mails
  - UA must know mail format
    - Previously: Text only (command line agents)
    - Now: MIME

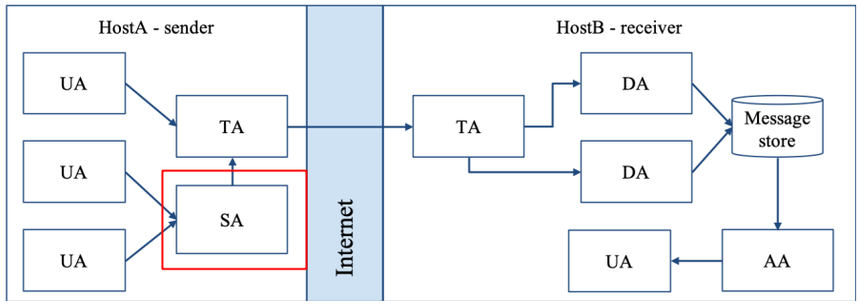
※ MIME (Multipurpose Internet Mail Extensions)

- Include several types of content that can be encoded in the mail
  - 7-bit base64, 8-bit binary, ...
  - image, video, virus, …



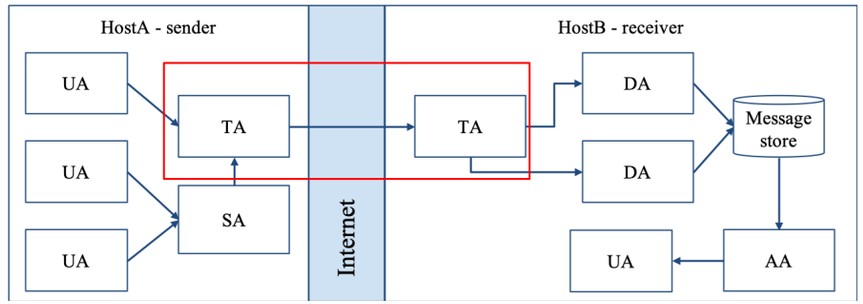
# Mail System – The Submission Agent

- Route mails to local MTA
  - Typical works that a MTA must do:
    - Ensuring that all hostname are fully qualified
    - Modifying headers
      - MessageID
      - Date
      - DomainKeys/DKIM
    - Logging errors
    - …
  - RFC2476 introduces the idea of splitting MTA
    - Let SA to share the load



# Mail System – The Transport Agent

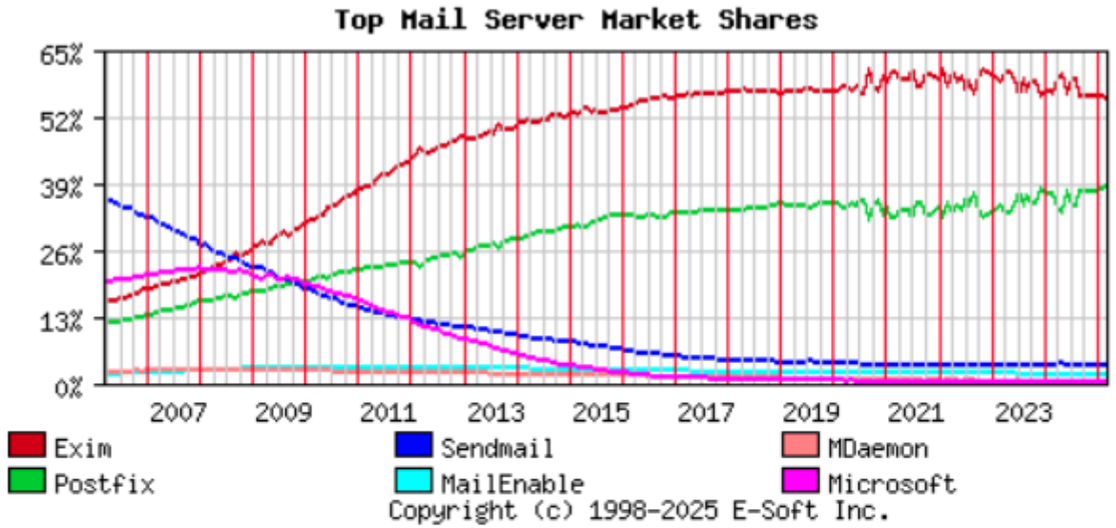
- Route mails among machines
  - Accept mail from UA, examine the recipients' addresses, and delivery the mail to the correct host
  - Protocols
    - SMTP (Simple Mail Transport Protocol)
      - RFC 821 (1982)
    - ESMTP (Extended SMTP)
      - RFC 2821 (2001) => 5321 (2008) => 7504 (2015)
  - Popular transport agents
    - sendmail http://www.sendmail.org/
    - Postfix http://www.postfix.org/
    - exim, qmail, …



# Mail System – Mail (MX) Server Survey

| Description> | Number of Servers | Percent |
|---|---|---|
| Total Number of MX Servers Queried | 1,100,168 | 100.0% |
| Number of Servers that didn't respond | 223,341 | 20.30% |
| Server didn't open socket | 220,688 | 20.06% |
| Server didn't provide banner | 2,653 | 0.24% |
| Server provided banner | 876,827 | 79.70% |
| Server banner identifies software in use | 549,567 | 49.95% |

**Basic Technology Breakdown**

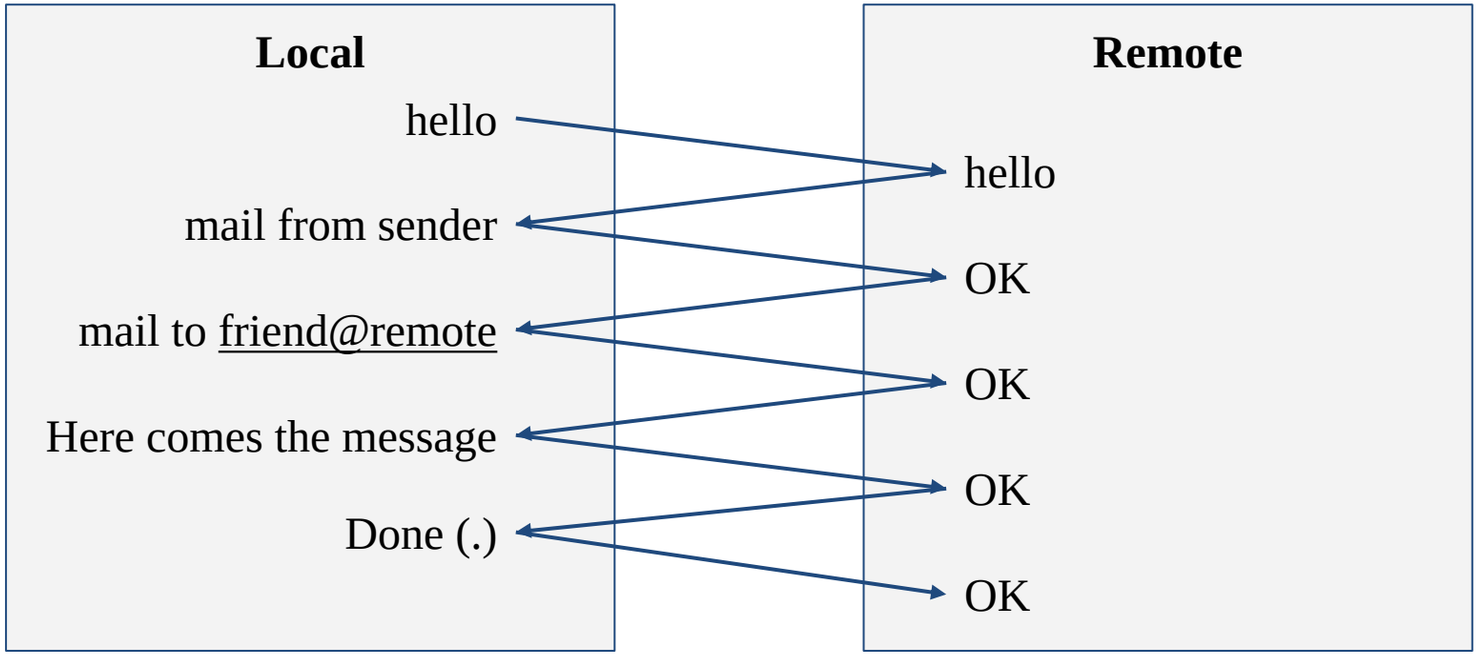



| Server Type | Number of Servers | Percent |
|---|---|---|
| Exim | 302,529 | 55.05% |
| Postfix | 211,702 | 38.52% |
| Sendmail | 18,979 | 3.45% |
| MailEnable | 9,894 | 1.80% |
| MDaemon | 2,188 | 0.40% |
| Microsoft | 1,109 | 0.20% |

Source: https://secure1.securityspace.com/s_survey/data/man.202502/mxsurvey.html , Statistics at March 1, 2025

# Mail System – Conversation between MTAs

- Conversation between MTAs
  - Threat of eavesdropping



# Mail System – SMTP Interaction

- Protocol: SMTP

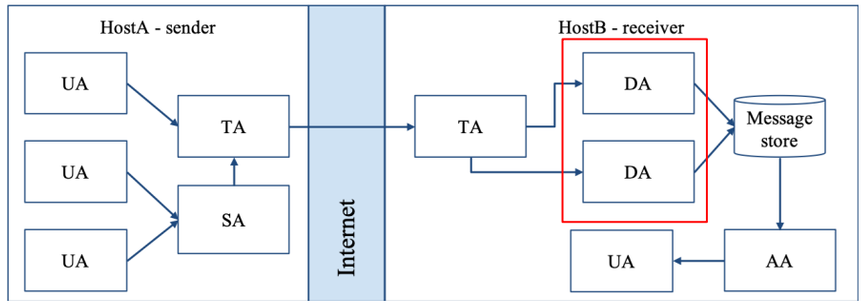
```
$ telnet smtp.example.com 25
Trying 140.113.235.103...
Connected to smtp.example.com.
Escape character is '^]'.
220 smtp.example.com ESMTP Postfix
ehlo me.example.com
250-smtp.example.com
250-PIPELINING
250-SIZE 204800000
250-VRFY
250-ETRN
250-ENHANCEDSTATUSCODES
250-8BITMIME
250 DSN
```

```
mail from: <alice@example.com>
250 2.1.0 Ok
rcpt to: <bob@example.com>
250 2.1.5 Ok
data
354 End data with <CR><LF>.<CR><LF>
From: haha <devnull@example.com>
To: admin@foobar.net

hehe... I spammed you!
.
250 2.0.0 Ok: queued as 81BD4FB4
quit
221 2.0.0 Bye
Connection closed by foreign host.
```

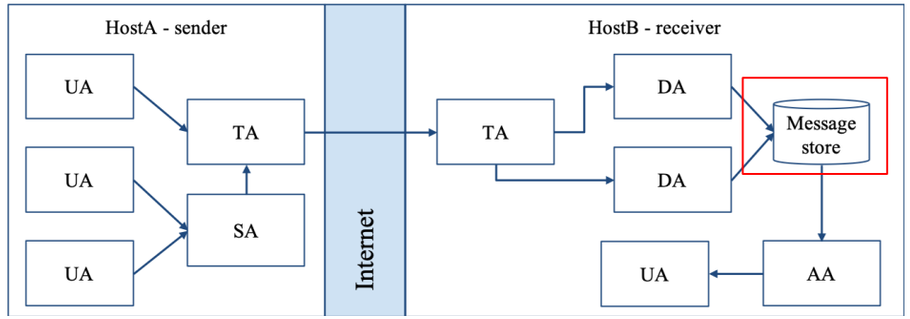
```
From: haha <devnull@example.com>
To: admin@foobar.net
Message-Id: <20230330070002.81BD4FB4@smtp.example.com>
Date: Thu,  30 Mar 2023 14:59:53 +0800 (CST)

hehe... I spammed you!
```

# Mail System – The Delivery Agent

- Place mails in users' mailboxes
  - Accept mail from MTA and deliver the mail to the local recipients
  - Type of recipients
    - User
    - Program
      - Sieve filters, procmail (deprecated), ...
  - Sieve - mail filtering language (RFC 5228)
    - Many implementations
    - Pigeonhole - Sieve implementation provided by Dovecot
      - Official documentation



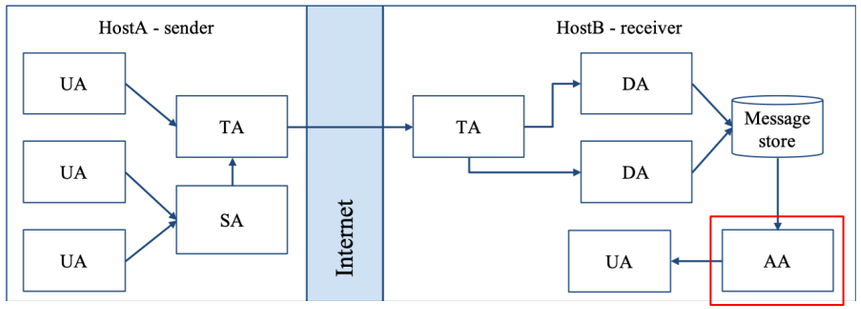
# Mail Storage




- The place on the local machine where email is stored
  - Usually the directory: /var/mail or /var/spool/mail
    - Users' mails are stored in files named with each user's login name
      - Eg. /var/mail/tsaimh
    - Permission "775" and root:mail as the owner and group owner
      - drwxrwxr-x  2 root  mail  512 Dec 16 15:51 mail/
  - Using database
    - When the organization is large or for ISP with millions of customers
    - Easy to search, categorize

# Mail System – The Access Agent

- Help user download mail from server
  - Protocols
    - IMAP (Internet Message Access Protocol)
    - POP3 (Post Office Protocol – Version 3)



# Mail Addressing – Domain (1)

- Two kinds of email addresses:
  - Route based address (obsolete)
    - Message will travel through several intermediate hosts to the destination
    - Format: `host!path!user`
      - E.g. `sender!path!to!destination!recipient`
      - This mail is sent from "sender" host to the user "recipient" at "destination" host
  - Location independent address (relies on DNS)
    - Simply identify the final destination
    - Format: `user@host.domain`
      - E.g. ta@nasa.cs.nctu.edu.tw

# Mail Addressing – Domain (2)

- Where to send the mail?
  - When you want to send a mail to tsaimh@cs.nctu.edu.tw, the MTA will:
    - First, lookup up the mail exchanger of "cs.nctu.edu.tw"

```
$ dig mx cs.nctu.edu.tw

;; ANSWER SECTION:
cs.nctu.edu.tw.         3600    IN      MX      5 csmx2.cs.nctu.edu.tw.
cs.nctu.edu.tw.         3600    IN      MX      10 csmx3.cs.nctu.edu.tw.
cs.nctu.edu.tw.         3600    IN      MX      5 csmx1.cs.nctu.edu.tw.
```

    - If there is any servers, try from servers with higher priority (smaller value)
    - If no MX records, mail it directly to the host (A record)

# Mail Addressing – Domain (3)

- Why using "Mail eXchanger"?
  - Centralize all the mail tasks to group of servers
    - Security enforcement, firewall control, …
  - More robust
    - load balancing, fail over, …

# Mail Addressing – Alias

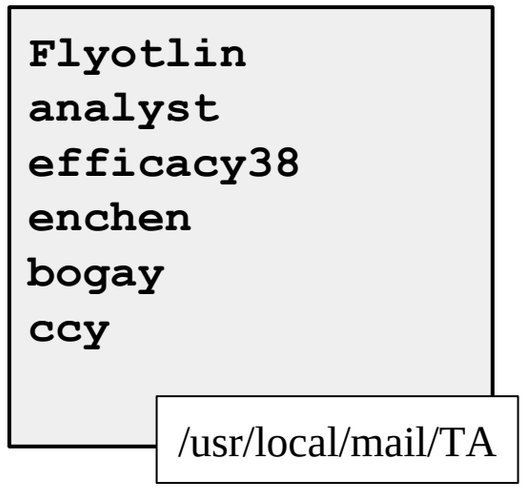
- Alias
  - Map a username to something else
    - Mailing list
    - Be careful of mail looping
- Several mechanisms to define aliases:
  - Traditional method: in files
  - Traditional method + NIS
  - LDAP (Light-weight Directory Access Protocol)
- When the mail server wants to resolve name
  - File-based method
  - LDAP-based method

# Mail Alias – Mechanisms (1)

- Places for defining alias
  - [sender] In configuration file of a MUA (e.g., ~/.mutt/muttrc )
    - MUA expands the alias before injecting the message into the mail system
  - [receiver] In the system-wide /etc/mail/aliases file
    - Read by MDA
    - Deliver to the new destination when receiving the mail
  - [receiver] In user's forwarding file, ~/.forward
    - Read by MDA after system-wide alias file
    - forward(5)

# Mail Alias – Mechanisms (2)

- The format of an entry in aliases file
  1. Local-name: recipient1,recipient2,…
     - E.g.
       - admin: tsaimh,lctseng,lwhsu,wangth,jnlin
       - tsaimh: tsaimh@nycu.edu.tw
       - root: ta
  2. Local-name: :include:filename
     - E.g.
       - ta: :include:/usr/local/mail/TA



# Mail Alias – Mechanisms (3)

- The format of an entry in aliases file
  3. Local-name: absolute-path-file
     - Appended to file
     - Ex:
       - complaints: /dev/null
       - troubles: trouble_admin,trouble_log
       - trouble_admin: :include:/usr/local/mail/troadm
       - trouble_log: /usr/local/mail/logs/troublemail
  4. Local-name: "|program-path"
     - Inject as STDIN
     - Ex:
       - autoftp: "|/usr/local/bin/ftpserver"
       - nahw3: "|/home/nahw3/receive.py"

# Mail Alias – Mechanisms (4)

- The hashed aliases DB
  - /etc/mail/aliases: plain text aliases information
  - /etc/mail/aliases.db: hashed version for efficiency
  - "newaliases" command
    - Rebuild the hashed version when changing the aliases file
    - Files read from ":include:" is outside the aliases file

# Mail Alias – Mechanisms (5)

- User maintainable forwarding file
  - ~/.forward
  - Format: comma-separated
  - E.g.
    - tsaimh@gmail.com
    - \tsaimh, tsaimh@gmail.com, tsaimh@nycu.edu.tw
  - backslash + username
    - Bypassing further redirection (deliver to mailbox directly)
  - Must be owned by user and with permission of 600
    - The path to .forward file should be writable only to user

# Mail Alias – Mechanisms (6)

- Alias must
  - postmaster and MAILER-DAEMON
    - Mail system maintainer
  - bin, sys, daemon, nobody, …
    - System accounts (root)
  - root
    - forward root mail to the administrator
      - /root/.forward
      - aliases

```
MAILER-DAEMON: postmaster
postmaster: root
bin:   root
bind:  root
daemon:root
games: root
kmem:  root
mailnull:     postmaster
nobody:root
operator: root
…
```

# Mail Headers (1)

- Defined by RFC2822
  - Mail reader will hide some uninteresting header information

```
Date: Wed, 18 Apr 2007 14:05:04 +0800
From: 大小姐 <lkkg-girl@mail.richhome.net>
Subject: 笑狗好可怕
To: Yung-Hsiang Liu <liuyh@nabsd.cs.nctu.edu.tw>
User-Agent: Mutt/1.5.15 (2007-04-06)

你趕快把牠趕跑好不好？
```

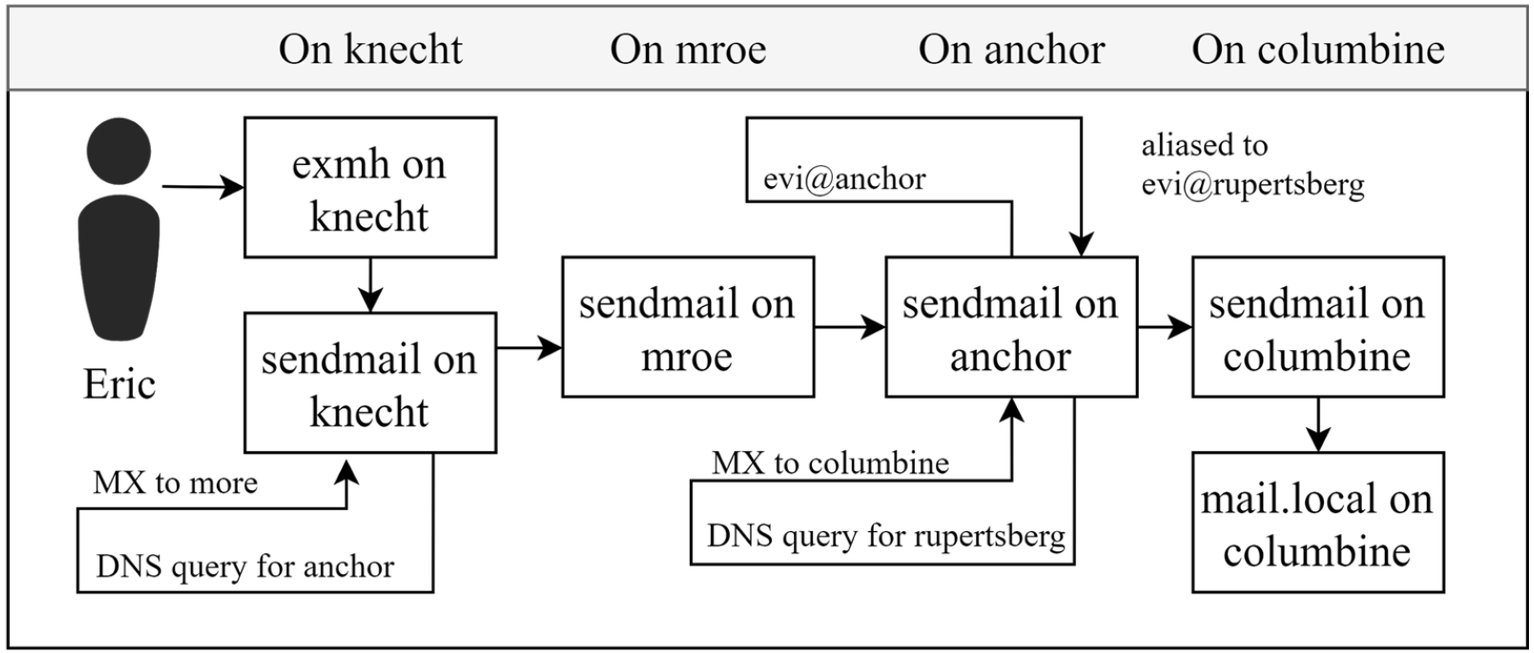
# Mail Headers (2)

```
From chwong@chbsd.cs.nctu.edu.tw  Wed Apr 18 14:07:21 2007
Return-Path: <chwong@chbsd.cs.nctu.edu.tw>
X-Original-To: liuyh@nabsd.cs.nctu.edu.tw
Delivered-To: liuyh@nabsd.cs.nctu.edu.tw
Received: from chbsd.cs.nctu.edu.tw (chbsd.csie.nctu.edu.tw [140.113.17.212])
        by nabsd.cs.nctu.edu.tw (Postfix) with ESMTP id 22EC73B4D51
        for <chwong@nabsd.cs.nctu.edu.tw>; Wed, 18 Apr 2007 14:07:21 +0800 (CST)
Received: from chbsd.cs.nctu.edu.tw (localhost [127.0.0.1])
        by chbsd.cs.nctu.edu.tw (8.13.8/8.13.8) with ESMTP id l3I654P3060925
        for <chwong@nabsd.cs.nctu.edu.tw>; Wed, 18 Apr 2007 14:05:04 +0800 (CST)
        (envelope-from chwong@chbsd.cs.nctu.edu.tw)
Received: (from chwong@localhost)
        by chbsd.cs.nctu.edu.tw (8.13.8/8.13.8/Submit) id l3I654AY060924
        for chwong@nabsd.cs.nctu.edu.tw; Wed, 18 Apr 2007 14:05:04 +0800 (CST)
        (envelope-from chwong)
Date: Wed, 18 Apr 2007 14:05:04 +0800
From: =?utf-8?B?5aSn5bCP5aeQ?= <lkkg-girl@mail.richhome.net>
To: Yung-Hsiang Liu <liuyh@nabsd.cs.nctu.edu.tw>
Subject: =?utf-8?B?56yR54uX5aW95Y+v5oCV?=
Message-ID: <20070418060503.GA60903@chbsd.csie.nctu.edu.tw>
MIME-Version: 1.0
Content-Type: text/plain; charset=utf-8
Content-Disposition: inline
Content-Transfer-Encoding: 8bit
User-Agent: Mutt/1.5.15 (2007-04-06)
Status: RO
Content-Length: 23
Lines: 1

你趕快把牠趕跑好不好？
```

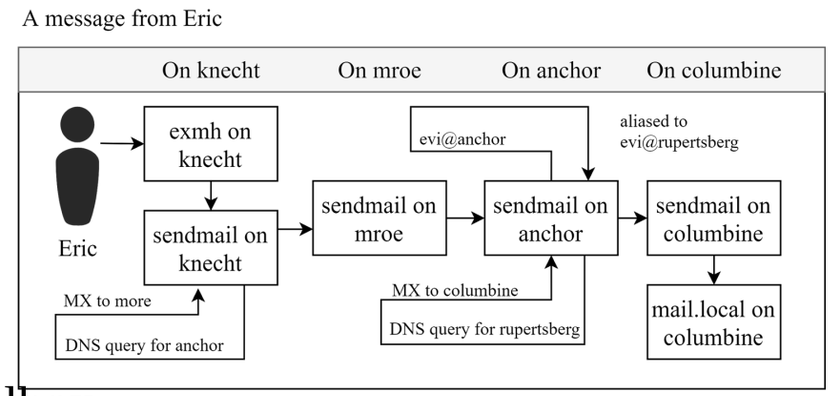
# Mail Transport Example (1)

- User eric@knecht.sendmail.org sends a email to user evi@anchor.cs.colorado.edu
  - $ dig mx anchor.cs.colorado.edu
    - mroe.cs.colorado.edu

A message from Eric

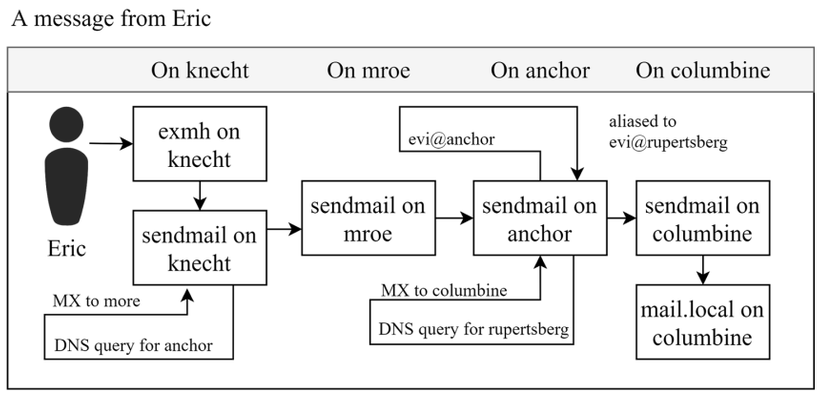


# Mail Transport Example (2)




- Headers in the example
  - From eric@knecht.sendmail.org
    - Added by mail.local when the mail is put in user's mailbox
    - Used to separate message boundary
  - Return-Path: eric@knecht.sendmail.org
    - The envelope "mail from"
    - Used to send the error message to this address
    - May be different to the "From" address in usual header
  - Delivered-To: evi@rupertsberg
    - Final envelope "rcpt to"

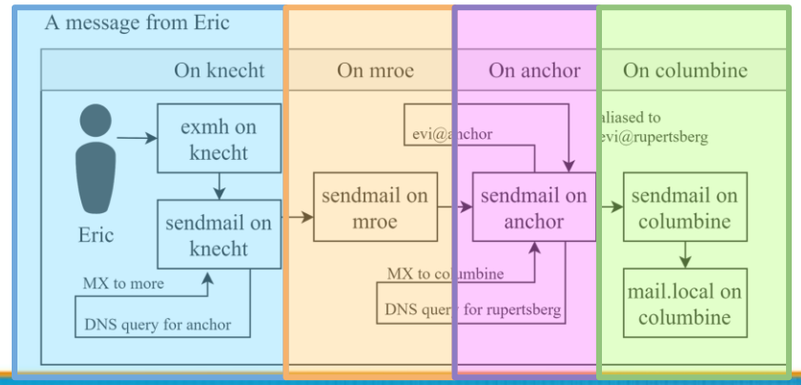
# Mail Transport Example (3)




- Headers in the example
  - Received: from knecht.sendmail.org (localhost [127.0.0.1]) by knecht.sendmail.org (8.9.3/8.9.2) with ESMTP id GAA18984; Fri 1 Oct 1999 06:04:02 -800 (PST)
    - Every machine that is ever processed this mail will add a "Received" record in **top** of headers
      - Sending machine
      - Receiving machine
      - Mail server software in receiving machine
      - Unique queue identifier of mail server in receiving machine
      - Date and time

# Mail Transport Example (4)

- Received: from **anchor.cs.Colorado.EDU** (root@anchor.cs.colorado.edu [128.138.242.1]) by **columbine.cs.colorado.edu (8.9.3/8.9.2)** with ESMTP id HAA21741 for <evi@rupertsberg.cs.colorado.edu>; Fri, 1 Oct 1999 07:04:25 -0700 (MST)
- Received: from **more.cs.colorado.edu** (more.cs.colorado.edu [128.138.243.1]) by **anchor.cs.colorado.edu** (8.9.3/8.9.2) with ESMTP id HAA26176 for <evi@anchor.cs.colorado.edu>; Fri, 1 Oct 1999 07:04:24 -0700 (MST)
- Received: from **knecht.sendmail.org** (knecht.sendmail.org [209.31.233.160]) by **more.cs.colorado.edu** (8.9.3/8.9.2) with ESMTP id HAA09899 fro <evi@anchor.cs.colorado.edu>; Fri, 1 Oct 1999 07:04:23 -700 (MST)
- Received: from **knecht.sendmail.org** (localhost [127.0.0.1]) by **knecht.sendmail.org** (8.9.3/8.9.2) with ESMTP id GAA18984; Fri 1 Oct 1999 06:04:02 -800 (PST)



# Mail Transport Example (5)

- Message-Id: <199910011404.GAA18984@knecht.sendmail.org)
  - Add by sender's MTA
- X-Mailer: exmh version 2.0.2 2/24/98
  - MUA
  - Non-standard header information
- To: Evi Nemeth <evi@anchor.cs.colorado.edu>
- Subject: Re: hi
- Date: Fri, 1 Oct 1999 06:04:02 -800

# Mail System Architecture

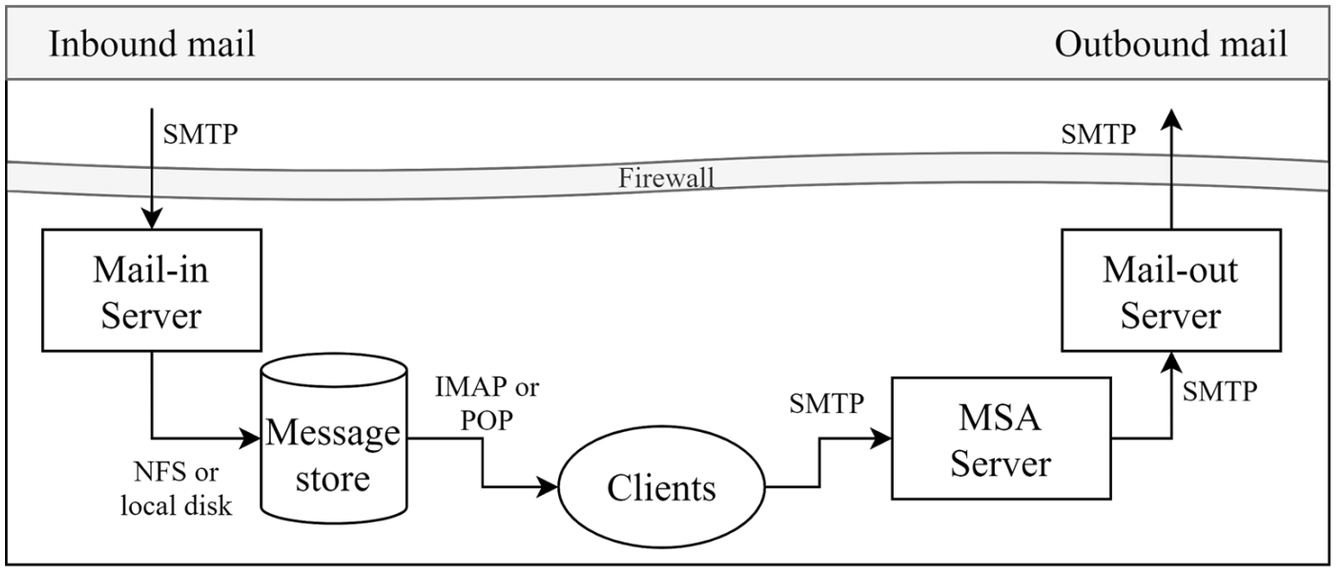
- Components in a mail system architecture
  - Mail servers for incoming and/or outgoing mails
  - Storage for mailboxes
  - IMAP or POP3 to integrate PC and remote clients

- Simplest architecture
  - Only one machine
    - MTA server for SMTP (Postfix)
    - Local disk storage for mailboxes
    - MAA server for IMAP/POP3 (Dovecot)

# Mail System Architecture – Scalable architecture for medium sites

- Centralize
  - At least one machine for incoming message and
    - Mail home can be the same host or another one
  - At least one machine for outgoing message
    - Each host run MSA and forward mail to the same mail-out server or send the mail directly

Mail System architeccture



# To, CC, and BCC

- You should always make sure you mail the right people
  - The **To field** is for people that the message directly affects, and that you require actions from.
  - The **CC (or Carbon Copy) field** is for people you want to see the message, but are not directly involved.
  - The **BCC field (Blind Carbon Copy**) is used when you want other people to receive the message, but you don't want the other recipients to know they got it.
- There are "To" and "CC," but not "BCC" in the email headers.
  - Why "No checking consistent 'To' in envelope and header"

# vacation

- vacation(1): E-mail auto-responder
  - returns  a message, ~/.vacation.msg by default
  - ~/.vacation.db
    - default database file for db(3)
  - ~/.vacation.{dir,pag}
    - default database file for dbm(3)
  - ~/.vacation.msg
    - default message to send

Stores messages people sent to you

- Use with forward(5)
  - \tsaimh, |/usr/bin/vacation