Part 1

How Things Work

Featuring:

- The commands that constitute the command portion of the SMTP command/response protocol
- The SMTP response codes and what they mean
- The structure of a basic mail message
- The ESMTP and MIME extensions for multi-media mail
- The POP and IMAP mailbox protocols
- The meaning of MUA, MSA and MTA and the role these things play in mail delivery
- The role that Sendmail plays in you mail architecture
- The interaction between Sendmail and DNS
- How Sendmail is run to collect inbound mail
- How to control Sendmail at startup and how to control it with signals
- How to install the Sendmail binaries with RPM
- How to compile Sendmail for a Linux system

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Internet Mail Protocols

The complexity of Sendmail configuration is legendary. Tales of administrators becoming entrapped in the maze of terse commands that make up the Sendmail configuration file are part of the folklore of Linux system administration. Surprisingly, the network protocols that underlie Sendmail are very simple.

A *network protocol* is the set of rules that computer systems must follow in order to exchange information over a network. Network protocols that operate over the Internet are part of the Internet Protocol suite. Unlike most Internet protocols that need to be explained at the network packet level, the e-mail protocols are simple command/response protocols that you can easily understand and manipulate. This chapter will both explain the e-mail protocols and show examples of how they can be easily observed and manipulated by the average user.

Understanding the e-mail protocols can help you understand what Sendmail does, which in turn can help you understand when and why certain configuration options are necessary. The ability to directly manipulate e-mail protocols from the Linux console is also a useful troubleshooting tool. And beyond these practical applications lies an equally important reason: True mastery of any subject requires that you really understand how the thing works.

The Internet Protocol Suite

The Internet is built with the Internet Protocol suite. The Internet Protocol (IP) is the foundation of the protocol suite, and the Simple Mail Transport Protocol (SMTP) is the mail delivery protocol in that suite.

IP defines the network addressing, thus the term *IP address*, and it defines the basic unit of information that moves though the network. This unit of information is a block of data, called a *datagram*, that contains addressing and administrative information as well as application-specific data. Because the datagram carries its own addressing information with it, it can move through the network independent of any other datagram. The benefits of this independence are robustness and efficiency. Robustness comes from the fact that each datagram can choose its own path through the network. If part of the network fails, the datagram can move around it on any available path. Efficiency comes from the minimal overhead involved in this scheme. Because each packet is independent, there is no need to keep track of other packets in the flow, which simplifies processing. The weakness of this independence is that sometimes the application data must span multiple datagrams. The IP protocol does not provide a way to sequence the data across datagrams.

The Transmission Control Protocol (TCP) offers applications a way to address the weaknesses of IP. When an application needs to send a stream of related data, TCP provides the features necessary for the data to arrive at the remote location reliably and in sequence. It maintains the sequence by embedding sequence numbers in the stream of transmitted data and ensures reliability by requiring acknowledgements from the remote end. SMTP creates a connection between the source and the destination of the e-mail. It uses TCP to create and manage this connection, and to guarantee that the information sent to the destination arrives in sequence and without errors. SMTP systems communicate over TCP port 25. The stream of data sent over the connection contains the commands of the SMTP protocol as well as the e-mail message.

A Simple Mail Transport Protocol

The SMTP protocol is defined in RFC 821 (“A Simple Mail Transport Protocol”). It is a cleartext command/response protocol. The e-mail source sends a command to the destination and waits for a response to the command. Table 1.1 lists the SMTP commands defined in RFC 821.

Table 1.1 Basic SMTP Commands

Command	Syntax	Purpose
Hello	**HELO** <*sending-host*>	Opens the SMTP session and identifies the source host.
From	**MAIL FROM:**<*from-address*>	Specifies the sender's mail address.
Recipient	**RCPT TO:**<*to-address*>	Specifies the mail address of the recipient.
Data	**DATA**	Signals the start of the mail message. The mail ends when a line containing only a dot (.) is sent.
Reset	**RSET**	Aborts a message.
Verify	**VRFY** <*address*>	Verifies an e-mail address.
Expand	**EXPN** <*list-name*>	Displays the e-mail addresses contained in the specified mailing list.
Help	**HELP** [<*command*>]	Displays a summary of all supported commands or, optionally, information about a specific command.
No Op	**NOOP**	Asks the destination host to do nothing except send an "OK" response.
Quit	**QUIT**	Ends the SMTP session.

RFC 821 defined some other commands that were not widely implemented. These obsolete commands are:

SEND Sends the mail message to a terminal.

SOML Sends the mail message to a terminal or delivers it to a mailbox.

`SAML` Sends the mail message to a terminal and delivers it to a mailbox.

`TURN` Turns the connection around so that the mail source is now the destination and the mail destination is now the source.

RFC 821 was written way back in 1982 when central computers with user terminals were in widespread use. `SEND`, `SOML`, and `SAML` assumed that there would be times when the source system would want to display a message on the recipient's terminal in a manner similar to the Linux `write` command. In reality, SMTP turned into a pure mail system that sends e-mail to a mailbox and does not send messages to a terminal.

The `TURN` command reverses the role between the sending and receiving mail systems. In a normal connection, the system that initiates the connection is the system that has mail to send. With the `TURN` command, the system that initiates the connection does not necessarily have mail to send. The initiating system is hoping to receive mail. It creates the connection to find out if the remote system has any mail to send to it. In a global Internet it is, of course, impossible to know what systems have mail to send you. So the `TURN` command was really intended as a way to move mail from a mailbox server to a client that has limited network service. Mailbox protocols like POP and IMAP, covered later in this chapter, reduced the demand for `TURN`, as did the wide deployment of full-time Internet access. Security concerns about the `TURN` command killed it.

For these reasons, `SEND`, `SOML`, `SAML`, and `TURN` were never widely implemented and you can safely ignore them when you see them in RFC 821. The 10 commands listed in Table 1.1 are the basic SMTP commands implemented on most systems.

As you'll see in the following sections, SMTP is such a simple protocol that it is possible to watch the protocol in action and to understand what is happening when you do. This is both a useful way to learn how the protocol functions and to detect when it is malfunctioning.

Using SMTP through *telnet*

The SMTP protocol is simple enough for you to "do it yourself." Use `telnet` to connect to port 25 on a destination host and manually type in a few SMTP commands. The example in Listing 1.1 was created on a Red Hat system running Sendmail 8.11.0.

Listing 1.1 Telnetting to the SMTP Port

```
[craig]$ telnet wren.foobirds.org 25
Trying 127.0.0.1...
Connected to wren.foobirds.org.
Escape character is '^]'.
220 wren.foobirds.org ESMTP Sendmail 8.11.0/8.11.0; Mon, 23 Oct 2000
    11:23:14 -0400
```

```
helo robin
250 wren.foobirds.org Hello robin [172.16.5.2], pleased to meet you
help
214-2.0.0 This is Sendmail version 8.9.3
214-2.0.0 Topics:
214-2.0.0       HELO    EHLO    MAIL    RCPT    DATA
214-2.0.0       RSET    NOOP    QUIT    HELP    VRFY
214-2.0.0       EXPN    VERB    ETRN    DSN     AUTH
214-2.0.0       STARTTLS
214-2.0.0 For more info use "HELP <topic>".
214-2.0.0 To report bugs in the implementation send email to
214-2.0.0     sendmail-bugs@sendmail.org.
214-2.0.0 For local information send email to Postmaster at your site.
214 2.0.0 End of HELP info
vrfy <norm>
250 2.1.5 <norm@24seven.wrotethebook.com>
vrfy <frank>
550 5.1.1 <frank>... User unknown
expn <staff>
250 2.1.5 <becky@ani>
250 2.1.5 <sara@hawk>
250 2.1.5 <david@ani>
250 2.1.5 Craig Hunt <craig@24seven.wrotethebook.com>
250 2.1.5 <kathy@robin>
quit
221 wren.foobirds.org closing connection
Connection closed by foreign host.
```

In Listing 1.1, a sample user sitting at the computer `robin` uses `telnet` to connect to the SMTP port on `wren`. The first three messages displayed (Trying, Connected, and Escape) are `telnet` messages that have nothing to do with SMTP or Sendmail. The first SMTP message begins with the code 220. This message comes from the remote server `wren`, and is issued in response to the TCP connection created by `telnet`. This message lets the local system know that the remote system will accept SMTP commands. This first message provides several pieces of information. The message

- identifies the remote host as `wren.foobirds.org`
- states that the remote system is running ESMTP, which is extended SMTP, a topic covered later in this chapter
- says that `wren` is running Sendmail version 8.11.0
- displays the time the connection is made

The first command entered by the user is HELO, which identifies the local system as robin and starts the SMTP session. The remote server responds with a message that begins with code 250, and indicates that the session has begun. In Listing 1.1, the user then types in the HELP command. In response to that, the remote system displays 10 lines, all of which start with the code 214. The most interesting part of this response are the commands listed under the heading Topics. These are the SMTP commands supported by wren.

> ***NOTE*** There are more commands listed in response to the HELP command in Listing 1.1 than are listed as part of RFC 821 in Table 1.1. That is because three of the commands in Listing 1.1 are extended SMTP commands that we have not yet discussed, two are new security protocol keywords (AUTH and STARTTLS), and one (VERB) is a non-standard command supported by Sendmail that is also discussed later.

The next two commands entered by the user are VRFY commands, which verify whether or not an e-mail address is valid. Listing 1.1 shows two different responses. One tells us that norm is a valid e-mail address and the other tells us that frank is not. If the address entered in a VRFY command does not contain a domain name or contains the domain name of the local computer, it is checked against both the user accounts and the aliases available on the system. If the address contains the domain name of a remote host, the address is only checked to see that it is syntactically valid. The system assumes that an address on a remote host will be forwarded to that host and that it is the responsibility of the remote host to determine whether or not the address is valid and the mail can be delivered.

The EXPN command is used to expand a mailing list. In Listing 1.1, the name of the mailing list is staff. The system responds to the query by listing all of the e-mail addresses contained in that mailing list.

The strangest thing about the HELP, VRFY, and EXPN commands is that they are designed more for interactive use than for communications between e-mail programs. The HELP command is clearly designed for interactive users. Program-to-program communications do not use the EXPN command because the responsibility for expanding a mailing list and delivering to the members of that list falls to the destination program. Therefore, the source program does not need to check the contents of the list. Even the VRFY command, which on the surface appears to have some utility in program-to-program communications, is not needed because the e-mail addresses are verified by default at the start of the delivery process, as shown below:

```
mail from: <craig@24seven>
250 <craig@24seven>... Sender ok
```

```
rcpt to: <frank>
550 <frank>... User unknown
```

The user closes the SMTP session in Listing 1.1 with the `QUIT` command. The remote system responds with a message that starts with the code 221. The last line in Listing 1.1 is not part of the SMTP session. The line that starts with "Connection closed" is a message from `telnet`.

SMTP Response Codes

Listing 1.1 shows that all of the response messages from the remote SMTP server begin with a numeric code. Table 1.2 lists the response codes defined in the RFCs.

Table 1.2 SMTP Server Response Codes

Response Code	Meaning
211	This is a system status message.
214	This is a help message.
220 *hostname*	The SMTP service is ready.
221 *hostname*	The SMTP connection is closing.
250	The requested action was completed successfully.
251	The recipient address is not local, and the mail will be forwarded.
252	The address cannot be verified, but it will be accepted for forwarding.
354	The destination server is ready to accept the mail data.
421 *hostname*	The requested service is not available, and the connection is closing.
450	The requested action was not performed.
451	The requested action aborted because of an error.
452	The requested action failed because of insufficient disk space.
500	The command was not recognized.

Table 1.2 SMTP Server Response Codes *(continued)*

Response Code	Meaning
501	The command had a syntax error in its parameters or arguments.
502	The command is not implemented on this server.
503	The sequence of commands is incorrect.
504	A parameter included with the command is not implemented on this server.
550	The requested action was not performed.
551	The recipient address is not local, and the mail must be manually forwarded.
552	The requested action was aborted because of insufficient disk space.
553	The mailbox name was invalid.
554	The transaction failed.

Every SMTP command elicits a response. A command is sent and a response comes back. From the explanations of the response codes in Table 1.2, it is easy to tell that response codes in the 200s and 300s indicate a successful transaction, while codes in the 400s and the 500s indicate failure, as shown by the few lines below:

```
RCPT TO: <craig>
503 Need MAIL before RCPT
```

The response code is only returned to the user who sent the message when the code indicates a failure. Most of the time, of course, you don't see these codes. Cooperating Sendmail programs on the local system and the remote system go about their business silently exchanging SMTP commands and responses. To watch Sendmail interact with the remote system, run the `sendmail` command in verbose mode.

Observing SMTP with Verbose Mode

Using `telnet` to connect to the SMTP port is a useful way to get a feel for the SMTP protocol, and it can be a useful test technique when you want to completely bypass your local copy of Sendmail to test the responses of a remote Sendmail server. But it is by its nature artificial. A user typing in SMTP commands *approximates* the exchange of protocol information based on a best guess of how the two systems will interact. In most cases, it is much better to sit back and observe the systems actually interacting. The -v (verbose) option of the `sendmail` command lets you do exactly that. Listing 1.2 shows a piece of mail being sent with verbose mode enabled.

Listing 1.2 The Protocol as Displayed by Verbose Mode

```
[craig]$ sendmail -v -t
To: craig@wren
From: craig@ani
Subject: Test
Please ignore this test.
^D
craig@wren... Connecting to wren.foobirds.org. via esmtp...
220 wren.foobirds.org ESMTP Sendmail 8.11.0/8.11.0; Mon, 23 Oct 2000
    11:42:34 -0400
>>> EHLO ani.foobirds.org
250-wren.foobirds.org Hello root@ani.foobirds.org [172.16.12.1],
    pleased to meet you
250-ENHANCEDSTATUSCODES
250-EXPN
250-VERB
250-8BITMIME
250-SIZE
250-DSN
250-ONEX
250-ETRN
250-XUSR
250-AUTH DIGEST-MD5
250 HELP

>>> MAIL From:<craig@ani.foobirds.org> SIZE=73
250 <craig@ani.foobirds.org>... Sender ok
>>> RCPT To:<craig@wren.foobirds.org>
250 <craig@wren.foobirds.org>... Recipient ok
>>> DATA
```

```
354 Enter mail, end with "." on a line by itself
>>> .
250 NAA01047 Message accepted for delivery
craig@wren... Sent (NAA01047 Message accepted for delivery)
Closing connection to wren.foobirds.org.
>>> QUIT
221 wren.foobirds.org closing connection
```

In addition to the verbose option, the `sendmail` command in Listing 1.2 is invoked with the `-t` option that accepts the mail message directly from the keyboard. In Listing 1.2, the user types in the To: address, the From: address, a Subject: line, and a one-line message. The user input is terminated by a Ctrl+D. Everything else in Listing 1.2 is output displayed by Sendmail.

Three of the lines displayed are informational messages directly from Sendmail. The first line displays the delivery triple: the delivery address `craig@wren`, the remote server name `wren.foobirds.org`, and the internal mailer name `esmtp`. You'll hear much more about the delivery triple later on. The other two lines created by Sendmail appear near the bottom of Listing 1.2. The first of these two lines displays the message identifier used to send the message, which is NAA01047 in the example. The second line informs us that Sendmail is ready to close the connection.

Most of the output displayed by `sendmail` is the SMTP protocol interaction. Every line that begins with >>> is a command sent from the local system to the remote system. Every line that begins with a response code is a response from the remote system. Only six commands are used to send the message:

`EHLO` This is the hello command. It is different from the one shown in Table 1.1 because this is the extended hello used by Extended SMTP, which is covered later in this chapter.

`MAIL From:` This is the From: address. Addresses used in the SMTP protocol exchange are called envelope addresses and are distinct from the header addresses sent as part of the message data, although header addresses and envelope addresses usually contain the same values. You'll hear more about these different address types when we discuss address rewriting and testing in Chapter 8, "Understanding Rewrite Rules."

`RCPT To:` This is the To: address. It is also an envelope address.

`DATA` The `DATA` command marks the beginning of the message.

`.` The dot (.) is used to mark the end of the message.

`QUIT` The `QUIT` command closes the session.

The SMTP protocol exchange is simple and straightforward and can easily be observed using the `sendmail -v` option. Observing an SMTP session shows you if the mail is leaving

your system and whether or not it is accepted by the remote system. This can be valuable information when you suspect a problem.

The one thing that is not shown in Listing 1.2 is the mail message that Sendmail sends between the `DATA` command and the closing dot (.). The exchange of protocol commands and responses is only a small part of the information that flows over an SMTP connection. The real purpose of SMTP is to carry data in the form of mail messages.

A Basic Mail Message

The format of the basic e-mail message is defined in RFC 822 ("Standard for the Format of ARPA Internet Text Messages"). According to RFC 822, an e-mail message consists of two parts: headers and a message body. As the name implies, the headers come at the head of the message before the message body. The message body is separated from the headers by a blank line—a line that contains nothing but a carriage return/line feed (CRLF) character. The message body is composed of lines, each of which contains fewer than 1000 bytes of seven-bit ASCII text.

Message Headers

Headers are individual lines of text that begin with a header name (also called a *field name* in RFC 822) separated by a colon from the variable data related to that header (this data is also called the *field body* in the RFC). Headers provide a record of the information used to deliver the mail. Headers tell you whom a message is bound for, whom it came from, when it was sent, and what computers handled the message as it moved through the network.

Message headers are distinct from the envelope headers we saw in the SMTP protocol exchanges. Envelope headers are limited to the From: and To: addresses. There are From: and To: headers in the message, but there are also a large number of other possible headers, which provide more information about how a message was handled than observing the SMTP interaction does. Listing 1.3 shows the headers that were created for the message sent in Listing 1.2.

Listing 1.3 A Complete Mail Message

```
From craig@ani.foobirds.org  Mon Oct 23 11:42:34 2000
Return-Path: <craig@ani.foobirds.org>
Received: from ani.foobirds.org (root@ani.foobirds.org [172.16.12.1])
    by wren.foobirds.org (8.9.3/8.9.3) with ESMTP id NAA01047
    for <craig@wren.foobirds.org>; Mon, 23 Oct 11:42:33 -0400
From: craig@ani.foobirds.org
```

```
Received: (from craig@localhost)
        by ani.foobirds.org (8.11.0/8.11.0) id JAA01401;
        Mon, 23 Oct 2000 09:47:44 -0400
Date: Mon, 23 Oct 2000 09:47:44 -0400
Message-Id: <200007291347.JAA01401@ani.foobirds.org>
To: craig@wren.foobirds.org
Subject: Test

Please ignore this test.
```

Listing 1.3 is the e-mail sent in Listing 1.2 as it was stored in `/var/spool/mail/craig` on `wren`, which is a Red Hat Linux system. `/var/spool/mail` is the directory that holds user mail. Each user is given a mailbox that is identified by the user's name. In this example, the mail was sent to the user `craig`, so the mail was written to the mailbox `/var/spool/mail/craig`.

The first line in Listing 1.3 is not a real message header. It is a special line, inserted by Sendmail to mark the beginning of each message in a mailbox. The line is sometimes called the *Unix header* or the *Unix From line*. The second line is the first message header. This message has a total of eight message headers:

Return-Path: This header contains the sender address from the envelope, which can be different than the sender address shown by the From: header. The address in the Return-Path: header is used only to notify the source of a message if a delivery error occurred.

Received: A Received: header is created by each site that handles a piece of mail. There are as many Received: headers as there are sites that processed the mail. In Listing 1.3, there are two Received: headers—one from `ani`, which was the site that originated the message, and one from `wren`, which was the site that accepted the message. The fact that there are only two Received: headers shows that the mail went directly from `ani` to `wren`. The first Received: header tells us that a message, which `ani` identified with message ID NAA01047, was received from `ani` by `wren` for the user `craig`.

From: This header identifies whom the mail is from.

Received: This second Received: header records the fact that the local host also handled the mail. The local host, `wren`, assigned a message ID of JAA01401 to the message.

Date: This header specifies the date and time the message was received.

Message-Id: This header provides a unique identifier for the message, composed of the time the message was received, the local message ID, and the domain name of the local computer.

To: This header identifies who is to receive the mail.

Subject: This header contains the subject line entered by the originator of the message.

Even though Listing 1.3 contains eight header lines, there are only seven different header types because Received: is repeated. These seven different header types are the set found on most pieces of mail. There are, however, many other headers besides these. Sendmail supports more than 30 different types of headers, and not all of the headers in a mail message are inserted by Sendmail. Some come directly from the user, as did the To:, From:, and Subject: headers in Listing 1.3. Others come from the user's mailer when it formats the mail. Sendmail ensures that all of the headers are correctly formatted and that all of the necessary headers are provided.

A blank line immediately follows the headers. This line separates the headers from the message body. In Listing 1.3, the message body is composed of only a single line of text. RFC 822 defines a protocol that can carry only text messages. Modern e-mail systems need to carry a much wider variety of data, so the e-mail protocols have been extended to do just that.

Multipurpose Internet Mail Extensions

RFC 822 defines a mail message that is composed completely of lines of seven-bit ASCII text. No provisions are made in that RFC to carry any other type of data. This is a major limitation for a modern network because it does not provide support for languages with a larger character set than U.S. English, and it does not support binary data. Imagine the complaints you would receive if your mail server could not handle the binary data produced by your users' favorite applications! RFC 822 also does not provide support for complex message bodies. In fact, it says almost nothing about the content and structure of the message body. The focus of RFC 822 is almost entirely on defining message headers.

The Multipurpose Internet Mail Extensions (MIME) were defined to address these weaknesses. MIME defines encoding techniques to carry a wide variety of data, and it defines a structure for complex message types. RFC 2045 ("Multipurpose Internet Mail Extensions (MIME) Part One: Format of Internet Message Bodies") defines two new headers that are used to give the mail message structure, to identify the type of data the message is carrying, and to identify the encoding techniques used for that data.

The Content-Type Header

The Content-Type: header identifies the type of data that the message is carrying. The general format of this header is:

```
Content-Type: type/subtype [attribute=value; ...]
```

The *type* field of the header defines the major type of data, and the *subtype* field defines the specific type of data. An example of this is `application/msword`, which defines the message as application data for Microsoft Word. The optional *attribute=value* pairs are used with some data types to provide additional information about the data carried in the message. An example of this is `text/plain; charset=us-ascii`, which states that the message is plain text composed of U.S. ASCII characters. RFC 2046 ("Multipurpose Internet Mail Extensions (MIME) Part Two: Media Types") defines seven fundamental media types:

`text` Basic text data. Examples of subtypes that go with the `text` type are `plain`, `enriched`, and `html`.

`image` Still graphic images. Some common subtypes for image data are `jpeg`, `gif`, and `tiff`.

`audio` Audio data. The subtype described in RFC 2046 is `basic`, which is the name for Pulse Code Modulation (PCM) data.

`video` Moving graphic images. Subtype examples of `video` are `mpeg` and `quicktime`.

`application` Binary data or data that must be processed by a specific program. Subtype examples include `octet-stream`, which is eight-bit binary data, and `msword`, which is data that is to be processed by a specific word processor.

`multipart` A message composed of several independent parts, each of which can contain its own type of data. The RFC defines four subtypes for this:

- `mixed`, in which each part is completely independent
- `alternative`, in which each part contains the same data in different formats
- `parallel`, in which each part should be viewed simultaneously
- `digest`, in which each part of the message is an encapsulated message

`message` The data is an encapsulated mail message, which can in turn contain any valid message type.

In addition to the seven data types, a few subtypes are mentioned in RFC 2046. But that is just the tip of the iceberg. There are literally hundreds of data subtypes. Vendors register the subtype of their data following the instructions in RFC 2048 ("Multipurpose Internet Mail (MIME) Part Four: Registration Procedures"). The large number of data

subtypes that have been registered indicates the number of applications that want to move data via e-mail. To see the latest listing of registered data types, download the file `media-types` from the `in-notes/iana/assignments` directory at `ftp.isi.edu`.

Because of the fact that MIME adds structure to a mail message, headers are no longer limited to the beginning of a message. Content-Type: headers can occur multiple times in a message. Listing 1.4 shows a mail message from a Caldera Linux system that uses MIME to encapsulate a message within the message.

Listing 1.4 A Message with MIME Headers

```
Received: from localhost (localhost)
        by ani.foobirds.org (8.9.3/8.9.3) with internal id IAB01301;
        Sat, 29 Jul 2000 08:13:52 -0400
Date: Sat, 29 Jul 2000 08:13:52 -0400
From: Mail Delivery Subsystem <MAILER-DAEMON@ani.foobirds.org>
Message-Id: <200007291213.IAB01301@ani.foobirds.org>
To: craig@ani.foobirds.org
MIME-Version: 1.0
Content-Type: multipart/report; report-type=delivery-status;
        boundary="IAB01301.964872832/ani.foobirds.org"
Subject: Returned mail: User unknown
Auto-Submitted: auto-generated (failure)
Status:

This is a MIME-encapsulated message

--IAB01301.964872832/ani.foobirds.org

The original message was received at Sat, 29 Jul 2000 08:13:12 -0400
from root@localhost

   ----- The following addresses had permanent fatal errors -----
frank@wren

   ----- Transcript of session follows -----
.... while talking to wren.foobirds.org.:
>>> RCPT To:<frank@wren.foobirds.org>
<<< 550 <frank@wren.foobirds.org>... Relaying denied
550 frank@wren... User unknown
```

```
--IAB01301.964872832/ani.foobirds.org
Content-Type: message/delivery-status

Reporting-MTA: dns; ani.foobirds.org
Arrival-Date: Sat, 29 Jul 2000 08:13:12 -0400

Final-Recipient: RFC822; frank@wren.foobirds.org
Action: failed
Status: 5.1.1
Remote-MTA: DNS; wren.foobirds.org
Diagnostic-Code: SMTP; 550 <frank@wren.foobirds.org>... Relaying denied
Last-Attempt-Date: Sat, 29 Jul 2000 08:13:52 -0400

--IAB01301.964872832/ani.foobirds.org
Content-Type: message/rfc822

Return-Path: <craig>
Received: (from root@localhost)
        by ani.foobirds.org (8.9.3/8.9.3) id IAA01301;
        Sat, 29 Jul 2000 08:13:12 -0400
Date: Sat, 29 Jul 2000 08:13:12 -0400
Message-Id: <200007291213.IAA01301@ani.foobirds.org>
To: frank@wren.foobirds.org
From: craig@ani.foobirds.org
Subject: Test

Please ignore this test.

--IAB01301.964872832/ani.foobirds.org--
```

The message in Listing 1.4 contains three different Content-Type: headers, each of which I marked in bold to make them easier to find. The first one identifies this as a message of type `multipart`. It is in fact a message composed of three distinct parts. The subtype of this `multipart` message is `report`. (The subtype `report` was not defined in RFC 2046; it was added later.) Two parameters are also defined on the first Content-Type: header. The `report-type` argument tells us this is a `delivery-status` report. The `boundary` argument defines the line that is used to separate each part in this multipart message. The boundary lines are also in bold to make them easier to find in the listing.

The second Content-Type: header declares that the second message in the multipart message is also a delivery status message. The third and final Content-Type: header states that

the last message in the multipart message is an RFC 822 message. This is a copy of the original message that generated the error.

MIME allows for complex message bodies, as Listing 1.4 illustrates. However, everything in Listing 1.4 is basic ASCII text. MIME permits a wider range of data types.

The Content-Transfer-Encoding Header

The large number of data types supported by MIME means that not everything can be sent as seven-bit ASCII data. The Content-Transfer-Encoding: header identifies the type of encoding used for the data in a MIME message. RFC 2045 defines five types of encoding:

7bit This is the standard seven-bit U.S. ASCII that e-mail has always supported. The data in this message is composed of lines of U.S. ASCII characters. Each line is less than 1000 characters long. This type identifies the encoding inherent in the data. No additional encoding is done.

8bit This is eight-bit binary data formatted into lines that are less than 1000 octets long. This type identifies the encoding inherent in the data. No additional encoding has been done.

binary This is eight-bit binary data that is not formatted into lines less than 1000 octets long. There is no difference between the eight-bit encoding type and the binary encoding type except for the fact that binary data is not restricted to a maximum line length. This type identifies the encoding inherent in the data. No additional encoding is done.

quoted-printable This is encoded text data. The bulk of the data in a quoted printable message is printable ASCII text, which is sent unencoded. Bytes of data that are not normally printable—those with a hexadecimal value less than 33 or greater than 127—are encoded as a string made up of the equal sign and characters representing the hexadecimal value of the desired byte. Thus, a byte containing the ASCII form feed, which has a hexadecimal value of 0C, would be sent as the three-byte string =0C. The equal sign itself is sent as =3D.

base64 This is encoded binary data. Three octets (24 bits) of binary data are sliced into four six-bit pieces. Two zero bits are prepended to each six-bit chunk to create four eight-bit characters. All of the characters created in this manner are a subset of U.S. ASCII that can be handled by any mail system. This allows encoded binary data to pass through any mail server. The disadvantages of base64 encoding are that it increases the size of a binary file by at least 33 percent and it has a maximum line length of 76 bytes that can further increase the size of the file by adding newline characters to meet this line-length requirement.

Of the five encoding techniques specified in RFC 2045, two are techniques for encoding the data in a message and three are used to identify the encoding already there. The

quoted-printable and base64 techniques make it possible to send data through any e-mail system. 7bit encoding is compatible with any system, because it is the original e-mail encoding system. The other two techniques, 8bit and binary, require a new mail system that can handle these new data formats without additional encoding. SMTP was extended to handle these new formats and the requirements of MIME mail.

Extended SMTP

SMTP was not designed to handle multiple data types; thus, it needed enhancements to handle MIME data. RFC 1869 ("SMTP Service Extensions") defines an extensible version of SMTP, not by defining specific service extensions, but by specifying a technique that systems can use to negotiate which SMTP extensions they support. RFC 1869 defines a new version of the SMTP `HELO` command named `EHLO`.

A system that runs ESMTP sends `EHLO` as the hello greeting to start the session. If the receiving system does not run ESMTP, it rejects `EHLO` as an error. The sending system can then initiate the session with the old `HELO` command or terminate the session. If the receiving system runs ESMTP, it responds to the `EHLO` command by sending a listing of the extended SMTP features it supports. Each feature is identified by a standard keyword. Thus the sending system knows the capabilities of the receiving system and can use any of the features that the remote system advertises.

Listing 1.2 shows a full ESMTP session. It opens with an `EHLO` command and the list of keywords sent in response to those commands. That `EHLO` command and response are excerpted in Listing 1.5.

Listing 1.5 The `EHLO` Command and Response

```
>>> EHLO ani.foobirds.org
250-wren.foobirds.org Hello root@ani.foobirds.org [172.16.12.1],
    pleased to meet you
250-ENHANCEDSTATUSCODES
250-EXPN
250-VERB
250-8BITMIME
250-SIZE
250-DSN
250-ONEX
250-ETRN
250-XUSR
250-AUTH DIGEST-MD5
250 HELP
```

The format of the EHLO command is simple—just the keyword EHLO followed by the domain name of the sending system. The response from the receiving system is the standard hello acknowledgement followed by a list of keywords. The keywords shown in Listing 1.5 are from a Red Hat Linux system running Sendmail version 8.11.0. By its very nature, the EHLO command evokes different responses from different systems.

Extended Service Keywords

Two of the advertised services are basic SMTP commands defined in RFC 821. HELP provides access to the online help system, and EXPN displays the addresses in a mailing list. This system advertises these services in the keyword list because many sites do not implement these basic commands.

Some of the keywords in the list indicate service extensions that are defined in various RFCs.

ENHANCEDSTATUSCODES This server uses the enhanced status codes that go with Delivery Status Notifications (DSNs). The enhanced status codes are defined in RFC 1893, "Enhanced Mail System Status Codes."

8BITMIME This keyword indicates that the server can accept eight-bit binary data, which means that `8bit` and `binary` data types can be sent to this system without any additional encoding. This extension was defined in RFC 1652 ("SMTP Service Extension for 8bit-MIMEtransport").

SIZE This server supports the SIZE extension, which was defined in RFC 1870 ("SMTP Service Extension for Message Size Declaration"). The sending system uses SIZE to tell the receiving system how large the message is in bytes. The receiving system uses the information to decide whether or not it can accept the e-mail. The MAIL From: line in Listing 1.2 is an example of the SIZE extension in action:

```
>>> MAIL From:<craig@ani.foobirds.org> SIZE=73
```

In this example, the SIZE keyword tells the receiving system that the message contains 73 bytes.

DSN This server can provide delivery status notification. For example, the remote user can request a return receipt notification when the message is read. This extension is defined in RFC 1891 ("SMTP Service Extension for Delivery Status Notifications").

ETRN This server allows remote sites to retrieve messages from the server's queue that are bound for the remote site . `ETRN` is an updated version of the `TURN` command that fixes the security problems that existed in `TURN`. This extension is defined in RFC 1985 ("SMTP Service Extension for Remote Message Queue Starting").

AUTH DIGEST-MD5 The AUTH keyword advertises the type of authentication supported by this server. In this case, the server supports Message Digest 5 (MD5) for authentication. The AUTH extension is defined in RFC 2554 ("SMTP Service Extension for Authentication").

There are also a few keywords in this list that are not standard services. VERB sets the remote mail server in verbose mode. ONEX limits the SMTP session to the transfer of a single message. XUSR is used when a user mail agent sends mail directly to a remote server instead of passing it through a mail transfer agent, such as Sendmail. (I don't know of any user mail agents designed to work this way.) VERB, ONEX, and XUSR are specific to Sendmail version 8; they are not defined in an RFC.

Mailbox Protocols

SMTP moves mail between e-mail servers, and MIME allows that mail to contain anything the user wants to send. SMTP is the protocol implemented by Sendmail, but it is not the only protocol used in delivering the mail to the end user. As we saw in Listing 1.3, Sendmail stores the mail it receives in a mailbox on the Linux server. Any user that can log in to the server can read their mail there. Many users, however, cannot or don't want to read their mail on the server. Those users want to move the mail from the server mailbox to a mail reader located on their desktop systems. There are two popular protocols designed to move mail from the mailbox server to the desktop client: Post Office Protocol (POP), which is the traditional mailbox protocol, and Internet Message Access Protocol (IMAP), which has recently become more popular.

A Sendmail server turns into a mailbox server when it runs either the POP or the IMAP daemon. All Linux systems can run both. Both POP and IMAP can be installed during the initial installation or later using a package manager like RPM. The POP and IMAP protocols are simple command/response protocols very similar to SMTP.

Post Office Protocol

The POP protocol verifies the user's login name and password, and moves the user's mail from the server to the user's local mail reader. There are two versions of POP: POP2 and POP3. Both protocols perform the same basic functions, and they both create connections using TCP to ensure reliability and data sequencing. But the two protocols are incompatible. POP2 uses TCP port 109 and POP3 uses TCP port 110. Linux systems come with both versions of POP, but most clients use POP3. For that reason, this section describes only the POP3 protocol.

POP3 is defined in RFC 1939 ("Post Office Protocol —Version 3"). It is a simple request/response protocol like SMTP. The client sends a command to the server and the server responds to the command. Table 1.3 shows the set of POP3 commands defined in RFC 1939.

Table 1.3 POP3 Commands

Command	Function
USER *username*	The username required for the login.
PASS *password*	The user's password required for the login.
STAT	Requests the number of unread messages/bytes.
RETR *msg*	Retrieves message number *msg*.
DELE *msg*	Deletes message number *msg*.
LAST	Requests the number of the last message accessed.
LIST [*msg*]	Requests the size of message *msg* or of all messages.
RSET	Undeletes all messages and resets the message number to 1.
TOP *msg n*	Prints the headers and the first *n* lines of message number *msg*.
NOOP	Does nothing except request an OK response from the remote server.
APOP *mailbox string*	Identifies a mailbox and provides an MD5 digest string for authentication. Used as an alternative to USER/PASS.
UIDL [*msg*]	Requests the unique ID for the specified message number, or a listing of unique IDs for all messages.
QUIT	Ends the POP3 session.

Like SMTP, the POP3 protocol is simple enough to be done by hand over a `telnet` connection. Listing 1.6 shows a sample POP3 session that demonstrates the function of several of the protocol commands.

Listing 1.6 Using the POP Protocol with `telnet`

```
[craig]$ telnet localhost 110
Trying 127.0.0.1...
Connected to ani.foobirds.org.
Escape character is '^]'.
+OK POP3 ani.foobirds.org v7.64 server ready
USER craig
+OK User name accepted, password please
PASS Wats?Watt?
+OK Mailbox open, 4 messages
STAT
+OK 4 8184
LIST
+OK Mailbox scan listing follows
1 1951
2 1999
3 2100
4 2134
.
RETR 1
+OK 1951 octets
... an e-mail message 1951 bytes long ...
.
DELE 1
+OK Message deleted
QUIT
+OK Sayonara
Connection closed by foreign host.
```

The first three lines after the `telnet` command (Trying, Connected, and Escape) are output from the `telnet` command, as is the very last line (Connection closed). All of the other lines in Listing 1.6 are POP3 commands and responses. Positive responses start with the string `+OK`, which indicates that the command executed successfully. When a command fails, the response begins with the string `-ERR`. The first `+OK` response in Listing 1.6 is in reply to the connection request from `telnet`. The response indicates that the POP server is ready.

The user then logs in with the `USER` and `PASS` commands. The username and password provided here must match a valid username and password found in the `/etc/passwd` file. Notice that the password is sent as clear text. POP3 provides a more secure MD5 login mechanism that is discussed in Chapter 12, "Sendmail Security."

The `STAT` command and the `LIST` command are used to inquire about the messages stored in the mailbox. `STAT` shows that there are four messages with a combined length of 8184 bytes. The `LIST` command shows the size of each individual message in the mailbox. When it comes to mail, size matters because the system downloading the mail needs to know it has sufficient disk space to store the mail. In Listing 1.6, all of the mail messages are small so storage is not an issue.

The first message from the mailbox is downloaded with the `RETR 1` command. It is then removed from the server mailbox with the `DELE 1` command. Normally, messages are retrieved in order and are deleted after they are retrieved, but they don't have to be. When using `telnet` to input the POP commands, you're in complete control. You can download messages out of order, you don't need to delete the messages you download, and you don't need to download messages you delete. Deleting messages instead of downloading them is often very useful. On occasion a corrupted or overly large message stored on the server causes download problems for the desktop client. From the client the user can log on via `telnet` and delete the offending message to get everything running normally again.

Of course, a POP connection is not normally run manually over a `telnet` connection. This is only done here to illustrate the function of the protocol. You will only `telnet` to the POP port for testing. Using your knowledge of the protocol and the configuration, you can `telnet` to the POP port and test whether your server responds. The `telnet` test proves that the daemon is available, installed, and ready to run.

Internet Mail Access Protocol

IMAP is an alternative to POP. It provides the same basic service as POP and adds features to support mailbox synchronization. Mailbox synchronization is the ability to read individual mail messages on a client or directly on the server while keeping the mailboxes on both systems completely up-to-date. On an average POP server, all contents of the mailbox are moved to the client and either deleted from the server or retained as if never read. Deletion of individual messages on the client is not reflected on the server because all of the messages are treated as a single unit that is either deleted or retained after the initial transfer of data to the client. IMAP provides the ability to manipulate individual messages on the client or the server and to have those changes reflected in the mailboxes of both systems.

IMAP uses TCP for reliable, sequenced data delivery. The IMAP port is TCP port 143. Like the POP protocol, IMAP is also a request/response protocol with a small set of commands. Table 1.4 lists the basic set of IMAP commands from version 4 of the IMAP protocol as defined in RFC 2060 ("Internet Message Access Protocol—Version 4rev1").

NOTE The `/etc/services` file lists two different ports for IMAP: 143 and 220. Port 220 is used by IMAP3. However, the current IMAP, which is IMAP4, was derived from IMAP2, which used port number 143. Confused? Don't be. Just remember that the correct port is 143.

Table 1.4 IMAP4 Commands

Command	Use
`CAPABILITY`	Lists the features supported by the server.
`NOOP`	Literally "No Operation," but sometimes used as a way to poll for new messages or message status updates.
`LOGOUT`	Closes the connection.
`AUTHENTICATE`	Requests an alternative authentication method.
`LOGIN`	Opens the connection and provides the username and password for plain text authentication.
`SELECT`	Opens a mailbox.
`EXAMINE`	Opens a mailbox as read-only.
`CREATE`	Creates a new mailbox.
`DELETE`	Removes a mailbox.
`RENAME`	Changes the name of a mailbox.
`SUBSCRIBE`	Adds a mailbox to the list of active mailboxes.
`UNSUBSCRIBE`	Deletes a mailbox name from the list of active mailboxes.
`LIST`	Displays the requested mailbox names from the complete set of all available mailbox names.

Table 1.4 IMAP4 Commands *(continued)*

Command	Use
LSUB	Displays the requested mailbox names from the set of active mailboxes.
STATUS	Requests the status of a mailbox.
APPEND	Adds a message to the end of the specified mailbox.
CHECK	Forces a checkpoint of the current mailbox.
CLOSE	Closes the mailbox and removes all messages marked for deletion.
EXPUNGE	Removes from the current mailbox all messages that are marked for deletion.
SEARCH	Displays all messages in the mailbox that match the specified search criterion.
FETCH	Retrieves a message from the mailbox.
STORE	Modifies a message in the mailbox.
COPY	Copies the specified messages to the end of the specified mailbox.
UID	Searches for or fetches messages based on the message's unique identifier.

This command set is more complex than the one used by POP because IMAP does more. These commands clearly illustrate the "mailbox" orientation of IMAP. The protocol is designed to remotely maintain mailboxes that are stored on the server. The protocol commands show that. Despite the increased complexity of the protocol, it is still possible to run a simple test of your IMAP server using `telnet` and a small number of the IMAP commands. Listing 1.7 shows just such a test.

Listing 1.7 Telnetting to the IMAP Port

```
[craig]$ telnet localhost 143
Trying 127.0.0.1...
Connected to ani.foobirds.org.
Escape character is '^]'.
```

```
* OK ani.foobirds.org IMAP4rev1 v12.252 server ready
a0001 login craig Wats?Watt?
a0001 OK LOGIN completed
a0002 select inbox
* 3 EXISTS
* 0 RECENT
* OK [UIDVALIDITY 965125671] UID validity status
* OK [UIDNEXT 5] Predicted next UID
* FLAGS (\Answered \Flagged \Deleted \Draft \Seen)
* OK [PERMANENTFLAGS (\* \Answered \Flagged \Deleted \Draft \Seen)]
* OK [UNSEEN 1] first unseen message in /var/spool/mail/craig
a0002 OK [READ-WRITE] SELECT completed
a0003 fetch 1 body[text]
* 1 FETCH (BODY[TEXT] {1440}
... an e-mail message that is 1440 bytes long ...
* 1 FETCH (FLAGS (\Seen))
a0003 OK FETCH completed
a0004 store 1 +flags \deleted
* 1 FETCH (FLAGS (\Seen \Deleted))
a0004 OK STORE completed
a0005 close
a0005 OK CLOSE completed
a0006 logout
* BYE ani.foobirds.org IMAP4rev1 server terminating connection
a0006 OK LOGOUT completed
Connection closed by foreign host.
```

Again, the first three lines and the last line come from `telnet`; all other messages come from IMAP. The first IMAP command entered by the user is `LOGIN`, which provides the username and password from `/etc/passwd` used to authenticate this user. Notice that the command is preceded by the string `A0001`. This is a "tag," which is a unique identifier generated by the client for each command. Every command must start with a tag. When you manually type in commands for a test, you are the source of the tags.

IMAP is a mailbox-oriented protocol. The `SELECT` command is used to select the mailbox that will be used. In Listing 1.7, the user selects a mailbox named "inbox." The IMAP server displays the status of the mailbox, which contains three messages. Associated with each message are a number of flags. The flags are used to manage the messages in the mailbox by marking them as Seen, Unseen, Deleted, etc.

The FETCH command is used to download a message from the mailbox. In Listing 1.7, the user downloads the text of the message, which is what you normally see when reading a message. It is possible, however, to download only the headers or flags.

After the message is downloaded, it is deleted. This is done by writing the Deleted flag with the STORE command. The DELETE command is not used to delete messages; it deletes entire mailboxes. Individual messages are marked for deletion by setting the Deleted flag. Messages with the Deleted flag set are not deleted until either the EXPUNGE command is issued or the mailbox is explicitly closed with the CLOSE command, as is done in Listing 1.7. The session in Listing 1.7 is then terminated with the LOGOUT command.

Clearly, the IMAP protocol is much more complex than SMTP or POP. It is just about at the limits of what can reasonably be typed in manually. Of course, you don't really enter these commands manually. The desktop system and the server exchange them automatically. They are only shown here to give you a sense of the IMAP protocol. About the only IMAP test you would ever do manually is to test if `imapd` is up and running. To do that, you don't even need to log in. If the server answers the `telnet`, you know it is up and running. All you then need to do is send the LOGOUT command to gracefully close the connection.

IMAP and POP are not part of Sendmail. Sendmail provides SMTP but other daemons are needed for POP and IMAP. Those protocols are covered here, however, because they are an important part of building a complete e-mail architecture for your enterprise. In the next chapter, we discuss the selection and placement of servers for your e-mail architecture. Mailbox servers running IMAP or POP will be an important part of that discussion.

In Sum

The simplicity of the protocols that underlie Sendmail stand in stark contrast to the complexity of Sendmail itself, particularly to the complexity of Sendmail configuration. The number of configuration options and the difficult concepts embodied in some of the configuration choices are the enemies of understanding Sendmail as a whole. The details of Sendmail can easily overwhelm the important concepts. It is the proverbial problem of not being able to see the forest because of all the trees. To attack this problem, the summary of each chapter will include a "complexity summary" to show the relative importance of the details covered, to reinforce the key concepts covered, and to provide some hints about how you can filter out the unneeded complexity. This chapter, however, does not need a "complexity filter" because the protocols used by Sendmail have a surprising lack of complexity.

The protocols that are the basis of the global e-mail system are simple command/response protocols that are so easy to understand that a system administrator can manually interact with a mail server over a `telnet` connection. Internet mail is carried by the Simple Mail Transport Protocol. SMTP, which is implemented by the Sendmail program, moves mail from server to server. The MIME extensions and ESMTP permit the mail system to move any kind of data. IMAP and POP move the mail from the mailbox located on the server to the mail reader located on the user's desktop. These protocols make it possible to move any type of data through the mail from any user to any other user in the world. Planning a complete enterprise e-mail architecture constructed from these protocols is the subject of our next chapter.

2

Understanding E-Mail Architecture

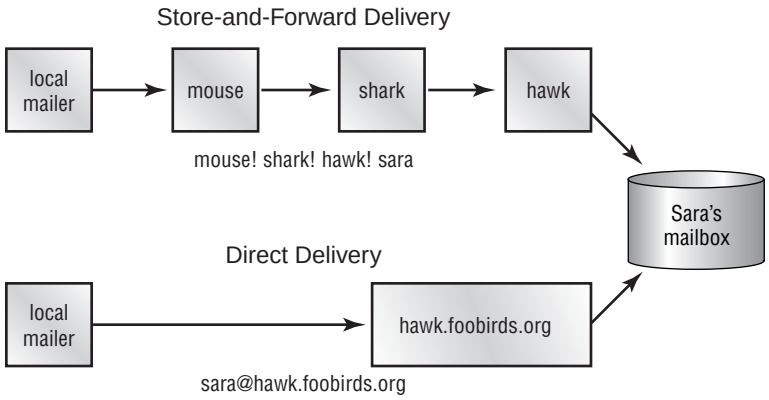
The capabilities of the network protocols described in Chapter 1, "Internet Mail Protocols," define the technical boundaries of the Internet mail architecture. The global scope of Internet mail makes it obvious that these protocols can create a flexible architecture supporting an enormous amount of e-mail traffic.

SMTP provides direct end-to-end mail delivery. This is one of its great strengths. In Chapter 1, `telnet` was used to simulate an SMTP connection for the purpose of examining the protocol interactions. Another thing the `telnet` test showed is that SMTP runs over the reliable, connection-oriented TCP transport. Using TCP means that end-to-end mail delivery is guaranteed. The person at the remote end might not read your mail, you may accidentally address it to the wrong person, or the server may redirect your mail, but you can rely on the fact that your mail message arrives intact.

Because of the direct delivery model, SMTP systems like Sendmail can provide immediate feedback about delivery. Everyone, at one time or another, has sent a message and gotten an immediate response saying that user so-and-so does not have an account on the remote host to which the mail was directed. This immediate feedback is available because the local system directly connects to the remote host, delivers the mail to that host, and accepts responses back from that host. If the response is an error, the error message can be immediately returned to the sender.

Some other mail systems use store-and-forward protocols like UUCP and X.400 that move mail toward its destination one hop at a time, storing the complete message at each hop and then forwarding it on to the next system. The message proceeds in this manner, one hop at a time, until final delivery is made. With a system like UUCP, your server will communicate directly only with hosts that are directly attached to your server. UUCP is a particularly good example of the store-and-forward model because the traditional UUCP bang address format clearly shows the path that the mail takes to its destination. In the UUCP bang address format, each host in the forwarding sequence is explicitly named and the last value in the address is the name of the user to whom the mail is addressed. Figure 2.1 uses UUCP and SMTP to illustrate both store-and-forward and direct delivery mail systems.

Figure 2.1 Direct delivery versus store-and-forward



Direct delivery allows SMTP to deliver mail without relying on intermediate hosts. If the delivery fails, the local system knows it right away. It can inform the user that sent the mail or queue the mail for later delivery without reliance on remote systems. The disadvantage of direct delivery is that it requires both systems to be fully capable of handling mail. Sometimes that's not the case, particularly with small systems such as PCs or mobile systems such as laptops. These systems are usually shut down at the end of the day and are frequently offline. Mail directed from a remote host fails with a "cannot connect" error when the local system is turned off or is offline. To handle these cases, SMTP can simulate the store-and-forward model by delivering the message to a mail server instead of delivering it to the end system. The remote mail server is then responsible for moving the mail to the end system.

The Domain Name System (DNS) tells the SMTP server when mail needs to be routed to another server instead of the end system.

The Role of DNS

All Internet connections depend on IP addresses. DNS is a distributed database system that maps hostnames to IP addresses. However, DNS can do much more than just map addresses. Address (A) database records are only part of the story. DNS running on Linux supports about 40 different database record types.

> ***NOTE*** Some knowledge of DNS is needed to fully understand e-mail architecture. However, this is not a book about DNS. If you need to run a DNS server, see *Linux DNS Server Administration* by Craig Hunt (Sybex, 2000), part of the Craig Hunt Linux Library.

DNS database records all have the same basic format. For the purposes of this book, the format of DNS database records can be simplified to three basic fields:

- The *name* field contains the name of the object to which the record applies. Generally, this is a domain name or hostname.
- The *type* field contains the database record type. For example, an address record has a type field that contains the letter A.
- The *data* field contains the data specific to the type of record. For example, an address record contains an IP address in the data field.

Of the forty possible record types, only a handful are used to build real DNS databases. Of this handful of records, one of the most important is the Mail Exchange (MX) record. MX records tell Sendmail where to deliver mail. The *name* field of an MX record contains the hostname that appears in the e-mail address, and the *data* field contains the hostname of the server to which the mail should be delivered. Two MX records that define the mail servers for the foobirds.org domain might contain the following:

```
foobirds.org.     MX      10 wren.foobirds.org.
foobirds.org.     MX      20 parrot.foobirds.org.
```

The *name* field contains the domain name foobirds.org., meaning that these records pertain to the entire domain. If mail is addressed to *user*@foobirds.org, the mail is directed to the mail exchangers defined by these records. This is a popular configuration, particularly when combined with the ability of the mail server to masquerade the hostname in outbound mail. Masquerading makes it look as if the mail sent by the local user

came from *user@domain*, which creates a balanced addressing scheme for both inbound and outbound mail.

> ***NOTE*** See Chapter 9, "Special m4 Configurations," for detailed information about masquerading hostnames.

The first sample MX record says that wren is the mail server for the foobirds.org domain with a preference of 10. The second MX record identifies parrot as a mail server for foobirds.org with a preference of 20. The lower the preference number, the more preferred the server is. The record with the preference of 10 is used before the record with the preference of 20, meaning wren is the preferred mail server for the foobirds.org domain and parrot is the backup server.

A backup mail exchange server is used only when the preferred server is down or offline. The backup server holds the mail and periodically attempts to send it on to the preferred server. When the preferred server comes back online, the backup server sends the mail to the preferred server. At that point, the backup server's job is done. A backup mail exchange server never deals directly with the mail recipient. Its only job is to get the mail to the preferred server.

The sample MX records redirect mail addressed to the domain foobirds.org, but they do not redirect mail addressed to an individual host. Therefore, if mail is addressed to jay@hawk.foobirds.org, it is delivered directly to hawk; it is not sent to a mail server. This is a very flexible configuration that permits people to use e-mail addresses of the form *user@domain* when they like, or to use direct delivery to an individual host when they want that.

Some systems are not capable of handling direct-delivery e-mail. An example is a Microsoft Windows system that doesn't run an SMTP mailer daemon. Mail addressed to such a system would not be successfully delivered, and worse, would probably be reported to you as a network error! To prevent this, MX records are generally assigned to these individual hosts to redirect mail addressed to the hosts to a valid mail server. Here are two examples:

```
puffin.foobirds.org.     MX      5 wren.foobirds.org.
robin.foobirds.org.      MX      5 wren.foobirds.org.
```

These MX records redirect mail addressed to puffin or robin to wren. In both cases, only one mail server is named for each host. With these records, mail addressed to daniel@puffin.foobirds.org is delivered to daniel@wren.foobirds.org. Sendmail does not need to select a server. All of the mail goes to wren. The next section examines how Sendmail uses the DNS responses.

Processing *MX* Records

When Sendmail has mail to deliver, it queries DNS for the MX records for the hostname in the e-mail address. It then sorts those MX records by preference number. Thus, the lower the preference number, the earlier in the list a server appears, which makes servers with low preference numbers preferable to servers with high preference numbers.

Sendmail then tries to deliver the mail to each mail server in order. It stops processing the list if it finds a server that will accept the mail or if it finds its own hostname in the mail exchange server list. If it cannot deliver the mail to any of the servers, it will use the address of the host and attempt to deliver directly to that host.

> ***NOTE*** The process of first querying for MX records and then querying for address records is an idealized process described in RFC 974 ("Mail Routing and the Domain System"). In reality, Sendmail uses the DNS ANY query to get any and all records about a host. That one query retrieves the MX records and the A records.

A backup mail exchange server determines how to deliver mail just like any other server by querying DNS for a list of MX records. However, it cannot just send the mail to each server in turn in the MX list because, in the hands of an MX server, MX records have the potential to create mail-routing loops.

Assume that we have three MX servers in this order of preference: `wren`, `parrot`, and `jay`. `wren` is down so the mail is delivered to `parrot`. `parrot` fetches the MX records and attempts to deliver the mail to `wren`. `wren` is still down. `parrot` would queue the mail and not attempt to deliver it to any other server on the MX list. This is to avoid loops. If `parrot` tries to deliver the mail to itself, a tight loop will ensue. If `parrot` tries delivering the mail to `jay`, a bigger loop ensues because `jay` would then start sending the mail back to `parrot`, who would send it back to `jay`, and so on. To avoid these loops, a mail server stops attempting to deliver the mail when it finds itself in the MX list and queues the mail for later delivery. In effect, a backup server only attempts to deliver mail to MX servers that are more preferred than it is. Thus, in this list of three servers, `parrot` will try to deliver mail only to `wren`.

Using the same three servers, `wren`, `parrot`, and `jay`, assume that both `wren` and `parrot` are down:

1. The mail comes to `jay`.
2. `jay` discovers that the more preferred servers are down.
3. `jay` queues the mail for later delivery.
4. Later, `jay` processes its queue. `wren` is still down but `parrot` is back in operation.

5. This time, `jay` delivers the mail to `parrot` and it becomes `parrot`'s responsibility to deliver the mail.
6. `parrot` keeps the mail in its queue until `wren` finally comes back online.

By sending mail only to more-preferred servers, mailers avoid mail-routing loops and gradually move mail closer to its final destination.

The `MX` record is only the first step in creating a mail server. The `MX` record is necessary to tell the remote computer where it should send the mail, but for the mail server to successfully deliver the mail to the intended user, it must be properly configured. How `wren` handles the mail as the preferred mail exchange server is a function of how Sendmail is configured on `wren`. DNS identifies servers and Sendmail is configured to create different types of servers. These servers are the components of mail architecture.

The Components of Mail Architecture

Conceptually, mail delivery is a simple thing—you want to get a message from point A to point B. All of the components of the mail system focus on doing this one task. They vary in how they do it and when they are needed to do it. A terminology has grown up to describe the different roles of the pieces of the mail architecture. Some of the terms are formally defined and others are loosely used. Understanding the terminology used to describe mail architecture and the role of the various components is a necessary part of understanding the mail system.

Formal Definitions

Most mail starts and ends its life in a message user agent (MUA). The MUA is the mail interface with which the user interacts. It is the application program that the user uses to read and write mail. `pine`, `elm`, and Netscape Messenger are some examples. Sendmail itself can be used as an MUA by running the `sendmail` command from the shell prompt, although this is generally only done for testing. MUA is the formal term used to describe the programs with which users create and read mail. Sometimes an MUA will be loosely called a mail "client," but as with most generalized terminology, calling an MUA a client is not very accurate because even a server can be a client in the right circumstances.

NOTE The word "message" is sometimes replaced by the word "mail" in these acronyms. Message user agent (MUA), message transfer agent (MTA), and message submission agent (MSA) are also commonly called mail user agent, mail transfer agent, and mail submission agent, respectively.

Message transfer agents (MTAs) move mail through the network. In the case of the Internet, an MTA is a program that uses SMTP to move complete mail messages over the network. Sendmail is the most widely used MTA for Linux systems. The Sendmail daemon runs a listener that attaches to TCP port 25, the SMTP port, to collect inbound mail coming from remote MTAs. MTA is a formal definition. An MTA is sometimes loosely referred to as a mail relay or a mail hub; however, relays and hubs do much more than just transfer mail.

As formally defined, an MTA is supposed to receive and send complete mail messages. Because the messages are complete, the MTA limits any modifications it makes to the message to just those mail headers that should be updated by every agent that handles the mail, such as the Received: header. When Sendmail receives mail from a remote server, it is clearly acting as an MTA. But when it receives mail directly from an MUA, Sendmail does more than modify a few headers—it may add headers and correct addresses. In this latter case, Sendmail is acting as a message submission agent (MSA). An MSA is the first MTA after the MUA, and it is permitted to make modifications to the message before transferring the mail. An MSA is sometimes loosely called a mail server; however, the term "server" encompasses many meanings.

TCP port 587 is used by MSAs. During start-up, the Sendmail daemon attaches a listener to port 587 to accept mail from MUAs that speak SMTP. On Linux systems, most MUAs do not speak SMTP to the Sendmail daemon through port 587. Instead, individual instantiations of Sendmail are launched by the MUAs to act as MSAs for outbound mail. They move the message to Sendmail using some form of interprocess communication—e.g., a pipe. The MUAs then rely on Sendmail to properly format the mail and handle the SMTP communication with the remote server.

> ***NOTE*** At one time, an MUA that spoke SMTP could use it to communicate with Sendmail by invoking the `sendmail` command with the `-bs` option. Now, the MUA can send the SMTP traffic to port 587 without invoking a separate instantiation of Sendmail.

Formal language is needed by protocol developers to accurately define the functions of the various components of the system. But just reading a paragraph full of MUA, MSA, and MTA is enough to make your head ache. People simply don't talk that way. Most of the time, the components of the e-mail architecture are described with more general terms.

Commonly Used Terminology

Most people do not use the terms MUA, MSA, and MTA when speaking about e-mail architecture. The more commonly used terms are described below.

Client A mail client is generally the end system on which mail is read or written. This could be an MUA, or a POP or IMAP client. However, the term "client" can also be applied to a remote system that is acting as a client during a protocol exchange. For example, later in this book you will see a variable named `client_addr` that holds the client's IP address. In that case, however, the "client" is not an end system at all; it is the remote MTA that initiated an SMTP connection. Look at the context in which the term "client" is used to discern the proper meaning.

Server A mail server is any system that handles either MSA or MTA functions. Any Linux system running Sendmail can be called a server. "Server" is the most general term. There are several different types of servers.

Hub A mail hub is a server that acts as a central collection point for all of its clients' mail. The mail hub may handle all of the mail processing for its clients. An extreme example of dependence on a hub is the Sendmail `nullclient` configuration. In a `nullclient` configuration, all mail, even messages between two users of the client system, is sent to the hub for processing and is stored on the hub. Generally, the term is used to refer to any server that is a collection point for mail.

Mailbox server A mailbox server is a server that holds mail until its clients are ready to read the mail. It is similar to a hub server except that "mailbox server" is generally used only when the clients are POP or IMAP clients. The terms "hub server" and "mailbox server" are often used interchangeably.

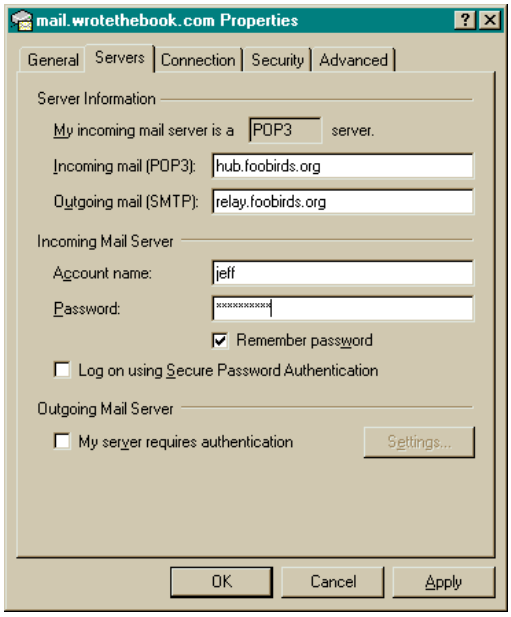
Relay A relay server acts as an MTA for its clients. It accepts mail from clients and sends that mail on to the destination address. Proper relay configuration is an important part of setting up Sendmail, particularly in the fight against spam e-mail. Chapter 11, "Stopping Spam," covers relay configuration extensively.

A mail server may handle more than one of these functions. A server may be called a relay when referring to its role in handling outbound mail. That same server may be called a hub or a mailbox server when referring to its role in storing inbound mail for its clients. And when it is referred to in general terms, it may just be called a mail server.

Client configuration acknowledges the dual role of mail servers. The configuration of a Windows client shown in Figure 2.2 identifies a Linux server to act as a POP3 mailbox server for inbound mail and a separate Linux server to act as a relay for outbound mail.

Of course, these could be the same Linux system, and they often are. In the example, two different systems are used to emphasize the two major server roles.

Figure 2.2 A PC client configuration

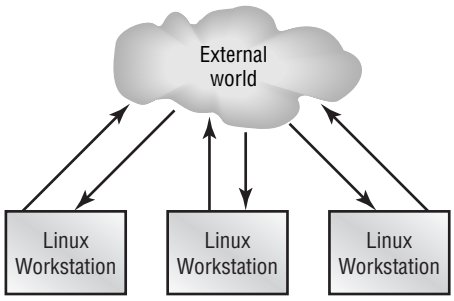


Often the simple view of the configuration seen from a Windows client does not reflect the true e-mail architecture of a network. In the next section, we examine two sample networks to put the components of e-mail architecture into context.

Sample Mail Architectures

The first sample architecture can be seen in Figure 2.3. It shows an engineering department in which every user has a Linux desktop. The cloud represents the outside world. The directional arrows indicate the flow of mail into and out of each system. As this figure illustrates, each Linux system is acting as its own server. It collects inbound mail and sends outbound mail for its own users. It does not, however, act as a relay or hub for any client systems or for any users on other systems.

Figure 2.3 A sample engineering department



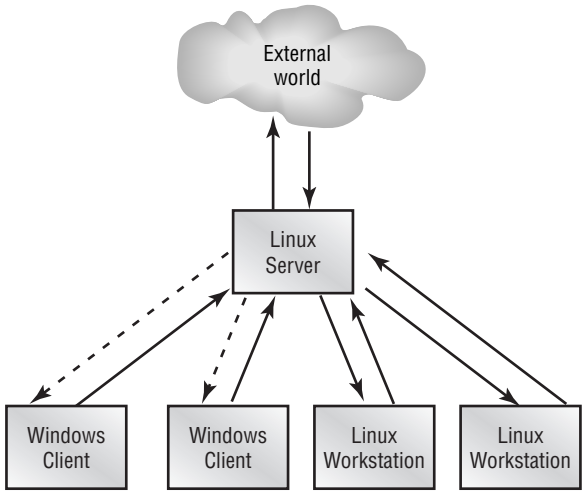
This configuration is surprisingly easy to create because it is the default configuration of a Linux system running Sendmail. The default Linux configuration runs the Sendmail daemon, which provides an SMTP listener on port 25 to collect inbound mail, and all of the MUAs running on Linux know about Sendmail and use it to send outbound mail. Further, the default Sendmail configuration blocks relaying from outside systems.

The configuration for the engineering department is simple, but maintenance is complex. Every system needs to be kept up to date with the latest Sendmail patches. In a department with just a few systems this is not too bad, but if the network grows very large, keeping all of the systems updated could be a big headache. To cope with a configuration like this you need sophisticated users who can help with the maintenance, which is why we showed this as a configuration for a small engineering department. Less sophisticated users require a more complex architecture.

Figure 2.4 shows a sales department. Pre- and post-sales technical support personnel and top sales people get Linux desktops. Sales trainees and clerical personnel get Windows desktops. The dashed arrows indicate that the Windows clients periodically retrieve mail from the server using POP or IMAP; the solid arrows to the Linux clients indicate that mail is immediately forwarded to those clients via SMTP.

The server is configured as both a relay and a mailbox server. The relay configuration is carefully created so that all systems within the local network can relay through the server but no remote systems can relay mail though the server. The server is also configured to forward all of the mail it receives for its Linux clients on to those clients. The Linux clients are configured to send all outbound mail through the server. (In Sendmail configuration, all mail can be sent through a single server by defining a `SMART_HOST` value in the configuration of the client.)

Figure 2.4 A sample sales department



The fact that all mail flows through one server simplifies maintenance. Patches can be applied to a single system and yet benefit the entire network. Mail can be filtered at a single point. If a firewall is put in place, it only needs to allow mail through to a single system. The biggest problem with this configuration is that it creates a potential single point of failure.

In these two simple sample networks, Sendmail systems are used as both clients and servers. Sendmail performs multiple tasks that are essential for efficient mail delivery, and Sendmail systems take on multiple roles in the e-mail architecture.

Sendmail's Roles

MSA, MTA, relay, and server are all terms used to describe the functions of components within the e-mail architecture. These words will appear again and again throughout this book. Understanding them is essential. Sendmail also has its own language to describe the functions it performs. Mailers, rulesets, rewrite rules, and aliasing are all words used to describe the work that Sendmail does. To read this book and understand the role of Sendmail, you need to know what each of these terms means. This section introduces "Sendmail speak" and links this new terminology to the roles that Sendmail plays in the e-mail architecture.

The tasks that a Sendmail server performs can be divided into two basic functional groups: the roles that Sendmail performs as a message submission agent and as a message transport agent. The distinctions between these roles can be subtle, and the roles sometimes overlap. But these two basic roles incorporate all of the tasks performed by a Sendmail server and help explain what various configuration values do and why they need to be defined. Much of the Sendmail configuration is used to specify how Sendmail should handle its duties as a message submission agent.

A Message Submission Agent

The functions of Sendmail described in this section might not meet the RFC definition of an MSA, but they come mighty close. An MTA that accepts a message directly from an MUA and takes an active role in formatting a complete mail message is an MSA. Sendmail

- accepts mail from an MUA
- determines the mail delivery program for the mail
- reformats the mail addresses for the selected mailer
- adds the headers required by the mailer
- sends the message to the mailer for delivery

In this book I'm using "message submission agent" to describe the role that Sendmail fills as the interface between the user's e-mail program (the MUA) and the mail delivery program (the MTA). Even when Sendmail is the MTA, things must be done to the mail received from the MUA to prepare it for delivery, and, of course, Sendmail is not the only MTA that can run on a Linux system. A user can create a wide variety of mail with an e-mail program. The mail entered by the user could be local mail bound for another local user; it could be Internet mail bound for a remote user; it could be data bound for a Linux program; it could even be mail bound for any one of a large number of obsolete mail systems. (See Appendix A, "`m4` Macro Command Reference," for a full list of the mailers supported by Sendmail.) All that a user mail program running on a Linux system needs to do is pass the mail message on to Sendmail. Sendmail is equipped to select the appropriate delivery agent and to properly prepare the mail for that delivery agent.

Sendmail Mailers

The mail delivery programs are called *mailers* in Sendmail terminology. The mailers available to Sendmail are defined inside the Sendmail configuration file. A mailer definition assigns an internal mailer name to a mail delivery program. These names are arbitrary, but most Linux systems use the standard mailers defined by the default Sendmail configuration. Chapter 5, "Understanding a Vendor's Configuration," describes each of the default mailers.

A mailer definition also provides Sendmail with the full pathname of the mail delivery program and the command-line arguments Sendmail should use when it launches that

mailer. If the mail delivery program is Sendmail itself, as it is for all of the SMTP mailers, a symbolic name, either IPC, which stands for Inter-Process Communication, or TCP, which stands for Transmission Control Protocol, is used instead of a pathname.

Mailer definitions take up a substantial portion of the Sendmail configuration file. Each mailer definition provides the instructions that Sendmail needs to properly prepare a message for a given mailer. This includes the commands that are used to process sender addresses and recipient addresses for the mailer. There are also flags associated with each mailer. The flags define optional processing required by the mailer and identify the message headers needed for the mailer. The number and type of headers vary from mailer to mailer.

The Sendmail configuration contains several mailers. Sendmail must select the correct mailer to deliver a piece of mail.

Determining the Delivery Triple

When Sendmail receives a piece of mail from an MUA, it determines what mailer will deliver the mail. Sendmail determines this from the delivery address included in the mail. It does this by literally converting the delivery address into a *delivery triple*. A delivery triple contains up to three values:

- the recipient's e-mail address
- the name of the mail server to which the mail will be sent
- the internal name of the mailer that will deliver the mail to the server

You can see the delivery triple that is produced for any given address by running the `sendmail` command with the `-bv` option and the address you want processed. Listing 2.1 shows the output of `sendmail -bv` for two different delivery addresses.

Listing 2.1 Examining the Delivery Triple

```
[craig]$ sendmail -bv ed@xy.com
ed@xy.com... deliverable: mailer esmtp, host xy.com, user ed@xy.com
[craig]$ sendmail -bv craig
craig... deliverable: mailer local, user craig
```

The first line in Listing 2.1 is a command that asks Sendmail to evaluate the delivery address `ed@xy.com`. Sendmail responds that the address is deliverable—which in this case means only that it is properly formatted, because the copy of Sendmail running on your server does not have any direct knowledge of whether or not the remote host can actually deliver mail to this address. The delivery triple for the address is also displayed. The name of the internal mailer that Sendmail will use to transport mail to this address is `esmtp`, which is the default name used for the extended SMTP mailer. The host to which Sendmail will transfer the mail is named `xy.com`, and the e-mail address that the mail will be delivered to is `ed@xy.com`.

The second command in Listing 2.1 is slightly different. It evaluates the delivery address `craig`. Because the address has no hostname part—i.e., no at-sign (`@`) followed by a host or domain name—the address is assumed to be the name of a user on the local system. Sendmail checks that the username is deliverable on the local host. The host value is not provided as part of the delivery triple for local mail delivery because no remote host is involved. The internal mailer name for local mail delivery is `local`, and in Listing 2.1 the user value that would be passed to the local mailer is `craig`.

Formatting E-Mail Addresses

Once Sendmail selects a mailer, it must properly format the mail for that mailer. Sendmail uses commands called *rewrite rules* to transform the e-mail address received from the MUA into the format required by the MTA. The bulk of the Sendmail configuration file is composed of rewrite rules. These are individual lines that define a pattern match and a transformation. If the input address matches the pattern defined in a rule, it is rewritten using the transformation defined in that rule.

Rules are grouped together into rulesets, which are internally identified by a name or a number. Rulesets can be called like functions from individual rewrite rules to process complex addresses. Certain rulesets are assigned special roles by Sendmail and are used to process different types of addresses. For example, delivery addresses are processed by the `canonify` ruleset (also known as ruleset 3), which processes all addresses to put them into the format expected by Sendmail, and then by the `parse` ruleset (also known as ruleset 0), which creates the delivery triple.

You can watch the rulesets in action by running the `sendmail` command with the `-bt` option. `-bt` places Sendmail in test mode. Once it is running in test mode, it will accept a list of rulesets and an address to process through those rulesets. In Listing 2.2, the `sendmail` command is run with the `-bt` argument and asked to process `ed@xy.com` through rulesets `canonify` and `parse`.

Listing 2.2 Watching Rewrite Rules in Action

```
[craig]$ sendmail -bt
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> canonify,parse ed@xyz.com
canonify           input: ed @ xyz . com
Canonify2          input: ed < @ xyz . com >
Canonify2        returns: ed < @ xyz . com >
canonify         returns: ed < @ xyz . com >
parse              input: ed < @ xyz . com >
Parse0             input: ed < @ xyz . com >
```

```
Parse0          returns: ed < @ xyz . com >
ParseLocal        input: ed < @ xyz . com >
ParseLocal      returns: ed < @ xyz . com >
Parse1            input: ed < @ xyz . com >
Mailertable       input: < xyz . com > ed < @ xyz . com >
Mailertable       input: xyz . < com > ed < @ xyz . com >
Mailertable     returns: ed < @ xyz . com >
Mailertable     returns: ed < @ xyz . com >
MailerToTriple    input: < > ed < @ xyz . com >
MailerToTriple  returns: ed < @ xyz . com >
Parse1          returns: $# esmtp $@ xyz . com $: ed < @ xyz . com >
parse           returns: $# esmtp $@ xyz . com $: ed < @ xyz . com >
> ^D
```

The `sendmail -bt` command shows much more detail than `-bv` did. Listing 2.2 shows that before the `canonify` ruleset returns a value the `Canonify2` ruleset is run, and before the `parse` ruleset returns five other rulesets are run. This shows that rulesets can be called by a rule from within other rulesets. That's what's happening in Listing 2.2. In all, eight rulesets process this delivery address. The result is the delivery triple. Notice here, however, that the label `mailer` is replaced by the symbol `$#`, the label `host` is replaced by `$@`, and the label `user` is replaced by `$:` in the triple. As you'll see in Chapter 8, symbols are heavily used in Sendmail rewrite rules.

The delivery address is only one type of address handled by Sendmail. Sendmail also processes the sender address and the recipient address. The sender address is the name of the user or process that initiated the mail. The recipient addresses are the list of recipients provided with the mail. The recipients are distinct from the delivery address in that only one address at a time from the list of recipients is used as the delivery address but the entire list of recipients is processed and included in each outbound mail message.

All addresses are processed through rewrite rules to convert the input addresses into a format that is acceptable for the mailer that will be transporting the mail. Because the rewriting is dependent on which mailer will be handling the mail, the delivery address is processed first to determine which mailer will be used. Once the mailer is selected, the other addresses can be processed through the standard rulesets and those that are specific to the mailer.

Processing and rewriting e-mail addresses is a central part of what Sendmail does. It is a large and complex topic. Chapter 8 covers the topic in detail.

Formatting Headers

In addition to modifying the mail addresses to make them correct for the mail delivery program, Sendmail ensures that all of the headers required by the mail delivery program are provided and are properly formatted. As noted above, the flags in a mailer definition identify the headers required for that mailer.

The Sendmail configuration file contains header templates that define the proper format for the various message headers. Each template has an associated flag. If a matching flag is found in the mailer definition, Sendmail knows that the mailer requires that particular header and adds it if it is not already contained in the mail message. The mail headers contained in the message that Sendmail receives from the MUA are maintained and forwarded to the mail delivery program. The flags and the header templates ensure that all of the required headers are provided even if the MUA fails to provide them.

The role of a message submission agent is central to what Sendmail is. Sendmail receives mail from the user's mail program, selects the correct mail delivery program for that mail, and properly formats the message headers and e-mail addresses for the selected mailer. The MSA function is very complex and it is the focus of most Sendmail configurations. Despite its complexity, serving as a message submission agent is not the only Sendmail function.

A Message Transfer Agent

Sendmail acts as an MTA when it receives mail from an external system because it is not the first-hop MTA and it doesn't modify the mail message. Therefore, Sendmail isn't acting as an MSA. The mail may be inbound mail destined for someone on the local system or mail being relayed through the local system to a remote server.

Sendmail is designed to deliver mail to the correct recipient. Outbound mail is handled by formatting it and passing it to the correct mailer for delivery. Inbound mail is handled by passing it to the correct user or system.

In certain circumstances, inbound mail needs to be forwarded before final delivery can be made. The To: address on the mail may be an alias for the real recipient. The recipient may define private forwarding for their mail. It is even possible that the hostname in the To: address is not the name of the local host and that the mail needs to be forwarded to a remote host for delivery. Three Sendmail features, *aliasing*, *forwarding*, and *relaying*, handle these three types of delivery.

Sendmail Aliases

Sendmail aliases perform important functions that are an essential part of creating a mail server. Mail aliases do the following:

Specify nicknames for individual users. Nicknames can be used to direct mail addressed to special names, such as postmaster or root, to the real users who do those jobs. When used in conjunction with the domain `MX` records covered earlier, aliases can be used to create a standard e-mail address structure for a domain.

Forward mail to other hosts. Sendmail aliases automatically forward mail to the host address included as part of the recipient address.

Define mailing lists. An alias with multiple recipients is a mailing list.

Mail aliases are defined in the `aliases` file, which is the database Sendmail uses to determine where to deliver inbound mail. Processing an address through the `aliases` database is called *aliasing*. It is a multi-step process.

1. First, Sendmail determines whether or not the address is a local address. Only mail addressed to the local system is processed through the `aliases` database. Mail is considered to be addressed to the local system when the recipient address has no host part—i.e., no *`@hostname`*—or the *`hostname`* in the host part of the address is either the name of the server itself or one of the names it recognizes as a *local host alias*. Local host aliases are not the same thing as aliases. Aliases are usernames defined in the `aliases` database. Local host aliases are hostnames defined in the `local-host-names` file. If Sendmail decides the mail is addressed to the local system, aliasing continues. Otherwise, the mail is processed for relaying. (Relaying is described in the next section.)
2. Next, the username from the recipient address is used as the key for an `aliases` database lookup. If the database does not return a value for the lookup, the mail is delivered to the user defined in the recipient address.
3. If the `aliases` database returns a value for the lookup, the value becomes the new database key.
4. Another lookup is done using the new key. If no value is returned for the lookup, the mail is delivered to the address that was used as the last key. If a value is returned, Sendmail goes back to step 3. Sendmail can loop through steps 3 and 4 up to ten times, because aliases can point to other aliases and can be nested up to ten levels deep.
5. If Sendmail loops through steps 3 and 4 the maximum number of times without resolving the aliases, it returns an error and does not deliver the mail.

Another level of aliasing occurs after the recipient is processed through the `aliases` database. The `aliases` database defines mail forwarding for the entire system. The `.forward` file, which can be created in any user's home directory, defines mail forwarding for an individual user. Once Sendmail identifies the user to which the mail will be delivered, it looks for a `.forward` file in the user's home directory. If the `.forward` file is found, the mail is forwarded to the e-mail address contained in that file. If the file is not found or is empty, the mail is delivered directly to the user's account.

> ***NOTE*** The `aliases` database, the `local-host-names` file, and the `.forward` file are all described in Chapter 6, "Using Sendmail Databases."

The Sendmail terms "forwarding" and "relaying" are often used interchangeably, but there is a slight difference. Forwarding refers to the act of transferring to another host mail that was originally addressed to the local host. For example, if mail addressed to `norm` on the local host is sent to `normane@hawk.foobirds.org` as a result of aliasing, you would say the mail has been forwarded to `hawk.foobirds.org`. Relaying, which is the next topic, is subtly different.

Mail Relaying

Relaying occurs when mail is transferred on toward its destination and neither the source nor the destination address of the mail is the address of the local system. For example: If a server named `wren.foobirds.org` receives mail from `ibis.foobirds.org` that is addressed to `craig@wrotethebook.com` and re-sends that mail to the host `wrotethebook.com`, `wren` is acting as a mail relay.

At one time mail relaying was the default configuration for Sendmail systems, but no more. Spammers used unsuspecting mail servers to relay their spam in order to hide the true origin of the nuisance mail. Now the default configuration is to relay no mail at all. In Figure 2.1, the sample systems use this default configuration. Each system sends its own e-mail. None of the systems accepts mail for relaying from any other system. It is up to you to loosen those restrictions if you need to provide mail relaying for some of your clients. (Proper relay configuration is described in Chapter 11.) In Figure 2.2, the server system is configured as a relay for the systems on the local area network.

By default, Sendmail does not relay mail. A server accepts mail addressed to the server itself or any of its local hostname aliases. It rejects all other mail. To enable relaying, the specific names of the hosts or domains that should be allowed to relay mail must be provided to Sendmail. The hostnames of relay clients can be provided in the `relay-domains` file or through the `access` database. Both of these files are covered in Chapter 6.

A Client

One possible role for a Linux system running Sendmail that is frequently overlooked is the role of a client. By default, every Linux system is a Sendmail server. It is a limited server, because it is set up to handle only mail from users who are directly logged in to the system, but it is a server nonetheless. Turning a Linux system into a true client takes some configuration effort, and it is rarely worth the effort. While the `nullclient` configuration is touched upon in Chapter 9, the true focus of this book is to properly configure the Sendmail server functions for every Linux system from a laptop to an enterprise server.

In Sum

The SMTP protocol runs on top of the TCP protocol. TCP is a reliable, connection-oriented protocol. It ensures that mail is always delivered, and it means that SMTP directly delivers mail to the remote system without dependence on intervening systems. This is a great mail-delivery model because it provides immediate feedback from the remote server about whether or not the mail was successfully delivered. However, this system demands a remote system that is fully capable of accepting SMTP mail. Unfortunately, that is not always the case. Sendmail queries DNS and uses the `MX` records it provides to route mail to a fully capable SMTP server for those systems that cannot handle their own SMTP mail.

The fact that both direct delivery to end systems and delivery to intervening mail servers are available to Sendmail creates the possibility of a variety of e-mail architectures. There are clients and servers, and the servers can be described in several different ways. Servers that collect inbound mail are described as hubs or mailbox servers. Servers that handle outbound mail are called relays or simply servers. To clarify the vagueness of this language, Internet standards documents define the functions of message user agents (MUAs), message submission agents (MSAs), and message transfer agents (MTAs).

Even with the narrowly defined terms MUA, MSA, and MTA, there can be confusion because most functions do not match any definition exactly. Various functions overlap across systems and things are not easily tied up in neat packages. The easiest way to avoid making the language of e-mail architecture overly complex is simply to use a little judgment. Don't be too rigid in interpreting the meaning of a term. Always look at things in context. Sendmail frequently uses the same word to describe two different things. Context is the clue to understanding.

Sendmail is the software that turns a Linux system into an e-mail server. It acts as an MSA and an MTA and can even be used as an MUA. Chapter 3, "Running Sendmail," looks at how Sendmail is installed on a Linux system and how it is run once it is installed.

3

Running Sendmail

Chapter 2, "Understanding E-Mail Architecture," illustrates the importance of Sendmail for a Linux system. Sendmail implements the SMTP protocol for Linux systems. It sends and receives SMTP mail for the system, and it acts as an interface between the user's mail program and the Internet. These vital tasks make Sendmail a basic component of most Linux systems.

Sendmail is such an essential part of a Linux system that it is usually installed by default and run at start-up. If it is not installed on your system, you need to know how to install it. Additionally, you need to know how to compile the Sendmail program for those times when you want to install the latest source code distribution of Sendmail on an existing Linux system. This chapter covers both of those topics. It also examines how and why the Sendmail process runs at start-up, and you'll look at the tools used to control whether or not starting the Sendmail daemon is part of the Linux boot process on your system.

Running Sendmail at Start-Up

Sendmail runs in two distinct modes: *real-time mode* for outbound mail delivery and *daemon mode* for collecting inbound mail and queue processing. When a *mail user agent (MUA)* has mail to send, it creates an instantiation of the Sendmail program to deliver that piece of mail. The instantiation of Sendmail lives long enough to deliver that one piece of mail. If it cannot successfully deliver the mail, it writes the mail to the mail queue and terminates. Most Sendmail processes have a very short life. The Sendmail daemon, on

the other hand, runs the entire time the system is running, constantly listening for inbound mail and periodically processing the queue to deliver undelivered mail. The Sendmail daemon, like most other daemons, is started at boot time.

The `ps` command reveals whether or not Sendmail is running on your system:

```
[root]# ps -C sendmail
  PID TTY          TIME CMD
  542 ?        00:00:36 sendmail
```

The low process ID (PID) shows that this process was started during the boot. Running this `ps` command on most Linux systems will show that Sendmail is running because, generally, Sendmail becomes part of the boot process when you first install Linux.

Many systems are running the Sendmail daemon unnecessarily. It is not necessary to run Sendmail as a daemon in order to send mail. Running the `sendmail` command with the `-bd` option is required only if your system directly receives SMTP mail. A Linux mail client can collect inbound mail from the mailbox server using POP or IMAP and can relay outbound mail through the mail relay server without running the Sendmail daemon. Deciding which systems should run the Sendmail daemon is part of the process of planning your e-mail architecture. Unneeded daemons consume system resources and provide holes through which network intruders can slither. Take care when selecting which systems really need any daemon, including Sendmail.

It is possible to enable or disable Sendmail after the system is installed, and there are several tools to do this. These tools vary depending on the type of start-up procedures used. Some Linux systems use BSD-style start-up procedures, while others use System V–style procedures.

On Linux distributions that use System V–style boot procedures, the script that starts Sendmail is usually found in the `/etc/rc.d/init.d` directory, where it is stored under a name such as `sendmail`, `mail`, or `mta`. On distributions that use BSD-style boot procedures, the commands that start Sendmail are stored in one of the `rc` scripts. For example, on Slackware 4.0, the commands to start Sendmail are found in the `rc.M` script located in the `/etc/rc.d` directory. Regardless of the name of the script used for this purpose, some start-up script is used to start Sendmail at boot time.

TIP To locate the Sendmail start-up script on your Linux system, go to the directory that holds start-up scripts and run the command **`grep sendmail *`** to search every file for references to Sendmail. Not sure where the start-up scripts are stored? Go to `/etc` and look for files or directories that begin with the string `rc`. Those are start-up files and directories.

On a BSD-Style Linux System

Linux systems such as Slackware that use BSD-style boot procedures start Sendmail by executing the `sendmail` command directly from one of the main start-up files. The code that runs the Sendmail daemon in the Slackware Linux `/etc/rc.d/rc.M` start-up script is very straightforward, as shown in Listing 3.1.

Listing 3.1 Starting Sendmail from a Slackware Boot Script

```
# Start the sendmail daemon:
if [ -x /usr/sbin/sendmail ]; then
  echo "Starting sendmail daemon"
  /usr/sbin/sendmail -bd -q 15m
fi
```

Listing 3.1 shows a Slackware system ready to run Sendmail. The first line is a comment, as indicated by the fact that it starts with a pound sign (#). The next lines are an `if` statement that checks whether or not the `sendmail` command is available. If the command is found, a message is displayed on the console indicating that Sendmail is starting and then the `sendmail` command is run.

The code in Listing 3.1 runs the `sendmail` command with the `-bd` and the `-q` options. In addition to listening for inbound mail, the Sendmail daemon periodically checks to see whether there is mail waiting to be delivered. It's possible that a Sendmail process that was started to send a message was not able to successfully deliver the mail. In that case, the process writes the message to the mail queue and counts on the daemon to deliver it at a later time. The `-q` option tells the Sendmail daemon how often to check the undelivered mail queue. In the Slackware example, the queue is processed every 15 minutes (`-q15m`).

To prevent Slackware from starting Sendmail at boot time, comment the lines shown in Listing 3.1 out of the `rc.M` script by placing a pound sign at the beginning of each line. To restore Sendmail to the boot process, remove the pound signs. These techniques are easy and they work, but they are far from elegant.

Directly editing a start-up script is easy, but dangerous. Most system administrators worry that an editing error will have a major negative impact on the next boot. I have never really had a major boot problem cause by an editing error, but I understand the fear. Distributions that use System V–style start-up procedures alleviate this fear by making it unnecessary to directly edit the start-up file.

On a System V–Style Linux System

Most Linux distributions use a System V–style boot process that allows the system to be initialized in different ways depending on the runlevel. All of the service initialization scripts are located in a single directory, usually called `/etc/rc.d/init.d` on Linux systems that use this style of start-up. The initialization scripts are indirectly invoked by links contained in directories assigned to each runlevel. Caldera and Red Hat are good examples of System V–style Linux systems.

NOTE A detailed description of the Linux boot process is beyond the scope of this book. To learn more about the boot process, runlevels, and start-up scripts, see *Linux Network Servers 24seven* by Craig Hunt (Sybex, 1999).

The code that Caldera and Red Hat use to start the Sendmail daemon is found in the `/etc/rc.d/init.d/sendmail` script. It is more complex than the code used by Slackware, because Red Hat and Caldera use script variables read from an external file to set the command-line options. The file they read is `/etc/sysconfig/sendmail`, which normally contains these two lines:

```
DAEMON=yes
QUEUE=1h
```

Changing the values in the `/etc/sysconfig/sendmail` file controls the daemon configuration. The `QUEUE` variable sets the time value of the `-q` option. In this case, it is one hour (`1h`), which is a value that I like even more than the 15 minutes used in Slackware configuration. Don't set this time too low. Processing the queue too often can cause problems if the queue grows very large due to a delivery problem such as a network outage.

If the variable `DAEMON` is equal to "yes," the `sendmail` command is run with the `-bd` option. If you are configuring a mail client and don't want to run Sendmail as a daemon, you could directly edit the `/etc/sysconfig/sendmail` file to set `DAEMON=no`.

TIP While changing the `DAEMON` value is one way to do this, it is generally a better idea to remove the `sendmail` script from the start-up as described below than it is to edit the contents of a script.

With System V–style start-up, you don't have to directly edit start-up files. One of the advantages of the System V–style boot procedure is that major services have their own start-up scripts and those scripts are indirectly invoked, which makes it possible to control whether or not a service is started at boot time by controlling whether or not the

script is invoked. The `sendmail` script is invoked indirectly from the runlevel directories by the `S80sendmail` script (see Listing 3.2). An examination of that script shows that it is just a symbolic link to the real `sendmail` script.

Listing 3.2 The Sendmail Link for Runlevel 3

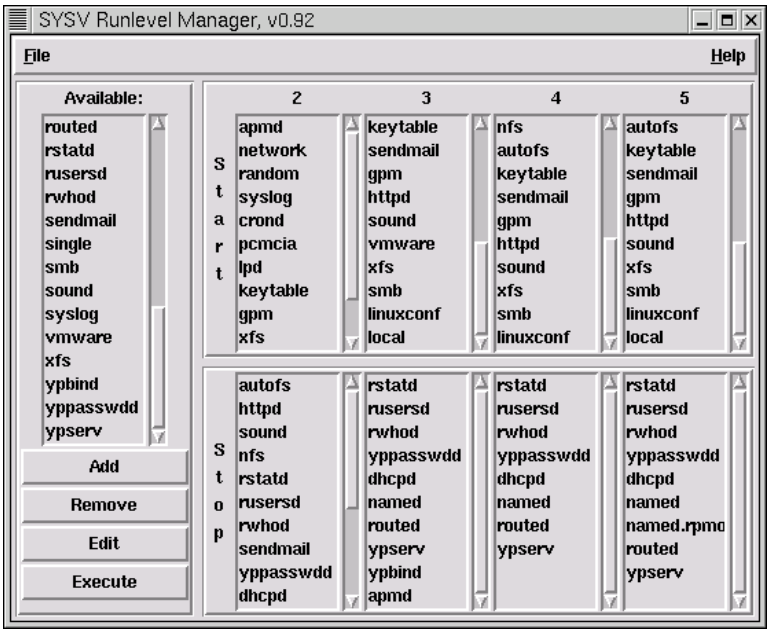
```
[craig]$ cd /etc/rc.d/rc3.d
[craig]$ ls -l S80sendmail
lrwxrwxrwx 1 root root 18 Dec 26 1999 S80sendmail -> ../init.d/sendmail
```

To enable or disable the `sendmail` start-up script for a specific runlevel, simply add or remove the symbolic link in that runlevel's directory. In and of itself this would be simple enough, but Linux systems make it even easier by providing tools to manage the runlevel directories.

Enabling Sendmail with *tksysv*

`tksysv` is an X Windows tool provided for the purpose of controlling scripts started at each runlevel. Figure 3.1 shows the main `tksysv` screen.

Figure 3.1 Enabling Sendmail with **tksysv**



All of the scripts that can be controlled by `tksysv` are listed on the left-hand side of the screen. On the right are the services that are started and stopped for runlevels 2, 3, 4, and 5. To disable a service for a specific runlevel, simply highlight the service in the Start list for that runlevel and click the Remove button. For example, to remove Sendmail from runlevel 5, which is traditionally used as the runlevel for dedicated X Windows workstations, click `sendmail` in the Start list under runlevel 5 and then click Remove. After that, Sendmail will no longer start when the system boots under runlevel 5.

To add Sendmail to a runlevel, highlight `sendmail` in the Available list and click Add. You'll be asked to select a runlevel. An example might be runlevel 3, which is traditionally the default runlevel for multiuser servers. Select the runlevel and click Done. You're then asked to select a script number. Use the default, which is 80 for the `sendmail` script. Click Add and the script is added to the start-up. The next time the system reboots under runlevel 3, Sendmail will be started.

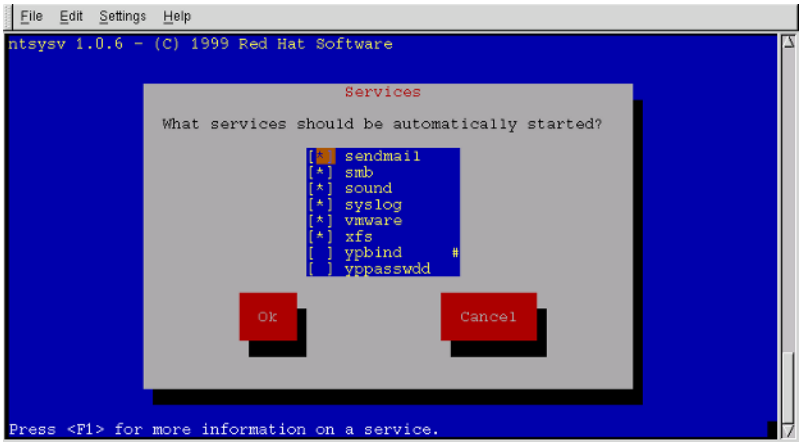
> ***TIP*** Of course you don't want to reboot your system just to run the `sendmail` start-up script. Use the Execute button to run the `sendmail` script immediately.

`tksysv` has a couple of nice features. First, it comes bundled with different versions of Linux. It runs just as well on Caldera as it does on Red Hat, and it runs just as well under Red Hat 6 as it does under Red Hat 7. Second, a clone of `tksysv` called `ntsysv` runs in text mode and therefore doesn't require X Windows. A dedicated e-mail server might not be running X Windows. In that case, you want a tool like `ntsysv` that runs in text mode.

Enabling Sendmail with *ntsysv*

`ntsysv` is even easier to use because it doesn't bother you with lots of questions about runlevels. It assumes the current runlevel as a default unless it is run with the `--level` argument. `ntsysv` presents you with a list of services that can be automatically started at boot time. One of these is Sendmail. The start-up script for every item in the list that has an asterisk next to it will be run during the next boot. Use the arrow keys to scroll down to the `sendmail` entry in the list and then use the space bar to select or deselect `sendmail`. When the settings are just what you want, tab over to the OK button and press Enter. That's all there is to it. Figure 3.2 shows the main `ntsysv` screen.

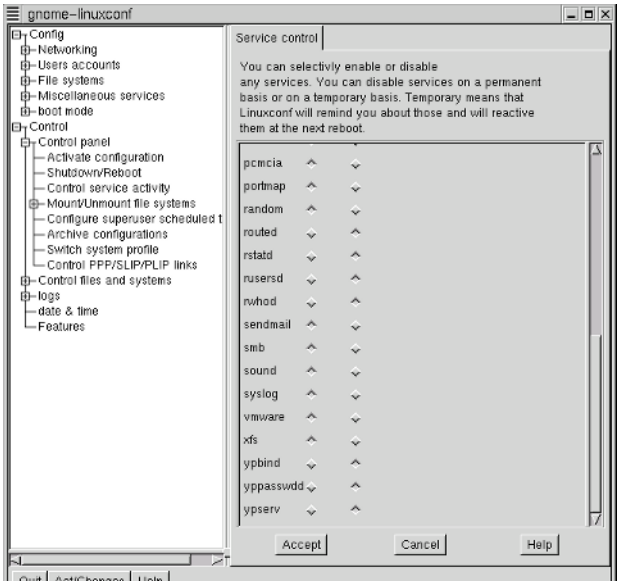
Figure 3.2 Enabling Sendmail with `ntsysv`



Enabling Sendmail with *linuxconf*

Another tool that is popular on Red Hat systems is `linuxconf`. `linuxconf` is a general-purpose system administration tool. One of the features it provides is a way to manage the start-up scripts. Figure 3.3 shows the `linuxconf` screen.

Figure 3.3 Enabling Sendmail with `linuxconf`



From the menu on the left-hand side of the `linuxconf` window, select Control ➢ Control Panel ➢ Control Service Activity. A list of services appears on the right-hand side of the window; it is the same list of services displayed by `ntsysv`. Again, as with `ntsysv`, you don't have to worry about runlevels. Simply enable or disable the `sendmail` script by selecting the appropriate button next to the `sendmail` entry.

Enabling Sendmail with *chkconfig*

One final tool that can be used to control the scripts that are run at boot time is `chkconfig`. This is a command-line tool based on the `chkconfig` program from the Silicon Graphics IRIX version of Unix. The Linux version has some enhancements, such as the ability to control which runlevels the scripts run under. The `--list` option of the `chkconfig` command displays the current settings:

```
[craig]$ chkconfig --list sendmail
sendmail 0:off 1:off 2:on 3:on 4:on 5:on 6:off
```

To enable or disable a script for a specific runlevel, specify the runlevel with the `--level` option, followed by the name of the script you wish to control and the action you wish to take, either `on` to enable the script or `off` to disable it. For example, to disable `sendmail` for runlevel 2, enter the command shown in Listing 3.3.

Listing 3.3 Controlling Sendmail with `chkconfig`

```
[root]# chkconfig --level 2 sendmail off
[root]# chkconfig --list sendmail
sendmail 0:off 1:off 2:off 3:on 4:on 5:on 6:off
```

Manually Running the Start-Up Script

The previous sections discussed several different ways to do essentially the same thing—enable or disable Sendmail at boot time. All of these approaches work. Choose the one that is compatible with the version of Linux you're running and that suits your tastes. But remember, most of the time you will install and enable Sendmail during the initial system configuration and will never again need to fiddle with the boot files.

It is far more likely that you will need to stop or restart a Sendmail process that is already running on your system. On most systems, this can be done by manually invoking the boot scripts. The `sendmail` start-up script on a Red Hat system accepts five arguments:

`stop` terminates the current Sendmail daemon process.

`start` starts a new Sendmail daemon if one is not currently running.

`restart` terminates the current Sendmail daemon and starts a new one. An alternate name for the same command is `reload`.

condrestart checks first to see if Sendmail is running. If one is running, it terminates the current Sendmail daemon and starts a new one. If Sendmail is not currently running, it starts Sendmail.

status displays the process ID of the current Sendmail daemon.

Listing 3.4 is an example of restarting the Sendmail daemon on a Red Hat system.

Listing 3.4 Restarting Sendmail with the Start-Up Script

```
[root]# /etc/rc.d/init.d/sendmail restart
Shutting down sendmail:                                    [  OK  ]
Starting sendmail:                                         [  OK  ]
```

NOTE If you're running Red Hat 6.0 or higher, an alternative to specifying the full path name of the `sendmail` start-up script is to enter **service sendmail restart**. On other versions of Red Hat, use the full pathname.

The primary limitation of the start-up scripts is that they all start the Sendmail daemon with only the `-bd` and the `-q` options. This is correct more than 99 percent of the time. But there are a few occasions when additional command-line arguments are needed. If the occasion is a test, it is simple enough to run Sendmail from the command line. If you need additional command-line arguments for every boot, the only option is to edit the start-up scripts or create your own start-up script to include the arguments you need. See Appendix B, "The `sendmail` Command," for a complete listing and description of the many command-line arguments that are available for the `sendmail` command.

Controlling Sendmail with Signals

Not every Linux system has a script that can be used to start, stop, and restart Sendmail. But on all systems, Sendmail can be controlled through signals. The Sendmail process handles three different signals. Well, four, if you count the fact that SIGTERM aborts Sendmail just as it does most other processes—but there are three signals that have a special meaning to Sendmail. These three signals are:

SIGHUP The SIGHUP signal causes the Sendmail daemon to restart and reread its configuration file. The most common use of SIGHUP is to force Sendmail to reload its configuration after the configuration file has been updated. SIGHUP can even be used to terminate the current copy of Sendmail and run a new one after the Sendmail program has been updated because SIGHUP causes a true restart, not just a reread of the configuration file.

SIGINT The SIGINT signal causes Sendmail to do a graceful shutdown. When Sendmail receives SIGINT, it removes the lock files if it is currently processing the queue, it switches back to the user ID that it started under to create a clean log entry, and then it exits without errors. Like most processes, Sendmail can be terminated by the kill signal, SIGTERM. However, SIGINT is a cleaner way to shut down Sendmail because, unlike SIGTERM, SIGINT will not leave unresolved log entries or unused lock files lying around.

SIGUSR1 Use the SIGUSR1 signal to cause Sendmail to write out its current status via `syslogd`. Details of Sendmail logging are covered in Chapter 12, "Testing Sendmail Security." For now, it is sufficient to understand that SIGUSR1 causes Sendmail to display information about the open file descriptors, information about its host connection cache, and output from the `debug_dumpstate` ruleset, if one is defined in your configuration. None of this output is of particular interest to a system administrator.

Listing 3.5 shows an example of passing a signal to Sendmail. In the example, the signal is SIGHUP but the same technique can be used to send any of the signals to Sendmail.

Listing 3.5 Restarting Sendmail with SIGHUP

```
[root]# ps -ax | grep sendmail
  542 ?        S      0:00 sendmail: accepting connections
[root]# kill -HUP 542
[root]# ps -ax | grep sendmail
  773 ?        S      0:00 sendmail: accepting connections
```

Listing 3.5 illustrates the effect of the SIGHUP signal by showing that the process ID of Sendmail changes after Sendmail is sent the signal. Clearly, a process must be terminated and restarted to change process IDs. The `kill` command used in this example is explained in the next section.

The *kill* Command

The `kill` command is used to send a signal to a running process. As the name implies, by default it sends the kill signal (SIGTERM). To use it to send a different signal, specify the signal on the command line. For example, specify `-INT` to send the SIGINT signal. The PID is usually provided on the `kill` command line to ensure that the signal is sent to the correct process.

As usual, there is more than one way to do something on a Linux system. You can learn the PID of Sendmail using the `ps` command:

```
[root]# ps -ax | grep sendmail
 542 ?        S      0:00 sendmail: accepting connections
```

You can also learn the PID by displaying the `sendmail.pid` file:

```
[root]# head -1 /var/run/sendmail.pid
542
```

Combining the last command with `kill`, you can send a signal directly to Sendmail. For example, to restart Sendmail you could enter the following command:

```
kill –HUP 'head -1 /var/run/sendmail.pid'
```

The `head -1 /var/run/sendmail.pid` command that is enclosed in single quotes is processed by the shell first. On our sample Linux system, the first line of the `sendmail.pid` file contains the PID 542. That is combined with the shell's `kill` command and then is processed as `kill -HUP 542`.

Signals, boot scripts, and everything else in this section has assumed that you have Sendmail already installed in your system. In the next section, we look at how to install Sendmail if you don't already have it or if you want to upgrade to the latest release.

Installing Sendmail

Sendmail is delivered with every major Linux distribution, and it is normally installed as part of the initial Linux installation. If it is not installed at that time, it can easily be added later using one of the package-management systems available for Linux.

To simplify the task of adding and deleting software on a running server, most Linux vendors have developed package-management systems. Slackware installs software from traditional tar files, but Debian and Red Hat have developed full-blown package-management systems. Debian and systems such as Corel that are based on Debian use the `dpkg` system. Most other Linux distributions use the Red Hat Package Manager (RPM). RPM is the most widely used package manager and the one this book covers in greatest detail. But before getting into RPM, let's take a quick look at the Debian package manager.

Installing Sendmail with *dpkg*

Locating a binary package in the correct format is the first step in installing a new software package with any package manager. Debian packages are found at `www.debian.org/distrib/packages`. These packages are intended for installation on the current Debian distribution but will usually work on any Debian-based release, such as Corel Linux.

After locating the upgrade package, use the dpkg command to remove the old software. Remove the currently installed Sendmail package with the following command:

```
[root]# dpkg -r sendmail
```

Next, use the dpkg command to install the new Debian package. For example, to install Sendmail 8.9.3 you would enter the following:

```
[root]# dpkg -i sendmail-wide_8.9.3+3.2W-20.deb
```

NOTE As of this writing, 8.9.3 is the most recent version of Sendmail available as a Debian package.

These dpkg examples are simple and clean. As we'll see in the discussion of RPM, package installations are not always this simple.

Locating RPM Software

To install Sendmail with RPM, you need to locate an updated Sendmail RPM package. If you failed to install Sendmail during the initial Linux installation and you just want to correct that oversight, you'll find the Sendmail RPM on the Linux CD-ROM. If you want to upgrade an existing installation, you need to search for the latest RPM packages.

www.sendmail.org provides the source code distribution of Sendmail, but RPM packages are not available from www.sendmail.org. To find RPM packages, go to your Linux vendor and to www.rpmfind.net.

Searching a Vendor Web Site

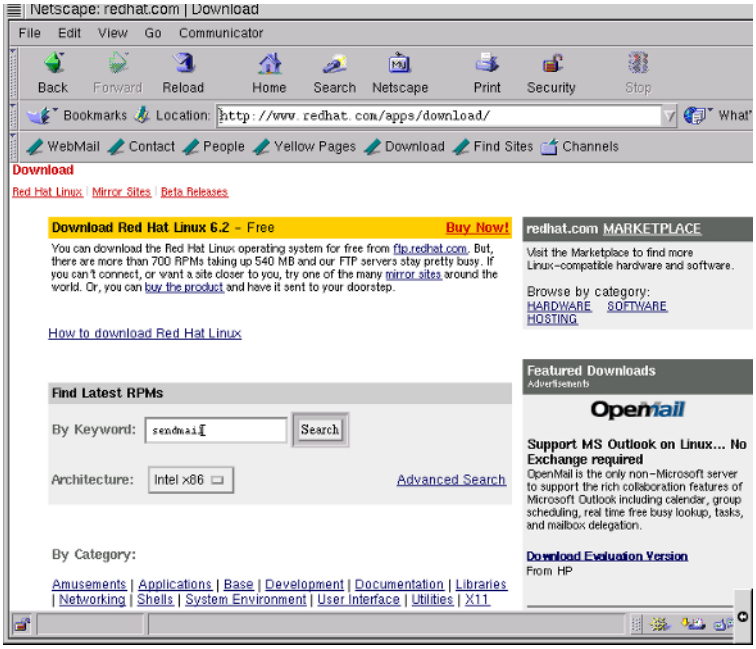
Because e-mail service is so important, all of the major Linux vendors make an effort to update their version of Sendmail when a critical bug is fixed or a major new feature is added. So a good place to start looking for updates is at your vendor's Web site.

Figure 3.4 shows the Red Hat Web site. Just like the Debian site, it contains a search page that lets you search for a binary package. In Figure 3.4, we ask Red Hat to list all of the available Sendmail RPM packages.

The search produces several matches. At this writing, the latest version of Sendmail available as an RPM is 8.11.0, which is the version of Sendmail used in the rest of this chapter. The packages returned by a search can be downloaded simply by clicking the name of the package and selecting an appropriate mirror server.

Searching the vendor site will probably provide the RPM package you need. However, I prefer a wider search that checks all of the sources of RPM packages to ensure that I don't miss the newest updates.

Figure 3.4 The Red Hat RPM search engine



Using *rpmfind.net* to Locate Sendmail Software

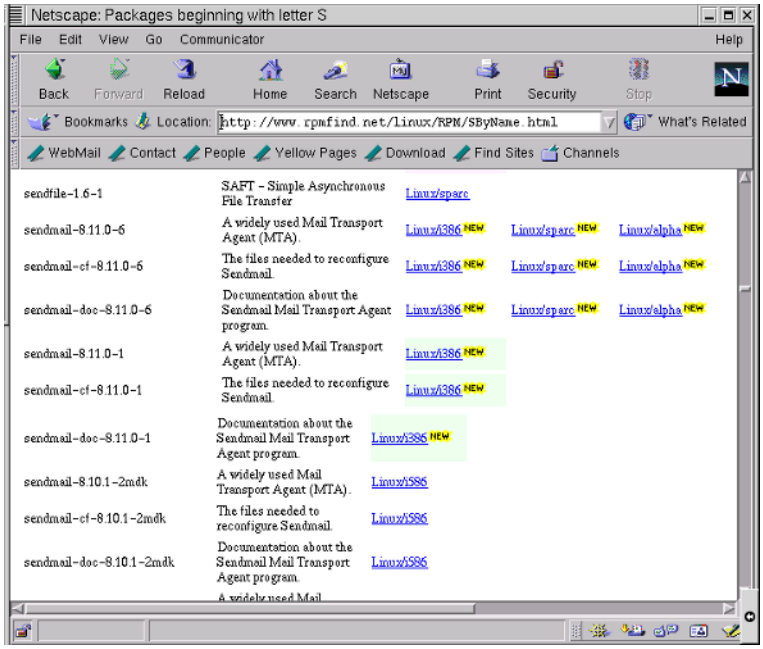
Vendors are not the only ones who make RPM packages available on the Net. To search a wide variety of RPM sources, go to `www.rpmfind.net`. Figure 3.5 shows the `www.rpmfind.net` Web site, which lists several Sendmail RPM packages.

The Web page in Figure 3.5 is the RPM repository database indexed alphabetically by name. The database is also indexed by distribution, by vendor, and by time of creation, if those things are helpful for your particular search. In this case, we are looking for Sendmail, so we just jump to "s" in the alphabetic listing.

Our sample Linux system is running Sendmail 8.9.3. Figure 3.5 shows that there are several newer Sendmail RPM packages available, with the newest being Sendmail 8.11.0-1. This particular Sendmail update contains three RPM packages:

- `sendmail-cf-8.11.0-1` contains the Sendmail configuration files, including the `cf` directory used extensively in this text.
- `sendmail-doc-8.11.0-1` contains the Sendmail documentation.
- `sendmail-8.11.0-1` is the heart of the system, including the Sendmail program.

Figure 3.5 The `rpmfind` Web site



Following the links from the page shown in Figure 3.5 will lead you to detailed information about each package and a link from which the package can be downloaded. All three of the packages should be downloaded. These are the RPM packages that you'll install later in this chapter.

> ***WARNING*** Installing an RPM from an unknown source could compromise your system's security. Only use RPMs from sources you trust, such as the Linux vendor.

Using Anonymous FTP to Download an RPM

RPM packages are also available via anonymous FTP. I prefer the Web because I can search through many packages stored at a wide variety of locations, but if you know where the package you want is located, FTP can be faster. The same packages shown in Figure 3.5 can be retrieved via anonymous FTP using the procedure shown in Listing 3.6.

Listing 3.6 Downloading the Sendmail RPM File

```
[craig]$ ftp rpmfind.net
Connected to rpmfind.net.
220 rpmfind.net FTP server ready.
User (rpmfind.net:(craig)): anonymous
331 Anonymous login ok, use your complete e-mail address as password.
Password:
230 Anonymous access granted, restrictions apply.
ftp> cd linux/contrib/libc6/i386
250 CWD command successful.
ftp> bin
200 Type set to I.
ftp> mget sendmail*8.11.0-1*
200 Type set to I.
mget sendmail-8.11.0-1.i386.rpm? y
200 PORT command successful.
150 Opening BINARY connection for sendmail-8.11.0-1.i386.rpm (259698 bytes)
226 Transfer complete.
ftp: 259698 bytes received in 2.63Seconds 98.74Kbytes/sec.
mget sendmail-cf-8.11.0-1.i386.rpm? y
200 PORT command successful.
150 Opening BINARY connection for sendmail-cf-8.11.0-1.i386.rpm
   (221066 bytes)
226 Transfer complete.
ftp: 221066 bytes received in 1.76Seconds 125.61Kbytes/sec.
mget sendmail-doc-8.11.0-1.i386.rpm? y
200 PORT command successful.
150 Opening BINARY connection for sendmail-doc-8.11.0-1.i386.rpm
    (482213 bytes)
226 Transfer complete.
ftp: 482213 bytes received in 4.56Seconds 105.75Kbytes/sec.
ftp> quit
221 Goodbye.
```

In this example, user input is shown in bold. The example has been edited to better fit on a book page, but is essentially what you would see if you performed this download.

In Listing 3.6 we log on to `rpmfind.net` with FTP. In this particular case, the files we want are in the `linux/contrib/libc6/i386` directory. The FTP mget command is used to retrieve all three files relating to Sendmail 8.11. Quick and easy—but only if you know where the files are located and exactly what RPM files you're looking for.

Installing Sendmail with RPM

Once the package is located, it can be installed using the `rpm` command. The `rpm` command is similar to the Debian `dpkg` command. It allows you to check the status of installed packages, remove outdated packages, and install updates.

Use the `rpm` command with the `-q` option or the `--query` option to check what packages are already installed in the system.

```
[craig]$ rpm --query sendmail
sendmail-8.9.3-10
```

This example queries `rpm` for the string `sendmail`. The response shows that Sendmail version 8.9.3 is installed on our sample system. At the time of this writing, the latest RPM version of Sendmail available from `www.rpmfind.net` and `www.redhat.com` is 8.11, so we decide to upgrade the sample system.

Before installing a new version of an RPM package, you can remove the old one by running `rpm` with the `--erase` option. (See the section "Cleaning Up After RPM" later in this chapter for an example of this.) Removing the old Sendmail RPM package is probably a good idea if you plan to compile and install the Sendmail program from the source code distribution. But if you plan to install a new RPM version of Sendmail, removing the old package is unnecessary. Use the `-U` option with the `rpm` command, as shown in Listing 3.7, to update an existing RPM installation with a newer package.

Listing 3.7 Updating Sendmail with RPM

```
[root]# rpm -U sendmail-doc-8.11.0-1.i386.rpm
[root]# rpm -U sendmail-cf-8.11.0-1.i386.rpm
[root]# rpm -U sendmail-8.11.0-1.i386.rpm
error: failed dependencies:
        openssl is needed by sendmail-8.11.0-1
        libsfio is needed by sendmail-8.11.0-1
        libcrypto.so.0 is needed by sendmail-8.11.0-1
        libsasl.so.7 is needed by sendmail-8.11.0-1
        libsfio.so is needed by sendmail-8.11.0-1
        libssl.so.0 is needed by sendmail-8.11.0-1
```

The Sendmail 8.11 package is composed of three components: the documents, the configuration files, and Sendmail itself. In Listing 3.7 the documents and configuration file components install without a hitch. The third component, however, fails to install. RPM informs us that several pieces of software required by Sendmail 8.11 are not available on this sample system. RPM calls required software *dependencies*. Sometimes other software depends on the package you're installing or removing, and sometimes the software you're installing depends on other software.

This is the worst-case scenario. We had hoped everything would be easy sailing. Now we need to track down all of the packages needed by Sendmail 8.11, install those packages, and then attempt to install `sendmail-8.11.0-1.i386.rpm` all over again. This bit of unpleasantness is a blessing in disguise. If we installed Sendmail 8.11 from source code and did not know that `openssl` and `libsfio` are required, some of the features of Sendmail would not work as advertised. It could take a long time tracking down the underlying problem. RPM makes sure that we know about the problem right from the start. We could force RPM to install `sendmail-8.11.0-1.i386.rpm` without the dependencies by adding the `--nodeps` argument to the `rpm` command line. But that's just asking for trouble. The best thing to do is track down and install the required packages.

A search of `www.rpmfind.net` informs us that we need three different RPM packages to fix the six dependencies: `openssl-0.9.5a-1.i386.rpm`, `libsfio-1999-1.i386.rpm`, and `cyrus-sasl-1.5.11-2.i386.rpm`. The first two packages, `openssl` and `libsfio`, are pretty obvious because RPM lists them as the first two dependencies needed by `sendmail-8.11.0-1.i386.rpm`. An examination of the list of files provided by each package shows that they provide every dependency except `libsasl.so.7`. A search for `libsasl.so.7` tells us that it is found in `cyrus-sasl-1.5.11-2.i386.rpm`. We download the three packages and install them as shown in Listing 3.8.

Listing 3.8 Fixing Dependency Problems for Sendmail 8.11

```
[root]# rpm -i openssl-0.9.5a-1.i386.rpm
error: file /usr/man/man1/passwd.1 from install of openssl-0.9.5a-1
       conflicts with file from package passwd-0.58-1
[root]# rpm -i --replacefiles openssl-0.9.5a-1.i386.rpm
[root]# rpm -i libsfio-1999-1.i386.rpm
[root]# rpm -i cyrus-sasl-1.5.11-2.i386.rpm
[root]# rpm -U sendmail-8.11.0-1.i386.rpm
[root]# rpm -q sendmail
sendmail-8.11.0-1
```

Even this installation didn't go completely perfectly. The `openssl-0.9.5a-1.i386.rpm` package creates a new `passwd` man page. The problem is, it doesn't own the old page. That page was put on the system by the `passwd-0.58-1.i386.rpm` package. RPM won't let a new package change a file that belongs to another package unless you tell it to. In this case, we want the new `passwd` documentation so we use the `--replacefiles` argument with the `rpm` command to replace the old `passwd` documentation with the new documentation.

All of the other installations run smoothly. Once the dependencies are resolved, `sendmail-8.11.0-1.i386.rpm` installs without complaint. A quick query to RPM shows that the new package is in place.

Next, restart Sendmail to make sure that the newly installed daemon is running, and run a quick test to make sure the new daemon is alive and servicing the SMTP port. Listing 3.9 shows these two commands.

Listing 3.9 Restarting and Testing Sendmail

```
[root]# /etc/rc.d/init.d/sendmail restart
Shutting down sendmail:                                    [  OK  ]
Starting sendmail:                                         [  OK  ]
[root]# telnet localhost 25
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
220 wren.foobirds.org ESMTP Sendmail 8.11.0/8.11.0;
    Sun, 13 Aug 2000 18:00:03 -0400
quit
221 2.0.0 wren.foobirds.org closing connection
Connection closed by foreign host.
```

As Listing 3.9 shows, Sendmail 8.11 is installed and running. Despite all of the problems encountered in this installation, Sendmail is upgraded and running after fewer than a dozen commands. Linux package managers have done much to simplify upgrades.

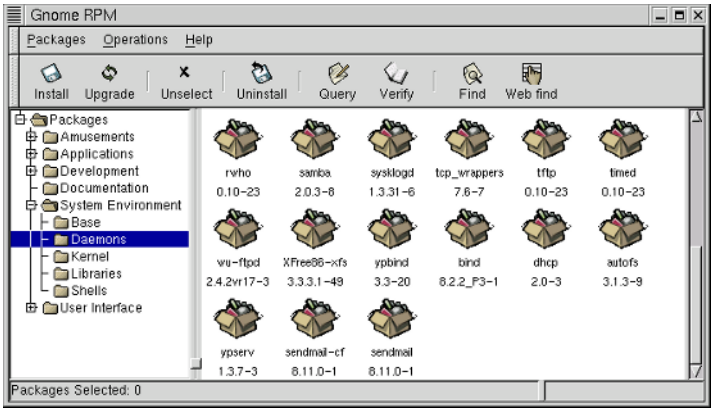
NOTE I have never had a problem with dependencies upgrading Sendmail before version 8.11. This just turned out to be a lucky break. Normally, things go so smoothly when preparing examples for Linux books that problems have to be described without actual examples. This time we were lucky enough to have a real problem. You might never see dependency problems when installing Sendmail yourself, but it is good to know how they are resolved.

X Tools for Installing Sendmail

In the previous section, we used the command-line version of `rpm`. It is easy to use, easy to explain, and it runs on most Linux systems—even those that don't have X Windows running. But if you are using X Windows, there are some graphical tools for running the Red Hat Package Manager. Several systems use a tool named `glint`. Systems with the KDE desktop environment use a tool named `kpackage`, and systems with the GNOME

desktop environment use a tool called `gnorpm`. Figure 3.6 shows `gnorpm` running on a Red Hat 6 system.

Figure 3.6 Installing Sendmail with `gnorpm`



Understanding `gnorpm` is easy once you understand the `rpm` command. The icons near the top of the window clearly parallel the `-U` (upgrade), `-q` (query), `-V` (verify), and `-e` (uninstall) command-line options. Simply highlight the package you're interested in and select the action you want to take. Figure 3.6 shows the test system after Sendmail was upgraded.

Even without GUI tools, it is simpler to upgrade an existing RPM package with a new one than it is to delete the package and replace it with software you compile yourself, for a couple of reasons:

- First, using the `rpm` command is easier than compiling software.
- Second, the features of `rpm`, such as pointing out dependencies and verifying the integrity of the software, are unavailable if you don't use `rpm`.

But the latest software is not always available as a binary package. The Debian example in this chapter illustrates that. Sometimes you must compile your own version of Sendmail from the source code to get the latest release. Compiling Sendmail is the next topic of this chapter.

Cleaning Up After RPM

We need to digress for a moment from the basics of upgrading with RPM. If you have RPM and your current Sendmail was installed via RPM, you should upgrade with RPM.

Take advantage of the tools your Linux system offers. However, if you are forced to upgrade with source code a system that was originally installed via RPM, you should clean out the RPM installation before upgrading.

The next section describes downloading and compiling the latest Sendmail source code. Before installing a new version of Sendmail that you have downloaded and compiled, remove the old RPM version with the `--erase` option, as in this example:

```
[root]# rpm --erase --nodeps sendmail-cf-8.9.3-1
[root]# rpm --erase --nodeps sendmail-8.9.3-1
```

The `--nodeps` option is added to this command line to force `rpm` to erase the Sendmail software, even though other packages are dependent on it. Attempting to erase Sendmail without using the `--nodeps` option displays an error message stating that other software depends on Sendmail, and it is not removed, as shown below.

```
[root]# rpm --erase sendmail
removing these packages would break dependencies:
        sendmail is needed by sendmail-cf-8.9.3-1
```

Failing to remove the Sendmail RPM package before installing a non-RPM version, such as a version that you compile yourself, means that the system will still think the old RPM version is installed. An `rpm --query` will continue to report the old Sendmail version number. If the `-V` option is used to verify the Sendmail RPM package, it may report false and misleading errors. Here is an example of what can happen when the components of Sendmail are changed or upgraded without using RPM and then are verified by the `rpm` command:

```
[craig]$ rpm -V sendmail
S.5....Tc   /etc/aliases
missing    /etc/rc.d/rc2.d/S80sendmail
S.5....T   /var/log/sendmail.st
```

The `-V` option prints out a line for each file in the package that fails verification. Values are printed at the beginning of the line to indicate which tests were failed. Each letter or number indicates a failure and each dot indicates a test that was passed. The possible values are as follows:

- `S` indicates that the file has the wrong file size.
- `M` indicates that the file is assigned the wrong file permissions or file type.
- `5` indicates that the file has an incorrect MD5 checksum.
- `D` indicates that the file is located on the wrong device.

- `L` indicates that the file is improperly a symbolic link.
- `U` indicates that the file has the wrong user ID (UID) assigned.
- `G` indicates that the file has the wrong group ID (GID) assigned.
- `T` indicates that the file has the wrong file creation time.
- `C` indicates that the file is a configuration file that is expected to change.

In the previous example, two files have the wrong checksum and the wrong creation date, and they are the wrong size. These are all things you would expect because these are not the original files. They are files that were installed over the original files. The file that is missing is the `S80sendmail` script we deleted in Listing 3.3. All of the other files associated with the Sendmail RPM check out fine. But even these three errors might set off alarm bells with the system's computer security officer. For this reason, clean out the RPM installation before installing Sendmail from source code as described in the following section.

Downloading and Compiling Sendmail

Even if your Linux system comes with its own version of Sendmail, obtaining the latest Sendmail source code distribution provides useful documentation, tools, and sample configuration files. Additionally, there are times when you need a security fix or update and the latest version of Sendmail has not yet been posted as an RPM or other binary distribution.

The latest Sendmail distribution is available via anonymous FTP from `ftp.sendmail.org`, where it is stored in the `pub/sendmail` directory. When you change to that directory, an informational message is displayed that tells you about the latest version of Sendmail. New releases are constantly being created. The following examples are based on Sendmail V8.11.0.

> ***NOTE*** Remember that things will change for future releases, so always review the `readme` files and installation documents that come with new software before beginning an installation.

To compile the Sendmail program, download the compressed tar file as a binary file and then uncompress and extract it with the `tar` command, as shown in Listing 3.10.

Listing 3.10 Downloading the Sendmail Source Code

```
[craig]$ ftp ftp.sendmail.org
Connected to ftp.sendmail.org.
```

```
220 pub2.pa.vix.com FTP server ready.
Name (ftp.sendmail.org:craig): anonymous
331 Guest login ok, send your e-mail address as password.
Password:
230 Guest login ok, access restrictions apply.
Remote system type is UNIX.
Using binary mode to transfer files.
ftp> cd pub/sendmail
ftp> get sendmail.8.11.0.tar.gz
local: sendmail.8.11.0.tar.gz remote: sendmail.8.11.0.tar.gz
200 PORT command successful.
150 Opening BINARY mode data connection for sendmail.8.11.0.tar.gz
   (1307858 bytes).
226 Transfer complete.
1307858 bytes received in 26 secs (50 Kbytes/sec)
ftp> quit
221-You have transferred 1307858 bytes in 1 files.
221-Thank you for using the FTP service on pub2.pa.vix.com.
221 Goodbye.
[craig]$ cd /usr/local/src
[craig]$ tar -zxvf /home/craig/sendmail.8.11.0.tar.gz
```

Next, change to the `sendmail-8.11.0` directory created by the tar file, and use the `Build` script to compile the new Sendmail program, as shown in Listing 3.11.

Listing 3.11 Compiling Sendmail with the `Build` Command

```
[craig]$ cd sendmail-8.11.0
[craig]$ ./Build
Making all in:
/usr/local/src/sendmail-8.11.0/libsmutil
Configuration: pfx=, os=Linux, rel=2.2.10, rbase=2, rroot=2.2,
   arch=i586, sfx=, variant=optimized
Using M4=/usr/bin/m4
Creating ../obj.Linux.2.2.10.i586/libsmutil using ../devtools/OS/Linux
Making dependencies in ../obj.Linux.2.2.10.i586/libsmutil
make[1]: Entering directory
     `/usr/local/src/sendmail-8.11.0/obj.Linux.2.2.10.i586/libsmutil'
cc -M -I. -I../../sendmail -I../../include -DNEWDB
      -DNOT_SENDMAIL debug.c
errstring.c lockfile.c safefile.c snprintf.c strl.c    >> Makefile
make[1]: Leaving directory
      `/usr/local/src/sendmail-8.11.0/obj.Linux.2.2.10.i586/libsmutil'
```

```
Making in ../obj.Linux.2.2.10.i586/libsmutil
make[1]: Entering directory
      `/usr/local/src/sendmail-8.11.0/obj.Linux.2.2.10.i586/libsmutil'
cc -O -I. -I../../sendmail -I../../include -DNEWDB
      -DNOT_SENDMAIL -c debug.c -o debug.o
cc -O -I. -I../../sendmail -I../../include -DNEWDB
      -DNOT_SENDMAIL -c errstring.c -o errstring.o
... Many, many, many lines deleted...
cc -O -I. -I../../sendmail -I../../include -DNEWDB
      -DNOT_SENDMAIL -c vacation.c -o vacation.o
cc -o vacation   vacation.o ../libsmdb/libsmdb.a
      ../libsmutil/libsmutil.a -ldb -lresolv -lcrypt -lnsl -ldl
groff -Tascii -man vacation.1 > vacation.0 ||
      cp vacation.0.dist vacation.0
make[1]: Leaving directory
      `/usr/local/src/sendmail-8.11.0/obj.Linux.2.2.10.i586/vacation'
```

`Build` detects the architecture of the system and builds the correct `Makefile` for your system. It then compiles Sendmail using the newly created `Makefile`.

According to the documentation, running `Build` is all you need to do on most systems to compile Sendmail. It certainly works on Caldera Linux systems, as this example illustrates. However, the installation notes warn of several possible problems that can occur with some Linux systems, which are described in the next section, "Known Problems."

Once Sendmail compiles, it is installed by using the `Build` command with the `install` option (see Listing 3.12).

Listing 3.12 Installing the New Sendmail Binaries

```
# ./Build install
Making all in:
/usr/local/src/sendmail-8.11.0/libsmutil
Configuration: pfx=, os=Linux, rel=2.2.10, rbase=2, rroot=2.2,
      arch=i586, sfx=, variant=optimized
Making in ../obj.Linux.2.2.10.i586/libsmutil
make[1]: Entering directory
      `/usr/local/src/sendmail-8.11.0/obj.Linux.2.2.10.i586/libsmutil'
... Many, many, many lines deleted...
Making in ../obj.Linux.2.2.10.i586/vacation
make[1]: Entering directory
      `/usr/local/src/sendmail-8.11.0/obj.Linux.2.2.10.i586/vacation'
install -c -o bin -g bin -m 555 vacation /usr/bin
```

```
install -c -o bin -g bin -m 444 vacation.0 /usr/man/man1/vacation.1
make[1]: Leaving directory
      `/usr/local/src/sendmail-8.11.0/obj.Linux.2.2.10.i586/vacation'
```

The `Build` command installs the man pages in the `/usr/man` directory and the executables in `/usr/sbin` and `/usr/bin`. It installs the help file (`sendmail.hf`) and the status file (`sendmail.st`) in `/etc/mail`.

Known Problems

The Sendmail documentation lists some problems that are known to affect compilation on Linux systems. The problems fall into several categories ranging from compiler problems to kernel problems.

Two problems relate to GNU tools that are commonly used on Linux systems. One is an incompatibility detected between GDBM and Sendmail 8.8. Later versions of Sendmail improved the heuristic to detect GDBM so that the Sendmail code can adapt to GDBM. The Sendmail release notes suggest using Berkeley DB instead of GDBM.

The other GNU problem is with the `gcc` compiler. Old versions of `gcc`, versions 2.4 and 2.5, cannot be used to compile Sendmail with the compiler optimization (`-O`) option set. This was fixed when version 2.6 was released. The Caldera system used to generate the example in Listing 3.10 uses the Experimental GNU Compiler Suite version 2.91, which is a follow-on to `gcc`.

Several problems are described that existed with very old kernels (pre–version 1.0), very old versions of `libc` (pre–version 4.7), and a very old version of the BIND domain name software (version 4.9.3). No one should currently be running any of this old software.

The Sendmail documentation also reports problems that relate to having previously compiled BIND on your system. The symptoms of this problem are unresolved references during the link phase of the Sendmail compile. If you have compiled BIND from source code on your system and BIND wrote header files in `/usr/local/lib` and `/usr/local/include`, these files may cause problems when Sendmail is compiled. The documentation suggests adding `-lresolv` to `LIBS` in the Sendmail `Makefile` to avoid this problem.

Finally, the documentation mentions problems with Linux kernel 2.2.0. This is the most worrisome of the problems reported because the documentation does not provide a workaround for this problem. I have never personally seen this problem, but if I did, I would upgrade the Linux kernel to the highest patch.

Frankly, none of the problems described in the Sendmail installation notes has ever struck any Linux system that I have worked with. A far more common occurrence is

for something to change in the new distribution that makes your old configuration obsolete. We look at that challenge next.

Configuration Compatibility

New versions of Sendmail can change things that make the old configuration incompatible with the new Sendmail program. Watch for these changes and adjust the configuration when they arise.

The `/etc/mail` directory is a new default location used by Sendmail version 8.11. The `Build install` command placed the help file and the status file in this new directory, but the help file and the status file locations are also defined in the Sendmail configuration file. If the files are not in the locations your mail server configuration expects, you can do one of two things:

- Simply move the files to the locations that you desire.
- Change the Sendmail configuration to point to `/etc/mail` for these files. This is the default location expected by Sendmail 8.11, so using these locations actually means removing the define macros that point to the "non-standard" locations for these files. Using the default locations means that you will have a simpler configuration file. See Chapter 5, "Understanding a Vendor's Configuration," for more information about the define macros used to specify file locations.

Regardless of what you do, the physical location of the files and the location of the files defined in the configuration must agree.

Sendmail 8.11 has also changed the location of the Sendmail configuration file (`sendmail.cf`). Traditionally, the file was located in the `/etc` directory, and that is where it is found on most Linux systems. Sendmail 8.11 uses the new `/etc/mail` directory for the `sendmail.cf` file. Attempting to run the newly compiled Sendmail binary on the sample system will fail, because Caldera keeps the `sendmail.cf` file in the `/etc` directory and Sendmail 8.11 is looking for it in the `/etc/mail` directory. A simple test shows this:

```
[root]# sendmail -v -t
/etc/mail/sendmail.cf: line 0: cannot open: No such file or directory
```

This needs to be fixed, and again you can either move the file or change the configuration. To change the configuration, provide the `sendmail` command with the correct path to the configuration file by using the `-C` command-line option—for example, `sendmail -C/etc/sendmail.cf`. The Sendmail start-up script must also be edited to insert this command-line option so that the correct configuration file is used every time the system reboots. Frankly, this is more trouble than it is worth. Just move the `sendmail.cf` file to `/etc/mail`. It is simpler and better because other newly installed mail tools might be looking for the `sendmail.cf` file at the new default location.

One other thing that should be checked before declaring the installation complete is the `sendmail.cf` file. New versions of Sendmail may add new configuration syntax that makes the older configuration files incompatible with the new release. The Sendmail program checks the version (`V`) command inside the `sendmail.cf` file to indicate the level of the configuration syntax. The easiest way to check compatibility is to use the `sendmail` command to send a piece of test mail:

```
[root]# sendmail -v -t -C/etc/sendmail.cf
Warning: .cf file is out of date: sendmail 8.11.0 supports
        version 9, .cf file is version 8
^D
No recipient addresses found in header
```

Running `sendmail` with the `-v` option tells the program to provide verbose messages, which is just what you want when you're testing. The `-t` option tells Sendmail that the mail will be typed in at the console. In this case, I immediately terminate the session with a Ctrl+D (which is what the `^D` illustrates), because I don't want to send mail, I just want to see the warning message. The new Sendmail program complains about the version level of the configuration file. In this particular case, mail would not be delivered successfully because too much has changed between Sendmail 8.9 and 8.11. This is not always the case. Sometimes you can force mail through an old configuration. But you shouldn't.

This example shows that this configuration is not compatible with the new release. To solve this incompatibility, you need to rebuild your configuration. Understanding basic Sendmail configuration and building your own custom configuration is the topic of Part 2 of this book.

In Sum

Sendmail runs in two different modes to handle outbound and inbound mail. Sendmail is started in real time to handle individual pieces of outbound mail, but runs as a daemon to collect inbound mail. There are several tools that help you control which systems run the Sendmail daemon as part of their start-up.

Before the Sendmail program can be run, it must be properly installed. Sendmail can be installed using a Linux package manager or compiled from source. Despite the complexity of Sendmail, it is installed in the same manner as all other Linux packages, and the same tools are used to control the Sendmail start-up process as are used with any other Linux start-up process. Installing and running Sendmail are two tasks that don't have any

special complexity. If you know how to install and run Linux processes, you know how to install and run Sendmail on a Linux system.

Once installed, Sendmail must be configured. Configuring Sendmail is the topic of Part 2, which starts with Chapter 4, "Creating a Basic Sendmail Configuration."

Part 2

Essential Configuration

Featuring:

- Where the Sendmail `m4` directories and files are located and what they do
- Understanding the basic `m4` macro language
- How to build `sendmail.cf` with `m4`
- What the `generic-linux.mc` file contains and what it does
- Understanding the Linux `OSTYPE` file
- Understanding the generic `DOMAIN` file and how to modify it
- Analyzing and improving the Red Hat configuration
- How to add database support to your Sendmail program and its configuration
- The role of the `local-host-names` file and the `relay-domains` file
- Uses for the `aliases` database, the user database, and the `genericstable`
- The syntax and structure of the `access` database
- Uses for the `virtusertable` and the `mailertable`

4

Creating a Basic Sendmail Configuration

At the conclusion of the last chapter, we compiled Sendmail 8.11 from the source code distribution. Much to our dismay, we discovered that the new Sendmail program would not run even after the `sendmail.cf` configuration file was moved to the `/etc/mail` directory where the new Sendmail expected to find it. Sendmail 8.11 complained that the `sendmail.cf` file provided with the Linux distribution was an older version that was not compatible with the new software release. The solution to this problem is to build a new `sendmail.cf` file that is compatible with the new software, and in this chapter that is just what we do.

Building a new Sendmail configuration, even a very basic one, is a multi-step process. The `sendmail.cf` configuration file is built from `m4` macros. To build your own configuration, you must

- Locate the correct `m4` macro libraries and files
- Have a basic understanding of the `m4` macro language
- Select an appropriate macro configuration file
- Modify the file as necessary
- Process your newly created macro configuration file through the `m4` macro processor

This chapter covers all of these steps while building a very basic configuration file that solves the incompatibility problem encountered when we upgraded to Sendmail 8.11 using the source code distribution. Remember that in Chapter 3, "Running Sendmail," we installed Sendmail under Linux in two different ways. Before we compiled and installed Sendmail from source code, we installed it using RPM. A few problems emerged during the RPM installation, but once the installation completed successfully everything was ready to run. There was no compatibility problem, and thus no reason to build a simple configuration to solve a compatibility problem.

However, even if you use RPM to install Sendmail, the topics covered in this chapter will be useful to you. Building this simple configuration provides an introduction to `m4` and provides the basis for understanding more complex configurations. We build on this simple configuration in later chapters to create a more robust, customized configuration suitable for a production e-mail server. This foundation is useful for all Sendmail administrators, whether or not you use RPM. Let's begin by locating the `m4` macro language source files provided with the Sendmail distribution.

The *cf* Directory Structure

`m4` is a general-purpose macro processor. It has a wide variety of uses and is not specifically intended for Sendmail configuration. `m4` macro definitions have been built by the people who maintain Sendmail in order to allow us to create a Sendmail configuration with `m4`.

The Sendmail distribution contains the `m4` source files needed to build the `sendmail.cf` file. These source files are found in the `cf` directory located under the top directory created by the Sendmail distribution tar file. The top directory created by the tar file always has a name based on the Sendmail distribution's version number. The format of this directory name is `sendmail-`*`version`*, where *`version`* is the version number. Thus the tar file for Sendmail 8.11.0 creates a top directory named `sendmail-8.11.0`, and the configuration files for that release are found in `sendmail-8.11.0/cf`. All this, of course, is relative to the directory in which you restore the tar file. In Chapter 3, we restored the tar file in `/usr/local/src`, so the complete path to the configuration files on our sample system is `/usr/local/src/sendmail-8.11.0/cf`. A listing of that directory shows 10 entries.

```
[craig]$ ls /usr/local/src/sendmail-8.11.0/cf
README  cf  domain  feature  hack  m4  mailer  ostype  sh  siteconfig
```

The `cf` directory contains a `README` file and nine subdirectories. The `README` file provides useful documentation on the `m4` language and how that language is used to build a `sendmail.cf` file. Always check this file for the latest changes and the newest features.

As you'll see later, the names of most of the subdirectories (`domain`, `feature`, `hack`, `mailer`, `ostype`, and `siteconfig`) are clearly identifiable as the names of `m4` macro commands used to build a Sendmail configuration. Only the `cf`, `m4`, and `sh` directories do not share names with `m4` macros. All of the directories, however, are worth exploring.

The *sendmail-cf* RPM Files

In this chapter, the `cf` directory and its subdirectories are described as part of the Sendmail source code distribution. These same files, however, are available as part of an RPM installation. In Chapter 3, we installed the RPM version of the `cf` directory. It was the RPM package identified as `sendmail-cf-8.11.0-1.i386.rpm`. It contains all of the files that are described in this chapter. The only difference is the location of the files. To find out where the files are stored, run an `rpm` query and ask for a file listing as follows:

```
[craig]$ rpm -q -l sendmail-cf
```

On our sample Red Hat system, this command shows that the `cf` directory is named `/usr/lib/sendmail-cf`. A listing of `/usr/lib/sendmail-cf` shows the following:

```
[craig]$ ls /usr/lib/sendmail-cf

README  cf  domain  feature  hack  m4  mailer  ostype  sh
siteconfig
```

Thus, if you're using an RPM installation, `/usr/lib/sendmail-cf` is equivalent to `cf` in these discussions. The same `README` file and the same nine subdirectories appear in `/usr/lib/sendmail-cf` on an RPM installation as appear in `cf` on a source code installation. Everything covered in this chapter applies regardless of how you installed Sendmail 8.11.

Little-Used Directories

Three of the directories (`hack`, `sh`, and `siteconfig`) in the `cf` directory have very little use for most configurations. For two of these directories, this lack of use directly relates to the lack of utility of the macro commands that they represent.

The `cf/hack` directory holds `m4` source files built by the local system administrator to solve temporary `Sendmail` configuration problems. Temporary code fixes are called *hacks*, thus the name for this directory and the command that uses it. The `HACK` command

is almost never used, and thus the `hack` directory is almost never used. An `ls` of the `hack` directory shows that it contains just one file.

```
[craig]$ ls hack
cssubdomain.m4
```

The one file contained in the `hack` directory is an old fix that was used for a few months at Berkeley to handle a domain name transition. The file is there only as an example. It could not be used by anyone but Berkeley and it is no longer of any use to them. Even the domain name transition handled by this hack could now be handled more easily with the database features built into the current Sendmail. The `hack` directory and `HACK` command are still there, but there is simply no good reason to use them.

The `cf/siteconfig` directory contains files that define the UUCP connectivity for the mail server. The files list the locally connected UUCP sites using a specific `sendmail m4` syntax. The `siteconfig` directory contains four sample files.

```
[craig]$ ls siteconfig
uucp.cogsci.m4  uucp.old.arpa.m4  uucp.ucbarpa.m4  uucp.ucbvax.m4
```

The `siteconfig` directory and the `SITECONFIG` command are still maintained for backward compatibility. However, this directory is obsolete and should no longer be used to define the UUCP connectivity for a UUCP mail server. Use the Sendmail databases described in Chapter 6, "Using Sendmail Databases," if you need to define UUCP connectivity.

The last little-used directory does not even map to an `m4` macro command. It is the `cf/sh` directory and it contains only one file.

```
[craig]$ ls -l sh
total 2
-rw-r--r--   1 craig  users     1128 Feb  7 1999 makeinfo.sh
```

Even the name of this file is different. All of the files we have seen so far are `m4` macro source files. As such, they all end with the `.m4` extension. This file, however, ends with the `.sh` extension, indicating that it is a shell script. The permission bits show that, even though it is a shell script, it is not executable. So it is probably not being used. Still, I'm curious. So I changed the permissions and ran the script.

```
[root]# chmod 744 makeinfo.sh
[root]# ./makeinfo.sh
```

```
##### built by root@ibis.foobirds.org on Thu Aug 17 09:36:03 EDT 2000
##### in /usr/local/src/sendmail-8.11.0/cf/sh
##### using as configuration include directory
define(`__HOST__', ibis.foobirds.org)dnl
```

The script produces three lines of comments that could be used to identify who built the `sendmail.cf` file, when they built it, and in what directory. The third line includes the name of the configuration directory when this is actually run by `m4`. The last line of output assigns a value to a variable. Of course, you don't really run this script. As I said, I was just curious. The script is used by the `m4` process when it builds the `sendmail.cf` file. You never use this script directly, and you never use this directory to store any of your own configuration files.

The *domain* Directory

The `cf/domain` directory is one of the directories where you are most likely to store your own configuration files. The purpose of the `domain` directory is to hold `m4` source files that define configuration values that are specific to your domain or network. The configuration file you create for your environment is then used in the macro configuration file via the `DOMAIN` command. Because the intent is for you to create your own file, the six files shown when you `ls` the domain directory are all just examples.

```
[craig]$ ls domain
Berkeley.EDU.m4      EECS.Berkeley.EDU.m4  berkeley-only.m4
CS.Berkeley.EDU.m4   S2K.Berkeley.EDU.m4   generic.m4
```

When you create your own domain configuration file, start by copying the sample file `generic.m4` to a name that is meaningful for your domain or network. For example, if your domain is `foobirds.org` you might copy `generic.m4` to `foobirds.m4`. Then edit the new file to set the values needed for your environment.

Creating your own domain file is an advanced configuration topic covered in later chapters. Basic configurations do not require a custom domain file.

The *cf* Subdirectory

Most of the work creating a basic configuration takes place in the `cf/cf` directory. This is the working directory of Sendmail configuration. It contains all of the macro configuration files, and it is where you will put your own macro configuration file when you build a custom configuration. Listing 4.1 shows that the `cf/cf` directory contains more than 40 files.

Listing 4.1 Contents of the `cf/cf` Subdirectory

```
[craig]$ cd /usr/local/src/sendmail-8.11.0/cf
[craig]$ ls cf
Build                           generic-solaris2.cf
Makefile                        generic-solaris2.mc
chez.cs.mc                      generic-sunos4.1.cf
clientproto.mc                  generic-sunos4.1.mc
cs-hpux10.mc                    generic-ultrix4.cf
cs-hpux9.mc                     generic-ultrix4.mc
cs-osf1.mc                      huginn.cs.mc
cs-solaris2.mc                  knecht.mc
cs-sunos4.1.mc                  mail.cs.mc
cs-ultrix4.mc                   mail.eecs.mc
cyrusproto.mc                   mailspool.cs.mc
generic-bsd4.4.cf               python.cs.mc
generic-bsd4.4.mc               s2k-osf1.mc
generic-hpux10.cf               s2k-ultrix4.mc
generic-hpux10.mc               tcpproto.mc
generic-hpux9.cf                test.cf
generic-hpux9.mc                test.mc
generic-linux.cf                ucbarpa.mc
generic-linux.mc                ucbvax.mc
generic-nextstep3.3.mc          uucpproto.mc
generic-osf1.cf                 vangogh.cs.mc
generic-osf1.mc
```

Most of these files—more than 30 of them—are sample macro control files. You can identify a macro control file by the `.mc` extension. Some are examples meant as educational tools. But most are prototypes or generic files meant to be used as the basis of your own configuration. Particularly interesting are the generic files designed for use with different operating systems. Generic files for Solaris, HPUX, BSD, Linux, and several other operating systems are included. For a Linux system administrator, the `generic-linux.mc` file is the one that garners the most attention.

Several of the files are identified by the `.cf` extension. These files are the result of processing macro configuration files through `m4` and are already in the proper format to be used as the `sendmail.cf` file. It is unlikely, however, that you will use one of these files directly. Unless the generic macro configuration file is exactly to your liking, the Sendmail configuration file produced from that `.mc` file will not be what you want. For example, the problem we want to solve is the fact that the `/etc/sendmail.cf` file on our sample system is not compatible with Sendmail 8.11. Using the `generic-linux.cf` file as the

`sendmail.cf` file might solve this problem, but as the test in Listing 4.2 shows, it doesn't work for our sample system.

Listing 4.2 Testing the `generic-linux.cf` File

```
[root]# sendmail -v -t -C /etc/sendmail.cf
Warning: .cf file is out of date: sendmail 8.11.0 supports version 9,
      .cf file is version 8
No recipient addresses found in header
^D
[root]# sendmail -v -t -C ./generic-linux.cf
./generic-linux.cf: line 66: fileclass: cannot open
       '/etc/mail/local-host-names'
: No such file or directory
```

The first `sendmail` test illustrates the problem we have with the old `sendmail.cf` file. It is version 8, and Sendmail 8.11 wants a version 9 configuration file. The second test uses the `-C` command-line argument to specify the `generic-linux.cf` file as the Sendmail configuration file. That test also fails. This time, the configuration is looking for a file named `/etc/mail/local-host-names`, which does not exist. We can fix the problem by creating the desired file or by simplifying the configuration so that it doesn't need that file. In this chapter we use the latter approach. (We don't cover the `local-host-names` file until the next chapter.)

The *cf/cf Build* Script

New Sendmail configurations are generally built inside the `cf/cf` directory. Two of the files in this directory are there to aid the build process. These are the `Build` shell script and the `Makefile` it uses. Listing 4.3 shows a Sendmail configuration file being constructed with the `Build` script.

Listing 4.3 Using the `cf/cf/Build` Script

```
[root]# ./Build test.cf
Using M4=/usr/bin/m4
rm -f test.cf
/usr/bin/m4 ../m4/cf.m4 test.mc > test.cf ||
    ( rm -f test.cf && exit 1 )
chmod 444 test.cf
```

The `Build` script is easy to use. Provide the name of the output file you want to create as an argument on the `Build` command line. The script replaces the `.cf` extension of the output file with the extension `.mc` and uses the macro configuration file with that name to

create the output file. Thus, putting `test.cf` on the `Build` command line means that `test.mc` will be used to create `test.cf`.

Despite the simplicity of the `Build` command, I never use it to build a Sendmail configuration and you probably won't either. The reason I don't use it is that the `m4` command line used to build a Sendmail configuration is also very simple. For the average Sendmail administrator, the `Build` script doesn't offer any significant advantages. The real reason the script exists in this directory is to make it simple for the people who maintain Sendmail to build several `.cf` files with one command. This helps the source code maintainers because, as we have seen, the Sendmail configuration files need to be rebuilt every time Sendmail is upgraded to keep the version number of the configuration file compatible with the version number expected by the new Sendmail system. `Build` has four special keyword arguments that construct multiple configuration files with one command:

`generic` The `generic` keyword builds the `.cf` files for the eight generic macro configuration files. These are the only `.cf` files that normally come with the Sendmail distribution.

`berkeley` The `berkeley` keyword builds the 16 different configuration files that were used at Berkeley. Because the Berkeley configurations are just used as examples, the `.cf` files for these configurations are not normally built.

`other` The `other` keyword builds any configurations listed in the `$OTHER` variable of the `Makefile`. In Sendmail 8.11, there is only one configuration listed in this variable and it is not delivered as a `.cf` file.

`all` The `all` keyword builds all of the configurations defined in the `$GENERIC`, `$BERKELEY`, and `$OTHER` variables in the `Makefile`.

If you need to build multiple configurations, it is possible to edit the `Makefile`, changing the `$OTHER` variable so that it contains the names of all of your configurations, and to then use `Build other` to create all of your configurations at one time. It's possible, but unlikely. Most Sendmail administrators do not have enough different configurations to bother with this. We won't mention `Build` again. In the rest of the book, the `m4` command is used directly to build the Sendmail configuration file.

The `cf/cf` directory and possibly the `cf/domain` directory are the only two directories to which you are likely to add configuration files. The four remaining directories are all used to build a configuration, but you use the files that are already there. It is unlikely you will add or change files in those directories.

The *ostype* Directory

Every macro configuration file must contain an `OSTYPE` command to process a macro source file from the `cf/ostype` directory. The files in this directory define operating

system–specific characteristics for the Sendmail configuration. Listing 4.4 shows the contents of the `ostype` directory.

Listing 4.4 The `cf/ostype` Directory

```
[craig]$ ls ostype
aix2.m4          bsdi2.0.m4    irix5.m4      ptx2.m4           sunos4.1.m4
aix3.m4          darwin.m4     irix6.m4      qnx.m4            svr4.m4
aix4.m4          dgux.m4       isc4.1.m4     riscos4.5.m4      ultrix4.m4
altos.m4         domainos.m4   linux.m4      sco-uw-2.1.m4     unixware7.m4
amdahl-uts.m4    dynix3.2.m4   maxion.m4     sco3.2.m4         unknown.m4
aux.m4           gnu.m4        mklinux.m4    sinix.m4          uxpds.m4
bsd4.3.m4        hpux10.m4     nextstep.m4   solaris2.m4
bsd4.4.m4        hpux11.m4     openbsd.m4    solaris2.ml.m4
bsdi.m4          hpux9.m4      osf1.m4       solaris2.pre5.m4
bsdi1.0.m4       irix4.m4      powerux.m4    sunos3.5.m4
```


The directory contains configuration files for more than 40 different operating systems. Solaris, BSD, Linux—they are all here and easily identified by name. In fact, there are many more operating system definitions in the `ostype` directory than there are generic macro configuration files in the `/cf/cf` directory. One thing that I find slightly surprising is that there is no `redhat.6.2.m4` or `slackware.7.0.m4` file. Different Linux distributions are at least as different as AIX 3 is from AIX 4, yet different Linux vendors don't create `OSTYPE` files. But it doesn't matter. You can start with the standard Linux `OSTYPE` and do all of your customization in the macro configuration file you build in the `cf/cf` directory.

The *mailer* Directory

In addition to an `OSTYPE` command, every useable server configuration must have at least one `MAILER` command. `MAILER` commands process source files from the `cf/mailer` directory. Each file in the `mailer` directory contains the definition of a set of mailers. Listing 4.5 shows the mailer definition files delivered with Sendmail 8.11.

Listing 4.5 The Contents of the `cf/mailer` Directory

```
[craig]$ ls mailer
cyrus.m4  local.m4   phquery.m4  procmail.m4  smtp.m4    uucp.m4
fax.m4    mail11.m4  pop.m4      qpage.m4     usenet.m4
```

The directory contains definitions for 11 different sets of mailers, all of which are described in this text. In this chapter, we use only the two most basic sets of mailers: `local.m4` for local mail delivery and `smtp.m4` for SMTP mail delivery.

The *feature* Directory

The `feature` directory contains the `m4` source code files that implement various Sendmail features. Listing 4.6 shows that there are more than 40 features available.

Listing 4.6 The `feature` Directory

```
[craig]$ ls feature
accept_unqualified_senders.m4   no_default_msa.m4
accept_unresolvable_domains.m4  nocanonify.m4
access_db.m4                    nodns.m4
allmasquerade.m4                notsticky.m4
always_add_domain.m4            nouucp.m4
bestmx_is_local.m4              nullclient.m4
bitdomain.m4                    promiscuous_relay.m4
blacklist_recipients.m4         rbl.m4
delay_checks.m4                 redirect.m4
dnsbl.m4                        relay_based_on_MX.m4
domaintable.m4                  relay_entire_domain.m4
generics_entire_domain.m4       relay_hosts_only.m4
genericstable.m4                relay_local_from.m4
ldap_routing.m4                 relay_mail_from.m4
limited_masquerade.m4           smrsh.m4
local_lmtp.m4                   stickyhost.m4
local_procmail.m4               use_ct_file.m4
loose_relay_check.m4            use_cw_file.m4
mailertable.m4                  uucpdomain.m4
masquerade_entire_domain.m4     virtuser_entire_domain.m4
masquerade_envelope.m4          virtusertable.m4
```

Describing these features and how they are used is one of the major tasks of this book.

The *m4* Directory

The last subdirectory in the `cf` directory is the `m4` directory. This is the directory that contains the `m4` macro definitions and the `sendmail.cf` skeleton code needed to build a `sendmail.cf` configuration file. Remember that `m4` is not a language designed to build Sendmail configurations. It is a general-purpose macro language. The commands you use to build a Sendmail configuration are macros defined by the Sendmail developers. This is the directory that contains the definitions of those macro commands. The `cf/m4` directory contains only four files.

```
[craig]$ ls m4
cf.m4  cfhead.m4  proto.m4  version.m4
```

Two of these files are very small. The `version.m4` file just defines one `sendmail.cf` variable—the `Z` variable. The `Z` variable is assigned the Sendmail version number, which in our examples is 8.11.0. Because this value changes with each Sendmail release, it is defined in a separate file for easy maintenance.

> ***NOTE*** The Sendmail version number is not the same thing as the `sendmail.cf` version number. In these examples the Sendmail version number is 8.11.0, but the `sendmail.cf` version number is 9. The fact that both the release number and the configuration file number are called version numbers can be confusing. Furthermore, neither one of these has anything to do with the `VERSIONID` macro, which is just used to store configuration control information to help you to track the changes you make to your `m4` macro configuration file. No wonder system administrators find Sendmail confusing!

The other very small file is `cf.m4`. This is an important file because it is the file specified on the `m4` command line to incorporate the library of Sendmail `m4` macro commands into the `m4` process. The `cf.m4` file does not contain the macro definitions. Instead it includes by reference the file that does contain those macro definitions.

The `m4` macros used to configure Sendmail are defined in the file `cfhead.m4`. This file includes lots of stuff, but the most important is the definition of many of the commands used to build a configuration.

The last file, `proto.m4`, is the largest. It contains raw `sendmail.cf` data exactly as it appears in the `sendmail.cf` file. The `proto.m4` file is the source of most of the content found in the `sendmail.cf` file.

The commands defined in the `cf/m4` directory and how they are used to build a configuration are the topics of the remainder of this chapter. Let's take a look at the `m4` macro language used for Sendmail configuration.

The *m4* Macro Language

The Sendmail program reads its configuration from the `sendmail.cf` file. The `sendmail.cf` file is a few hundred lines long, and every line is written in a terse syntax that is easy for Sendmail to parse but difficult for a human to read and write. As the system administrator, your job is to create the `sendmail.cf` file. Luckily, you do that not with hundreds of lines of arcane code but with a few lines of macro code.

The `sendmail.cf` file is created from a macro configuration (`.mc`) file that usually contains fewer than 20 lines of `m4` commands. The `m4` commands that you will use to build a basic Sendmail configuration are listed in Table 4.1.

Table 4.1 Common `m4` Commands

Command	Usage
`define`	Defines a value for a configuration variable.
`divert`	Directs the output of the `m4` process.
`dnl`	Deletes all characters up to, and including, the next newline character.
`DOMAIN`	Selects a file containing attributes for your specific domain.
`FEATURE`	Identifies an optional Sendmail feature to be included in the configuration.
`MAILER`	Identifies a set of mailers to be included in the `sendmail.cf` file.
`OSTYPE`	Selects a file containing operating system–specific attributes.
`undefine`	Clears the value set for a configuration variable.
`VERSIONID`	Defines version control information for the configuration.

The commands shown in Table 4.1 are the most commonly used `m4` macro commands. All of the commands shown in uppercase are macro commands defined in the `cfhead.m4` file. The commands shown in lowercase are built-in `m4` commands. The subset of commands shown in Table 4.1 is all you need to build a basic configuration. As such, they all deserve a more thorough explanation.

Controlling *m4* Output

The `m4` program is a stream-oriented macro processor. It views the data it handles as a stream of text characters. It collects input data from various files, expands macros embedded in those files, and directs the output stream of characters to another file. Two of the commands in Table 4.1 are used to control the stream of output characters: `divert` and `dnl`.

The `divert` command directs the output stream to different targets. As of Sendmail 8.11, there are 11 different targets for the data stream. The 11 possible divert values are listed in Table 4.2.

Table 4.2 Possible Values for the `divert` Command

Value	Meaning
-1	Discard this output.
0	Send this data through normal processing.
1	Use this data for hostname resolution.
2	Add this data to ruleset 3.
3	Add this data to ruleset 0.
4	Add this data to the UUCP-specific sections of ruleset 0.
5	Use this data to define domain names this server will relay.
6	Add this data to the Local Info section of the `sendmail.cf` file.
7	Save this data as a mailer definition.
8	Use this data to define a spammers blacklist.
9	Add this data to ruleset 1 or 2.

Most of the values that can be specified with `divert` are used only by the Sendmail developers. They are used, in essence, as buffers to hold data for specific parts of the `sendmail.cf` file. The data is collected in these buffers and then moved to the `sendmail.cf` file in the final stage of processing. It is possible to use any of these values in a configuration, but unlikely and unnecessary because commands exist to send data to the correct buffers without resorting to `divert` commands. For any reasonable configuration, the `divert` command is used with only two different settings:

- `divert` is set to -1 to discard the output. Thus `divert(-1)` is found at the start of a block of text that is not to be written to the `sendmail.cf` file. While the block of text could be anything that's not intended for the output file, it is usually the copyright statement that is found at the beginning of many of the sample configuration files. The `divert(-1)` command at the start of the copyright means that the copyright is treated as a large comment.

- `divert` is set to 0 to direct the stream to the output file—e.g., `sendmail.cf`. If the `divert(-1)` command is used at the start of a large comment, `divert(0)` is used at the end of the comment to redirect the stream to the output file.

The `dnl` command is also used to control the output stream. The `dnl` command accepts no arguments. Its two basic functions are determined by its position on the command line:

- If the `dnl` command occurs at the end of a line, after another `m4` command, it is used to clean up unwanted blank lines from the output file. For example, `dnl` on the line `OSTYPE(linux)dnl` ensures that any extraneous output generated after the `linux` `OSTYPE` macro is expanded doesn't get written to the `sendmail.cf` file.
- If the `dnl` command occurs at the beginning of the line, the line is treated as a comment. For example, the line `dnlNext define the domain name` is a comment. If the sample line did not begin with `dnl`, `m4` would interpret "define" and "domain" as `m4` commands. Messy! Always start each comment line with `dnl`, unless it is a large comment bracketed by `divert` commands.

The `divert` and `dnl` commands direct `m4` output but they do not define or generate the output data. The other `m4` commands are used to generate the actual configuration file.

The Basic Commands

In broad terms, there are two types of files used to build an `m4` configuration. One of these is the macro configuration file, which is traditionally identified by the `.mc` file extension. The macro configuration file is the input file for the `m4` command, and its name appears on the `m4` command line. The other files are `m4` source files that are referenced by the macro configuration file. Traditionally, `m4` source files are given the file extension `.m4`. Almost all `m4` macro commands from Table 4.1 can appear in either type of file, although three of the commands are generally found only in the macro configuration file:

`OSTYPE` The `OSTYPE` macro is required, and it is always found in the macro configuration file. The `OSTYPE` macro command loads an `m4` source file that defines operating system–specific information. File and directory paths, mailer pathnames, and system-specific mailer arguments are the kind of information generally found in an `OSTYPE` file. The Sendmail source distribution provides more than 40 predefined operating system macro files, and you can create your own for a specific Linux distribution if you like. (We discuss this option when we evaluate the vendor-supplied macro configuration files in the next chapter.) The only argument passed to the `OSTYPE` command is the name of the `m4` source file that contains the operating system–specific information. Here is the command that processes the `linux.m4` `OSTYPE` source file:

```
OSTYPE(linux)
```

DOMAIN The DOMAIN macro loads a file that contains information specific to your domain or network. The DOMAIN source file is a perfect place for commands that affect hostnames and domain names, and that define values, such as mail relay names, that are specific to your network. Because the information is specific to your domain, you must create your own DOMAIN source file. The Sendmail source code distribution provides a sample DOMAIN source file, named `generic.m4`, that you can use as a starting point for creating your own configuration. Assume you created a DOMAIN source file that you called `foobirds.m4`. The following command, placed in the macro control file, uses `foobirds.m4` to help in building the `sendmail.cf` file:

```
DOMAIN(foobirds)
```

The DOMAIN command is optional. When it is used, it normally appears only in the macro configuration file.

MAILER The MAILER macros identify the various sets of mailer definitions that should be included in the `sendmail.cf` file. A useable configuration must have at least one MAILER command; almost every Linux configuration has the following two:

MAILER(local) The MAILER(local) macro command adds the `local` mailer and the `prog` mailer to the configuration. The `local` and `prog` mailers are essential, so any useable configuration will have at least this MAILER command.

MAILER(smtp) The MAILER(smtp) macro adds mailers for SMTP, Extended SMTP, eight-bit SMTP, directed delivery SMTP, and relayed mail. Every Linux system that sends SMTP mail, whether directly or through a mail server, has this MAILER command.

In addition to these two important sets of mailers, there are nine other sets of mailers available with the MAILER command. Most of them are of very little interest to the average system administrator, but for the sake of completeness they are all covered in Appendix A, "`m4` Macro Command Reference."

OSTYPE, DOMAIN, and MAILER are generally found only in the macro configuration file. The other four commands in Table 4.1 are found in both macro configuration and macro source files:

VERSIONID The VERSIONID macro defines version control information. This macro is optional, but is found in most `m4` files. The command has no required format for the argument. Use any version control information you desire. The basic format of the VERSIONID macro is:

```
VERSIONID(`version-control-data')
```

WARNING A quoted string in the argument field of any `m4` macro must begin with ` and end with '. This is important. If other quotes marks are used, you will have errors in your configuration.

`FEATURE` The `FEATURE` macro identifies an optional Sendmail feature for inclusion in the `sendmail.cf` file. A single `m4` file can contain several `FEATURE` commands. The format of the `FEATURE` macro is:

```
FEATURE(`feature-name'[, `parameter'[, `parameter']...])
```

The *feature-name* identifies the requested feature. There are more than 40 Sendmail features available, all of which are listed in Appendix A. Some of these features can be configured with optional parameters. Many features, and the optional parameters used to configure those features, are used in examples in this book. Next to the `define` command, the `FEATURE` command is the most heavily used command in the `m4` configuration.

`define` The `define` command is used to set the value of a configuration variable for the `sendmail.cf` file. As you'll see in Chapter 7, "The `sendmail.cf` File," this file contains hundreds of variables called macros, classes, and options. The `define` command identifies the variable by name and sets the value for the variable using this format:

```
define(`variable-name', `value')
```

There are hundreds of variable names, most of which you will never use. The important ones are covered in examples in the text. A full list is provided in Appendix A.

`undefine` The `undefine` command is the opposite of the `define` command. It returns the value of a variable to the system default. Thus, the only argument provided to the `undefine` command is the variable name:

```
undefine(`variable-name')
```

At first glance, the `undefine` command may seem odd. Why would you define a variable value only to undefine it? The answer is, you didn't define it in the first place—someone else did. Configurations are built by bringing together several `m4` source files that already exist. An existing file may have several values you want for your configuration, and a few you don't want. The `undefine` command lets you use what you want from the `m4` source file while resetting the values you don't want.

The basic configuration commands appear in an `m4` configuration file in the following order:

- `VERSIONID`, when used, is the first macro in the file.
- `OSTYPE` is defined before the other essential macros.

- DOMAIN, when used, comes next.
- define commands that affect a FEATURE macro that will be specified in the macro configuration file must come before that FEATURE macro.
- FEATURE macros come next.
- define commands that specify variable settings for the configuration, other than those that affect a previously identified FEATURE, come after the FEATURE macros.
- MAILER macros are the last basic commands in the file.

As you'll see later, there are several more commands that can be used in the m4 configuration files. These commands add complexity to the structure, but the basic structure is as described above.

The nine commands covered so far are used to build most configurations. The syntax and the purpose of the commands have been described, but until you see the commands in the context of a configuration file, it is difficult to imagine exactly how they are used.

A Sample Macro Configuration File

The Sendmail distribution comes with a large number of sample macro configuration files. One that is sure to draw the attention of a Linux system administrator is the file generic-linux.mc. Listing 4.7 shows the contents of this file:

Listing 4.7 The generic-linux.mc File

```
divert(-1)
#
# Copyright (c) 1998, 1999 Sendmail, Inc. and its suppliers.
#       All rights reserved.
# Copyright (c) 1983 Eric P. Allman.  All rights reserved.
# Copyright (c) 1988, 1993
#       The Regents of the University of California.  All rights reserved.
#
# By using this file, you agree to the terms and conditions set
# forth in the LICENSE file which can be found at the top level of
# the sendmail distribution.
#
#


#
#  This is a generic configuration file for Linux.
#  It has support for local and SMTP mail only.  If you want to
#  customize it, copy it to a name appropriate for your environment
```

```
#  and do the modifications there.
#

divert(0)dnl
VERSIONID(`$Id: generic-linux.mc,v 8.1 1999/09/24 22:48:05 gshapiro
          Exp $')
OSTYPE(linux)dnl
DOMAIN(generic)dnl
MAILER(local)dnl
MAILER(smtp)dnl
```

The sample file starts with a `divert(-1)` command that discards what follows. Because the following text will not appear in the output file, it is only provided as a comment or informational message. In this case, the discarded text includes a copyright notice and some general information about the file and how it should be used. The block of text ends with a `divert(0)dnl` line that redirects the output to the output file, which in effect turns `m4` processing back on. In the future, when we display the contents of a macro control file we will show only the active commands and ignore the block of text at the start of the file for the sake of clearer and shorter listings. However, you should know that most sample files start with a similar block of text.

An optional `VERSIONID` macro is the first macro command in the `generic-linux.mc` file. The version control information is intended for the people who maintain this sample file. You can safely ignore it. When you create your own configuration files, you should use version control information that is meaningful to you or to the tools you use to maintain the file.

The sample `OSTYPE` command tells `m4` to process the file `../ostype/linux.m4` for operating system attributes. No surprise here. Using Linux operating system attributes is just what you would expect in a file named `generic-linux.mc`. The macro configuration file must have one `OSTYPE` command, and it must occur before most of the other configuration commands in the file.

The `DOMAIN` command in Listing 4.7 processes the file `../domain/generic.m4`. The configuration settings in `generic.m4` are samples of the type of commands you might include in your own `DOMAIN` `m4` source file. The `DOMAIN` command line is included in the `generic-linux.mc` file primarily as an example of how the command is used in a macro configuration file.

The `generic-linux.mc` file ends with two `MAILER` commands. These are the same two `MAILER` commands that were described in the preceding section. Almost all Linux Sendmail configurations have these two lines. If additional mailers, such as the UUCP mailers, are added to the configuration, they are added after these two `MAILER` statements.

Let's follow the advice at the beginning of the `generic-linux.mc` file to build our own simple configuration file.

Building a Simple *m4* Configuration File

The problem we want to solve is very straightforward. We have installed Sendmail 8.11 on the sample system and we want a basic configuration that will work with that release. We aren't concerned yet with building a full-featured Sendmail configuration. We just want to get the system running. Let's start with the `generic-linux.mc` file.

Begin by changing to the `cf/cf` directory and copying the `generic-linux.mc` file to `test.mc`. Make sure the file permission for `test.mc` is 644 so that you can edit the file:

```
[root]# cd /usr/local/src/sendmail-8.11.0/cf/cf
[root]# cp generic-linux.mc test.mc
[root]# chmod 644 test.mc
```

Now edit the file to create the new configuration. Our goal is to create the simplest possible configuration in order to get the system running. To do that, remove the `DOMAIN(generic)` line from the `test.mc` macro configuration file; it is primarily included as an example and has not been customized for our domain. While editing the file, don't forget to update the `VERSIONID` macro to reflect the fact that this is a new configuration file. The following `tail` command shows the macros in the file after the edits:

```
[root]# tail -5 test.mc
divert(0)dnl
VERSIONID(`test.mc, v1.0')
OSTYPE(linux)dnl
MAILER(local)dnl
MAILER(smtp)dnl
```

The new `test.mc` file is even simpler than the `generic-linux.mc` file.

The *m4* Command Line

The new `test.mc` configuration file cannot be used by Sendmail directly. The `test.mc` file is an input file for the `m4` command. The next step in creating the new Sendmail configuration is to process the `test.mc` file through `m4` as shown in Listing 4.8.

Listing 4.8 Running `m4`

```
[root]# m4 ../m4/cf.m4 test.mc > test.cf
```

The example shows the m4 command format used to build a sendmail.cf file. The pathname ../m4/cf.m4 is the path to the m4 source tree required to build a sendmail.cf file. This must be specified on the m4 command line if it is not included in the macro configuration file with an include command. Notice that the pathname is a relative pathname starting with ../. Older versions of m4 actually required a relative pathname. Changing to the cf/cf directory was not just a convenience; it was a necessary part of running m4 with the correct source tree path. This is no longer necessary on Linux systems. The GNU m4 program used with Linux can accept an absolute pathname for this argument, which means that the macro configuration file can be stored anywhere on the system. Red Hat takes advantage of this fact when installing Sendmail via RPM. RPM places a copy of the Red Hat macro configuration file in /etc/mail and includes an absolute pathname to cf.m4 inside the macro configuration file.

The second command-line argument is the name of the new macro configuration file, test.mc. m4 reads the source files ../m4/cf.m4 and test.mc, and it outputs the file test.cf. The file output by the m4 command is in the correct format for a sendmail.cf file.

Testing the Configuration File Compatibility

The test.cf file is in the correct format to become the sendmail.cf file, but before moving it to /etc/mail/sendmail.cf, you should make sure it works. A quick test will tell you, as shown in Listing 4.9.

Listing 4.9 Testing Compatibility

```
[root]# sendmail -v -t -C /etc/sendmail.cf
Warning: .cf file is out of date: sendmail 8.11.0 supports
        version 9, .cf file is version 8
^D
No recipient addresses found in header
[root]# sendmail -v -t -C ./test.cf
^D
No recipient addresses found in header
```

As Listing 4.9 shows, the new test.cf configuration file resolves the compatibility problem that appears when we upgraded Sendmail by compiling new source code. The test doesn't prove anything else, and I won't pretend this simple configuration is the best possible configuration, but it meets the goal we set of getting Sendmail up and running.

Installing the New Configuration

Once you decide to use the new configuration file, move it to the location where Sendmail expects to find its configuration file. The name of the configuration file for Sendmail 8.11

defaults to `/etc/mail/sendmail.cf`. On most Linux systems, the configuration file is `/etc/sendmail.cf`. Put the new file in the appropriate location for your system. In this example, we compiled Sendmail 8.11 from source code with the default setting, so we need to move `test.cf` to `/etc/mail/sendmail.cf`, which we do in Listing 4.10.

Listing 4.10 Putting a New Configuration File in Place

```
[root]# mv /etc/mail/sendmail.cf /etc/mail/sendmail.cf.hold
mv: /etc/mail/sendmail.cf: No such file or directory
[root]# cp test.cf /etc/mail/sendmail.cf
[root]# sendmail -v -t
To: craig@wren.foobirds.org
From: craig
Subject: Test
Please ignore this test.
^D
craig@wren.foobirds.org... Connecting to wren.foobirds.org. via esmtp...
220 wren.foobirds.org ESMTP Sendmail 8.11.0/8.11.0;
    Tue, 29 Aug 2000 20:42:44 -0
400
>>> EHLO ibis.foobirds.org
250-wren.foobirds.org Hello root@almond.nuts.com [172.16.12.1],
    pleased to meet you
>>> MAIL From:<craig@ibis.foobirds.org> SIZE=78
250 2.1.0 <craig@ibis.foobirds.org>... Sender ok
>>> RCPT To:<craig@wren.foobirds.org>
250 2.1.5 <craig@wren.foobirds.org>... Recipient ok
>>> DATA
354 Enter mail, end with "." on a line by itself
>>> .
250 2.0.0 e7U0fRg00818 Message accepted for delivery
craig@wren.foobirds.org... Sent (e7U0fRg00818 Message
      accepted for delivery)
Closing connection to wren.foobirds.org.
>>> QUIT
221 2.0.0 wren.foobirds.org closing connection
```

The first step is to move the current `sendmail.cf` file to a backup file, called `sendmail.cf.hold` in Listing 4.10. In this case, the move is unsuccessful because we just installed Sendmail from source files and there was no `/etc/mail/sendmail.cf` file. Still, I always run `mv` first just to make sure I don't overwrite a file that I later want to recover.

Next, we copy the `test.cf` file to `/etc/mail/sendmail.cf` and run a test to make sure everything is working. This time we don't need to use the `-C` argument with the `sendmail` command because the Sendmail configuration file is in the correct location. Also, this time we run a complete test and actually send a piece of mail. The mail is delivered correctly and is properly formatted.

We have a complete, working Sendmail 8.11 system. Of course, we're not going to leave it at this—we wouldn't have much of a book if we did. In the following chapters we will add to this basic configuration to create a more advanced custom configuration. To create an advanced configuration, we will use additional `m4` configuration commands.

More *m4* Commands

This is a chapter about basic configuration. But as you might imagine, the basic commands covered in this chapter are not the whole story. Several other `m4` commands must be understood just to read all of the sample macro configuration files that come with the Sendmail distribution. Table 4.3 identifies and describes the other commands found in the sample files. The one command listed in lowercase is a built-in `m4` command. All of the other commands, which are listed in uppercase, are macros the Sendmail development team created for Sendmail configuration.

Table 4.3 More `m4` Commands

Command	Purpose
`EXPOSED_USER`	Overrides masquerading for specific users.
`HACK`	Processes a file that contains temporary fixes.
`include`	Incorporates an external `m4` file into this file by reference.
`LOCAL_CONFIG`	Marks the start of a section that contains `sendmail.cf` commands.
`LOCAL_RULE_`*n*	Marks the start of a section that contains rewrite rules. The *n*, which must be 0, 1, 2, or 3, identifies the ruleset that the rewrite rules are added to.
`LOCAL_RULESETS`	Marks the start of a ruleset to be added to the configuration.
`MASQUERADE_AS`	Defines a domain name that is used to rewrite the host part of sender addresses.

Table 4.3 More m4 Commands *(continued)*

Command	Purpose
MODIFY_MAILER_FLAGS	Defines mailer flags used to override the current mailer flag settings.
SITE	Identifies the names of UUCP sites connected to the server.
SITECONFIG	Points to the file that contains the SITE commands for the UUCP mail server.
UUCPSMTP	Maps a UUCP hostname to an Internet hostname.

The first and most important thing to realize about the commands in Table 4.3 is that there are some you will never use. Just because a command shows up in a sample file, it doesn't mean that it is the correct command for you or even a recommended command. Some of the sample files that come with Sendmail are very old. Some of the commands used in these files are obsolete and can be ignored. The last three commands in Table 4.3 are good examples. SITE, SITECONFIG, and UUCPSMTP are obsolete techniques for configuring the system to handle UUCP mail. These functions have been replaced by the databases described in Chapter 6.

Another command you can safely ignore is HACK. As the name implies, it is intended to process a file that contains a hack to fix a mail problem. All normal mail problems can be addressed through the normal configuration. A hack is supposed to be something temporary, a fix that needs to be addressed in the configuration but that you know will not be required in the near future. The idea is that the fix can be put in a separate file in the cf/hack directory and then discarded when no longer needed. The problem with hacks is that they tend to develop a life of their own. The duration of a problem is rarely known. A hack that seems temporary soon becomes permanent. Generally it is better to permanently fix all problems in the "regular" configuration instead of creating a hack. A "permanent" fix can be removed as easily as a hack when it is no longer needed.

Use the include command to simplify the m4 command line. In Listing 4.8, the m4 command line begins with the argument ../m4/cf.m4 to ensure that the macro definitions and header files in the cf/m4 directory are available to the m4 process. This argument must be added to the command line every time m4 is run. It is possible to include the cf.m4 file inside the macro configuration file so that it doesn't have to be specified on the command line. If the following line is added to the beginning of the test.mc file:

```
include '../usr/local/src/sendmail-8.11.0/cf/m4/cf.m4'
```

the `test.mc` file can be processed with the following `m4` command:

```
[root]# m4 test.mc > test2.cf
```

Readers who use `include` commands in other languages generally think the `include` command can be used to separate a complex configuration into several files and then bring those files together for processing. While that is true for `m4` in general, it is not true for Sendmail configuration. All macro configuration files are short files that do not benefit from being segmented. The only time you'll see `include` used in the files provided with the Sendmail distribution is when `cf.m4` itself includes the large and complex `cfhead.m4` file. And the only time you will use `include` is when you want to include the `cf.m4` file into your macro configuration file to simplify the `m4` command line.

The `LOCAL_CONFIG`, `LOCAL_RULESET`, and `LOCAL_RULE_`*n* commands allow you to put raw `sendmail.cf` configuration commands directly in the `m4` source file. These commands, and other related commands, mean that everything that can be done in the `sendmail.cf` file can be done in the `m4` macro source files. (`sendmail.cf` configuration commands are discussed in Chapter 7.) We use the `LOCAL_CONFIG`, `LOCAL_RULESET`, and `LOCAL_RULE_`*n* commands several times in this text to define complex `sendmail.cf` configurations.

The `MODIFY_MAILER_FLAGS` command is used to override the flags set for a mailer. Mailer flags are described in Chapter 7, "The `sendmail.cf` File," and a listing of all of the mailer flags is found in Appendix C, "Sendmail Variables, Options, and Flags." The `MODIFY_MAILER_FLAGS` command has two arguments: the name of the mailer and the flag to be modified. The flag is preceded by a + if it is to be added to the existing set of flags or by a - if an existing flag is to be removed.

The `MASQUERADE_AS` and `EXPOSED_USER` commands both deal with masquerading. Frequently, an organization wants all of its outbound mail to appear as if it came from one source. This is done to create clean and consistent e-mail addresses, and to hide the names of internal systems that should not be directly receiving mail. *Masquerading* is the name for this type of mail rewriting. `MASQUERADE_AS` defines the hostname that is used as the hostname part for all outbound mail. If `MASQUERADE_AS('foobirds.org')` is set in the configuration, mail from `craig@wren.foobirds.org` goes out as mail from `craig@foobirds.org`.

`EXPOSED_USER` addresses a problem created by masquerading. Assume that mail from `root@wren.foobirds.org` and `root@ibis.foobirds.org` is passed through the server with the `MASQUERADE_AS('foobirds.org')` setting. If both addresses are rewritten to `root@foobirds.org`, you have a problem. There is no way for the recipient to know exactly where the message really originated, and the remote user could not reply to the correct address. Usernames, like root, that are found on every system should not be

masqueraded. The EXPOSED_USER command is used to define the usernames that should not be masqueraded.

Masquerading is covered extensively in Chapter 9, "Special m4 Configurations." There are several more m4 commands that relate to masquerading, all of which will be covered in that chapter.

The commands in Table 4.1 and Table 4.3 are just the tip of the m4 iceberg. Many more commands are covered in Part 2 of the text as examples of advanced configurations, and all of the m4 commands are covered in Appendix A. This chapter does not provide exhaustive coverage of the m4 language. It is an introduction to m4 that helps you understand the m4 commands contained in the sample files. Understanding these basic commands should help you read the macro configuration file provided by your vendor, which is a topic we tackle in Chapter 5, "Understanding a Vendor's Configuration."

In Sum

Sendmail reads its configuration from the sendmail.cf file. However, this file is not directly configured by the Sendmail administrator. Instead the file is constructed indirectly from m4 macros.

The Sendmail distribution provides the m4 source files necessary to build a Sendmail configuration. The m4 source files are contained in the nine subdirectories of the cf directory. For most configurations, eight of the nine subdirectories can be ignored because they are either unused or they contain source files that are never modified by the system administrator. The only subdirectory that the administrator needs to work with for most configurations is the cf/cf directory.

The cf/cf directory contains the macro configuration files. The Sendmail administrator creates a macro configuration file that selects the source files that provide the features necessary for the Sendmail configuration. Most macro configuration files are not built from scratch. The Sendmail distribution provides about 20 different sample macro configuration files. You select a macro configuration file that matches your needs and only make small adjustments if they are necessary.

The macro configuration file is then processed through m4 to produce the sendmail.cf file. But even this step may not be necessary if you don't need to change the sample macro configuration file for your configuration. Several Sendmail configuration files built from sample macro configuration files are included in the cf/cf directory.

To select and modify the correct macro configuration file, you must have a basic understanding of the m4 Sendmail macro configuration language. Use the tables in this chapter and the list of configuration commands in Appendix A to help you read and modify the

macro configuration file. Don't bother memorizing the details of the Sendmail configuration language; you won't build new configurations often enough to make that skill worthwhile. Instead, learn the basic commands in Table 4.1 and look up the details in a reference like Appendix A.

A configuration can be built by starting with a sample file and modifying it for your configuration, as was done in this chapter. But an even more common way to configure Sendmail is to use the macro configuration file provided with your Linux distribution. In the next chapter, we examine the default mail server configuration that comes with Red Hat Linux.

5

Understanding a Vendor's Configuration

Legend has it that Sendmail configuration is one of the most difficult tasks a system administrator will ever face. Like most legends, this one is only partly true. For the vast majority of Linux systems, the administrator's role in Sendmail configuration is so simple it is almost trivial. The reason is plain: Someone else has already done the difficult parts of the configuration for you. In the Linux world, that someone is the vendor who created your Linux distribution.

Of course, this is a book for professional system administrators. If you're reading this book, you don't need help mastering a trivial task. So in this chapter we analyze the configuration that the vendor provides you. We look in detail at a basic configuration that comes with the Sendmail source code distribution and at the configuration included in the RPM for the Red Hat Linux distribution. We look at the decisions made by the developers of these configurations and at the effect that those decisions have on the systems we manage. We will use the insight we gain here to enhance our own custom configuration. Let's begin by looking at the problems we have had with the source code installation and at the `generic-linux.m4` configuration that comes with the Sendmail distribution.

The Generic Linux Configuration

The challenge in Chapter 4, "Creating a Basic Sendmail Configuration," was to find or create a `sendmail.cf` file that is compatible with Sendmail 8.11. Because the Sendmail 8.11 distribution comes with a file named `generic-linux.cf` that is already in the proper format to be used as a `sendmail.cf` file, the first thing we tried was to use the `generic-linux.cf` file without modification. The result was this error:

```
[root]# sendmail -v -t -C./generic-linux.cf
./generic-linux.cf: line 66: fileclass:
      cannot open '/etc/mail/local-host-names'
: No such file or directory
```

The `generic.linux.mc` file that created the `generic-linux.cf` file has only five significant command lines:

Listing 5.1 The Commands Contained in `generic-linux.mc`

```
[craig]$ tail -5 generic-linux.mc
VERSIONID(`$Id: generic-linux.mc,v 8.1 1999/09/24 22:48:05 gshapiro Exp $')
OSTYPE(linux)dnl
DOMAIN(generic)dnl
MAILER(local)dnl
MAILER(smtp)dnl
```

We know that the `VERSIONID` macro has no effect other than holding user-defined version control information. We also know that the `OSTYPE` macro and the two `MAILER` macros are required for a functioning system. This leads us to guess that removing the optional `DOMAIN` macro is the best place to start attacking the problem. Therefore, in Chapter 4 we created a simple `m4` macro configuration file that did not contain the `DOMAIN` macro and used it to produce a `sendmail.cf` file compatible with Sendmail 8.11. It worked, and we got Sendmail up and running.

Sometimes a quick solution based on an educated guess is all that you have time for. But when you get some free time you are drawn back to the problem to find out why that guess worked and to figure out if there is a better long-term solution to the problem. We need to know more about the macro source files called by the `generic-linux.mc` file in order to:

- find out why the simple change worked for our problem
- see if there is a better way to solve our problem
- find out what features were lost by our quick and dirty solution
- learn more about configuring Sendmail

The first source file called by the generic-linux.mc file is, predictably enough, the linux.m4 OSTYPE file. The contents of the linux.m4 file must be analyzed to fully understand the generic Linux Sendmail configuration.

The Linux *OSTYPE* File

The OSTYPE file contains operating system–specific configuration values. The biggest configuration variation between the different operating systems that run Sendmail is the location of files. Variables that define pathnames are commonly stored in the OSTYPE file. Since this file is specific to the Linux operating system and this book is about running Sendmail on Linux, let's take a close look at the Linux OSTYPE file.

The command OSTYPE(linux) loads a file named linux.m4 from the ostype directory. Listing 5.2 shows the contents of this OSTYPE file:

Listing 5.2 The linux.m4 OSTYPE File

```
[craig]$ cat ../ostype/linux.m4
divert(-1)
#
# Copyright (c) 1998, 1999 Sendmail, Inc. and its suppliers.
#       All rights reserved.
# Copyright (c) 1983 Eric P. Allman.  All rights reserved.
# Copyright (c) 1988, 1993
#       The Regents of the University of California.  All rights reserved.
#
# By using this file, you agree to the terms and conditions set
# forth in the LICENSE file which can be found at the top level of
# the sendmail distribution.
#
#

divert(0)
VERSIONID(`$Id: linux.m4,v 8.11.16.1 2000/05/09 18:48:58 gshapiro
          Exp $')
define(`confEBINDIR', `/usr/sbin')
ifdef(`PROCMAIL_MAILER_PATH',,
        define(`PROCMAIL_MAILER_PATH', `/usr/bin/procmail'))
FEATURE(local_procmail)
```

The file begins with a copyright notice. The copyright notice is bracketed by a divert(-1) statement and a divert(0) statement, so it is treated as a comment and can be safely ignored. The VERSIONID macro can also be ignored.

> ***NOTE*** In the rest of this chapter, to reduce the size of the listings, the copyright statements that start the files are not printed, but you should be aware that they are there.

The first real configuration command in the file is a `define` statement that assigns a value to the `confEBINDIR` parameter. This parameter stores the path of the directory that holds certain executable binary files. The Sendmail 8.11 default for `confEBINDIR` is `/usr/libexec`. This `define` changes the setting to `/usr/sbin`. Both of these directories exist on Linux systems, but the `/usr/sbin` directory is the one that is more commonly used to hold system binary files, and in this case it is the correct setting. The `confEBINDIR` path is used to locate the `smrsh` mailer, which is frequently used as the `prog` mailer on Linux systems. (The `prog` mailer, which is used to send mail files to programs, uses an unrestricted shell by default. Chapter 12, "Sendmail Security," describes the advantages of using the `smrsh` mailer.) A couple of quick `ls` commands on our sample Linux system show that the correct value for `confEBINDIR` is `/usr/sbin`:

```
[craig]$ ls /usr/libexec/smrsh
ls: /usr/libexec/smrsh: No such file or directory
[craig]$ ls /usr/sbin/smrsh
/usr/sbin/smrsh
```

The second configuration command is also a `define`. This one is a little more complex. This `define` is contained inside an `ifdef`. The `ifdef` has nothing to do with configuring Sendmail. It is a built-in `m4` conditional command that checks whether or not a variable has already been set to a value. The `ifdef` command has three fields:

- the name of the variable that is being tested
- the action to take if the variable has been set
- the action to take if the variable has not been set

In Listing 5.2, the `ifdef` tests the variable `PROCMAIL_MAILER_PATH`. If the variable has already been defined, nothing is done. We know this by the fact that the second field of the `ifdef` is empty—notice the two commas right in a row (`,,`). If the variable has not yet been set, the `define` contained in the third field of the `ifdef` is executed. This is exactly what happens on our sample system, because we did not assign any value to `PROCMAIL_MAILER_PATH` in the macro configuration file.

The `define` assigns the variable `PROCMAIL_MAILER_PATH` the path value `/usr/bin/procmail`. This overrides the Sendmail default for `PROCMAIL_MAILER_PATH`, which is

/usr/local/bin/procmail. A quick ls shows that the new value is correct for our sample system:

```
[craig]$ ls -l /usr/bin/procmail
-rwxr-xr-x   1 root   root     68276 Aug 10  1999 /usr/bin/procmail
```

Don't *ifdef*

I have a philosophical objection to having an ifdef inside the OSTYPE file. I understand why it had to be done: it was done to create an OSTYPE file that would work for all versions of Linux. However, that is my basic objection. If different Linux distributions require different OSTYPE settings, the developers of those distributions should create an OSTYPE file for their distribution that contains the correct setting. After all, that is what the OSTYPE file is for. There is no reason why there shouldn't be an ostype/redhat.m4 file, and an ostype/suse.m4 file, and an ostype/slackware.m4 file, and a file for any other distribution you can imagine. You'd think that distribution developers would want to put their names in the ostype directory, but the fact is that not a single Linux distribution developer has added an OSTYPE file to the ostype directory of the Sendmail source code distribution.

As Listing 5.2 shows, the last line in linux.m4 is a FEATURE macro. The feature that this macro adds to the configuration is local_procmail, which specifies that procmail will be used as the local mailer. As you'll see in Chapter 11, "Stopping Spam," procmail is a very powerful mailer. The fact that Linux uses procmail as the local mailer is a plus. The local_procmail feature accepts up to three optional arguments:

- The path to the mailer. This defaults to the path value assigned to PROCMAIL_MAILER_PATH, which in Listing 5.2 is /usr/bin/procmail. The same effect could have been obtained with the following FEATURE command:

  ```
  FEATURE(`local_procmail', `/usr/bin/procmail')
  ```

- The command line for executing the mailer. The default is procmail -Y -a $h -d $u, where $h is replaced by the *detail* value if the *user*+*detail* addressing syntax is used, and $u is replaced by the username from the recipient address. $h and $u are the Sendmail variables that hold the remote hostname and the remote user's address in a standard delivery triple. In this case, however, procmail is being used as a local mailer, so there is no remote hostname and the $h variable is used to hold the *detail* value. (See Appendix C, "Sendmail Variables, Options, and Flags," for a full listing of the Sendmail variables.)
- The flags for this mailer. The default is SPfhn9. (See Appendix C, "Sendmail Variables, Options, and Flags," for a full listing of mailer flags.)

> ***NOTE*** With the local_procmail feature, procmail is being used as the local mailer. The command-line arguments and the mailer flags affected are those set by LOCAL_MAILER_FLAGS and LOCAL_MAILER_ARGS, not those set by PROCMAIL_MAILER_FLAGS and PROCMAIL_MAILER_ARGS, which are used by the MAILER (procmail) command—this despite the fact that local_procmail uses the path from PROCMAIL_MAILER_PATH instead of the path from LOCAL_MAILER_PATH. Oh well, no one said Sendmail was easy to understand.

The linux.m4 OSTYPE file defines the directory path for the smrsh program, the path for procmail, and a feature that uses procmail as the local mailer. Clearly, the OSTYPE file is a good place to look for file pathnames and mailer options. None of the settings in linux.m4 relate to the problem we saw when we tried to use the generic-linux.cf file on our sample system, but everything in the linux.m4 file is worth understanding because all of these settings affect the configuration of a Linux system.

The second m4 source file loaded by generic-linux.mc, as shown in Listing 5.1, is the generic.m4 file from the domain directory. Let's look at that file in detail.

The Generic *DOMAIN* File

The DOMAIN command is optional. It loads the m4 source file that you create to configure values specific to your domain or network. You don't have to create a DOMAIN source file, but it is highly recommended that you do if you have any domain-specific processing.

Host and username processing, domain name masquerading, mail relaying, and anti-spam features are the types of information normally found in a DOMAIN source file. Listing 5.3 shows the generic.m4 DOMAIN file used by the generic-linux.mc macro configuration file.

Listing 5.3 The Configuration Commands in domain/generic.m4

```
[craig]$ tail -6 generic.m4
VERSIONID(`$Id: generic.m4,v 8.15 1999/04/04 00:51:09 ca Exp $')
define(`confFORWARD_PATH', `$z/.forward.$w+$h:$z/.forward+$h:$z/
.forward.$w:$z/.
forward')dnl
define(`confMAX_HEADERS_LENGTH', `32768')dnl
FEATURE(`redirect')dnl
FEATURE(`use_cw_file')dnl
EXPOSED_USER(`root')
```

The generic.m4 file contains six m4 commands after the copyright notice. The first is a VERSIONID macro that can be ignored. The first significant command is a define command.

Defining the *.forward* Path

The first define command assigns a value to the confFORWARD_PATH variable. This variable holds a colon-separated list of the paths that Sendmail searches when looking for a .forward file. (Chapter 2, "Understanding E-Mail Architecture," explains the purpose of the .forward file.)

The default value of confFORWARD_PATH is $z/.forward.$w:$z/.forward, where $z is the recipient's home directory and $w is a valid name for this host. (See Appendix C for a full list of the Sendmail variables, including $z and $w.) Thus if the recipient's home directory is /home/jill and the hostname is gull, the path list is interpreted as /home/jill/.forward.gull:/home/jill/.forward.

The first define in Listing 5.3 increases the complexity of the .forward path list. It retains the two paths from the default search list and inserts in front of them the value $z/.forward.$w+$h:$z/.forward+$h. The $z and $w variables serve the same purpose as before. The $h variable contains the *detail* value when the *user+detail* addressing syntax is used and procmail is used as the local mailer. We know that procmail is being used as the local mailer because we saw the local_procmail feature in the linux.m4 OSTYPE file. Given this specific configuration, local mail on a host named egret addressed to craig+sybex would prepend the following .forward search path to the standard path: /home/craig/.forward.egret+sybex:/home/craig/.forward+sybex.

The *+detail* Syntax

The +*detail* syntax is an adaptation of the mailbox syntax used in the Cyrus mailers. The Cyrus mailers allow mail to be addressed to a specific mailbox. In a Cyrus address, the *detail* is a mailbox name. Thus mail addressed to rebecca+inbox is placed in a mailbox named inbox owned by the user rebecca.

The problem with this is that neither Sendmail nor Linux uses a mailbox architecture. Sendmail writes mail to a single spool file for each user, and Linux user mail agents read mail from a single spool file for each user. Thus, mail bound for user rebecca is written to and read from the file /var/spool/mail/rebecca. Mailboxes exist on Linux systems, but they exist because the user mail agent reads the mail from the single spool file and then routes it to different mailboxes based on some filtering rules defined inside the user mail agent.

> The +*detail* syntax is rarely used in the addresses entered by users. It requires an odd form of addressing that most users don't like, and it solves a problem that user mail agents have already solved to the satisfaction of most users. If used at all, the +*detail* syntax is used internally to `sendmail` or `procmail` in the same way the pseudo-domains are used to help the mail programs route the mail. (Not sure what a pseudo-domain is? Don't worry—you'll see one in a second.)

Defining the `confFORWARD_PATH` variable seems more like a command that should happen in the `OSTYPE` source file than in the `DOMAIN` source file. It defines a file path, which is something that commonly happens in the `OSTYPE` file, and this specific path is directly related to using `procmail` as the local mailer, which is also defined in the `OSTYPE` file. This just goes to show you that you really cannot tell where something will be defined in a Sendmail configuration. The only way to know the complete configuration is to look at all of the files.

The definition of the `.forward` search path is the most complex `define` in the `generic.m4` file. The second `define` is much easier to understand. It sets the maximum number of bytes allowed for all headers. By default no limit is set. In the `generic.m4` file shown in Listing 5.3, the maximum length is set to 32,768 bytes (32KB). That is more than enough for any reasonable set of headers. Headers longer than that might indicate a mail problem or some form of mail abuse. So perhaps this limit is being set to detect mail problems or abuse. But most likely this value is being set in the `generic.m4` file to provide another example of `define` command syntax.

The two `define` commands that open the `generic.m4` `DOMAIN` file are followed by two `FEATURE` commands that add optional capabilities to the Sendmail configuration.

Adding Support for the *.REDIRECT* Pseudo-Domain

The `FEATURE(redirect)` macro adds support for the `.REDIRECT` pseudo-domain. A pseudo-domain is a domain-style extension added to an e-mail address by Sendmail to define special handling for the address. The `.REDIRECT` pseudo-domain works together with the `aliases` database to handle mail for people who no longer read mail at your site but who still get mail sent to an old address.

After enabling this feature, add aliases for each obsolete mailing address in the form:

```
old-address         new-address.REDIRECT
```

For example, assume that Jay Henson is no longer a valid e-mail user in your domain. His old username, `jay`, should no longer accept mail. His new mailing address is `HensonJ@industry.com`. Enter the following alias in the `/etc/aliases` file:

```
jay                 HensonJ@industry.com.REDIRECT
```

Now when mail is addressed to the `jay` account, the following error is returned to the sender telling them to try a new address for the recipient:

```
551 User not local; please try <HensonJ@industry.com>
```

This is a useful feature for any site that is small enough, or organized enough, to keep track of the e-mail address of employees who have moved on to new jobs. It is a courtesy to the ex-employee and, better yet, it cuts down on the number of requests the postmaster receives asking for the ex-employee's new e-mail address.

The second `FEATURE` command also specifies a useful feature.

Adding Support for Local Host Aliases

The `FEATURE(use_cw_file)` command loads the class `w` variable from a file. The name of the file is defined with the `confCW_FILE` variable. Unless modified with the `confCW_FILE` variable, the default file used to load class `w` is `/etc/mail/local-host-names`.

Class `w` holds a list of valid hostnames for which the local computer will accept mail. Normally, if a system running Sendmail receives mail addressed to another hostname, it assumes the mail belongs to that host and forwards the mail to that host if the local host is configured as a relay, or discards the mail if it is not configured as a relay. If your system should accept mail that is addressed to another host, the name of the other host should be added to class `w`. Class `w` contains a list of acceptable hostnames even if neither the `use_cw_feature` nor the `local-host-names` file is used. Anything you put in the `local-host-names` file is added to those names when the `use_cw_file` feature is used. Listing 5.4 shows the default contents of class `w` on a computer named `ibis.foobirds.org`.

Listing 5.4 Examining Class `w`

```
[root]# sendmail -bt
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> $=w
[172.16.12.1]
ibis.foobirds.org
ibis
localhost
[127.0.0.1]
> ^D
```

Chapter 10, "Testing Sendmail," describes Sendmail test mode in detail. For now, it is sufficient to understand that the `-bt` option puts Sendmail into test mode and that you can ask Sendmail to display the contents of a variable when it is running in test mode. In this case, we ask for the contents of the class `w` variable (`$=w`). `ibis` is not configured with the `use_cw_file` feature. The contents of the class `w` variable on `ibis` are the default values set by the system. By default, class `w` includes the IP address of the local system and the local computer's full domain name and unqualified domain name. It also includes the special name `localhost` and the special address, 127.0.0.1, that is assigned to that name.

The default values are adequate for most Sendmail systems. Most systems that run Sendmail do so to provide mail for the users that log onto that system. Only a subset of the systems running Sendmail are configured to provide mail services for other computers. If you run Sendmail on a desktop system, you probably don't need the `use_cw_file` feature, but when you run Sendmail as a server for a group of computers, you will probably use this feature.

The primary use for the `local-host-names` file is to hold the names of computers that use the local system as their MX server. This means that the MX server needs to know the names of the systems for which it is providing mail exchange services. You can't just pick a remote system as an MX server. Prior agreement between the server administrator and the client administrator is needed to ensure that mail won't be rejected by the server.

Eureka!

`FEATURE(use_cw_file)` is clearly the cause of the problem we had using the `generic-linux.cf` configuration file. The error message "cannot open '/etc/mail/local-host-names': No such file or directory" makes this crystal clear. Recall that one of the first problems we encountered with the Sendmail 8.11 upgrade was that the `sendmail.cf` file was in the wrong directory. The Linux sample system kept the Sendmail configuration files in the `/etc` directory and 8.11 wants those files in `/etc/mail`. Considering the fact that Sendmail 8.11 introduced the `/etc/mail` directory, the problem could simply be that the `local-host-names` file is located in the wrong directory. But it goes beyond that. A quick check of the `/etc` directory shows that there is no file named `local-host-names`:

```
[craig]$ ls /etc/local-host-names
ls: /etc/local-host-names: No such file or directory
```

Prior to Sendmail 8.11, the file that added hostnames to class w was called sendmail.cw. As shown below, copying the /etc/sendmail.cw file that already existed on the sample system to /etc/mail/local-host-names solves the problem created by the Sendmail 8.11 upgrade:

```
[root]# sendmail -v -t -Cgeneric-linux.cf

generic-linux.cf: line 66: fileclass: cannot open '/etc/mail/
local-host-names':

No such file or directory

[root]# cp /etc/sendmail.cw /etc/mail/local-host-names

[root]# sendmail -v -t -Cgeneric-linux.cf

To: craig@wren.foobirds.org

From: root

Subject: Discard this test

^D
```

This simple problem is the kind of thing that drives experienced system administrators crazy. The filename local-host-names may be more logical than the name sendmail.cw, but since when did logic have anything to do with Sendmail configuration! Once you have learned that class w values are stored in sendmail.cw, you don't really want to learn that they are now stored in local-host-names. It would be much simpler if things just stayed the same. But things are always changing and you need to be prepared for it.

All I can do is recommend that you carefully read the release notes that come with every new Sendmail source code distribution. Even when you do, things will escape your attention and problems will appear. However, applying the knowledge this book gives you about Sendmail should make it much easier for you to handle these problems.

Protecting the *root* Account from Masquerading

Masquerading, which is covered in Chapter 9, "Special m4 Configurations," hides the real hostname in outbound mail and replaces it with the hostname you wish to advertise to the outside world. The name that replaces the real hostname is usually the name of the mail server, or the domain name if a single server handles mail for an entire domain. Refer

back to Listing 5.3. The last line in the `generic.m4` file is the `EXPOSED_USER` macro. The `EXPOSED_USER` macro adds usernames to class `E`. The users listed in class `E` are not masqueraded, even when masquerading is enabled.

Some usernames, such as root, occur on many systems and are therefore not unique across a domain. For those usernames, converting the host portion of the address makes it difficult to sort out where the message really came from and makes replies impossible. For example, assume that mail from `root@wren.foobirds.org` and `root@ibis.foobirds.org` is passed through a server that converts both addresses to `root@foobirds.org`. There is no way for the recipient to know exactly where the message really originated, and the remote user could not reply to the correct address. The `EXPOSED_USER` command in Listing 5.3 prevents that from happening by ensuring that root is not masqueraded.

The primary reason this macro is included in the `generic.m4` `DOMAIN` source file is to serve as a warning to the experienced Sendmail administrator that something has changed. Experienced Sendmail administrators may think that root is already part of class `E`, because prior to Sendmail 8.10 root was the default value for class `E`. In Sendmail 8.11, there are no default values in class `E`. The `EXPOSED_USER(root)` command must be added to the configuration if you want to protect root from masquerading. Of course, this command has no real effect in the generic configuration because this configuration does not include any commands to enable masquerading. But the message is clear. If you want to protect the root user from masquerading, include the `EXPOSED_USER` command in your configuration.

This command illustrates the main purpose of the `generic.m4` file—it is intended as a training tool. The file is designed to show you the type of commands you should include in your own `DOMAIN` source file. The `generic.m4` file is really just an example. The `DOMAIN` source file should be specific to your environment. If you use one, you're expected to create it yourself.

This concludes the `DOMAIN` file, but it does not conclude the `generic-linux.mc` macro control file shown in Listing 5.1. There are still two more macros in that file left to explain. The last two source files invoked by the `generic-linux.mc` macro configuration file are `MAILER` source files. As the "Eureka!" sidebar explains, we know those files didn't cause the problem we had using the `generic-linux.cf` file, but because they are an essential part of every Linux configuration, let's take a look at what they do.

The Essential Mailers

The two `MAILER` commands in the `generic-linux.mc` file are found in most Sendmail configurations. These commands identify the sets of mailers included in the Sendmail configuration.

The `MAILER(local)` macro includes the `local` mailer that is used to deliver local mail between users of the system and the `prog` mailer that is used to send mail files to programs running on the system. Even though these mailers will be added by default, the `MAILER(local)` macro is traditionally included in the configuration. In part this tradition arises from the fact that most configurations are built from a sample configuration file, and all of the generic macro configuration files include the `MAILER(local)` macro. It takes more effort to remove the macro than it does to leave it in, and it costs nothing to leave it in the configuration. In fact, it provides the slight benefit of making the configuration more "self-documenting."

The `MAILER(smtp)` macro includes all of the mailers needed to send SMTP mail over a TCP/IP network. The mailers included in this set are:

`smtp` This mailer can handle only traditional seven-bit ASCII SMTP mail. It is outmoded because most modern mail networks handle a variety of data types.

`esmtp` This mailer supports Extended SMTP (ESMTP). It understands the ESMTP protocol extensions and it can deal with the complex message bodies and enhanced data types of MIME mail. This is the default mailer used for SMTP mail.

`smtp8` This mailer sends eight-bit data to the remote server, even if the remote server does not indicate that it can support eight-bit data. Normally, a server that supports eight-bit data also supports ESMTP and thus can advertise its support for eight-bit data in the response to the EHLO command. (See Chapter 1, "Internet Mail Protocols," for a description of the SMTP protocol and the EHLO command.) It is possible, however, to have a connection to a remote server that can support eight-bit data but does not support ESMTP. In that rare circumstance, this mailer is available for use.

`dsmtp` This mailer allows the destination system to retrieve mail queued on the server. Normally, the source system sends mail to the destination in what might be called a "push" model, where the source pushes mail out to the destination. On demand SMTP allows the destination to "pull" mail down from the mail server when it is ready to receive the mail. This mailer implements the ETRN command that permits on-demand delivery. (See Chapter 1 for a description of the ETRN protocol command.)

`relay` This mailer is used when SMTP mail must be relayed through another mail server. Several different mail relay hosts can be defined.

Every server that is connected to or communicates with the Internet uses the `MAILER(smtp)` set of mailers, and most systems on isolated networks use these mailers because they use TCP/IP on their enterprise network. Despite the fact that the vast majority of Sendmail systems require these mailers, installing them is not the default. To support SMTP mail, you must add the `MAILER(smtp)` macro to your configuration.

In addition to these two important sets of mailers, there are nine other sets of mailers available with the `MAILER` command, all of which are covered in Appendix A, "`m4` Macro Command Reference." Most of them are of very little interest for an average Linux configuration. The two sets of mailers included in the `generic-linux.mc` configuration are the only ones that most administrators ever use.

Tweaking the Mailer Configurations

Let's diverge for a moment from the discussion of the `generic-linux.mc` configuration file to talk about mailer configuration. You're strongly encouraged to create your own `DOMAIN` source file in the `domain` directory. You might even be bold enough to create an `OSTYPE` file for your Linux distribution in the `ostype` directory. But `MAILER` source files are different. The mailers loaded by the `MAILER` macros are defined in the `mailer` directory. You will never directly edit a file in that directory or add your own files to that directory. To modify the settings of a specific mailer, use the configuration variables created for this purpose. Table 5.1 lists the variables used to tune the `local` and `prog` mailers and all of the mailers included in the set of SMTP mailers.

Table 5.1 Mailer Configuration Variables

Variable	Purpose
`DSMTP_MAILER_ARGS`	`dsmtp` mailer arguments.
`ESMTP_MAILER_ARGS`	`esmtp` mailer arguments.
`LOCAL_MAILER_ARGS`	Arguments for local mail delivery.
`LOCAL_MAILER_CHARSET`	Character set for local 8-bit MIME mail.
`LOCAL_MAILER_DSN_DIAGNOSTIC_CODE`	Delivery status notification code used for local mail.
`LOCAL_MAILER_EOL`	End-of-line character for local mail.
`LOCAL_MAILER_FLAGS`	Local mailer flags added to "`lsDFMAw5:/|@q`".
`LOCAL_MAILER_MAX`	Maximum size of local mail.
`LOCAL_MAILER_MAXMSG`	Maximum number of messages delivered with a single connection.

Table 5.1 Mailer Configuration Variables *(continued)*

Variable	Purpose
LOCAL_MAILER_PATH	Local mail delivery program.
LOCAL_SHELL_ARGS	Arguments for prog mail.
LOCAL_SHELL_DIR	Directory in which the shell should run.
LOCAL_SHELL_FLAGS	Flags added to lsDFM for the shell mailer.
LOCAL_SHELL_PATH	Shell used to deliver piped e-mail.
RELAY_MAILER_ARGS	Relay mailer arguments.
RELAY_MAILER_FLAGS	Flags added to "mDFMuX" for the relay mailer.
RELAY_MAIL_MAXMSG	Maximum number of messages for the relay mailer delivered by a single connection.
SMTP8_MAILER_ARGS	smtp8 mailer arguments.
SMTP_MAILER_ARGS	smtp mailer arguments.
SMTP_MAILER_CHARSET	Character set for SMTP 8-bit MIME mail.
SMTP_MAILER_FLAGS	Flags added to "mDFMuX" for all SMTP mailers.
SMTP_MAILER_MAX	Maximum size of messages for all SMTP mailers.
SMTP_MAIL_MAXMSG	Maximum number of SMTP messages delivered by a single connection.

It is very unlikely that you will need to change a mailer setting. But if you do, use the appropriate variable. Don't directly edit the MAILER source files. For example, if you want to limit the size of messages handled by the SMTP mailers to 2,000,000 bytes, you could add the following define to your configuration:

```
define(`SMTP_MAILER_MAX', `2000000')
```

Variable definitions, like those shown in Table 5.1, are available for all mailers. See the "OSTYPE" section of Appendix A for a complete list of these variables.

> ***NOTE*** Appendix A lists these variables in the discussion of the OSTYPE file because that is where mailer and path information is supposed to be stored. However, most Sendmail administrators don't want to take it upon themselves to create their own OSTYPE file. Most administrators add commands like these directly to the macro configuration file.

The `linux.m4` OSTYPE file shown in Listing 5.2 tweaked the mailer path setting for `PROCMAIL_MAILER_PATH`. That is the only mailer setting touched by the `generic-linux.mc` configuration, and it is indicative of how rarely mailer settings need to be changed.

The analysis of the `generic-linux.mc` has shown us several things. We have discovered the interrelationships of the various `m4` source files and we have learned the purpose and syntax of several different configuration commands. Also, we discovered that the `generic-linux.cf` file delivered with the Sendmail 8.11 source code distribution works fine for our sample Linux system once the various files required by Sendmail are placed in the correct directories under the correct names.

Next we analyze the Sendmail configuration that was installed as part of the RPM package on our sample Red Hat system. That configuration worked fine from the start. The analysis of the Red Hat configuration is not to debug a problem: it is to learn about the configuration provided by the vendor and to see what we can do to improve it.

The Red Hat Configuration

In Chapter 3, "Running Sendmail," Sendmail 8.11 was installed on a sample Red Hat system using the `rpm` command. Three RPM packages were installed in this way: the documentation, the configuration files, and the Sendmail program. The Sendmail configuration file examined in this section is the file that was installed as part of `sendmail-cf-8.11.0-1.i386.rpm`.

The RPM package creates a directory structure in `/usr/lib/sendmail-cf` that is very similar to the `cf` directory structure from the Sendmail source code distribution. An `ls` of `/usr/lib/sendmail-cf` shows the following directories:

```
[craig]$ ls /usr/lib/sendmail-cf
README  cf  domain  feature  hack  m4  mailer  ostype  sh  siteconfig
```

This directory contains the same `cf`, `m4`, `ostype`, `feature`, `mailer`, and `domain` subdirectories we saw in Chapter 4, and they perform the same functions. The macro control

file for the Red Hat configuration is found in the /usr/lib/sendmail-cf/cf subdirectory. It is pretty easy to locate. Among the numerous generic files is one file simply named redhat.mc. This is the file we are looking for. Change to /usr/lib/sendmail-cf/cf and cat that file.

```
[craig]$ cd /usr/lib/sendmail-cf/cf
[craig]$ cat redhat.mc
divert(-1)
dnl This is the macro config file used to generate the
dnl /etc/ sendmail.cf file. If you modify the file you will have to
dnl regenerate the /etc/sendmail.cf by running this macro config
dnl through the m4 preprocessor:
dnl
dnl        m4 /etc/sendmail.mc > /etc/sendmail.cf
dnl
dnl You will need to have the sendmail-cf package installed for this
to work.
include(`/usr/lib/sendmail-cf/m4/cf.m4')
VERSIONID(`linux setup for Red Hat Linux')dnl
OSTYPE(`linux')
define(`confDEF_USER_ID',``8:12'')dnl
undefine(`UUCP_RELAY')dnl
undefine(`BITNET_RELAY')dnl
define(`confAUTO_REBUILD')dnl
define(`confTO_CONNECT', `1m')dnl
define(`confTRY_NULL_MX_LIST',true)dnl
define(`confDONT_PROBE_INTERFACES',true)dnl
define(`PROCMAIL_MAILER_PATH',`/usr/bin/procmail')dnl
define(`ALIAS_FILE',`/etc/aliases')dnl
define(`UUCP_MAILER_MAX', `2000000')dnl
define(`confUSERDB_SPEC', `/etc/mail/userdb.db')dnl
dnl define(`confPRIVACY_FLAGS', `authwarnings,novrfy,noexpn')dnl
dnl define(`confTO_QUEUEWARN', `4h')dnl
dnl define(`confTO_QUEUERETURN', `5d')dnl
```

```
dnl define(`confQUEUE_LA', `12')dnl
dnl define(`confREFUSE_LA', `18')dnl
FEATURE(`smrsh',`/usr/sbin/smrsh')dnl
FEATURE(`mailertable',`hash -o /etc/mail/mailertable')dnl
FEATURE(`virtusertable',`hash -o /etc/mail/virtusertable')dnl
FEATURE(redirect)dnl
FEATURE(always_add_domain)dnl
FEATURE(use_cw_file)dnl
FEATURE(local_procmail)dnl
FEATURE(`access_db')dnl
FEATURE(`blacklist_recipients')dnl
dnl We strongly recommend to comment this one out if you want to
dnl protect yourself from spam. However, the laptop and users on
dnl computers that do not have 24x7 DNS do need this.
FEATURE(`accept_unresolvable_domains')dnl
dnl FEATURE(`relay_based_on_MX')dnl
MAILER(smtp)dnl
MAILER(procmail)dnl
```

Wow! This is one of the largest macro configuration files I have ever seen! The first thing we need to do is cut this monster down to size and attack it piecemeal. One thing we can do is eliminate the comments. Every line that begins with `dnl` is a comment that can be ignored for this exercise. Use `grep` to weed out every line that begins with `dnl`. Listing 5.5 shows the result.

Listing 5.5 The Active Commands in the Red Hat Macro Control File

```
[craig]$ grep -v '^dnl' redhat.mc
divert(-1)
include(`../m4/cf.m4')
VERSIONID(`linux setup for Red Hat Linux')dnl
OSTYPE(`linux')
define(`confDEF_USER_ID',``8:12'')dnl
undefine(`UUCP_RELAY')dnl
undefine(`BITNET_RELAY')dnl
define(`confAUTO_REBUILD')dnl
define(`confTO_CONNECT', `1m')dnl
define(`confTRY_NULL_MX_LIST',true)dnl
```

```
define(`confDONT_PROBE_INTERFACES',true)dnl
define(`PROCMAIL_MAILER_PATH',`/usr/bin/procmail')dnl
define(`ALIAS_FILE',`/etc/aliases')dnl
define(`STATUS_FILE', `/var/log/sendmail.st')dnl
define(`UUCP_MAILER_MAX', `2000000')dnl
define(`confUSERDB_SPEC', `/etc/mail/userdb.db')dnl
FEATURE(`smrsh',`/usr/sbin/smrsh')dnl
FEATURE(`mailertable',`hash -o /etc/mail/mailertable')dnl
FEATURE(`virtusertable',`hash -o /etc/mail/virtusertable')dnl
FEATURE(redirect)dnl
FEATURE(always_add_domain)dnl
FEATURE(use_cw_file)dnl
FEATURE(local_procmail)dnl
FEATURE(`access_db')dnl
FEATURE(`blacklist_recipients')dnl
FEATURE(`accept_unresolvable_domains')dnl
MAILER(smtp)dnl
MAILER(procmail)dnl
```


Okay, it is still surprisingly large, but it is not as bad as it looks. We have already covered many of the lines in this file and don't need to cover them again. `divert` and `include` were covered in Chapter 4. We know what the `VERSIONID` macro does and can ignore it. The `OSTYPE(`linux')` macro is the same one covered earlier in this chapter, and during that discussion of the `linux.m4` file we covered `PROCMAIL_MAILER_PATH` and `FEATURE(local_procmail)`. We also covered `FEATURE(redirect)`, `FEATURE(use_cw_file)`, and `MAILER(smtp)` during the discussion of the `generic-linux.mc` configuration. So we've made a good start. Still, there are lots of commands to discuss.

Understanding the Defines and Undefines

The first new command in this configuration is a `define` command that overrides the default setting of `confDEF_USER_ID`, which is the variable that holds the user ID and group ID used by Sendmail. By default `confDEF_USER_ID` is set to `1:1`, which on a Red Hat system is user `bin` and group `bin`. In the `redhat.mc` configuration file this is changed to `8:12`, which is user `mail` and group `mail`. Having a specific user ID and group ID for Sendmail is a good idea. The `bin` user can be used for a wide variety of programs. Creating a specific `mail` user and group makes it easier to track actions back to Sendmail and to control the access Sendmail is given to the rest of the system.

The next two lines are `undefine` commands that clear the names of the relay servers from the `UUCP_RELAY` and the `BITNET_RELAY` variables. Clearing these variables means that all UUCP sites must be directly connected and that the `.BITNET` pseudo-domain will not

work on this system. (BITNET is an outdated mail network that is no longer used.) However, in this specific configuration there aren't any server names to clear from `UUCP_RELAY` or `BITNET_RELAY`. By default, `UUCP_RELAY` and `BITNET_RELAY` are empty, so there are no default values to clear. We know the commands that have been executed so far in the macro configuration file and in the `linux.m4` file, and none of those have set any relay server names. Therefore these two commands are unnecessary for this configuration.

Next comes a series of nine `define` commands. We know that `PROCMAIL_MAILER_PATH` specifies the path to the `procmail` program. The other eight `define` variables, however, are new. They are:

`confAUTO_REBUILD` This boolean tells Sendmail whether or not it should automatically rebuild the `aliases` database. It defaults to `false`, meaning that the `aliases` database must be manually rebuilt as described in Chapter 6, "Using Sendmail Databases." If set to `true`, Sendmail checks to see if the `aliases` source file is newer than the `aliases.pag`, `aliases.dir`, and `aliases.db` database files. If it is, Sendmail automatically rebuilds the database. This capability can be exploited in a denial of service attack. A fix was added to address this vulnerability prior to Sendmail version 8.10, but the Sendmail developers have deprecated this option and strongly recommend that you not use it.

`confTO_CONNECT` This parameter defines the amount of time Sendmail will wait for the TCP connection to complete. By default, Sendmail sets no time limit and counts on the TCP/IP parameters configured in the kernel to handle this time out. The Red Hat configuration shown in Listing 5.5 sets this timeout to one minute (`1m`), which seems like plenty of time to wait for a network connection to complete.

`confTRY_NULL_MX_LIST` This boolean tells Sendmail whether or not it should attempt to deliver mail directly to hosts that list this server as their best mail exchange server. The Red Hat configuration sets this to `true`, so the server will attempt to deliver mail to its own MX clients. By default, this is set to `false`, which causes mail outbound for an MX client to be flagged as a configuration error. The default is correct for most configurations. As Chapter 2 explained, the MX server collects mail for its clients and either waits for the client to pull down the mail with a protocol such as POP or routes the mail to the correct destination using one of the Sendmail databases. It doesn't, however, forward mail on to a client using the same address that originally delivered the mail to the server. However, as we saw in the discussion of class `w` earlier in this chapter, the MX server only knows who its clients are if it is properly configured. If it receives mail that MX records say it should accept

but that class `w` says it should not accept, it has a configuration error. The Red Hat configuration forgives this configuration error and attempts to deliver the mail directly to the client.

`confDONT_PROBE_INTERFACES` This boolean tells Sendmail whether or not it should add the names and addresses of all of the network interfaces to class `w`. The default is `false`, which means that Sendmail *does* probe all network interfaces and automatically adds the names and addresses of those interfaces to class `w`. With the default setting, a second interface installed in the server is automatically detected and considered an acceptable e-mail address. The Red Hat configuration sets this to `true`, which means that only the names and addresses associated with the primary network interface are added to class `w`. If another interface is installed in the Red Hat system, it must be manually added to class `w` before it will be considered an acceptable e-mail address.

`ALIAS_FILE` This parameter defines the path of the `aliases` file. The default path is `/etc/mail/aliases`. The Red Hat configuration sets this to `/etc/aliases`, which was the default prior to Sendmail 8.11 and is the most common location for the `aliases` file on Linux systems.

`STATUS_FILE` This parameter defines the path to the `statistics` file. The default is `/etc/mail/statistics`. This default is new as of Sendmail 8.11, which changes the name of the file from the previous default of `sendmail.st` to `statistics`. The Red Hat configuration maintains the traditional name and places the file in the Linux `/var/log` directory.

`UUCP_MAILER_MAX` This parameter defines the maximum acceptable size of a UUCP mail message. The default is 100,000 bytes. The Red Hat configuration sets this to 2,000,000 bytes.

`confUSERDB_SPEC` This parameter defines the path to the user database and determines whether or not the database is used. By default no path to the user database is defined. When no path is defined, the user database is not used in processing mail addresses. The Red Hat configuration declares that the path to the user database is `/etc/mail/userdb.db`. This means that Sendmail will check for the existence of that file and will use it to process addresses after the `aliases` database is applied to the address and before the user's `.forward` file is applied. The user database is covered in detail in Chapter 6.

Understanding the Features

The redhat.mc macro configuration file shown in Listing 5.5 also includes 10 FEATURE commands. We have already discussed the redirect, use_cw_file, and local_procmail features, but there are seven new features that we haven't seen before. These are:

smrsh The smrsh feature tells Sendmail to use smrsh instead of /bin/sh as the program for the prog mailer. This is a highly recommended feature. The SendMail Restricted Shell (smrsh) limits what can be run via the prog mailer, which is an important improvement to Sendmail security.

The argument associated with the smrsh feature is the pathname of the smrsh program. The default is to look for a program named smrsh in the directory defined by the confEBINDIR variable. In the redhat.mc file, the path of the smrsh program is explicitly set to /usr/sbin/smrsh. As we saw earlier, the smrsh directory path is set to /usr/sbin with the confEBINDIR variable in the linux.m4 OSTYPE file. Because of that, an explicit path was not really required for the redhat.mc configuration and is probably only used to make the configuration self-documenting.

mailertable This feature tells Sendmail to use the mailertable database to route specific domain names to specific mailers. The argument for the mailertable feature defines the database type and the path to the database. The default database type is hash and the default path is /etc/mail/mailertable. The redhat.mc configuration explicitly identifies the database type as hash and the path as /etc/mail/mailertable. Since these are the defaults, the argument provided with the mailertable feature is not really required for the redhat.mc configuration and is probably only used to make the configuration self-documenting. Chapter 6 covers the mailertable database in detail.

virtusertable This feature tells Sendmail to use the virtusertable database to map domain names and hostnames to specific e-mail addresses. This database is an extended alias database that accepts incoming mail that has a domain name or hostname found in class w or class {VirtHost} and routes that mail as directed by the virtusertable database. Chapter 6 describes how this database is used.

The argument for the virtusertable feature defines the database type and the path to the database. The default database type is hash and the default path is /etc/mail/virtusertable. The argument provided with the virtusertable feature in the redhat.mc configuration is not really required because it reiterates the defaults. It is probably only used to make the configuration self-documenting.

always_add_domain This feature tells Sendmail to add the domain name to locally delivered mail. By default, a username is sufficient for local delivery. A quick test illustrates the effect always_add_domain has on a local address:

```
[root]# sendmail -bt -Cgeneric-linux.cf
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> /tryflags HS
> /try local craig
Trying header sender address craig for mailer local
canonify           input: craig
Canonify2          input: craig
Canonify2        returns: craig
canonify         returns: craig
1                  input: craig
1                returns: craig
HdrFromL           input: craig
AddDomain          input: craig
AddDomain        returns: craig
MasqHdr            input: craig
MasqHdr          returns: craig
HdrFromL         returns: craig
final              input: craig
final            returns: craig
Rcode = 0, addr = craig
> ^D
[root]# sendmail -bt -Credhat.cf
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> /tryflags HS
> /try local craig
Trying header sender address craig for mailer local
```

```
canonify          input: craig
Canonify2         input: craig
Canonify2       returns: craig
canonify        returns: craig
1                 input: craig
1               returns: craig
HdrFromL          input: craig
AddDomain         input: craig
AddDomain       returns: craig < @ *LOCAL* >
MasqHdr           input: craig < @ *LOCAL* >
MasqHdr         returns: craig < @ wren . foobirds . org . >
HdrFromL        returns: craig < @ wren . foobirds . org . >
final             input: craig < @ wren . foobirds . org . >
final           returns: craig @ wren . foobirds . org
Rcode = 0, addr = craig@wren.foobirds.org
> ^D
```

We run two tests using Sendmail in `-bt` mode. In both cases we ask Sendmail to process a header/sender address, and we give it the address `craig` to process through the `local` mailer. The first test uses the `generic-linux.cf` configuration, which does not use the `always_add_domain` feature. The address goes in as `craig` and comes out as `craig`. In the second test we use the `redhat.cf` configuration, which uses the `always_add_domain` feature. In the second test, `craig` is converted to `craig@wren.foobirds.org`. The effect of `always_add_domain` is clearly shown.

This is a good feature to use. The address shown, even on local mail, is valid everywhere. This helps avoid confusion among your users, and confused users are something you want to avoid!

`access_db` This feature tells Sendmail to use the `access` database to decide what hosts, domains, and networks are acceptable sources of e-mail. An optional argument that defines the database type and path can be used with the `access_db` feature. The default database type is `hash` and the default path is `/etc/mail/access`. The access database is described in Chapter 6. Its use in fighting spam is covered in Chapter 11.

`blacklist_recipients` This feature allows the `access` database to be used to block mail to specific recipients. Normally, the `access` database is used to control mail from undesirable sources. With this feature, the `access` database also can be

used to control mail bound for certain destinations. The `blacklist_recipients` feature is covered in detail in Chapter 11.

`accept_unresolvable_domains` This feature tells Sendmail to accept mail from a source even if the domain name of the source cannot be resolved by DNS. By default, Sendmail takes the hostname in the MAIL FROM: header and asks DNS to map that name back to an address before it will accept incoming mail. This option overrides that default behavior.

Allowing mail from unresolvable domains is a potential security problem, but this feature is often necessary for systems that do not have full-time DNS service. Such systems are laptops that might be disconnected from the network or systems sitting behind a firewall that are not given full DNS access. The Red Hat configuration includes this feature because Red Hat must create a configuration that will work with the widest range of systems. If you have full-time DNS service for your network—and you should—you should remove this feature from your configuration.

Following this batch of `FEATURE` commands are two `MAILER` commands. The first is the `MAILER(smtp)` command that we have already discussed. The second is the `MAILER(procmail)` command. Looking at this command, you might think it has something to do with the `local_procmail` parameter described earlier. It doesn't. `local_procmail` means that the mailer named `local` will use the program `procmail`. `MAILER(procmail)` means that a mailer named `procmail` that uses the `procmail` program will be added to the configuration. These two are unrelated. The mailer installed by `MAILER(procmail)` is used only if you configure entries in the `mailertable` to use it.

That's it—a big complex configuration that includes important capabilities, such as `smrsh`, and not so important capabilities, like `MAILER(procmail)`. As we saw in Chapter 4, this configuration works fine and delivers mail for our Red Hat system. But it is only a start. As the discussion of the `accept_unresolvable_domains` feature and the comments inside the `redhat.mc` file make clear, we are expected to create our own configuration that suits our needs. In the next section we do just that. Starting with the `redhat.mc` file, we create our own Red Hat configuration.

Modifying the Red Hat Configuration

There are lots of good things in the `redhat.mc` configuration, a couple of undesirable things, and a few redundancies. Since we are going to rewrite the configuration, I think we should also reorganize it to move some things out of the macro configuration file into macro source files where those items are a better fit. As a result, we will edit `the redhat.mc` file, create a new `OSTYPE` file, and create a new `DOMAIN` file. To do this we first

copy `redhat.mc` to `redhat811.mc`, `ostype/linux.m4` to `ostype/redhat7.0.m4`, and `domain/generic.m4` to `domain/foobirds.m4`.

Next we edit the files. First I edited the macro configuration file, `redhat811.mc`, changing the `DOMAIN` command to load `foobirds.m4` instead of `generic.m4`. Then I moved the `confDEF_USER_ID` parameter to the new `OSTYPE` file because I consider the user ID and group ID setting specific to Red Hat Linux. Next I deleted the two `undefines` because they serve no purpose. I also deleted `confAUTO_REBUILD` because it is a deprecated option.

I considered moving `confTO_CONNECT` to the `OSTYPE` file because it is designed to override the default TCP timeout settings used by the Linux operating system. Instead, I decided to delete it because I have not had any TCP timeout problems and don't anticipate any. Likewise I considered moving `confTRY_NULL_MX_LIST` to the `DOMAIN` file because this option is clearly related to how domain MX records are handled. But I decided to delete the option instead because it causes Sendmail to handle MX records in a non-standard way. Unless I must break a standard to get things running, I don't want to.

I deleted the `confDONT_PROBE_INTERFACES` option because I want Sendmail to include all of the server's interfaces as part of class `w`. The `confDONT_PROBE_INTERFACES` option is primarily useful on laptop systems where PCMCIA interfaces may be added or removed from a running system. Since I'm not running my server on a laptop, I don't want this option. For the same reason, I deleted the `accept_unresolvable_domains` feature from the configuration, which is primarily used on laptops. I have good DNS service and therefore should not use that feature.

Some lines required no decision. `PROCMAIL_MAILER_PATH` and `local_procmail` are already in the `OSTYPE` file, and `redirect` and `use_cw_file` are already in the `DOMAIN` file. However, the `confMAX_HEADERS_LENGTH` option that came from the `generic.m4` file seemed unnecessary to me, so I deleted it from the new `DOMAIN` file. I also deleted the `ifdef` conditional from the `OSTYPE` file to set `PROCMAIL_MAILER_PATH` unconditionally.

I moved `ALIAS_FILE`, `STATUS_FILE`, and `smrsh` to the `OSTYPE` file because file locations and mailer options are usually stored there. I deleted the `UUCP_MAILER_MAX` setting because the configuration does not define any UUCP mailers. I moved `confUSERDB_SPEC`, `always_add_domain`, `access_db`, and `blacklist_recipients` to the new `DOMAIN` file because I decided to put all domain, masquerading, and anti-spam configuration in that file. The remaining configuration commands I left in the macro configuration file. Confused? Take a look at Table 5.2. It lists every line from the original `redhat.mc` configuration file and tells what we did with it.

Table 5.2 Rewriting the Red Hat Configuration File

Command	Disposition
OSTYPE	Kept in the macro configuration file.
confDEF_USER_ID	Moved to the OSTYPE file.
UUCP_RELAY	Deleted.
BITNET_RELAY	Deleted.
confAUTO_REBUILD	Deleted.
confTO_CONNECT	Deleted.
confTRY_NULL_MX_LIST	Deleted.
confDONT_PROBE_INTERFACES	Deleted.
PROCMAIL_MAILER_PATH	Located in the OSTYPE file.
ALIAS_FILE	Moved to the OSTYPE file.
STATUS_FILE	Moved to the OSTYPE file.
UUCP_MAILER_MAX	Deleted.
confUSERDB_SPEC	Moved to the DOMAIN file.
smrsh	Moved to the OSTYPE file.
mailertable	Kept in the macro configuration file.
virtusertable	Kept in the macro configuration file.
redirect	Located in the DOMAIN file.
always_add_domain	Moved to the DOMAIN file.
use_cw_file	Located in the DOMAIN file.
local_procmail	Located in the OSTYPE file.
access_db	Moved to the DOMAIN file.

Table 5.2 Rewriting the Red Hat Configuration File *(continued)*

Command	Disposition
blacklist_recipients	Moved to the DOMAIN file.
accept_unresolvable_domains	Deleted.
MAILER(smtp)	Kept in the macro configuration file.
MAILER(procmail)	Kept in the macro configuration file.

Listing 5.6 shows the contents of all three files for the new configuration. Examining the listing will make it clear what went where.

Listing 5.6 Custom DOMAIN, OSTYPE, and Macro Control Files

```
[root]# cat redhat811.mc
VERSIONID(`Red Hat Linux Configuration for Sendmail 8.11')dnl
OSTYPE(`redhat7.0')
DOMAIN(`foobirds')
FEATURE(`mailertable',`hash -o /etc/mail/mailertable')dnl
FEATURE(`virtusertable',`hash -o /etc/mail/virtusertable')dnl
MAILER(smtp)dnl
MAILER(procmail)dnl
[root]# cat ../ostype/redhat7.0.m4
VERSIONID(`Red Hat Linux release 7.0')dnl
define(`confDEF_USER_ID',``8:12'')dnl
define(`ALIAS_FILE',`/etc/aliases')dnl
define(`STATUS_FILE', `/var/log/sendmail.st')dnl
define(`confEBINDIR', `/usr/sbin')
FEATURE(`smrsh')dnl
define(`PROCMAIL_MAILER_PATH', `/usr/bin/procmail'))
FEATURE(local_procmail)
[root]# cat ../domain/foobirds.m4
VERSIONID(`Setting for the foobirds.org domain')dnl
define(`confFORWARD_PATH',
`$z/.forward.$w+$h:$z/.forward+$h:$z/.forward.$w:$z/.
forward')dnl
define(`confUSERDB_SPEC', `/etc/mail/userdb.db')dnl
FEATURE(always_add_domain)dnl
FEATURE(`access_db')dnl
```

```
FEATURE(`blacklist_recipients')dnl
FEATURE(`redirect')dnl
FEATURE(`use_cw_file')dnl
EXPOSED_USER(`root')
```

The `redhat811.mc` macro control file has been reduced to a more readable seven lines. The `OSTYPE` command was edited to call the new `redhat7.0.m4` `OSTYPE` source file and the `DOMAIN` command was added to call the new `foobirds.m4` `DOMAIN` source file. These three files combine all of the desirable features that we saw in the `generic-linux.mc` configuration and in the `redhat.mc` configuration.

In Sum

A Sendmail configuration is not built from scratch. Start from one of the sample files that is provided as part of the Sendmail source code distribution or start with the configuration file that comes from your distribution vendor. Read and understand the vendor's configuration before modifying it to create your own. Don't assume the vendor's configuration is right for you. A vendor often must make compromises to create a configuration that runs on a wide variety of systems. Focus the configuration you create on those capabilities that you actually need.

Starting from a sample configuration can simplify the creation of your configuration, but the sample configurations carry their own level of complexity. Some, like `generic-linux.mc`, are reasonably simple, but may not provide the features you need. Others, like `redhat.mc`, are more complex than necessary. The way to attack the complexity of the sample configuration files is one line at a time. Even a very large macro configuration file probably has fewer than 30 lines. Using a reference, such as this book, get a general idea of what each line does. Discard those lines that are clearly unnecessary for your configuration. Then research the others in more detail to select those that you want to keep.

The analysis of the configurations in this chapter have shown that Sendmail relies heavily on database files to route mail, convert addresses, and control spam. In the next chapter, we look at the databases used by Sendmail and describe how you can use those databases to configure your system.

6

Using Sendmail Databases

Mention Sendmail configuration to a group of Linux administrators. The first thing that most of them will think of is a large `sendmail.cf` file filled with terse configuration commands that are difficult to read. Some think of an `m4` macro control file built from a complex configuration language that has hundreds of options. A very few think of database files. Yet database files play an important role in Sendmail configuration—a bigger role for the average system administrator than either the `sendmail.cf` or the macro configuration files.

The reason that the databases play such a big role for the average administrator is not that the databases are more important than the other files; they're not. The reason is that many administrators use the `sendmail.cf` provided by the Linux distribution vendor and never change it. Or they build a custom configuration when they install Sendmail and never change that. They then use the Sendmail databases for day-to-day configuration changes and to control the way in which Sendmail processes mail.

Sendmail uses several databases. In this chapter you'll learn about all of them. I use the term "databases" loosely. Some of the files described here are flat files; others are true databases. Regardless of their structure, all of these files are used to control the operation of Sendmail. Understanding the role of the databases and using them to your advantage

are essential parts of becoming an effective Sendmail administrator. Let's begin by understanding how database support is incorporated in Sendmail and specified in the Sendmail configuration.

Adding Database Support

The `aliases` database is the only database included in every configuration. If you want to use any other database, you need to add that database to your Sendmail configuration. There are two levels of configuration required for database support:

- First, the Sendmail program must be compiled with database support. Several compiler options are available to select the database support appropriate for your server.
- Second, the Sendmail configuration must be built with database support. Various features and defines are available to include database support in your server's configuration.

Understanding the various database compiler options, how they are set, and how you can tell which ones are set for your server is essential. These options tell you what database types are supported by your system and should be checked before you attempt to implement any new database feature. The database compiler options are covered next.

Database Compiler Options

If you have experience with compiling Sendmail, you may be tempted to look for the database compiler options in the `Makefile` in the Sendmail distribution's source code directory. You may even remember, or have read, that the database compiler options are set in the `Makefile` with the `DBMDEF=` directive—e.g., `DBMDEF= -DNEWDB -DNIS`. But all that has changed. Now, compiler options are set in the files located in the `devtools` directory of the Sendmail source code distribution. See Chapter 3, "Running Sendmail," for details about the `devtools` directory.

The default database compiler options are normally changed in an operating system–specific file in the `devtools/OS` directory or in a file you create specially for your server in the `devtools/Site` directory. The command that is used in those files to select support for different database types is `confMAPDEF`. The default `devtools/OS/Linux` file does not contain a `confMAPDEF` command because the default database types determined by the `build` process are generally correct for Linux. Create your own file in `devtools/Site` only if you want to define optional database types. The function of the `confMAPDEF` command parallels that of the old `DBMDEF= Makefile` variable, and it accepts the same values, which are shown in Table 6.1.

Table 6.1 Available confMAPDEF Database Options

Option	Usage
AUTO_NIS_ALIASES	Searches the NIS server for aliases.
AUTO_NETINFO_ALIASES	Searches the netinfo server for aliases.
AUTO_NETINFO_HOSTS	Searches the netinfo server for host addresses.
HESIOD	Adds support for Hesiod databases.
LDAPMAP	Adds support for LDAP databases.
MAP_NSD	Adds support for Irix NSD databases.
MAP_REGEX	Allows database searches using regular expressions.
NDBM	Adds support for Unix ndbm databases.
NETINFO	Adds support for NeXT netinfo databases.
NEWDB	Adds support for the hash and btree databases.
NIS	Adds support for Sun NIS databases.
NISPLUS	Adds support for Sun NIS+ databases.
OLD_NEWDB	Adds support for an outdated form of the db databases.
PH_MAP	Adds support for a CCSO phonebook database.
UDB_DEFAULT_SPEC	Specifies the default path used for the user database.
USERDB	Adds support for the user database.
YPCOMPAT	Adds support for an outdated SunOS version of NIS.

The Table shows a large number of database options, many more than you will ever use. No system uses all of these database types. They are included as options to support a wide range of operating systems. For example, three options, AUTO_NETINFO_ALIASES, AUTO_NETINFO_HOSTS, and NETINFO, support a database specific to the NeXT operating system, and another, MAP_NSD, is specific to Irix. Two options, OLD_NEWDB and YPCOMPAT, are described as outdated. Clearly, a Linux system administrator can ignore many of these

options. All of the options are there if you ever need them; it is just unlikely that you ever will. The options that are most useful to a Linux administrator are:

NEWDB This option adds the basic database support used on Linux systems. It provides both `hash` and `btree` databases. This one option provides all you need to build and access most local Sendmail databases.

MAP_REGEX This option adds a new feature to Sendmail that permits databases to be searched with regular expressions. Anyone who has used regular expressions with `grep` knows that they are much more powerful than simple wildcard characters. This added power is useful when you need to create complex rules to block spammers.

USERDB This option adds support for the user database, which can be used to process e-mail addresses on both inbound and outbound e-mail. A related option is `UDB_DEFAULT_SPEC`, which defines the default path to the user database. The path can also be set with the `confUSERDB_SPEC` define in the Sendmail configuration, as we saw in the `redhat.mc` file in Chapter 5, "Understanding a Vendor's Configuration." I prefer setting the path value in the configuration instead of compiling it into Sendmail because it is more easily changed when it is set in the configuration. However, some path value must be explicitly defined before Sendmail can use the user database.

NIS This option provides access to Network Information System (NIS) databases. These are administrative databases, such as `/etc/mail/aliases` and `/etc/hosts`, stored on the NIS server. The related database options `NISPLUS` and `YPCOMPAT` are rarely used on Linux systems. NIS+, which is an upgraded version of NIS, is not often used in Linux environments; `YPCOMPAT` creates compatibility with a version of NIS that has not been produced in several years. `YPCOMPAT` permits use of the old "plus syntax," in which a `+` is placed at the end of a local administrative database to tell the system to first search the local database and then search the database on the NIS server. Thus, with `YPCOMPAT` and a `+` at the end of the `/etc/mail/aliases` database, Sendmail first checks the local `aliases` database and then checks the one on the NIS server. Sounds like a good idea, but it is completely unnecessary. The `AUTO_NIS_ALIASES` option does exactly the same thing. It tells Sendmail to check the local `aliases` database first and then check the NIS server, and it does it without the outdated plus syntax. (Details of setting up an NIS server on a Linux system are covered in the *Linux DNS Server Administration* book of this series.)

To force Sendmail to use these four database options, you could either edit the `devtools/OS/linux.m4` file or create a file in the `devtools/Site` directory that contained the following line:

```
define(`confDEFMAP', `-DNEWDB -DNIS -DMAP_REGEX -DUSERDB')
```

Once the line is inserted in the file of your choice, recompile Sendmail to put the options into effect. (See Chapter 3 for instructions on compiling Sendmail.)

However, before going to all this trouble, check which options your Sendmail program is already using. The default database option settings vary based on the database libraries detected by the Sendmail source distribution's `build` routine. On a Linux system, the default is usually `-DNEWDB`. But `build` does a good job of detecting the capabilities of your system, so your Sendmail program could include additional options. Listing 6.1 shows the options compiled into the Sendmail program delivered with the `sendmail-8.11.0.i386.rpm` RPM file.

Listing 6.1 Checking the `sendmail` Compile Options

```
[root]# sendmail -bt -d0.4
Version 8.11.0
 Compiled with: MAP_REGEX LOG MATCHGECOS MIME7TO8 MIME8TO7 NAMED_BIND
                NETINET NETUNIX NEWDB NIS QUEUE SASL SCANF SFIO SMTP
                STARTTLS USERDB
canonical name: wren.foobirds.org
        a.k.a.: wren
 UUCP nodename: wren.foobirds.org
        a.k.a.: wren
        a.k.a.: [172.16.12.3]

============ SYSTEM IDENTITY (after readcf) ============
      (short domain name) $w = wren
  (canonical domain name) $j = wren.foobirds.org
         (subdomain name) $m = foobirds.org
              (node name) $k = wren.foobirds.org
========================================================

ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> ^D
```

Listing 6.1 shows Sendmail being run in `-bt` test mode. Sendmail is also being passed the debug value `-d0.4`. This debug value causes Sendmail to display several lines of information before accepting input. We don't really have any input for Sendmail to process; we just want to see the display so we enter Ctrl+D to exit.

The first line displayed by the Sendmail program tells us this is Sendmail 8.11.0. The second line is the one we're interested in. It lists all of the options that Sendmail was compiled with. Four of these, `MAP_REGEX`, `NEWDB`, `NIS`, and `USERDB`, are related to databases, and

they are the four options we want. This display makes it clear that there is no need for us to recompile Sendmail to set database options. If your system doesn't have the options you want, make sure you have all of the necessary database libraries before setting the compiler options and recompiling Sendmail.

Listing 6.1 shows that the Sendmail delivered with the Red Hat RPM is ready to run all of the databases we could want, assuming support for the databases is included in the Sendmail configuration. The configuration options used to add support for Sendmail databases is the next topic.

Configuration Options

As noted at the beginning of this section, the `aliases` database is the only database that is available to Sendmail by default. All of the other databases described in this chapter must be added to the Sendmail configuration before they can be used. The following defines and features are used to configure support for the optional databases, as well as some important files:

`define(`confUSERDB_SPEC', `path')` The `confUSERDB_SPEC` option tells Sendmail to apply the user database to local addresses after the `aliases` database is applied and before the `.forward` file is applied. The *`path`* argument given with this option is the full pathname of the database. There is no default for the path unless Sendmail is compiled with `UDB_DEFAULT_SPEC`. Setting the path with the `confUSERDB_SPEC` option is much simpler and more flexible than using `UDB_DEFAULT_SPEC`. The following `define` command enables the user database and tells Sendmail that it can be found in `/etc/mail/userdb.db`.

```
define(`confUSERDB_SPEC', `/etc/mail/userdb.db')
```

`define(`confCR_FILE'[, `path'])` The `confCR_FILE` option tells Sendmail to add the list of hosts permitted to relay mail from the specified file to the class `R` variable. The full pathname of the file can be provided as an argument to the option. If the pathname is not provided, it defaults to `/etc/mail/relay-domains` for Sendmail 8.11.

`FEATURE(`use_ct_file'[, `path'])` The `use_ct_file` feature tells Sendmail to add trusted usernames from the file to the class variable `t`. The full pathname of the file is an optional argument. If the pathname is not provided, Sendmail 8.11 defaults to `/etc/mail/trusted-users`.

`FEATURE(`use_cw_file'[, `path'])` The `use_cw_file` tells Sendmail to add hostname aliases from the file to the class variable `w`. The full pathname of the file is an optional argument. If the pathname is not provided, Sendmail 8.11 uses `/etc/mail/local-host-names` as the default.

FEATURE(`access_db'[, `*specification*']) The access_db feature tells Sendmail to use the access database to control mail relaying and mail delivery based on the source of the mail. An optional database specification can be provided to define the database type and the full pathname of the database. By default, the database type is hash and the database path is /etc/mail/access.

FEATURE(`mailertable'[, `*specification*']) The mailertable feature tells Sendmail to use the mailer table to map the domain name in a delivery address to a specific mailer and host for delivery. An optional database specification can be provided to define the database type and the full pathname of the database. By default, the database type is hash and the database path is /etc/mail/mailertable.

FEATURE(`virtusertable'[, `*specification*']) The virtusertable feature tells Sendmail to use the virtusertable database to map the recipient address in incoming e-mail to a different recipient address. This function is similar to the one performed by the aliases database, except that the virtusertable aliases domain names, not just usernames. An optional database specification can be provided to define the database type and the full pathname of the database. By default, the database type is hash and the database path is /etc/mail/virtusertable.

FEATURE(`genericstable'[, `*specification*']) The genericstable feature tells Sendmail to use the genericstable database to map the sender address on outbound mail to a different sender address. An optional database specification can be provided to define the database type and the full pathname of the database. By default, the database type is hash and the database path is /etc/mail/genericstable.

FEATURE(`domaintable'[, `*specification*']) The domaintable feature tells Sendmail to use the domain table to map one domain name to another. An optional database specification can be provided to define the database type and the full pathname of the database. By default, the database type is hash and the database path is /etc/mail/domaintable.

FEATURE(`uucpdomain'[, `*specification*']) The uucpdomain feature tells Sendmail to use the uucpdomain database to map UUCP site names to Internet domain names. An optional database specification can be provided to define the database type and the full pathname of the database. By default, the database type is hash and the database path is /etc/mail/uucpdomain.

FEATURE(`bitdomain'[, `*specification*']) The bitdomain feature tells Sendmail to use the bitdomain database to map BITNET hostnames to Internet domain names. (BITNET is an outdated IBM network that you won't use.) An optional database specification can be provided to define the database type and the full pathname of the database. By default, the database type is hash and the database path is /etc/mail/bitdomain.

There are more databases available for Sendmail than you will ever use. A couple are of little or no value to Linux sites—the `bitdomain` database converts addresses for a network that no Linux site uses and the `uucpdomain` database converts UUCP "bang" addresses, the old *`host`*`!`*`user`* e-mail addresses, that almost no one uses anymore. Other available databases have overlapping functions that might mean you don't need to use both of them at your site. The `redhat.mc` configuration delivered with the RPM contains fewer than half of the defines and features listed above, and that configuration probably has more database capabilities than you will really need. To help you evaluate which databases you do need, we'll examine all of them in more detail.

The Cr, Cw, and Ct Files

The first three databases we cover are not, in the strict sense of the word, databases. They are disk files used to load `sendmail.cf` class variables. The "cr" and "cw" files perform important roles in configuring Sendmail, but changes in the security atmosphere of the network mean that the "ct" file no longer has a useful role.

The file that loads the `t` class variable is often called the "ct" file because the traditional name of this file was `/etc/sendmail.ct`. In Sendmail 8.11 the default name of this file is `/etc/mail/trusted-users`, but the function of the file remains the same. It is used to add usernames to the list of users that are trusted to send mail under another user's name. By default, class `t` contains the usernames daemon, root, and uucp.

You will never use the `/etc/mail/trusted-users` file, and there are some good reasons why you won't. First, it is a bad idea to let people send out mail under other people's names. So in general, you don't want to expand the list of trusted users. Second, if you decide you absolutely must add usernames to the trusted user list, you won't add enough names to justify putting them in a separate file. For example, assume you want to add the username "mail" to the trusted user list. You could edit the macro configuration file to add the `FEATURE(use_ct_file)` command, rebuild the `sendmail.cf` file, and create a `trusted-users` file containing the single word `mail`. But why would you? You could just as easily edit the macro configuration file to add the `define(`confTRUSTED_USERS', `mail')` command, rebuild the `sendmail.cf` file, and be done with it. Not only is this second approach slightly easier, it is safer because there is one fewer file created and thus one fewer file where the permissions could be set incorrectly.

WARNING Despite this example, neither `confTRUSTED_USERS` nor `use_ct_file` is recommended because you shouldn't add any users to the trusted user list. Trusting users is a bad idea in this age of spammers and security crackers.

Unlike the "ct" file, which is never used, the "cr" file is always used. The "cr" file is really named the `relay-domains` file. Sendmail always uses the data it finds in the `relay-domains` file. The purpose and structure of that file is the next topic.

The *relay-domains* File

When mail arrives at a Sendmail server, it is either accepted, rejected, or relayed. If it is addressed to the server itself, by any name that the server accepts as its own, the mail is accepted for local delivery, meaning that the mail is either placed in the mailbox of a local user or routed as directed by one of the Sendmail databases. If the mail is not addressed to the server itself, the mail is either rejected or relayed. Mail is relayed by re-sending it to the delivery address. Prior to Sendmail 8.9, all mail addressed to another host that was received by a Sendmail server was relayed. Now, no mail is relayed unless you explicitly tell Sendmail to relay it. This change was a big headache for many system administrators who were using a Sendmail server to relay outbound mail for their PCs. But the change was necessary. Spammers were exploiting the relaying feature of Sendmail to hide the true source of spam. Now all administrators must pay the price of spam, and that price is the extra work necessary to create an explicit relay configuration.

One way to explicitly enable relaying is to list the names of hosts allowed to relay mail in the `/etc/mail/relay-domains` file. Sendmail copies anything written in that file to the class variable `R`. Any host listed in class variable `R` is allowed to relay mail. Listing 6.2 shows the contents of a simple `relay-domains` file.

Listing 6.2 Using the `relay-domains` File

```
[root]# cat /etc/mail/relay-domains
ibis.foobirds.org
[root]# ps -ax | grep sendmail
  542 ?        S      0:00 sendmail: accepting connections
[root]# kill -HUP 542
[root]# sendmail -bt
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> $=R
ibis.foobirds.org
> ^D
```

A SIGHUP signal is passed to the Sendmail process to ensure that it reads the hostnames from `relay-domains` into class `R`. The test in Listing 6.2 shows that class `R` was successfully modified.

> ***NOTE*** The hosts listed in `relay-domains` and in class `R` are the sources of relayed mail; they are not the destinations. Class `w`, covered in the next section, contains destination hostnames. Class `R` contains source hostnames.

Listing 6.2 adds only one domain name to class `R`. It is possible to add a limited number of domains to class `R` from inside the Sendmail configuration by using the `RELAY_DOMAIN` macro. For example, the following command placed inside the Sendmail configuration file would have the same effect as the `relay-domains` file shown in Listing 6.2:

```
RELAY_DOMAIN(`ibis.foobirds.org')
```

However, using the `relay-domains` file is simpler than using the `RELAY_DOMAIN` macro. The `RELAY_DOMAIN` command requires modifying the Sendmail macro configuration and rerunning `m4` to build the new `sendmail.cf` file. Using the `relay-domains` file does not. By default, Sendmail checks for a file named `/etc/mail/relay-domains` and adds the names it finds there to class `R`. No modifications to the configuration are required. You would need to place a command in the macro configuration only if you wanted to change the default filename of the `relay-domains` file. There are two ways this can be done:

`define(`confCR_FILE'[, `*path*'])` This `define` command sets the path to the file loaded into class `R`. It defaults to `/etc/mail/relay-domains`, which means that even if you have not explicitly set any value for this file in your configuration, Sendmail uses a file with that name to load class `R`. The `confCR_FILE` option is only needed if you want to change the default filename. For example, the following command causes Sendmail to load class `R` from a file named `/etc/relay-hosts`:

```
define(`confCR_FILE', `/etc/relay-hosts')
```

**`RELAY_DOMAIN_FILE(`*path*')`** This macro can be used to specify the path to the file that loads class `R`. For example, the following command loads class `R` from a file named `/etc/relay-for`:

```
RELAY_DOMAIN_FILE(`/etc/relay-for')
```

There are three commands relating to setting relay values for class `R`, `RELAY_DOMAIN`, `RELAY_DOMAIN_FILE`, and `confCR_FILE`. But you don't need to use any of them. Just create a file named `/etc/mail/relay-domains` and put the names of the hosts for which your server should relay mail in that file. That's all there is to it.

The "cr" file is a default feature of the Sendmail configuration. Nothing needs to be done to the Sendmail configuration to add it. On the other hand, the "cw" file, which is discussed next, must be specifically added to the configuration even though its role is as important as that of the "cr" file.

The *local-host-names* File

In Chapter 5, both the generic Linux configuration and the Red Hat configuration contain the `FEATURE(use_cw_file)` command. That feature reads the `/etc/mail/local-host-names` file and adds the hostnames listed there to the hostnames and addresses defined in class `w`. Listing 5.4 in Chapter 5 shows that, by default, class `w` contains the special name `localhost`, the special address 127.0.0.1, and the system's IP addresses, full domain names, and unqualified hostnames. Anything you put in `local-host-names` is added to these default values.

The system checks class `w` to decide whether or not it should accept inbound mail for local delivery. The Sendmail server only accepts mail for local delivery that is addressed to the server. Yet many systems might use the Sendmail server as a mailbox server to collect and hold their mail. If the mail that the server should collect and hold is literally addressed to another system, the name of that system needs to be added to class `w`. Once added to class `w`, the other system's hostname is treated by Sendmail as if it were a hostname alias for the server. Mail addressed to systems listed in class `w` is accepted as if it were mail addressed to the server. An example will make this clear.

Assume that `robin.foobirds.org` is a PC that uses the server `wren.foobirds.org` as a mailbox to collect and hold mail. An MX record is placed in the DNS server that directs `robin`'s mail to `wren`. Listing 6.3 shows what happens when `logan` on `bear.mammals.org` sends mail to `jill` on `robin` before class `w` is updated.

Listing 6.3 A Failed Test of Class `w`

```
[craig@ibis]$ sendmail -v -t
To: jill@robin.foobirds.org
From: logan
Subject: Class w test
^D
jill@robin.foobirds.org... Connecting to wren.foobirds.org.
   via esmtp...
220 wren.foobirds.org ESMTP Sendmail 8.11.0/8.11.0;
   Thu, 21 Sep 2000 16:27:59 -0400
>>> EHLO bear.mammals.org
250-wren.foobirds.org Hello root@bear.mammals.org [172.16.12.1],
   pleased to meet you
>>> MAIL From:<logan@bear.mammals.org> SIZE=62
250 2.1.0 <logan@bear.mammals.org>... Sender ok
>>> RCPT To:<jill@robin.foobirds.org>
550 5.7.1 <jill@robin.foobirds.org>... Relaying denied
```

```
>>> RSET
250 2.0.0 Reset state
/home/logan/dead.letter... Saved message in /home/logan/dead.letter
Closing connection to wren.foobirds.org.
>>> QUIT
221 2.0.0 wren.foobirds.org closing connection
```

Other than deleting several lines from the EHLO response to save a few trees, the test in Listing 6.3 appears exactly as it happened. Sendmail was invoked with `-v` and `-t` so that I could type the test in from the keyboard and receive verbose responses. The first four lines, which are shown in bold, are what I typed in. The remainder is the response from the remote e-mail server. As the To: line clearly shows, the mail was addressed to `jill@robin.foobirds.org`. The first line displayed by Sendmail says that it is connecting to `wren.foobirds.org` via the `esmtp` mailer. Mail addressed to `robin.foobirds.org` is being sent to `wren.foobirds.org`, which means that `wren` must be the preferred mail exchange server for `robin`. Great, except that apparently nobody told the administrator of `wren`! The 550 response line, shown in bold italics, is an error message saying that `wren` will not relay mail from `bear` to `robin`. Well, we didn't want it to relay mail, but we did want it to accept mail for `robin`, which it clearly won't do. What is wrong is that the name `robin.foobirds.org` is not a valid alias for `wren.foobirds.org`, so `wren` will not accept mail for `robin`.

To correct this, `robin` must be added to class `w`. There are two ways this can be done. One way is to add the value directly to class `w` in the Sendmail configuration using the `LOCAL_DOMAIN` macro command, as in this example:

```
LOCAL_DOMAIN(`robin.foobirds.org')
```

This works well if there are only a few hosts to add. It is straightforward and everything is contained in the Sendmail configuration file.

The other way to add hostnames to class `w` is to put them in the `local-host-names` file. Putting the hostname aliases in the `local-host-names` file is better whenever there are several names to add or the list of names changes over time. In the case of both the `generic-linux.mc` and `redhat.mc` configurations, using the `local-host-names` file is also simpler because the `FEATURE(use_cw_file)` command is already in the configuration. Thus there is no need to add a `LOCAL_DOMAIN` command or to rebuild the `sendmail.cf` file. Listing 6.4 shows the `local-host-names` file with two entries for `robin` and it shows a SIGHUP signal being sent to Sendmail to make sure Sendmail loads the new values.

Listing 6.4 Entries in the `local-host-names` File

```
[root]# cat local-host-names
# local-host-names - include all aliases for your machine here.
#
robin.foobirds.org
robin
[root]# ps -ax | grep sendmail
  542 ?        S      0:00 sendmail: accepting connections
[root]# kill -HUP 542
[root]# sendmail -bt
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> $=w
robin.foobirds.org
wren.foobirds.org
[172.16.12.3]
wren
localhost
robin
> ^D
```


Now `wren` will accept mail for `robin`, although it won't necessarily know what to do with it. If Jill will be downloading her mail from a mailbox on `wren`, you must create a valid user account for Jill to allow Sendmail to create the necessary spool directory to hold her mail and to allow her to download the mail via POP or IMAP. If Jill's mail is supposed to be forwarded to another system, mail routing instructions need to be given to Sendmail through the `aliases` database or another appropriate database. Clearly, while adding hostnames to class `w` is essential, it is only a first step. A possible next step is to configure the `aliases` database.

The *aliases* Database

Once mail is accepted by the Sendmail server for local delivery, Sendmail must decide *how* to deliver the mail. It must determine whether the user identified in the recipient address is a local user with a local mailbox, or a user alias whose mail must be forwarded on to the real recipient. The primary database used to make this determination is the `aliases` database.

Sendmail aliases perform important functions that are an essential part of creating a mail server. Mail aliases do the following:

Specify nicknames for individual users. Nicknames can be used to direct mail addressed to special names, such as `postmaster` or `root`, to the real users that do those jobs. Aliases can simplify creation of a standard e-mail address structure for a domain because mail aliases have a more flexible structure than login usernames.

Forward mail to other hosts. Sendmail aliases automatically forward mail to the host address included as part of the recipient address.

Define mailing lists. An alias with multiple recipients is a mailing list.

Mail aliases are defined in the `aliases` file. The location of the `aliases` file is set by the `ALIAS_FILE` define in the Sendmail configuration. The `redhat.mc` configuration file in Chapter 5 uses `ALIAS_FILE` to set the location of the `aliases` file to `/etc/aliases`. By default, Sendmail 8.11 locates the file in the `/etc/mail` directory (`/etc/mail/aliases`). Regardless of where it is located, the basic format of entries in the `aliases` file is:

`alias``: `*`recipient`*

The *`alias`* is the username from the e-mail address, and *`recipient`* is the name to which the mail should be delivered. The *`recipient`* field can contain a username, another alias, or a full e-mail address containing both a username and a hostname. Additionally, there can be multiple recipients for a single alias to create a mailing list. The `aliases` file delivered with a Red Hat system, with a few additions to illustrates the full range of uses for aliases, is shown in Listing 6.5.

Listing 6.5 The Basic Red Hat `aliases` Database

```
#
#       @(#)aliases     8.2 (Berkeley) 3/5/94
#
#  Aliases in this file will NOT be expanded in the header from
#  Mail, but WILL be visible over networks or from /bin/mail.
#
#       >>>>>>>>>>      The program "newaliases" must be run after
#       >> NOTE >>      this file is updated for any changes to
#       >>>>>>>>>>      show through to sendmail.
#

# Basic system aliases -- these MUST be present.
MAILER-DAEMON:  postmaster
postmaster:     root
```

```
# General redirections for pseudo accounts.
bin:            root
daemon:         root
games:          root
ingres:         root
nobody:         root
system:         root
toor:           root
uucp:           root

# Well-known aliases.
manager:        root
dumper:         root
operator:       root
webmaster:      root

# trap decode to catch security attacks
decode:         root

# Person who should get root's mail
root:          staff

# System administrator mailing list
staff: kathy, craig, david@parrot, sara@hawk, becky@parrot
owner-staff: staff-request
staff-request: craig

# User aliases
jill: jill@egret.foobirds.org
norman.edwards: norm
edwardsn: norm
norm: norm@hawk.foobirds.org
rebecca.hunt: becky@parrot
andy.wright: andy
sara.henson: sara
kathy.McCafferty: kathy
kathleen.McCafferty: kathy
```


The Red Hat `aliases` file opens with several comment lines, which begin with a pound sign (#). Ignore the information about which mail programs display aliases in the headers of mail messages; it is not really significant. The comment that is significant is the one that tells you to run `newaliases` every time you update this file. Sendmail does not read the

`aliases` file directly. Instead, it reads a database file produced from this file by the `newaliases` command.

> ***NOTE*** `newaliases` is not really a program; it is a link to Sendmail. The `aliases` database can also be built by running `sendmail` with the `-bi` argument—e.g., `sendmail -bi`.

The next 15 lines in Listing 6.5 define aliases for special names. All of these, except the `webmaster` alias that I added, come pre-configured in the Red Hat `aliases` file. The first two, `MAILER-DAEMON` and `postmaster`, are aliases that people expect to find on any system running Sendmail. Most of the others are aliases assigned to the daemon usernames that are found in the `/etc/passwd` file. No one can actually log on using the daemon usernames, so any mail that might be directed to these pseudo accounts is forwarded to a real user account. In the example, this mail is forwarded to the `root` user account.

Of course you don't really want people logging onto the `root` account just to read mail, so the `aliases` file also has an alias for `root`. In the example, I edited the `root` entry to forward all mail addressed to `root` to `staff`, which is another alias. Notice how often aliases point to other aliases. Doing so is very useful because it allows you to update one alias instead of many when the real user account that the mail is delivered to changes.

The `staff` alias is a mailing list. A mailing list is simply an alias with multiple recipients. In the example, several people are responsible for maintaining this mail server. Messages addressed to `root` are delivered to all of these people through the `staff` mailing list.

Two special aliases are associated with the mailing list. The `owner-staff` alias is a special alias used by Sendmail for error messages relating to the `staff` mailing list. The format that Sendmail requires for this special alias is `owner-`*`list`*, where *`list`* is the name of the mailing list. The other special alias, `staff-request`, is not required by Sendmail but it is expected by remote users. By convention, manual mailing list maintenance requests, such as being added to or deleted from a list, are sent to the alias *`list`*`-request`, where *`list`* is the name of the mailing list.

The last nine lines are user aliases I added to the file. These lines direct mail received at the mail server to the computers where the users read their mail. The first alias directs the mail this server receives for Jill. (Refer back to Listing 6.3.) Remember that when we discussed class `w`, it was pointed out that simply adding a hostname to class `w` does not mean that the server will be able to handle the mail for a specific user on that remote host. The user needs either an account on the server or an alias in the `aliases` database. This alias means that it is not necessary to create a user account for Jill on the mail server because her mail is forwarded to `egret.foobirds.org`. It is `egret`'s job to see that Jill gets her mail.

Aliases can be in a variety of formats to handle the various ways that e-mail is addressed to a user. The next three lines, which forward mail to `norm@hawk.foobirds.org`, all illustrate this. Mail addressed to `norman.edwards` or to `edwardsn` is mapped to the alias `norm`, and the alias `norm` forwards the mail to `norm@hawk.foobirds.org`. Thus the server will accept mail addressed in any of three different formats and make sure it gets to the correct recipient on the remote system `hawk.foobirds.org`.

The last five lines all have the same alias format: first name, dot, last name. This format is a popular one for e-mail addressing. When combined with an MX record in DNS that says that this server is the mail exchanger for the entire domain, it creates the simplified mail-addressing schemes used at many organizations. Assume the MX record for the domain `foobirds.org` points to this server. Mail addressed to `Rebecca.Hunt@foobirds.org` would actually be delivered to `becky@parrot.foobirds.org`. Notice that e-mail addresses are not case sensitive.

The `aliases` database is used on every system to specify how mail is forwarded. The `aliases` database handles mail forwarding for the entire system. It is also possible for individual users to define personal forwarding for their own mail in the `.forward` file. While the `.forward` file is not strictly a database, its close relationship to systemwide aliases make this a good time to take a quick look at the `.forward` file.

Defining Personal Mail Aliases

As some of the lines in the `aliases` file in Listing 6.5 illustrate, one of the main functions of the `aliases` file is to forward mail to other accounts or other computers. The `aliases` file, because it impacts the entire system, must be maintained by the system administrator. Thus, if a user wants to set up forwarding for their account through the `aliases` file, they need to ask the system administrator for help. The `.forward` file, which can be created in any user's home directory, defines mail forwarding for an individual user and is completely under the control of the user. Often, the `.forward` file is the most convenient place to set up forwarding.

It is possible to use the `.forward` file to do something that can be done in the `aliases` file. For example, if Norman Edwards had an account on a system but didn't really want to read his mail on that system, he could create the following `.forward` file:

```
norm@hawk.foobirds.org
```

The function of this entry is very similar to the `norm` alias line in Listing 6.5. It forwards all mail received in this user's account on the local system to the `norm` account at `hawk.foobirds.org`.

However, simple forwarding is not the primary use for the `.forward` file. A much more common use for this file is to invoke special mail processing before mail is delivered to your personal mail account. Chapter 11, "Stopping Spam," illustrates this when `procmail` and mail filtering are discussed.

The `aliases` database and the `.forward` file are the default files used to process user addresses. Sendmail will use both of these files if it finds them. There is no need to define them inside the Sendmail configuration; they are used by default. There is also an optional database that can be used to process users' addresses. It is the user database, and it is our next topic.

The User Database

The user database is available to Sendmail only if Sendmail is compiled with the `USERDB` compiler flag and the path to the user database is defined inside the Sendmail configuration using the `confUSERDB_SPEC` option. Listing 6.1 shows that the Sendmail delivered with the Red Hat RPM has the `USERDB` compiler flag set, and in Chapter 5 we saw that the `redhat.mc` file contained the following `define` command:

```
define(`confUSERDB_SPEC', `/etc/mail/userdb.db')
```

From these things, we know that we can use the user database on our sample Red Hat system. If your system doesn't meet both of these conditions, you can't use this database until you update the configuration.

Sendmail applies the user database to inbound mail after the `aliases` database and before the `.forward` file. But unlike the `aliases` and `.forward` files, the user database can also be applied to outbound mail to transform the sender address and, in effect, create a reverse alias. Listing 6.6 shows a realistic user database file based on the last four lines of the `aliases` database in Listing 6.5.

Listing 6.6 A Sample User Database File

```
[root]# cd /etc/mail
[root]# cat userdb
andy.wright:maildrop andy
andy:mailname andy.wright@foobirds.org
sara.henson:maildrop sara
sara:mailname sara.henson@foobirds.org
kathy.McCafferty:maildrop kathy
kathleen.McCafferty:maildrop kathy
kathy:mailname katheleen.mccafferty@foobirds.org
[root]# makemap btree userdb.db < userdb
```

In Listing 6.6, we change to the /etc/mail directory and display the contents of the user database file we have created. We arbitrarily named this file userdb. Like the aliases file, the user database file must be converted to a true database before it can be used by Sendmail. Use the makemap command to build the database. The makemap program reads the standard input and writes out the specified database of the type selected. The makemap command is fully described later in this chapter. In Listing 6.6, the command has two arguments: the database type and the name of the database to be written. The user database must be of the btree type, and the name of the user database must be the one defined inside the Sendmail configuration.

The entries in the user database look something like the entries in the aliases database except for the addition of a keyword, either maildrop or mailname. The entries that use the keyword maildrop are almost exactly like entries in the aliases database. The value before the colon (:) is the user alias and the value after the keyword maildrop is the recipient address. The first entry in the sample userdb file:

```
andy.wright:maildrop andy
```

performs exactly the same function as this line from the aliases database:

```
andy.wright: andy
```

Both of these take mail addressed to andy.wright and deliver it to the user account andy. The similarity between entries in the aliases database and maildrop entries in the user database are so strong that the following lines from the aliases file shown in Listing 6.5:

```
staff: kathy, craig, david@parrot.foobirds.org, sara@hawk.foobirds.org
owner-staff: staff-request
staff-request: craig
```

can be rewritten in the user database as follows:

```
staff:maildrop kathy,craig,david@parrot.foobirds.org,sara@hawk.foobirds.org
owner-staff:maildrop craig
staff-request:maildrop craig
```

This shows that just like an alias database entry, a maildrop entry can accept multiple delivery addresses, which in effect creates a mailing list. The only difference in these three entries, other than the addition of the keyword maildrop, is that maildrop entries cannot point to aliases. The recipient address in a maildrop entry must be a real address—thus the change that maps owner-staff to the real address craig instead of the alias staff-request.

> ***NOTE*** The fact is that none of the `maildrop` lines shown in Listing 6.6 is needed if this system has the `aliases` file shown in Listing 6.5. That `aliases` file would have already done the mapping of inbound addresses before the user database was even called. The `maildrop` lines are shown in Listing 6.6 as examples. If you decide to use `maildrop` entries, don't duplicate entries already in the `aliases` database. Some administrators prefer using `maildrop` entries over `aliases` when they also want to take advantage of the `mailname` entries so that everything can be done in one file.

The `mailname` entries provide a feature that is not available in the `aliases` database. The `mailname` entries rewrite outbound addresses. The value before the colon (`:`) is the local username. The value following the keyword `mailname` is the sender address that should be used on mail originating from the user. Thus the line

```
andy:mailname andy.wright@foobirds.org
```

converts the sender address on all mail from the user `andy` to

```
andy.wright@foobirds.org.
```

Converting outbound addresses is a very important function because it balances the way addresses are treated. Remote users send mail to the address `andy.wright@foobirds.org`. The MX record for `foobirds.org` directs the mail to a server—say, `wren.foobirds.org`. `wren` maps `andy.wright` through the `aliases` database and delivers the mail to `andy`. Without the `mailname` entry and the user database, when `andy` replies to the mail his address goes out as `andy@wren.foobirds.org`. Not very neat! With the `mailname` entry shown above, his mail goes out with the address `andy.wright@foobirds.org`, which is just what the remote user expects. Nice!

However, the user database is not the only way to rewrite outbound addresses, as we will see later. The decision to use the user database is primarily a matter of taste based on the database that you like best and find most understandable. While using the user database is largely a matter of choice, using the `access` database is often a matter of necessity, particularly in a world full of spammers.

The *access* Database

The `access` database is a powerful configuration tool for mail relay servers. It provides much finer control over the relay process than is provided by the `relay-domains` file. Unlike the `relay-domains` file, the `access` database is not a default part of the Sendmail

configuration. If you want to use the `access` database, you must add the `access_db` feature to your configuration. The `generic-linux.mc` configuration did not include support for the `access` database, but the `redhat.mc` configuration did with the following command:

```
FEATURE(`access_db')dnl
```

This command uses the default database type `hash` and the default pathname `/etc/mail/access.db`. You could change these values by providing an optional argument field to the command, as in this example:

```
FEATURE(`access_db', `btree /var/mail/access')
```

However, I recommend against changing these defaults. The `hash` type is supported on all Linux systems and all administrators expect to find the `access` database in `/etc/mail`. Changing these values doesn't gain you anything and it can cause confusion. Add the `access_db` feature to your configuration, but use the default arguments.

Use the `access` database to accept or reject mail based on the source or destination of the mail. Each line in the database contains two fields: the address field and the action field. The address field is the key to the database and the action field is the value returned from the database that specifies the action that Sendmail should take in regard to mail to or from the specified address.

The Address Field

The address field can define a user, an individual e-mail address, a source IP address, a network address, or the name of a domain. The address field can begin with an optional tag to tell Sendmail to limit checks for that address field to certain conditions. Three optional tag keywords are available:

To: The action is taken only when mail is being sent to the specified address.

From: The action is taken only when mail is received from the specified address.

Connect: The action is taken only when the specified address is the address of the system at the remote end of the SMTP connection.

The tag field is not required. It provides finer control over e-mail access, but fine control is not always needed. In many cases, you want broader control over relaying, not finer control, because you don't want to accept mail from a bad source and you don't want to send them mail, either. If no tag field is included, the default is to treat the address as the source of the mail. Thus, by default, the action is taken only if the mail comes from the specified address. Add the following `blacklist_recipient` feature to the Sendmail configuration:

```
FEATURE(`blacklist_recipients')
```

to make Sendmail apply the rules defined in the `access` database to both source and destination addresses.

The address in the address field can define an individual, a host, a domain, or a network:

- An individual is defined using either a full e-mail address in the form *user@host.domain* or a username in the form *username@*.
- A host is identified by its hostname or its IP address.
- A domain is identified by a domain name.
- A network is identified by the network portion of an IP address.

Listing 6.7 illustrates the various possible address fields. The listing is a contrived example that includes each tag type and each address type.

Listing 6.7 Address Formats for the `access` Database

```
spammer@bigisp.com              REJECT
makemoneyfast@                  REJECT
wespamu.com                     REJECT
172.18                          REJECT
[172.20.12.6]                   REJECT
From:weselljunk.com             REJECT
To:bigmoney@foolsgetrich.com    REJECT
Connect:wepushporn.com          REJECT
```

The first two lines in this `access` database define two individual users. These lines tell Sendmail to reject any mail from the e-mail address `spammer@bigisp.com` and any mail from a user named `makemoneyfast`. The third line defines an entire domain. It rejects mail from any host in the domain `wespamu.com`. The fourth line defines an entire network. It rejects mail from any computer whose IP address begins with network number 172.18. The fifth line defines a specific computer with the address 172.20.12.6. The square brackets surrounding the individual address mean that this IP address is literally in the e-mail address because it doesn't resolve to a hostname or is flagged by Sendmail as "might be forged."

NOTE Addresses that don't map to hostnames are rejected by default, so normally there would be no need to have an entry that rejects `[172.20.12.6]` in the `access` database. But as noted above, Listing 6.7 is a contrived example meant to show different address formats.

The last three entries have optional tag fields. Mail from the domain `weselljunk.com` is rejected but users are allowed to send mail to that domain. Mail is accepted from the user `bigmoney@foolsgetrich.com` but local users are not allowed to reply to that address. Any connection to the domain `wepushporn.com` is rejected.

All of the examples in Listing 6.7 tell Sendmail to reject the mail. Rejecting the mail is only one of the actions available through the `access` database.

The Action Field

The second field in each entry in the `access` database is a keyword that tells Sendmail what action to take. Table 6.2 lists the valid keywords and the actions they cause.

Table 6.2 `access` Database Actions

Keyword	Action
DISCARD	Drops any message from or to the specified address.
OK	Absolutely accepts messages from or to the specified address.
REJECT	Issues an error message and drops any mail from or to the specified address.
RELAY	Relays mail coming from the specified address.
[**ERROR:**[*dsn:*]]*code text*	Returns the specified RFC 821 response *code* and the *text* to the source of the mail. Optionally, the string `ERROR:` or `ERROR:` and an `RFC 1893 DSN` code can be used.

NOTE The actions in Table 6.2 are described as affecting mail "from or to" an address. This is only true if the `blacklist_recipients` feature is used. If that feature is not used, the actions only affect mail coming from a source address unless the address is modified by an optional tag.

The access database shown in Listing 6.8 illustrates how the various action field values are used.

Listing 6.8 Specifying Different Actions in the access Database

```
wespamu.com             REJECT
172.18                  DISCARD
weselljunk.com          550 Junk mail is not accepted
wepushporn.com          ERROR:5.7.1:550 Relaying denied to spammers
friendly.org            OK
129.6                   RELAY
```

The REJECT command causes Sendmail to return a standard error message to the source and then discard the mail. The DISCARD command drops the mail without sending any message back to the source. Most anti-spam authorities discourage silently discarding mail because they feel it does not discourage the spammer. For all the spammer knows, you received the mail, so they just keep sending more junk.

The action taken for weselljunk.com and wepushporn.com is similar to the action taken when a REJECT action command is specified, except that in these two cases you define the error messages sent. In both cases, mail from these domains is rejected and an error message is returned to the sender. In the case of weselljunk.com, the error message returned to the sender is "550 Junk mail is not accepted." In the case of wepushporn.com, the error message returned to the sender is "550 5.7.1 Relaying denied to spammers." This error message includes delivery status notification code 5.7.1. If you use a DSN code in your error message, use a valid DSN code from RFC 1893 that is compatible with the RFC 821 error code and the message you send. The action field for this error message starts with the keyword ERROR:. If you use this keyword with a DSN code, you must use the format **ERROR**:*dsn*:*code*, where *dsn* is a valid DSN code and *code* is a valid RFC 821 code. This format is used as an example. It is not required. You could have just as easily specified this error with the following entry:

```
wepushporn.com                  550 5.7.1 Relaying denied to spammers
```

The OK command in Listing 6.8 causes Sendmail to accept mail from friendly.org regardless of other conditions. For example, if mail arrives from a hostname that includes the friendly.org domain and cannot be resolved by DNS, Sendmail accepts that mail even though the accept_unresolvable_domains feature has not been enabled. To allow this you must, of course, fully trust friendly.org.

The RELAY command causes Sendmail to relay mail for network 129.6 even if basic relaying is not enabled on the system. Like the OK command, using the RELAY command means that you fully trust every host on network 129.6.

> ***TIP*** If you don't have anything else in your database, you probably want an entry like the one for network 129.6 for your own network. As discussed above, Sendmail blocks all mail relaying, even mail from your clients. Use the `access` database and an entry like `129.6 RELAY` to enable relaying for every host attached to your local network.

Once you build your access list, it must be converted into a database before Sendmail can use it. Use the `makemap` command to do the job, as shown below.

```
makemap hash /etc/mail/access.db < /etc/mail/access.txt
```

This command reads the entries in a text file named `/etc/mail/access` and uses them to build a `hash` type database in the file named `/etc/mail/access.db`.

The `local-host-names` and `relay-domains` files and the `aliases` and `access` databases are probably the most important databases that were configured in the `redhat.mc` configuration file. But they are not the only databases configured there. Two others, `virtusertable` and `mailertable`, are configured in `redhat.mc`. Of these, `virtusertable` is the most useful.

The *virtusertable*

The `virtusertable` is a database that routes mail for virtual mail domains. A virtual mail domain is similar to a virtual host in the Apache Web server. In the same way that a Web server can be configured to serve Web pages for host computers that do not physically exist, the Sendmail server can be configured to provide mail service for mail domains that do not have any existence beyond the Sendmail server itself. Creating a virtual mail domain allows you to advertise a meaningful domain name to the outside world without having to create all of the services necessary to support a full domain.

Defining a Virtual Domain

Each entry in the `virtusertable` has two fields: a virtual domain and a delivery address. The first field contains the virtual domain name found in the e-mail address. The second field contains the address to which the mail is really delivered. The virtual domain name contained in the first field can be a complete address in the form of *`user@domain`* or it can be a partial address in the form *`@domain`*. When the *`@domain`* format is used, mail to any user in the specified domain is routed to the mail address contained in the second field. Some sample `virtusertable` entries are shown in Listing 6.9.

Listing 6.9 Sample Virtual Domains

```
sales@bridal-gowns.com    jill
info@patient-rights.org   sara@hawk.foobirds.org
@imaginary.com            david@lion.mammals.org
```

These three sample entries show basic virtual domains and delivery addresses. Mail addressed to `sales@bridal-gowns.com` is really delivered to the `jill` account on the Sendmail server. (Looks like Jill is in the business of selling bridal gowns.) Requests e-mailed to `info@patient-rights.org` are forwarded to `sara@hawk.foobirds.org`. Mail sent to any username in the `imaginary.com` domain is forwarded to `david@lion.mammals.org`.

Sendmail must be configured to accept mail addressed to the virtual domains. In Listing 6.9, Sendmail must either accept `bridal-gowns.com`, `patient-rights.org`, and `imaginary.com` as aliases for the local host or recognize them as virtual domains. You know from the discussion of the `local-host-names` file earlier in this chapter that Sendmail accepts any name contained in class `w` as an alias for the local host. From that earlier discussion, you know how to add the three virtual domains to class `w`. But it is not necessary to turn a virtual domain into a hostname alias to get the `virtusertable` working. An alternative is to tell Sendmail that the virtual domain is a virtual domain by storing the domain name in the `{VirtHost}` class.

Domain names can be added to the `{VirtHost}` class one at a time using the `VIRTUSER_DOMAIN` macro inside the Sendmail configuration. For example, the three domains from Listing 6.9 could be added with the following three macros:

```
VIRTUSER_DOMAIN(`bridal-gowns.com')
VIRTUSER_DOMAIN(`patient-rights.org')
VIRTUSER_DOMAIN(`imaginary.com')
```

Once these lines are inserted in the macro configuration file, rerun `m4` to build the new `sendmail.cf` file and reload Sendmail to load the new configuration. This technique is complex and not very flexible, so the `VIRTUSER_DOMAIN` macro is only suitable if you have few virtual domains and they do not change often.

An alternate way to load the `{VirtHost}` class is from a file. Use the `VIRTUSER_DOMAIN_FILE` macro to specify the path to the file that contains the list of virtual domains. For example, the following command tells Sendmail to copy `/etc/mail/virtual-domains` to class `{VirtHost}`:

```
VIRTUSER_DOMAIN_FILE(`/etc/mail/virtual-domains')
```

After adding the VIRTUSER_DOMAIN_FILE command to the macro configuration file, rerun m4 to build the new sendmail.cf file. Then add the virtual domains from Listing 6.9 to the new virtual-domains file, one domain per line, as shown below:

```
[craig]$ cat /etc/mail/virtual-domains
bridal-gowns.com
patient-rights.org
imaginary.com
```

Whenever new virtual domains are added to the file, send Sendmail the SIGHUP signal to make sure it reads the new values and loads them into class {VirtHost}.

> ***TIP*** Both the VIRTUSER_DOMAIN and VIRTUSER_DOMAIN_FILE macros require changing and rebuilding the sample configuration. Because we already had the local-host-names file in our configuration, it would be easier to add the virtual domains to that file. It works just as well because Sendmail checks both class w and class {VirtHost} when processing virtual domains.

Defining *virtusertable* Delivery Addresses

The delivery address in all three sample entries in Listing 6.9 is a simple e-mail address. It doesn't have to be. The second field can contain a dynamic address that uses values from the input address or an error message that Sendmail returns to the sender. Listing 6.10 shows a larger virtusertable with a variety of values in the delivery address field.

Listing 6.10 A Sample virtusertable

```
sales@bridal-gowns.com    jill
info@patient-rights.org   sara@hawk.foobirds.org
@imaginary.com            david@lion.mammals.org
sales@outofbusiness.com   error:nouser User address is not valid
sales@weRbroke.com        error:5.1.5 Destination address invalid
@other.org                %1@local.org
+*@thatplace.com          %2@newplace.com
```

The first three entries have already been explained. Mail is accepted with a virtual domain address and routed to a real e-mail address. The e-mail address in the second field must

be a real address; it cannot be another virtual domain address. For example, the following `virtusertable` entries would not work as you might think:

```
sales@bridal-gowns.com    sales@imaginary.com
@imaginary.com            david@lion.mammals.org
```

This cannot be used to forward mail addressed to `sales@bridal-gowns.com` to `david@lion.mammals.com`. Unlike aliases that can point to other aliases, virtual domains cannot point to other virtual domains.

The next two lines in Listing 6.10 illustrate the use of error messages. Mail addressed to `sales@outofbusiness.com` is not delivered. Instead, an error message that says "User address is not valid" is returned to the sender. Mail sent to `sales@weRbroke.com` returns the error message "Destination address invalid" to the sender.

Error messages must start with the keyword `error`, which is the name of a special mailer that is built into Sendmail. Separated by a colon from the keyword `error` is an error condition, specified either as a keyword or as a DSN code. The DSN code can be any valid code defined in RFC 1893. The error condition keyword must be a keyword recognized by the `error` mailer. A list of valid error condition keywords is found in Chapter 8, "Understanding Rewrite Rules," in the discussion of the error mailer.

TIP Use DSN codes. They are an Internet standard and are well defined in the RFC. The error condition keywords are internal to Sendmail and subject to change in future releases.

The last two lines in Listing 6.10 provide examples of how values from the input address can be used in the outbound address. The `@other.org` entry provides the classic example. The username part of the input address is passed in the `%1` variable, so that `%1` in the outbound address is replaced by the username from the input address. Using the `virtusertable` shown in Listing 6.10, mail addressed to `pat@other.org` would be delivered to `pat@local.org` and mail sent to `doris@other.org` would be forwarded to `doris@local.org`.

This is a powerful feature. Obviously, it can be used to ease the transition when you change domain names, but that is a rare occurrence. More importantly, this feature can be used when the products you sell are not clearly associated with your official domain name. Assume you have an online mall that sells party products. The real name of your domain is `stuffycorporation.com`, but you also own the domains `funstuff.com` and

happythings.com. The following two lines in the virtusertable would route mail to the correct employee regardless of the domain to which it was addressed:

```
@funstuff.com       %1@stuffycorporation.com
@happythings.com    %1@stuffycorporation.com
```

The last line in Listing 6.10 shows that the *detail* value in the *+detail* syntax can be passed to the outbound address as %2. Mail sent to sales+info@thatplace.com would be delivered to info@newplace.com and mail to sales+orders@thatplace.com would be delivered to orders@newplace.com. Notice that the use of *+detail* syntax must be indicated in the first field of the virtusertable entry by placing +* before the @ in the virtual domain address. Users find e-mail addresses complex enough without using the *+detail* syntax. For this reason, the syntax is rarely used unless you have a program that automatically generates this syntax for the user. It is covered here for the sake of completeness, but you will probably not use it in your configuration.

Before the virtusertable can be used by Sendmail, it must be turned into a hash database using makemap. Listing 6.11 shows a successful build and test of the virtusertable database.

Listing 6.11 Building and Testing the virtusertable

```
[root]# cat local-host-names
# local-host-names - include all aliases for your machine here.
#
robin.foobirds.org
robin
bridal-gowns.com
patient-rights.org
imaginary.com
outofbusiness.com
weRbroke.com
other.org
thatplace.com
[root]# cat virtusertable
sales@bridal-gowns.com   jill
info@patient-rights.org  sara@hawk.foobirds.org
@imaginary.com           david@lion.mammals.org
sales@outofbusiness.com  error:nouser User address is not valid
sales@weRbroke.com       error:5.1.5 Destination address invalid
@other.org               %1@local.org
+*@thatplace.com         %2@newplace.com
```

```
[root]# makemap hash virtusertable < virtusertable
[root]# sendmail -bv sales@bridal-gowns.com
sales@bridal-gowns.com... deliverable: mailer local, user jill
```

The `virtusertable` database is built with the `makemap` command and then tested using `sendmail` with the `-bv` argument. The `-bv` argument causes the `sendmail` command to process the address entered on the command line as a delivery address. The test shows that the address `sales@bridal-gown.com` will be delivered via the `local` mailer to the user account `jill`. This is just what we expected based on the first line of the `virtusertable` file.

In Listing 6.11 we examine the contents of the `local-host-names` file and the `virtusertable` source file. The `local-host-names` file shows that all of the virtual domains have been added to class `w`. If the virtual domains are not added to class `w` or class `{VirtHost}`, the `sendmail -bv` test produces the following result:

```
[root]# sendmail -bv sales@bridal-gowns.com
sales@bridal-gowns.com... deliverable: mailer esmtp,
   host bridal-gowns.com, user sales@bridal-gowns.com
```

This test shows that Sendmail believes that `bridal-gowns.com` is an external domain that can be reached through the `esmtp` mail. If we defined the virtual domain in the `local-host-names` file and forgot to provide the mapping in the `virtusertable`, either by not including it in the file or not running `makemap`, `sendmail -bv` produces the following result:

```
[root]# sendmail -bv info@patient-rights.org
info@patient-rights.org... deliverable: mailer local, user info
```

Here the virtual domain is accepted, but the address is not mapped to the external host as we wished. A simple `sendmail -bv` test can tell you if the `virtusertable` is working and can indicate what's wrong if it isn't.

There are many good reasons to use the `virtusertable`, particularly if you run an ISP that provides service to a large number of customers or you run an e-business site. It is easy to see why Red Hat includes this in their default Sendmail configuration. The last database included in the `redhat.mc` file, the `mailertable`, is more rarely used.

The *mailertable*

The `mailertable` is rarely needed. It maps domain names to the internal mailer that should handle mail bound for that domain. The reason that this database is rarely needed is that Sendmail usually routes mail to the correct mailer without any help from you. You

only need this table to handle exceptional circumstances. An exceptional case might be a remote server that cannot handle standard mail. For example: From the discussion of the `MAILER(smtp)` command in Chapter 5, you know that Sendmail sends out SMTP mail using the `esmtp` mailer and that there are several other mailers available to handle SMTP mail in special ways. One of these is the `smtp8` mailer that is designed to send eight-bit MIME data to outdated mail servers that support MIME but cannot understand Extended SMTP. If the domain `cluelesscollege.edu` used such a mail server, you could put the following entry in the `mailertable` to handle the mail:

```
.cluelesscollege.edu        smtp8:oldserver.cluelesscollege.edu
```

A `mailertable` entry contains two fields. The first field is the key. It contains the host portion of the delivery address. It can contain either the full name of the host—e.g., `emma.cluelesscollege.edu`—or just the domain name. To specify a domain name, start the name with a dot, as in the example above. If a domain name is used, it matches every host in the domain.

The second field in the entry is the value returned for the key. It normally contains the name of the mailer that should handle the mail and the name of the server to which the mail should be sent. Optionally, a username can be specified with the server address in the form *`user@server`*. Additionally, the mailer that is specified can be the internal `error` mailer. If the `error` mailer is used, the value following the mailer name is an error message instead of a server name. Here is an example of each of these alternative entries:

```
.cluelesscollege.edu        smtp8:oldserver.cluelesscollege.edu
booby.foobirds.org          esmtp:postmaster@wren.foobirds.org
dodo.foobirds.org           error:nohost This host is extinct
```

Normally, mail passing through the `mailertable` is sent to the user to which it is addressed. For example, mail to `jane@emma.cluelesscollege.edu` is sent through the `smtp8` mailer to the server `oldserver.cluelesscollege.edu` addressed to the user `jane@emma.cluelesscollege.edu`. Adding a username to the second field, however, changes this normal behavior and causes Sendmail to route the mail to an individual instead of a mail server. For example, mail sent to any user at `booby.foobirds.org` is sent instead to `postmaster@wren.foobirds.org`. There, presumably, the mail is handled manually. Finally, mail handled by the `mailertable` does not have to be delivered at all. Instead, an error message can be returned to the sender. Any mail sent to `dodo.foobirds.org` returns the error message "This host is extinct" to the sender. The error message is constructed exactly as it is for the `virtusertable`, using either the `Sendmail` error condition keywords or the DSN error codes.

Returning error messages is not the only thing that can be done with the `mailertable` that replicates a feature of the `virtusertable`. It is possible to use the `mailertable` to route mail for a virtual domain. For example, the following entry routes mail addressed to anyone in the `bridal-gowns.com` virtual domain to the user account `jill`:

```
.bridal-gowns.com    local:jill
```

The advantage of using the `mailertable` for virtual domains is that, if you are already using the `mailertable` for some other purpose, you can do everything in one configuration file. The disadvantage is that you cannot specify individual users in the virtual domain, only domain names, and you don't get the cool features of the `virtusertable`, such as the ability to capture and reuse usernames with the `%1` variable. Personally, I prefer `virtusertable`.

One other interesting thing you can do with the `mailertable` is to use it to route all of the mail on a client system to a central mail server. Suppose you had a Red Hat Linux client system that you wanted to configure to send all of its mail to `mailserver.foobirds.org` for processing. You could create a custom macro configuration on the client with a `define` command that sets `SMART_HOST` to `mailserver.foobirds.org`, or you could simply create a `mailertable` with a single entry:

```
esmtp:mailserver.foobirds.org
```

`SMART_HOST` is a variable in the macro configuration file that can be set to the name of a mail server that handles all outbound mail for the client. The `mailertable` entry does essentially the same thing. The dot (`.`) in the first field matches all domain names. This means that all non-local mail will be sent through the `esmtp` mailer to `mailserver.foobirds.org` for delivery. This is exactly what we want for our imaginary client, and it is exactly what the `SMART_HOST` define would have given us. But this is simpler.

Once a `mailertable` source file is built, it must be processed through `makemap`. By default, Sendmail expects the `mailertable` database to be in `hash` database format.

The likelihood that you will need to deal with a server that cannot handle standard Internet mail is remote. Time has already solved most of the incompatibilities that made the `mailertable` and the wide variety of mailers necessary. The other uses of the `mailertable` can be performed by other databases. So why is the `mailertable` database included in the default `redhat.mc` configuration? It is there to provide access to the `procmail` mailer. The `redhat.mc` file contains the command `MAILER(procmail)`. This command has nothing to do with the `FEATURE(local_procmail)` command. The `local_procmail` feature causes Sendmail to use `procmail` as the `local` mailer. The `MAILER(procmail)` macro makes `procmail` available for mail other than local mail, but

it does not add any rewrite rules to use `procmail`. To make use of the `procmail` mailer for non-local mail, you need to add it to the `mailertable`, as in this example:

```
.fishorfowl.org          procmail:fishorfowl.org
```

This example sends mail for the domain `fishorfowl.org` through `procmail`. The primary reason for using `procmail` is that it offers powerful tools for filtering mail. (The filtering features of `procmail` are covered in Chapter 11.) In the case of the sample entry shown above, we must assume that mail bound for `fishorfowl.org` requires special filtering.

Of the databases defined in the default Red Hat configuration, `mailertable` is the one you are least likely to use. Unless you need `procmail` to filter outgoing mail or you must send mail to a server that can't handle standard mail, you won't create any entries in this database.

Despite the large number of databases configured in `redhat.mc`, there are four more databases not included in that configuration. Of these four databases, only `genericstable` gets much use.

The *genericstable*

The `genericstable` database rewrites sender addresses. A `genericstable` entry is composed of two fields: the original sender address, which acts as the key, and the rewritten sender address, which is the value returned for the key. Like other databases, the `genericstable` source file must be processed through `makemap` to build a `hash` database before Sendmail can use it. Listing 6.12 shows a reasonable `genericstable` source file.

Listing 6.12 Mapping Sender Addresses with `genericstable`

```
andy    andy.wright@foobirds.org
sara    sara.henson@foobirds.org
kathy   katheleen.mccafferty@foobirds.org
```

Given the `genericstable` shown in Listing 6.12, mail sent from the user account `andy` is sent out with a sender address of `andy.wright@foobirds.org`. If you remember the discussion of the user database earlier in the chapter, this probably sounds familiar. Entries in the `genericstable` perform exactly the same function as the `mailname` entries in the user database—both types of entries rewrite sender addresses.

The `genericstable` database has one small feature not found in the user database. It can accept *`+detail`* syntax in the original address and pass the *`detail`* part of the address as variable `%1` to the output address, in the following manner:

```
sales+*@insects.org       %1@sales.insects.org
```

Of course, the *`+detail`* syntax is only important if you actually use it, and it is rarely used.

If a domain name is included in the first field of a `genericstable` entry, that domain name must be defined in class `G`. Values can be stored in class `G` using the `GENERICS_DOMAIN` macro or they can be loaded into class `G` from the file identified by the `GENERICS_DOMAIN_FILE`. For example, the following command stores the domain name `insects.org` in class `G`:

```
GENERICS_DOMAIN(`insects.org')
```

While the next command loads class `G` from a file named `/etc/mail/generics-domains`:

```
GENERICS_DOMAIN_FILE(`/etc/mail/generics-domains')
```

The domain names in class `G` normally require an exact match. Using the `GENERICS_DOMAIN(`insects.org')` macro shown above, *`user`*`@insects.org` would match the requirements set by class `G` but *`user`*`@fly.insects.org` would not match, even though `fly.insects.org` is part of the `insects.org` domain. To get Sendmail to match all hosts and subdomains within a domain defined in class `G`, use `FEATURE(`generics_entire_domain')`.

The similarities between the user database and the `genericstable` mean that you can use either one of these databases to rewrite sender addresses. The syntax of `genericstable` entries is a little simpler because `genericstable` does not use keywords like `mailname`. But the `genericstable` only handles sender addresses. Recipient addresses must be handled in a separate database, either `/etc/aliases` or the user database. Some administrators like the simplicity of the `genericstable` database; others prefer the user database so they can have everything in one file. It is primarily a matter of taste. Both files work in the same way.

I generally prefer to use `aliases` for recipient addresses and the `genericstable` for sender addresses because that's what I'm used to. I have several configurations already set up this way. However, the `redhat.mc` file does not have `genericstable` support in the configuration. To use `genericstable` with that configuration, I must add the `FEATURE(`genericstable')` command to the macro configuration and rerun `m4` to build a new `sendmail.cf` file. In the case of the `redhat.mc` configuration, it is probably just easier to use the user database.

The `genericstable` is the only database that I use that Red Hat did not include in the configuration. The other three databases that Red Hat did not configure are very seldom used.

Little-Used Databases

The three remaining databases have very little use in current configurations because they deal with outdated networks, outmoded syntax, or rare situations. These three databases are:

`domaintable` The `domaintable` is intended to ease the transition from an old domain name to a new domain name by translating the old name to the new name on all mail. You are rarely in the situation where you must change domain names, but if you are this database can help. The old domain name is the key and the new domain name is the value returned for the key. For example, assume we changed the domain name for the sales division from `sales.business.com` to `marketing.business.com`. We could put the following line in the `domaintable` to handle the address mapping:

```
sales.business.com        marketing.business.com
```

The `domaintable` source file must be converted to a `hash` type database with `makemap` before Sendmail can use it. Also, support for the `domaintable` must be added to the configuration with the `FEATURE(`domaintable')` command before Sendmail will even attempt to use the file.

`uucpdomain` The `uucpdomain` database converts e-mail addresses from the `.UUCP` pseudo-domain into old-fashioned UUCP bang addresses. The key to the database is the hostname from the `.UUCP` pseudo-domain. The value returned for the key is the bang address. It is very unlikely that you will use this database. Most sites no longer use UUCP for mail, and those that do don't use bang addresses. Bang addresses are almost never used anymore because current UUCP mailers handle e-mail addresses that look just like Internet addresses.

`bitdomain` BITNET is an IBM-mainframe-to-IBM-mainframe network that was created at a time when IBM did not offer TCP/IP protocols for their mainframes. The `bitdomain` database converts BITNET hostnames to legal Internet hostnames. BITNET is outdated. You will not use it at your site.

Well, that's finally it: almost a dozen different files and databases, more databases than you will ever want or use. And most of them are built using the `makemap` command.

The *makemap* Command

The `makemap` command is included with Sendmail as a tool to help you build databases. Of all the true databases discussed in this chapter, only one, the `aliases` database—which is built by the `newaliases` command—is not built by the `makemap` command.

The `makemap` command reads the standard input and writes out a database according to the instructions you provide on the command line. The command line accepts three arguments: the command options, the database type, and the name of the output database file.

The name of the file is obvious. It must match the name of the database that is configured in Sendmail. One minor point: It is not necessary to include the filename extension, either in the Sendmail configuration or on the `makemap` command line. If you don't provide a filename extension, `makemap` will apply the correct extension to the filename based on the database type. Since Sendmail knows the database type from its configuration, it will search for a file with the correct extension. For example, we used this command to build the `virtusertable`:

```
[root]# makemap hash virtusertable < virtusertable
```

A simple reading of this command might imply that we read and wrote a file named `virtusertable`. In fact, we read a file named `virtusertable` and wrote a file named `virtusertable.db`, because `makemap` adds the correct `.db` extension to the output filename for `hash` type databases.

The type field of the `makemap` command can accept many different database types to support the wide variety of different databases used on different computers. On Linux systems, however, the database type will be either `hash` or `btree`, the two database types provided by the `NEWDB` compiler option. The type selected must match the database type defined for the specific database in the Sendmail configuration. All of the databases built by `makemap`, except for the user database, default to `hash` type databases in the Sendmail configuration. The user database defaults to `btree`.

In this chapter, none of the `makemap` examples included command line options because they are not generally required. Table 6.3 lists all available `makemap` command line options.

Table 6.3 makemap Command Line Options

Option	Purpose
–d	Permit duplicate keys in the database.
–f	Allow uppercase characters in the database keys.
–N	Append a null character to the end of each key.
–o	Append the new entries to an existing database.
–r	Overwrite duplicate keys.
–v	Run in verbose mode.

The –d option forces makemap to accept duplicate keys. Normally, duplicate keys produce an error. Don't use duplicate keys. The key is the value looked up in the database. Duplicates can cause unpredictable results and they are not supported in most types of databases.

Also, don't add null characters to the end of keys. This was necessary for some systems, like the old SunOS system, but it is not necessary for Linux. You don't need the –N option on a Linux system.

Normally, e-mail addresses are case-insensitive. Craig.Hunt@foobirds.org is the same as craig.hunt@foobirds.org. makemap eliminates case by converting everything to lowercase characters. The –f option overrides the standard behavior and forces makemap to maintain case. Because e-mail addresses are supposed to be case insensitive, maintaining case is probably not a good idea.

The –o and –r options are related. Normally, makemap reads the source file and replaces the old database with an entirely new file. The –o option tells makemap to save the old database and add the entries from the source file to it. Adding entries to the database increases the possibility of duplicate keys. The –r option tells makemap that if an entry from the source file duplicates a key already in the database, it should replace the database entry with the new entry. The –r option only make sense when the –o option is used.

The –v option produces verbose output. It lets you watch the progress of the makemap command. Listing 6.13 shows the result of the –v option.

Listing 6.13 Using –v with the makemap Command

```
[root]# makemap -v hash virtusertable < virtusertable
key=`info@patient-rights.org', val=`sara@hawk.foobirds.org'
key=`@imaginary.com', val=`david@lion.mammals.org'
key=`sales@outofbusiness.com', val=`error:nouser User address is not valid'
key=`sales@weRbroke.com', val=`error:5.1.5 Destination address invalid'
key=`@other.org', val=`%1@local.org'
key=`+*@thatplace.com', val=`%2@newplace.com'
```

makemap is an important tool needed to build most Sendmail databases. It is simple to use, but you need to understand how it is used and remember to use it every time a database is modified. Whenever you edit a database source file, rerun makemap and then run a simple test to make sure Sendmail is properly using the new database.

In Sum

At most sites, the Sendmail macro configuration file and the sendmail.cf file are built just once. The bulk of the configuration, and particularly the bulk of the ongoing configuration maintenance, takes place in the Sendmail databases. The Sendmail databases are a powerful tool for bypassing the complexity of the Sendmail configuration files. There is no need to add a RELAY_DOMAIN macro and rebuild the Sendmail configuration when a line added to the relay-domains file does the same job. There is no need to set SMART_HOST and rebuild the Sendmail configuration when a single line in the mailertable will do the same thing. The databases simplify Sendmail configuration.

Unfortunately, like everything else about Sendmail, the databases themselves have too much complexity. There are too many ways to do the same thing. The user database replicates functions done by /etc/aliases and the genericstable. The mailertable can be made to do the same thing as the virtusertable. Entries in class w can have the same effect as entries in class {VirtHost} and there are a couple of different ways to get entries into both of these classes. In order to troubleshoot configurations created by others, you need to understand the role of every database and you need to understand the fact that these overlapping functions exist. But in your own configuration, you need to eliminate this overlap by focusing on a subset of databases and by using those databases for specific purposes. Here are a few suggestions, in no particular order, to help you choose the correct database for the job.

- Define all of your server's hostname aliases in the local-host-names file.
- Use the aliases database to process recipient addresses. It is available on every system and is already configured.

- Use either the `genericstable` or the user database to process sender addresses, but do not use both. If you use the user database, don't use `maildrop` commands to replicate recipient names already covered by the `aliases` database.
- Use the `access` database to control mail delivery and relaying. It provides finer control than the `relay-domains` file. Only use `relay-domains` where it is adequate to the task, such as on small departmental systems that don't need the full range of services provided by the `access` database.
- Use the `virtusertable` only if you truly need to support virtual domains. This database probably only applies to e-business sites and ISPs.
- Use the `mailertable` only if you use `procmail` for non-local mail. Most other uses of the `mailertable` are less than optimal solutions for real problems. For example, upgrading the external system to accept Extended SMTP is a better solution than using the `mailertable` to force mail through `smtp8`.
- Solve DNS transition problems with proper DNS configuration. Avoid using `domaintable` as anything other than a short-term fix.
- Don't use the `trusted-users` file, the `bitdomain` database, or the `uucpdomain` database.

The Sendmail databases are the final topic in Part 2, "Essential Configuration," and they are the most frequently used tools of basic configuration. The next chapter, "The `sendmail.cf` File," begins Part 3, "Advanced Configuration." Considering the complexity we have already seen, and the advanced nature of the skills needed to master this complexity, it might be hard to believe things could get more advanced. But they can. In the next part of this book, we drill deeper into the configuration and look at ways we can customize Sendmail at this deep level.

Part 3

Advanced Configuration

Featuring:

- The structure of the `sendmail.cf` file and the commands used to build it
- How values are set for `sendmail.cf` variables and classes
- How databases and mailers are defined in `sendmail.cf`
- Editing and testing `sendmail.cf`
- Special rulesets and when they are invoked
- All of the rulesets used by Sendmail and what they do
- Pattern matching in rewrite rules
- Transforming e-mail addresses with rewrite rules
- What address masquerading is and when it is used
- Rewriting the user portion of addresses
- Creating your own rewrite rules
- Building a relay client configuration

7

The *sendmail.cf* File

You use the `m4` commands covered in the previous part of this book to create the Sendmail configuration. The file you build to hold those commands is the macro configuration file. However, Sendmail does not use the macro configuration file that you create. That file must be processed by `m4` to build Sendmail's runtime configuration. The file that defines the Sendmail runtime configuration is `sendmail.cf`.

The `sendmail.cf` file is a large complex file divided into seven different sections. All Linux `sendmail.cf` files have the same structure, because they are all created from the `m4` macros that come in the Sendmail distribution. The section labels from the `sendmail.cf` files provide an overview of the structure and the functions of this file. The sections are:

Local Info This section defines the configuration information specific to the local host.

Options This section sets the options that define the Sendmail environment.

Message Precedence This section defines the Sendmail message precedence values.

Trusted Users This section defines the users who are allowed to change the sender address when they are sending mail.

Format of Headers This section defines the headers that Sendmail inserts into mail.

Rewriting Rules This section holds the commands that rewrite e-mail addresses from user mail programs into the form required by the mail delivery programs.

Mailer Definitions This section defines the programs used to deliver the mail. The rewrite rules used by the mailers are also defined in this section.

Each section is examined in detail in this chapter. It is unlikely that you will directly modify the `sendmail.cf` file except for the smallest of changes. Changing the macro configuration and rebuilding a new `sendmail.cf` is the preferred technique for making configuration changes. Yet understanding the structure of the `sendmail.cf` file, and the syntax and purpose of the configuration commands it contains, is an essential skill for every Sendmail administrator. Understanding the `sendmail.cf` file helps you better understand the purpose of the macro configuration commands and lets you observe their impact on the underlying configuration. More importantly, the Sendmail test tools run with the `sendmail.cf` configuration file. To effectively monitor a test, you need to understand the test output, which is often based on the structure of the `sendmail.cf` file.

Our analysis of the `sendmail.cf` file begins at the beginning with the first section, Local Info, and moves section by section through the entire file. The Local Info section contains the widest variety of configuration statements, and it is the part of the `sendmail.cf` file that is most often modified by system administrators.

The Local Info Section

The first section in the `sendmail.cf` file contains information that is specific to the local host: information such as the hostname, the names of any mail relay hosts, and the mail domain name. It also contains information specific to your copy of Sendmail, such as the name that Sendmail uses to identify itself when it returns error messages, and the version number of the Sendmail distribution you're running. Additionally, the Local Info section contains the definitions of the optional databases used by Sendmail. This collection of diverse information is gathered together at the beginning of the `sendmail.cf` file to make it easier to locate in case manual editing is required.

The Local Info section of the `sendmail.cf` file generated for Sendmail 8.11 from the `redhat.mc` file is shown in Listing 7.1. It has been edited to reduce the number of unneeded lines. It should be largely identical to the Local Info section on your Linux system, but it won't be exactly the same. Don't worry about the differences; they are all related to comments and the number of blank lines. The commands are unchanged.

Listing 7.1 The Full Local Info Section

```
##################
#   local info   #
##################

Cwlocalhost
# file containing names of hosts for which we receive email
```

```
Fw/etc/mail/local-host-names
# my official domain name
#Dj$w.Foo.COM

CP.

# "Smart" relay host (may be null)
DS
# operators that cannot be in local usernames
CO @ % !
# a class with just a dot (for identifying canonical names)
C..
# a class with just a left bracket (for identifying domain literals)
C[[
# access_db acceptance class
C{Accept}OK RELAY
# Hosts that will permit relaying ($=R)
FR-o /etc/mail/relay-domains
# arithmetic map
Karith arith
# possible values for tls_connect in access map
C{tls}VERIFY ENCR
# who I send unqualified names to (null means deliver locally)
DR
# who gets all local email traffic
DH
# dequoting map
Kdequote dequote
# class E: names that should be exposed as from this host, even
   if we masquerade
# class L: names that should be delivered locally
# class M: domains that should be converted to $M
# class N: domains that should not be converted to $M
#CL root
# who I masquerade as (null for no masquerading) (see also $=M)
DM
# my name for error messages
DnMAILER-DAEMON
# Mailer table (overriding domains)
Kmailertable hash -o /etc/mail/mailertable
```

```
# Virtual user table (maps incoming users)
Kvirtuser hash -o /etc/mail/virtusertable

CPREDIRECT

# Access list database (for spam stomping)
Kaccess hash /etc/mail/access
# Configuration version number
DZ8.11.0
```

Blank lines are ignored. Lines that begin with # are comments. Comments are invaluable aids to understanding the arcane `sendmail.cf` file. Lines that begin with an uppercase character are configuration commands. Listing 7.1 contains the commands `D`, `C`, `F`, and `K`.

The local information is defined by `D` commands that define macro variables, `C` commands that define class variables, `F` commands that load class values from files, and `K` commands that define databases of information. The `sendmail.cf` command syntax is very terse. The commands are only one character long and many variables also have one-character names. Add to this the fact that the value assigned to the variable is crammed right next to the variable name and you have configuration commands that are terse and hard to read. Let's take a closer look at the `D`, `C`, `F`, and `K` commands so that we can decipher what is happening in the Local Info section.

The Define Macro Command

The define macro command (`D`) defines a variable and assigns a value to it. Once the variable is defined, the stored value is used by other `sendmail.cf` commands and directly by Sendmail itself. Variables provide the flexibility that permits the same basic `sendmail.cf` configurations to run on many different systems, simply by modifying a few system-specific macro variables.

Traditional variable names are a single ASCII character, with user-created macro variables using uppercase letters as names and Sendmail internal macros using lowercase letters and special characters as names. These rules have changed. Now Sendmail predefines the meaning of several variables with uppercase names, and in Sendmail version 8 variable names are not restricted to a single character. Long variable names are enclosed in curly braces—e.g., `{VirtHost}` is a valid variable name. However, a quick check of the `sendmail.cf` delivered with the Red Hat RPM shows that not a single long variable name was used with a define macro command. Listing 7.2 shows a `grep` that displays every `D` command contained in the entire `sendmail.cf` file.

Listing 7.2 The Define Macro Commands Found in `sendmail.cf`

```
[craig]$ grep '^D' /etc/sendmail.cf
DS
DR
DH
DM
DnMAILER-DAEMON
DZ8.11.0
```

Listing 7.2 shows some interesting things. First, most of the macro variables are not set. The first three `D` commands set values for the `S`, `R`, and `H` variables. Each of these variables identifies an external mail relay server.

- The `S` variable stores the name of the relay host defined by the `SMART_HOST` variable in the `m4` macro configuration. The `SMART_HOST` relay is a central mail server that handles all outgoing mail.
- The `R` variable holds the name of a relay host that handles local mail. The `LOCAL_RELAY define` command in the `m4` macro configuration sets the value for `R`. When `R` is set, the local computer does not handle its own local mail. Mail addressed from local user `craig` to local user `kathy` is not handle by the `local` mailer; it is relayed through the server specified by the `R` variable.
- The `H` variable stores the mail server name defined by the `MAIL_HUB` command in the `m4` macro configuration. The `MAIL_HUB` server handles all local mail in which the recipient address includes the name of the local host. Therefore, while mail addressed to `kathy` might be handled by the `LOCAL_RELAY`, mail from any user logged into `chicken.foobirds.org` that was addressed to `kathy@chicken.foobirds.org` would be relayed through the `MAIL_HUB` server.

It is easy to see why these variables are not set on our sample system. These external relays are used only when the local system does not handle its own e-mail—for example, in a client configuration. So far we have been creating server configurations.

The fourth variable that is not set is `M`. It has nothing to do with relaying. The `M` variable holds the masquerade value. We will play with variable `M` later in this chapter and hear much more about masquerading in Chapter 9, "Special `m4` Configurations."

Only two of the variables in Listing 7.2 have a value assigned to them. The `n` variable holds the sender name that Sendmail uses to send generated error messages. This value can be set in the macro configuration with the `confMAILER_NAME` option. But if it is not set, it defaults to `MAILER-DAEMON`, which is exactly what happened in our sample configuration.

The Z variable is set to 8.11.0 in Listing 7.2. By default, Z is set to the Sendmail version number. The default can be overridden in the macro configuration file by setting a value with the confCF_VERSION option, but it rarely is. About the only time anyone ever changes the Z variable is when they manually update the sendmail.cf file and they want to signal the update to others. People who edit the sendmail.cf file directly will place detailed comments right next to the changes they make, modify the Z variable, and place comments explaining the change near the Z variable declaration. For example, assuming you edited the sendmail.cf file to set a value for M, in addition to placing comments next to the DM command you might make the following modifications to notify others of the change:

```
# Configuration version number
DZ8.11.0/20001004
# Notes on locally made configuration changes
# 20001004 - set the M macro variable to foobirds.org.
#     Change made by Craig Hunt x4096.
```

Again, changes like this are rarely made. Most system administrators maintain the Sendmail configuration through the macro configuration file, not through directly editing the sendmail.cf file. The macro configuration file provides a hook into your revision control system with the VERSIONID macro, making it unnecessary to modify confCF_VERSION to set Z when the macro configuration file is used.

The last two D commands clearly show the run-together nature of sendmail.cf configuration commands. Look at the command

```
DnMAILER-DAEMON
```

D is the command. n is the name of the macro variable. And MAILER-DAEMON is the value being assigned to the variable. The uninitiated find these run-together commands hard to read. When macro variables reference other macro variables, they become even more difficult to read.

To use the value stored in a variable, reference it as $*x*, where *x* is the variable name. Variable references can be used in pattern matching—for example, to test if the username in the sender address was equal to $n. They can also be used to assign values to other variables.

NOTE Macro variables are normally expanded when the sendmail.cf file is read. A special syntax, $&*x*, is used to expand macro variables when they are referenced. The $&*x* syntax is used only with certain internal variables that change at runtime.

None of the define macro commands shown in Listing 7.2 use other macro variables to assign values. In fact, the only D command in the sendmail.cf file on our sample Red Hat system that does use another variable is commented out, as the following grep command shows:

```
[craig]$ grep '^#D' /etc/sendmail.cf
#Dj$w.Foo.COM
```

If this code were not commented out, it would define the value for macro variable j. It defines j as containing the value of variable w ($w), plus the literal string .Foo.COM. w contains your host's unqualified hostname. j is supposed to contain the fully qualified domain name of your host—i.e., hostname plus domain name. Clearly, if you need to define a value for j, you must remove the # that turns this line into a comment and change .Foo.COM into your real domain name. Luckily you never need to manually set j on a Linux system. Running under Linux, Sendmail can automatically determine the correct value for j. This line is included in the configuration only as an aid to administrators of some outdated systems that required manual configuration.

Like j, the values of most internal macro variables are not set in the sendmail.cf file; they are assigned internally by Sendmail. Appendix C, "Sendmail Variables, Options, and Flags," provides a complete listing of all of the predefined variables used by Sendmail.

Using a variable to set a variable is not the only variation of the D command syntax that we didn't see in the sendmail.cf file from our sample Red Hat system. The D command also has a conditional syntax that our sample file did not contain.

Using Conditionals

One variation of the D command syntax that deserves special comment is the conditional format. A D command with the conditional syntax is shown below:

```
Dq$g$?x ($x)$.
```

The D is the define macro command; the q is the variable being defined; and the $g says to assign q the value found in g. The $?x ($x)$. is the conditional statement The $?x is a conditional test. It checks whether or not x has a value set. If x has been set, the value defined by ($x) is assigned to q. The $. ends the conditional.

Given this, the assignment of q is interpreted as follows:

- q is assigned the value of g;
- if x is set, q is also assigned a literal blank, a literal left parenthesis, the value of x, and a literal right parenthesis.

So if `g` contains `kathy@foobirds.org` and `x` contains Kathleen McCafferty, `q` will contain

```
kathy@foobirds.org (Kathleen McCafferty)
```

But if `g` contains `sara@hawk.foobirds.org` and `x` is empty, `q` will contain only

```
sara@hawk.foobirds.org.
```

`$?` is the test—the "if" of the conditional. `$.` is the "endif." The conditional also has "else," which is `$|`. The full syntax of the conditional is

```
$?x value1 $| value2 $.
```

which is interpreted as

```
if ($?) x is set;
    use value1;
else ($|);
    use value2;
end if ($.).
```

This same conditional syntax can be used in other `sendmail.cf` configuration commands. We didn't see it in the `D` commands from our sample system, but we will see it later in the configuration file when we look at the `H` command.

All of the `D` commands shown in Listing 7.2 are found in the Local Info section of the `sendmail.cf` file. Another command that is almost exclusively used in the Local Info section is the `C` command.

The Define Class Command

A `C` command defines a Sendmail class. A class is an array of values. Classes are used for anything with multiple values that are handled in the same way, such as multiple names for the local host or a list of domain names for which mail will be relayed. The `C` command can define the values for a class variable on a single line or on multiple lines. For example, the following line:

```
C{Accept}OK RELAY
```

performs the same function as these two lines:

```
C{Accept}OK
C{Accept}RELAY
```

The syntax of the `C` command is similar to that of the `D` command. The first character is the command `C`. It is followed by the name of the class variable, which in turn is followed

by the value being assigned to the variable. If multiple values are assigned on a single line, they are separated by white space.

Like the Sendmail variables assigned by the D command, class variables traditionally had single character names, with user-created classes using uppercase letters for names and Sendmail internal classes using lowercase letters for names. Now, classes can use long names by enclosing the name inside curly braces—e.g., {Accept}. Listing 7.3 uses a grep command to show all of the C commands contained in the sendmail.cf file delivered with the Red Hat RPM:

Listing 7.3 The Define Class Commands Found in sendmail.cf

```
[craig]$ grep '^C' /etc/sendmail.cf
Cwlocalhost
CP.
CO @ % !
C..
C[[
C{Accept}OK RELAY
C{tls}VERIFY ENCR
CPREDIRECT
C{src}E F H U
```

The first C command in Listing 7.3 adds the value localhost to class w. From the discussion of the local-host-names file in the previous chapter, you know that class w holds all of the computer's hostname aliases. In that chapter we used sendmail –bt to view the contents of class w, so you also know that class w contains much more than just the word localhost. Unlike a D command, which overwrites the contents of a variable to set the variable to a specific value, C commands are additive. This C command doesn't replace everything in class w with the word localhost; it adds the word localhost to whatever else is there.

The class variable P is a good example of the additive nature of C commands. The second C command in Listing 7.3 stores the value . (dot) in class variable P. Later, in the second-to-last line of Listing 7.3, another C command stores the value REDIRECT in the same class variable P. After the latter command, P contains both a . (dot) and the word REDIRECT, as this sendmail –bt test shows:

```
[root]# sendmail -bt
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> $=P
```

```
.
REDIRECT
> ^D
```

`P` holds the list of pseudo-domains. As explained earlier, pseudo-domains are not real domains found in the DNS; they are values used to request special processing from Sendmail. The dot is always defined as part of this class. The value `REDIRECT` is added because the `redhat.mc` file that built this `sendmail.cf` file contained the `FEATURE(redirect)` command. The `CPREDIRECT` command in this `sendmail.cf` file clearly demonstrates the direct impact that the macro configuration you build has on the Sendmail configuration.

The third `C` command assigns the values `@`, `%`, and `!` to the class variable `O`. Class `O` holds tokens that are used to divide the parts of an e-mail address. These three values are characters that cannot be used in local usernames, because they have special meanings in e-mail addresses. Everyone is familiar with the role that `@` plays in an address. Those who are familiar with UUCP known that `!` is used in traditional UUCP bang addressing. And the `%` character is used in old systems as a way to forward an e-mail address to a remote system for processing. These are default values set by Sendmail that do not need to be modified.

The next two `C` commands, `C..` and `C[[`, are unique for two reasons. First, they demonstrate that variables can be given names that are special characters. Here we are assigning values to the class variable `.` and to the class variable `[`. Secondly, and more surprisingly, the commands assign these variables a value that exactly matches the name of the variable. Thus variable `.` is assigned the value `.` and variable `[` is assigned the value `[`. Strange! We know from the discussion of the `D` command that variables can be used in pattern matching. Class variables are only used in pattern matching. So why create a variable for `.` and `[` when a pattern match could just as easily compare against the literal value? There are reasons.

Special symbols are used when referring to classes in a pattern. Above, we saw that the value in an individual variable is referred to as `$`*x*, where *x* is the variable name. The `$=` symbol matches any value in a class, and the `$~` symbol matches any value not in a class. Thus `$=P` means any value in class `P` and `$~[` means anything that is not in class `[`.

One reason to define classes named `.` and `[` is that classes are expandable. The characters . and [have special meaning in addresses. The . character separates the parts of a domain name. The [character encloses raw IP addresses that are being used in place of hostnames in e-mail addresses. Classes allow Sendmail to compare a value against a list of values, instead of against a single value. This means that if the range of possible characters that can be used to separate domain names ever increases or the range of characters used to

enclose special addresses ever changes, values could be added to the . and [classes to handle these changes without changing the entire sendmail.cf file.

The second advantage of a class over a literal is that the $~ syntax allows Sendmail to check for a "not equal" condition. A grep of the sample sendmail.cf in Listing 7.4 shows that, at least in the case of the [class, this capability is important.

Listing 7.4 Checking How Classes Are Used

```
[craig]$ grep '\$\=\.' /etc/sendmail.cf
[craig]$ grep '\$\=\[' /etc/sendmail.cf
[craig]$ grep '\$\~\.' /etc/sendmail.cf
[craig]$ grep '\$\~\[' /etc/sendmail.cf
R< $~[ : $* > $*    $>MailerToTriple < $1 : $2 > $3  check -- resolved?
R$* <$~[ : $* > $*  $>MailerToTriple < $2 : $3 > $4  check -- resolved?
R< $~[ : $* > $*    $>MailerToTriple < $1 : $2 > $3  "." found?
```

Listing 7.4 shows some interesting things. When used in the configuration, class variable . must be referenced as either $=. or $~., and class variable [must be referenced as either $=[or $~[. Using grep to search for these values shows how these class variables are used. First off, class . is not used at all, and there are no tests using $=[to see if a value exists in the [class variable. However, $~[is used to select addresses that do not start with a [. This is not the time to discuss the exact details of the pattern matching. Pattern matching is covered in detail in Chapter 8. The thing to understand here is that even inexplicable commands such as C[[might have a valid use.

> ***NOTE*** Remember that your system might be different. These same class names may be used for other purposes on your system. This only shows how they are used in our example sendmail.cf. Carefully read the comments in your sendmail.cf file for guidance as to how classes and variables are used in your configuration.

The next two lines in Listing 7.3 are:

```
C{Accept}OK RELAY
C{tls}VERIFY ENCR
```

These two C commands both use long class variable names, {Accept} and {tls}, and both define keywords used to configure some aspect of Sendmail. You recognize the OK and RELAY keywords from the discussion of the access database in Chapter 6, "Using Sendmail Databases." You'll see the VERIFY and ENCR keywords in the discussion of STARTTLS in Chapter 12, "Sendmail Security."

The last line in Listing 7.3 is `C{src}E F H U`. It does essentially the same thing as the two commands just described above. It defines a long class variable name, `{src}`, and it assigns a list of values to that class that are used in the Sendmail syntax. In this case, the values are tags internally assigned by Sendmail to addresses to aid it in processing the various types of addresses that can be found in the Sendmail databases. What is unique about this `C` command is that it occurs outside of the Local Info section. All of the other `C` commands are found in Local Info. This illustrates the fact that, while most variables are declared in the Local Info section, they can be declared anywhere in the `sendmail.cf` file as long as they are declared before they are used. This `C` command occurs immediately before the ruleset that uses it. On the other hand, all active `F` commands in our sample `sendmail.cf` file are located in the Local Info section.

Loading a Class Variable from a File

The `F` command loads values into a class variable from a file. The Local Info section from the sample `sendmail.cf` file contains only two `F` commands, which are shown in Listing 7.5.

Listing 7.5 Commands that Load Class Variables from a File

```
[root]# grep '^F' /etc/sendmail.cf
Fw/etc/mail/local-host-names
FR-o /etc/mail/relay-domains
```

The first `F` command is the simplest form of the command syntax—the `F` command followed by the variable name, in this case `w`, and the pathname of the file that is to be loaded into the variable, which in this case is `/etc/mail/local-host-names`. This simple form of the `F` command is the most commonly used, but it is not the only format. The `F` command syntax accepts an optional switch value before the pathname of the file and an optional `scanf` pattern after the file pathname.

By default, Sendmail reads data from the file using the `scanf` pattern `%s`, which means it reads the first white space–delimited string from each line in the file. A different `scanf` pattern can be provided on the `F` command line if Sendmail is compiled with the `SCANF` compiler option. We saw from the `sendmail -bt -d0.4` command in Listing 6.1 in Chapter 6 that the copy of Sendmail delivered with the Red Hat RPM does use the `SCANF` compiler option. Therefore, we could enter a command in the following format if we needed to:

```
Fw/etc/mail/local-host-names %.25s
```

This command reads data from `local-host-names` into class `w` but it reads no more than 25 characters from a string even if a whitespace character has not been encountered. Why would you do this? You wouldn't. This is just an example of the possible syntax. I never use a `scanf` pattern with the `F` command, and neither should you. You should not expect

Sendmail to clean up a file as it is reading it. You should present Sendmail with files that are already clean and properly formatted. Doing otherwise confuses the other system administrators who might be called in to maintain your system and introduces the possibility that you will create a bad `scanf` pattern that can be exploited by an intruder in a buffer-overflow attack.

> ***NOTE*** `scanf` is a C language library routine. C programming and the details of `scanf` are beyond the scope of this book. For more information, see *The C Programming Language* by Brian Kernighan and Dennis Ritchie (Prentice Hall, 1988).

The second `F` command in Listing 7.5 loads class `R` from the file `/etc/mail/relay-domains`. As you'll recall from Chapter 6, class `R` holds the names of domains for which Sendmail will relay mail and the `relay-domains` file is the traditional way to load values into class `R`. The interesting thing about this `F` command is that the `–o` switch is used before the pathname. The `–o` switch tells Sendmail that the `relay-domains` file is optional. Notice that the `local-host-names` file used in the first `F` command does not have the `–o` switch, and therefore is mandatory. That's why we got the error "cannot open '/etc/mail/local-host-names'" in Listing 4.2 of Chapter 4 ("Creating a Basic Sendmail Configuration") when we tried to use the `generic-linux.cf` configuration file without a `local-host-names` file, but we got no complaint at all about the fact that we didn't have a `relay-domains` file. The `–o` switch is very useful because it creates a more forgiving configuration that works in a wide variety of situations.

While the `–o` switch is the only switch available with the `F` command, the `K` command, our next topic, has several possible switch values. The `K` command is the most complex command used in the Local Info section. It needs to be. Unlike the `F` command that works with simple flat files, the `K` command deals with true database files.

The Keyed File Command

The last of the four commands from the Local Info section is the `K` command, which defines a Sendmail database's characteristics for the `sendmail.cf` file. The `K` command has the most complex syntax of any command in the Local Info section. The basic format of a `K` command is:

```
K name type switches path
```

The various pieces of the command are separated by white space, although the white space between `K` and *`name`* is optional and rarely used. `K`, of course, is the command. *`name`* is the name used inside `sendmail.cf` to reference this database. The *`name`* can be any text string you want, but the *`name`* should be something logical, such as the external filename of the database.

The *K* Command Type Argument

type is the database type. Several database types were discussed in Chapter 6 in relationship to which compiler options add support for which database types. The long list of database types discussed in Chapter 6, however, is only part of the story. Sendmail has several internal database types. Table 7.1 lists all of the valid *type* values.

Table 7.1 Valid K Command Type Values

Type	Description
arith	An internal routine for doing arithmetic.
btree	A type added by the NEWDB compiler option.
bestmx	An internal routine that retrieves the MX record for a host.
dbm	A type added by the NDBM compiler option.
dequote	An internal routine that removes quotation marks.
dns	An internal routine that retrieves the address record for a host name.
hash	A type added by the NEWDB compiler option.
hesiod	A database located on a hesiod server.
host	An internal table for hostnames.
implicit	The type used for the aliases database file.
ldap	A database located on an LDAP server.
netinfo	A database located on a NeXT netinfo server.
nis	A database located on an NIS server.
nisplus	A database located on an NIS+ server.
null	An internal routine that returns "Not found" for all lookups.
ph	A database located on a CCSO Nameserver.
program	Passes the query to an external program.

Table 7.1 Valid K Command Type Values *(continued)*

Type	Description
regex	An internal routine that handles regular expressions.
sequence	Defines a search list to search multiple databases.
switch	References an entry in the nsswitch.conf file or the host.conf file to create a database sequence.
text	A text file database.
user	The type used for the /etc/passwd file.

On a Linux system, many of these database types are not used. The internal types are always available, but are set up by Sendmail when they are needed and thus require no intervention by you. btree and hash are the only two types you are likely to use for the external databases that you create yourself. But even in that case, you will declare the database using a FEATURE macro in the macro configuration file; you won't create your own K commands in the sendmail.cf file. As noted in Chapter 6, all of the databases created by FEATURE commands default to hash type.

The *K* Command Switches

The *switches* that optionally follow *type* on the K command line specify optional processing. Table 7.2 lists the valid switches.

Table 7.2 Valid K Command Switches

Switch	Description
–A	Accepts values from duplicate keys.
–a	Appends the specified string to the values returned by the lookup.
–f	Preserves uppercase.
–k	Identifies the column used as the key in a flat file lookup.
–m	Verifies the key but doesn't return a value.
–N	Indicates that the keys in the database always end with a null byte.

Table 7.2 Valid K Command Switches *(continued)*

Switch	Description
–0	Indicates that the keys in the database never end with a null byte.
–o	Specifies that the database is optional, so no error is produced if the file is not found.
–q	Preserves quotes in the keys, which are normally removed.
–s	Replaces spaces with the specified character.
–v	Identifies the column used as the value in a flat file lookup.
–z	Specifies the character used to delimit columns for flat file lookups.

Some of these switches mirror options defined when the database is built. These are:

–A This option makes sense only for a database that has duplicate keys, which means the database must be built with the `makemap –d` option. Recall the `staff` mailing list from Listing 6.5 in Chapter 6. The alias `staff` pointed to five recipient addresses. Assume that that mailing list was replicated as a group of five entries in some odd database that allowed duplicate keys:

```
staff  kathy
staff  craig
staff  david@parrot
staff  sara@hawk
staff  becky@parrot
```

If the `K` command that declared this odd database inside the `sendmail.cf` file did *not* have the `–A` switch, a query for `staff` would return `kathy`. But if the `–A` switch was used, Sendmail would access all of the duplicate keys and append all of the values returned for those keys. Thus, a query for `staff` would return `kathy`, `craig`, `david@parrot`, `sara@hawk`, and `becky@parrot`, which exactly matches the original mailing list. Of course, you wouldn't actually do this, because the `aliases` database already handles mailing lists and does a better job of it. This is just an example.

–f This option preserves uppercase characters. It directly relates to the `–f` option used with `makemap` that preserves uppercase characters when the database is built. Normally, all characters are converted to lowercase characters. E-mail addresses are

supposed to be case insensitive. Avoid introducing case-sensitivity into a process that is defined as case insensitive. Don't use –f.

–N This option tells Sendmail that the database keys end with a null character. If the makemap command used to build the database used –N, which inserts a null character at the end of each key, the database can be read using the –N switch on the K command line. The inverse of this is the –O switch that tells Sendmail that the keys do not end with null characters. If neither the –N nor the –O switches are used, Sendmail will successfully match keys whether or not the keys end in a null character. Using either –N or –O reduces the robustness of Sendmail. –N or –O might slightly increase the performance of database lookups, but they do so at the cost of reliability.

Two switches handle embedded spaces. Spaces are not allowed inside standard RFC 822 e-mail addresses. If spaces are included, they must be enclosed in quotes or replaced with characters that are allowed. The –q switch retains the quotes, which are normally removed unless they are "escaped" by a backslash character. The –s switch converts spaces to another character. For example, –s- converts spaces to dashes. The –s switch is only used with dequote, because dequote is the internal routine that removes the quote marks that surround embedded spaces.

Three switches are used to treat traditional flat files as if they were databases. –k identifies the column of text that should be used as the key, –v identifies the column of text that should be used as the value returned for the key, and –z identifies the character that is used to separate columns in the flat file. By default, white space separates columns. The /etc/passwd file is a classic flat file that is not delimited by white spaces. Each column in /etc/passwd is separated by a colon (:). Imagine using the passwd file as a database to retrieve the home directory based on the login username. Here is the passwd entry for craig on our sample system:

```
[craig]$ grep '^craig' /etc/passwd
craig:x:500:500:Craig Hunt:/home/craig:/bin/bash
```

The first column contains the username, and the sixth column contains the home directory. The –k and –v switches count columns from zero. So the first column is 0 and the sixth column is 5. The following K command defines a database that uses /etc/passwd to convert a username to a home directory path:

```
Khomedir text -z: -k0 -v5 /etc/passwd
```

Here K is the command. homedir is the internal name used for this database, and text is the database type. –z: –k0 –v5 are the switches, and /etc/passwd is the path. Given this declaration, a rewrite rule later in the sendmail.cf file could pass the key value craig to the homedir database and receive /home/craig as a response. Would you actually do

this? Probably not. Sendmail already knows the home directory associated with a local username without any help from you. (It is the values stored in variable `$z`.) Just because Sendmail provides a configuration option doesn't mean you will ever need to use it.

Most switches fall into the category of configuration options that you will never use. The `–m` switch verifies that a key exists but does not return the value for the key. This is rarely used because a successful lookup in a normal database both validates the key and returns the value for the key. The `–a` switch appends a fixed string to the value returned for a lookup. For example, `–a.foobirds.org` adds the string `.foobirds.org` to every response from the database. This switch is rarely used, because if every value in a database needs to have a specific value appended, it can very easily be done when the database is originally built without any manual modification of the `sendmail.cf` file.

The most commonly used, and most important, switch is `–o`. `–o` tells Sendmail that a database is optional. With this switch, a `K` command can be included in `sendmail.cf` in anticipation of the need for a database without requiring that the database be present. Without the `–o` switch, Sendmail will fail on the first command that attempts to access the database if the database file cannot be found. Using `–o` makes Sendmail more forgiving and more robust.

We have covered most of the `K` command syntax: the database name, the database type, and the switches. The last field in the `K` command is the *`path`*. This is simply the pathname of the database, generally written without the filename extension. (The K command adds the correct extension—for example, `.db`—to the pathname based on the database type.) The *`path`* value is only required if the database is external to Sendmail. As the list of database types made clear, several of the databases declared by `K` commands are internal to Sendmail. When an internal database is used, no *`path`* is needed. Some sample `K` commands from the `sendmail.cf` file will make the structure of the command clear.

Realistic *K* Commands

The sample configuration contains five `K` commands, all of which are shown in Listing 7.6.

Listing 7.6 The `K` Commands Found in `sendmail.cf`

```
[craig]$ grep '^K' /etc/sendmail.cf
Karith arith
Kdequote dequote
Kmailertable hash -o /etc/mail/mailertable
Kvirtuser hash -o /etc/mail/virtusertable
Kaccess hash /etc/mail/access
```

Let's work our way through Listing 7.6 from the bottom up. The last `K` command declares a database named `access`. The database is the standard `hash` type. The file that contains

the database is /etc/mail/access. All of this information—the internal name, the database type, and the file that holds the database—defined by the K command is the direct result of the FEATURE(`access_db') command from our sample macro configuration file. The access database, which is used to control mail relaying and delivery, is covered in Chapter 6.

The previous two K commands define the virtuser and mailertable databases that result from the following commands found in the sample macro configuration file:

```
FEATURE(`mailertable', `hash -o /etc/mail/mailertable')
FEATURE(`virtusertable', `hash -o /etc/mail/virtusertable')
```

Both are hash type databases, and both use the –o switch, which means that Sendmail will run even if these files are not found. Notice that the K command for the access database did not use the –o switch. If the file /etc/mail/access.db is not found, Sendmail will fail if a command attempts to use the access database. Even if you don't have any entries for the access database, create an empty /etc/mail/access.db file in order to make Sendmail more robust, as in this example:

```
[root]# touch /etc/mail/access
[root]# makemap hash /etc/mail/access < /etc/mail/access
```

The mailertable, the virtusertable, and the access database are all covered in Chapter 6. The other two databases, however, were not covered in that chapter. Both the arith and dequote databases are pseudo-databases. That means that they are not real databases. Instead they are internal Sendmail routines that are accessed by rewrite rules as if they were databases. The dequote map, which has already been discussed, is used to remove quotation marks from addresses. The arith map is used to do arithmetic functions for STARTTLS security. STARTTLS is covered in Chapter 12.

The four commands, D, C, F, and K, illustrate everything that is done in the Local Info section of the sendmail.cf file. The Local Info section is the most important section of the file from the standpoint of a system administrator trying to directly configure sendmail.cf, because it defines the configuration information that varies from system to system. We have covered every command in the Local Info section of our sample system, but before moving on to the Options section, we should cover the only configuration command that occurs before the Local Info section—the version level command.

The Version Level Command

The version level command (V) defines the version of the sendmail.cf file. This should not be confused with the Z variable that identifies the Sendmail source code release number or the m4 VERSIONID macro that defines revision control information for the macro

source files. The V command tells Sendmail the level of syntax and commands required to support the configuration. If the Sendmail program cannot support the requested commands and syntax, it complains about the commands it does not understand and displays the following version level error message:

```
[root]# sendmail -v -t
/etc/sendmail.cf: line 83: readcf: map arith: class arith
not available
/etc/sendmail.cf: line 211: DaemonPortOptions parameter
   "Name=MTA" unknown
/etc/sendmail.cf: line 212: DaemonPortOptions parameter
   "Name=MSA" unknown
/etc/sendmail.cf: line 212: DaemonPortOptions parameter "M=E" unknown
Warning: .cf version level (9) exceeds sendmail version 8.9.3
   functionality (8)
```

On the other hand, if the Sendmail program is newer than the configuration, the program can support more features than the configuration uses. In that case, Sendmail displays the error we first saw in Chapter 3, "Running Sendmail."

```
[root]# sendmail -v -t -C /etc/sendmail.cf
Warning: .cf file is out of date: sendmail 8.11.0 supports version 9,
   .cf file is version 8
No recipient addresses found in header
^D
```

The version level command is a key component of warning Sendmail about potential incompatibility.

You don't change the V command in the `sendmail.cf` file. And unlike most other things in the `sendmail.cf` file, you do not control the setting of the V command using an `m4` macro in the macro control file. The V command is inserted into the `sendmail.cf` file when it is first built by `m4`. Listing 7.7 shows the commands that occur before the Local Info section, including the V command.

Listing 7.7 The V Command from the Sample sendmail.cf

```
# level 9 config file format
V9/Berkeley

# override file safeties - setting this option compromises security,
# addressing the actual file configuration problem is preferred
# need to set this before any file actions are encountered in
   the cf file
#O DontBlameSendmail=safe

# default LDAP map specification
# need to set this now before any LDAP maps are defined
#O LDAPDefaultSpec=-h localhost
```

The format of the V command is **V***level*/*vendor*. The *level* number on the V command line indicates the version level of the configuration syntax. V9 is the version supported by Sendmail 8.11.0. The *vendor* part of the V command identifies whether any vendor-specific syntax is supported. The default *vendor* value for the Sendmail distribution is Berkeley, which is the vendor value used for Linux.

Everything after the V command and before the Local Info section is a comment, as indicated by the fact that the lines start with a # character. However, two of these lines are commented-out option commands:

```
#O DontBlameSendmail=safe
#O LDAPDefaultSpec=-h localhost
```

The first one disables Sendmail's file security, which is obviously a bad idea. It is used only when absolutely required to read a given file. The second one defines the default LDAP map specification, which is only used if LDAP is used. As the O command indicates, both of these are options, and they are the only options that are located outside of the Options section of our sample sendmail.cf file. They occur before the Local Info section because they must be declared before they are used, and if they are used at all it is by file and database references that occur in the Local Info section of the file. All other options are found in the Options section.

The Options Section

The Sendmail program uses option values to define the Sendmail environment. There are nearly 100 options, all of which are listed in Appendix C. A few samples from the sendmail.cf file are shown in Listing 7.8 to illustrate what options do.

Listing 7.8 Sample Option Commands from `sendmail.cf`

```
# location of alias file
O AliasFile=/etc/aliases
# Forward file search path
O ForwardPath=$z/.forward.$w:$z/.forward
# timeouts (many of these)
O Timeout.queuereturn=5d
O Timeout.queuewarn=4h
```

These options all have something to do with Sendmail functions that have already been discussed. The first `O` command sets the location of the `aliases` file to `/etc/aliases`. The second option defines the location of the `.forward` file. Notice the `$z` and `$w` included in this option. These are Sendmail variables in action. Given the fact that you already know that the `.forward` file is in the user's home directory, you can guess that the value of the `$z` variable is the user's home directory. The `$w` variable contains the computer's hostname, indicating that it is possible to use the computer's hostname as a filename extension on a `.forward` file.

> ***NOTE*** A variable and a class variable can exist with the same name, and still be two different things. A variable is used to provide a value, as in Listing 7.8 where `$w` provides a hostname, and a class is used to test a value. `$w` is not the same as `$=w`. `$=w` holds all of the names by which the local host is known. `$w` holds only the primary hostname of the local host and thus returns only a single value.

The last two options in the example relate to processing the queue of undelivered mail. The first of these options tells Sendmail that if a piece of mail stays in the queue for five days (`5d`), it should be returned to the sender as undeliverable. The second of these options tells Sendmail to send the user a warning message if a piece of mail has been undeliverable for four hours (`4h`).

This section requires no direct modifications. All of the options can be set through the `m4` macro configuration file. The four values shown in Listing 7.8 could be set with these `m4` commands:

```
define(`ALIAS_FILE', `/etc/aliases')
define(`confFORWARD_PATH', `$z/.forward.$w:$z/.forward')
define(`confTO_QUEUERETURN', `5d')
define(`confTO_QUEUEWARN', `4h')
```

The options in the `sendmail.cf` file that comes with your Linux system are correctly defined for that system. I have never directly edited the Options section of a Linux

sendmail.cf file. In fact, the last time I edited an Options section was years ago, before the development of the m4 macros. It was sometimes necessary back then to move a sendmail.cf from one operating system to another. In those cases, it was necessary to edit the options to fit the new environment. That is not necessary now, because the m4 macros build a sendmail.cf customized for the target operating system. The Message Precedence section that follows the Options section also requires no modifications.

The Message Precedence Section

Message Precedence is used to assign priority to messages entering the queue. By default, mail is considered "first-class mail" and is given a precedence of 0. The higher the precedence number, the greater the precedence of the message. But don't get excited. Increasing priority is essentially meaningless. About the only useful thing you can do is select a negative precedence number, which indicates low-priority mail. Because error messages are not generated for mail with a negative precedence number, low priorities are useful for mass mailings. The precedence values from the sample sendmail.cf are shown in Listing 7.9.

Listing 7.9 Standard Message Precedence Values

```
############################
#   Message precedences    #
############################
Pfirst-class=0
Pspecial-delivery=100
Plist=-30
Pbulk=-60
Pjunk=-100
```

The P command defines precedence. The format of the command is:

P*name*=*number*

where P is the command. *name* is the text name used to request the precedence and *number* is the numeric precedence value associated with the text name.

To request a precedence, mail must include a Precedence header that specifies the name associated with the desired precedence. For example, to request a precedence of -30, add the following header to the mail message:

```
Precedence: list
```

Precedence values are rarely used, and to be of any use at all, the remote user must know the precedence names. The five precedence values included in the sendmail.cf file are the standard names that are known to all other mail systems. If you add a new precedence

value, most remote users will never know the name associated with the precedence and thus will not use it. The precedence values that come with your Linux system are more than you'll ever need.

The Trusted Users Section

Trusted users are allowed to change the sender address when sending mail. The `T` command defines trusted users. It syntax is:

```
T=user
```

where `T` is the command and *`user`* is a valid username from the `/etc/passwd` file.

The trusted users defined in the `sendmail.cf` file that comes with your Linux system are `root`, `uucp`, and `daemon`. The entire Trusted Users section is shown in Listing 7.10.

Listing 7.10 The `sendmail.cf` Trusted Users Section

```
######################
#   Trusted users    #
######################
# this is equivalent to setting class "t"
#Ft/etc/mail/trusted-users
Troot
Tdaemon
Tuucp
```

The `T` command is not the only way to define trusted users. Any user listed in class `t` is a trusted user. As described in Chapter 6, usernames can be added to class `t` with the `confTRUSTED_USERS` parameter or the `use_ct_file` feature in the `m4` macro configuration. If `use_ct_file` is specified, trusted users are read from the `/etc/mail/trusted-users` file. In this configuration, the `use_ct_file` feature was not used. If it had been used, the `F` command located before the `T` commands in Listing 7.10 would not be commented out.

NOTE Do not modify the Trusted Users list. Allowing users to send mail using another user's name is a potential security problem.

The Format of Headers Section

The Format of Headers section defines the headers that Sendmail inserts into mail. Headers are defined by the `H` command. The header definitions from the `sendmail.cf` file are shown in Listing 7.11.

Listing 7.11 Header Formats in `sendmail.cf`

```
#########################
#   Format of headers   #
#########################
H?P?Return-Path: <$g>
HReceived: $?sfrom $s $.$?_($?s$|from $.$_)
   $.$?{auth_type}(authenticated$?{auth_ssf} (${auth_ssf} bits)$.)
   $.by $j ($v/$Z)$?r with $r$. id $i$?{tls_version}(using
   ${tls_version} with cipher ${cipher} (${cipher_bits} bits)
   verified ${verify})$.$?u for $u; $|; $.$b
H?D?Resent-Date: $a
H?D?Date: $a
H?F?Resent-From: $?x$x <$g>$|$g$.
H?F?From: $?x$x <$g>$|$g$.
H?x?Full-Name: $x
# HPosted-Date: $a
# H?l?Received-Date: $b
H?M?Resent-Message-Id: <$t.$i@$j>
H?M?Message-Id: <$t.$i@$j>
```

Each header line begins with the `H` command, which is optionally followed by header flags enclosed in question marks. The header flags control whether or not the header is inserted into mail bound for a specific mailer. If no flags are specified, the header is used for all mailers. If a flag is specified, the header is used only for a mailer that has the same flag set in the mailer's definition. (Mailer definitions are covered later in this chapter.) Header flags only control header insertion. If a header is received in the input, it is passed to the output, regardless of the flag settings.

Each line also contains a header name, a colon, and a header template. These fields define the structure of the actual header. Macros in the header template are expanded before the header is inserted in a message. The first header in Listing 7.11 contains `$g`, which tells Sendmail to use the value stored in the `g` macro. The `g` macro holds the sender's e-mail address. Assume that the sender is David. After the macro expansion, the header might contain:

```
Return-Path: <david@wren.foobirds.com>
```

The headers in Listing 7.11 provide examples of using the conditional syntax in header templates. The conditional syntax is an if/else construct where `$?` is the "if," `$|` is the "else," and `$.` is the "endif." This is exactly the same conditional syntax that was described for the `D` command, and it is used in the same way. An example from Listing 7.11 is:

```
H?F?Resent-From: $?x$x <$g>$|$g$.
```

`H` is the command. `?F?` is a flag value. `Resent-From:` is the header name, and `$?x$x <$g>$|$g$.` is the template, which uses conditional syntax. This conditional template says that if (`$?`) macro `x` exists, use `$x <$g>` as the header template, else (`$|`) use `$g` as the template. Macro `x` contains the full name of the sender. Thus, if it exists, the header is

```
Resent-From: David Craig <david@wren.foobirds.org>
```

If `x` doesn't exist, the header is

```
Resent-From: david@wren.foobirds.org
```

The headers provided in the Linux `sendmail.cf` file are sufficient for a basic installation. You'll see additional header declarations in Chapter 11, "Stopping Spam," for mail filtering, but the basic declarations shown in Listing 7.11 will be found on all systems.

All five sections discussed so far—Local Info, Options, Message Precedence, Trusted Users and Format of Headers—define configuration values used by Sendmail. These sections are essentially passive, telling Sendmail things such as the structure of headers or the locations of files. These sections have not defined the actions that Sendmail should take. That changes with the next section. The Rewrite Rules section contains the instructions that Sendmail uses to process mail.

The Rewriting Rules Section

The Rewriting Rules section defines the rules used to parse e-mail addresses from user mail programs and rewrite them into the form required by the mail delivery programs. Rewrite rules match the input address against a pattern and, if a match is found, rewrite the address in a new format using the rules defined in the command. The format of a rewrite rule is:

```
Rpattern    template
```

where `R` is the command. *`pattern`* selects the address to be modified and *`template`* rewrites the address.

Rewrite rules divide e-mail addresses into tokens for processing. Tokens are strings of characters delimited by operators defined in the `OperatorChars` option, and the operators themselves. The left-hand side of a rewrite rule contains a pattern defined by macro variables and literal values and by special symbols. The tokens from the input address are matched against the pattern. If the address matches the pattern, the address is rewritten using the template defined in the right-hand side of the rewrite rule. The template is also defined with literals, macro values, and special symbols.

A rewrite rule may process the same address several times because, after being rewritten, the address is again compared against the pattern. If it still matches, it is rewritten again. The cycle of pattern matching and rewriting continues until the address no longer matches the pattern. Then no further processing is done by this rewrite rule, and the address is passed to the next rule in line.

Individual rewrite rules are grouped together in rulesets so that related rewrite rules can be referenced by a single name or number. The `S` command marks the beginning of a ruleset and identifies it with a name and optionally a number. Therefore, the command `Sfinal=4` marks the beginning of the ruleset known as either `final` or `4`, and `SLocal_check_mail` marks the beginning of the `Local_check_mail` ruleset.

> ***NOTE*** Prior to Sendmail 8.11, many rulesets were known only by numbers and did not have associated names.

Rewrite rules are the heart of the `sendmail.cf` file and they make up the bulk of the command lines in the configuration file. The sample `sendmail.cf` we have been examining in this chapter contains more than 425 rewrite rules. The number of rules, the complexity of the syntax, and the importance of rewrite rules all demand that rewrite rules receive detailed coverage. For that reason, the entire following chapter is dedicated to rewrite rules.

Not all rewrite rules are found in the Rewrite Rules section. Several rulesets are associated with specific mailers defined in the Mailer Definitions section.

The Mailer Definitions Section

The Mailer Definitions section defines the instructions used by Sendmail to invoke the mail delivery programs. Mailer definitions begin with the mailer command (`M`). Searching through the Mailer Definitions section of the sample `sendmail.cf` configuration file for lines that begin with `M` produces the mailer definitions list shown in Listing 7.12.

Listing 7.12 The Mailers defined in `sendmail.cf`

```
Mesmtp,         P=[IPC], F=mDFMuXa, S=EnvFromSMTP/HdrFromSMTP,
                R=EnvToSMTP, E=\r\n, L=990,
                T=DNS/RFC822/SMTP,
                A=TCP $h
Msmtp8,         P=[IPC], F=mDFMuX8, S=EnvFromSMTP/HdrFromSMTP,
                R=EnvToSMTP, E=\r\n, L=990,
                T=DNS/RFC822/SMTP,
                A=TCP $h
Mdsmtp,         P=[IPC], F=mDFMuXa%, S=EnvFromSMTP/HdrFromSMTP,
                R=EnvToSMTP, E=\r\n, L=990,
                T=DNS/RFC822/SMTP,
                A=TCP $h
Mrelay,         P=[IPC], F=mDFMuXa8, S=EnvFromSMTP/HdrFromSMTP,
                R=MasqSMTP, E=\r\n, L=2040,
                T=DNS/RFC822/SMTP,
                A=TCP $h
Mlocal,         P=/usr/bin/procmail, F=lsDFMAw5:/|@qSPfhn9,
                S=EnvFromL/HdrFromL, R=EnvToL/HdrToL,
                T=DNS/RFC822/X-Unix,
                A=procmail -Y -a $h -d $u
Mprog,          P=/usr/sbin/smrsh, F=lsDFMoqeu9, S=EnvFromL/HdrFromL,
                R=EnvToL/HdrToL, D=$z:/,
                T=X-Unix/X-Unix/X-Unix,
                A=smrsh -c $u
Mprocmail,      P=/usr/bin/procmail, F=DFMSPhnu9,
                S=EnvFromSMTP/HdrFromSMTP,
                R=EnvToSMTP/HdrFromSMTP,
                T=DNS/RFC822/X-Unix,
                A=procmail -Y -m $h $f $u
```

The `sendmail.cf` file created by the `redhat.mc` macro configuration contains eight mailer definitions. The first five mailer commands define mailers for TCP/IP mail delivery. The first one, designed to deliver traditional seven-bit ASCII SMTP mail, is called `smtp`. The next mailer definition is for Extended SMTP mail and is called `esmtp`. (It is the default mailer used for Internet mail.) The `smtp8` mailer definition handles unencoded eight-bit SMTP data bound for remote servers that can't handle Extended SMTP. The `dsmtp` mailer is used when the recipient server initiates the mail connection and downloads mail with the `ETRN` command. Finally, `relay` is a mailer that relays TCP/IP mail through an external mail relay host. All of these mailers were covered in Chapter 5, "Understanding a Vendor's Configuration," in relationship to the `MAILER(smtp)` macro

configuration command that inserts this set of mailers into the `sendmail.cf` file. This set of mailers is required by every system that sends mail over a TCP/IP network, such as the Internet.

Two other mailer definitions in the list are required by Sendmail, and thus found in all configurations. The first of these defines a mailer for local mail delivery. This mailer must always be called `local`. The second definition specifies a mailer, which is always called `prog`, for delivering mail to programs. Sendmail expects to find both of these mailers in the configuration and requires that they be given the names `local` and `prog`. All other mailers can be named anything the system administrator wishes. However, in practice, that is not the case. Because the `sendmail.cf` files on all Linux systems are built from the same `m4` macros, they all use the same mailer names. The `m4` macro that adds `prog` and `local` to the configuration is `MAILER(local)`. This sample configuration uses `smrsh` as the `prog` mailer and `procmail` as the `local` mailer because of the `FEATURE(`smrsh', `/usr/sbin/smrsh')` and the `FEATURE(local_procmail)` commands in the `m4` configuration that created this `sendmail.cf` file.

The last definition is for `procmail`. This `procmail` mailer has nothing to do with the use of `procmail` as the `local` mailer. This definition invokes `procmail` with the `–m` command-line argument, which allows `procmail` to be used for mail filtering. `procmail` mail filtering features are covered in Chapter 11.

The *M* Command

The `M` command defines the mail delivery programs used by Sendmail. The syntax of the command is:

```
Mname, field=value, field=value, ...
```

`name` is an arbitrary name used internally by Sendmail to refer to the mailer. With the exception of the `prog` and `local` mailer names required by Sendmail, the name doesn't matter as long as it is used consistently within the `sendmail.cf` file to refer to this mailer. For example, the mailer used to deliver SMTP mail within the local domain could be called `smtp` on a Linux system, and `ether` on some other system. The function of both mailers is the same, only the names are different. The basic mailer names are the same from system to system only because they come from the same `m4` macros. Customized mailers created inside the `sendmail.cf` file by adventurous Sendmail administrators can be named anything.

The mailer name is followed by a comma-separated list of *`field=value`* pairs that define the characteristics of the mailer. Table 7.3 shows the single character field identifiers, a text name for the field, and a description of the value associated with the field. No mailer requires all of these fields.

Table 7.3 Mailer Definition Fields

Field	Name	Value
P	Path	The full pathname of the mailer program.
F	Flags	The `sendmail` flags used by this mailer.
S	Sender	The rulesets that process sender addresses for this mailer.
R	Recipient	The rulesets that process recipient addresses for this mailer.
A	Argv	This mailer's command line.
E	End-of-line	The end-of-line string for this mailer.
M	Maxsize	The maximum message length supported by this mailer.
L	Linelimit	The maximum line length supported by this mailer.
D	Directory	The `prog` mailer's execution directory.
U	Userid	The user and group ID used to run the mailer.
N	Nice	The `nice` value used to run mailer.
C	Charset	The default Content-type for 8-bit MIME characters.
T	Type	The MIME error types this mailer supports.

The Path (`P`) field contains either the path to the mail delivery program, the literal string `[IPC]`, or the literal string `[TCP]`. Mailer definitions that specify `P=[IPC]` or `P=[TCP]` use Sendmail to deliver the mail. (`P=[TCP]` is not commonly used.) The path to a mail delivery program varies from system to system depending on where the systems store the programs.

The Flags (`F`) field contains the Sendmail flags used for this mailer. These are the mailer flags referenced above in the "Format of Headers" section, but mailer flags do more than just control header insertion. There are a large number of flags. All of them and their functions are described in Appendix C.

The Sender (`S`) and the Recipient (`R`) fields identify the rulesets used to rewrite the sender and recipient addresses for this mailer. Each ruleset is identified by its name or number.

Understanding the role of the S and R rulesets is important when troubleshooting the Sendmail configuration because these rulesets add the variety that is necessary to handle addresses differently for different mailers.

The Argv (A) field defines the mailer command line. It is the argument vector passed to the mailer. It contains, along with the executable command and the command-line arguments, macro expansions that provide the recipient username ($u), the recipient hostname ($h), and the sender's from address ($f). These macros are expanded before the argument vector is passed to the mailer.

Maxsize (M) defines, in bytes, the longest message that this mailer will handle, while Linelimit (L) defines, in bytes, the maximum length of a line that can be contained in a message handled by this mailer. The End-of-line (E) field defines the characters used to mark the end of a line. A newline is the default.

The Directory (D) field specifies the working directory for the prog mailer. More than one directory can be specified for the directory field by separating the directory paths with colons. The prog mailer definition in Listing 7.12 uses the recipient's home directory, which is the value returned by the $z. If that directory is not available, it then uses the root (/) directory.

You can specify the user and the group ID used to execute the mailer with the Userid (U) field. For example U=mail:mail says that the mailer should be run under the user ID mail and the group ID mail. If no value is specified for the Userid field, the value defined by the DefaultUser option is used. Note that none of the mailers in Listing 7.12 used the Userid field.

Nice (N) changes the nice value for the execution of the mailer. This allows you to change the scheduling priority of the mailer. This is rarely used. If you're interested, see the nice man page for appropriate values.

The last two fields are used for MIME mail. Charset (C) defines the character set used in the Content-type header when an eight-bit message is converted to MIME. If Charset is not defined, the value defined in the DefaultCharset option is used. If that option is not defined, unknown-8bit is used as the default value.

The Type (T) field defines the type information used in MIME error messages. MIME type information defines the mailer transfer agent type, the mail address type, and the error code type. The default is dns/rfc822/smtp.

Analyzing a Sample M Command

Examining one of the mailer entries from Listing 7.12 explains the structure of all of the mailer definitions. The entry for the `smtp` mailer from Listing 7.12 is:

```
Msmtp,          P=[IPC], F=mDFMuX, S=EnvFromSMTP/HdrFromSMTP,
                R=EnvToSMTP, E=\r\n, L=990,
                T=DNS/RFC822/SMTP,
                A=TCP $h
```

Let's examine each field in this definition:

`M` Beginning a line with an `M` indicates that the command is a mailer definition.

`smtp` Immediately following the `M` is the name of the mailer, which in this case is `smtp`.

`P=[IPC]` The `P` argument defines the path to the program used for this mailer. In this case it is `[IPC]`, which means this mail is delivered by Sendmail. Other mailer definitions, such as `local`, have the full path of some external program in this field.

`F=mDFMuX` The `F` argument defines the Sendmail flags for this mailer. Other than knowing that these are mailer flags, the meaning of each individual mailer flag is of little interest, because the flags are correctly set by the `m4` macro that builds the mailer entry. In this case, `m` says that this mailer can send to multiple recipients at once; `DFM` says that Date, From, and Message-ID headers are needed; `u` says that uppercase should be preserved in hostnames and usernames; and `X` says that message lines beginning with a dot have an extra dot prepended.

`S=EnvFromSMTP/HdrFromSMTP` The `S` argument defines the rulesets that process sender addresses. The ruleset names can be different for every mailer, allowing different mailers to process e-mail addresses differently. In this case, the sender address in the mail "envelope" is processed through ruleset `EnvFromSMTP`, and the sender address in the message is processed through ruleset `HdrFromSMTP`. These rulesets are also addressable as `11` and `31` respectively. So it is possible that you'll see `S` for the `smtp` mailer defined as `S=11/31` on some systems.

`R=EnvToSMTP` The `R` argument defines the ruleset used to process recipient addresses for this mailer. Every mailer can have a different `R` value to allow each mailer to handle recipient addresses differently. Like the `S` field described above, the `R` field can have two rulesets, one for the envelope header and one for the mail header, separated by a slash. In this case, one ruleset (`EnvToSMTP`) is applied to all recipient addresses for the `smtp` mailer. `EnvToSMTP` is also known as ruleset 21, so this could have been written as `R=21`.

`E=\r\n` The `E` argument defines how individual lines in a message are terminated. In this case, lines are terminated with a carriage return and a line feed.

L=990 The L argument defines the maximum line length for this mailer. In this case, the mailer can handle messages that contain individual lines up to 990 bytes long.

T=DNS/RFC822/SMTP The T argument defines the MIME types for messages handled by this mailer. In this case, the mailer uses DNS for hostnames, RFC822 for e-mail addresses, and SMTP for error codes.

A=TCP $h The A argument defines the command used to execute the mailer. In this case, the argument refers to an internal Sendmail process. In other cases—the `local` mailer is a good example—the A argument is clearly a command line.

NOTE One of the confusing little idiosyncrasies of Sendmail is that the path to Sendmail's internal mail delivery can be either TCP or IPC. For this version of Sendmail, TCP was used in the A argument. On your version it might be IPC.

It is good to know how mailer definitions are structured, but the basic mailer definitions built from the `m4` macros contain all the mailers you'll need to run Sendmail in a TCP/IP network environment. You shouldn't need to modify any mailer definitions for an average configuration. In fact, nothing in the `sendmail.cf` files needs direct modifications for an average configuration. But this section of the book doesn't limit itself to average configurations, so in the next section we directly edit the `sendmail.cf` file and use test tools to observe the impact of the change.

Editing the *sendmail.cf* File

It's important to realize how rarely the `sendmail.cf` file needs to be modified on a typical Linux system. The configuration file that comes with your Linux system will work. Generally, you modify the Sendmail configuration not because you need to, but because you want to. You modify the configuration to improve the way things operate, not to get them to operate, and when you do modify it, you change the `m4` macro configuration—not `sendmail.cf`. Despite this, in this section we edit the `sendmail.cf` file to change the way that Sendmail works.

TIP Before you make any change to `sendmail.cf`–even a minor one—copy `sendmail.cf` to a work file such as `test.cf` and edit the work file. Never edit `sendmail.cf` without having a backup copy.

Assume our Linux system is named `parrot.foobirds.org`. Using the default configuration, the From address on outbound e-mail is *`user`*`@parrot.foobirds.org`. This is a valid

address, but it's not exactly what you want. You want to hide the hostname in outbound e-mail by using the address *user*@foobirds.org. Sendmail calls hiding the real hostname "masquerading." Chapter 9, "Special m4 Configurations," provides much more coverage on masquerading, but for now all we need to know is that we want to masquerade as foobirds.org.

To create the new configuration, you need to understand the purpose of the macro variable M, found in the Local Info section of the sendmail.cf file. The comment for the D command that sets M says "who I masquerade as." Checking Listing 7.1, you find that no value is assigned to macro M, which means that masquerading is not being used. To replace the name of the local host in outbound mail with the name of the domain, set M to the domain name, as shown below.

```
# who I masquerade as (null for no masquerading)
DMfoobirds.org
```

Given this value for M, parrot rewrites the sender addresses on outbound mail to *user*@foobirds.org.

After setting a value for the M macro in the test.cf file, run a test to see if it works. Running Sendmail with the test configuration does not affect the Sendmail daemon that was started by the boot script. A separate instantiation of Sendmail is used for the test.

Testing Your New Configuration

To test the new configuration, run the sendmail command with the -bt option. Sendmail displays a welcome message and waits for you to enter a test. The details of testing Sendmail and of the –bt syntax are covered in Chapter 10, "Testing Sendmail." For now, all you need to know is that we want to see if the header sender address is properly rewritten to masquerade the hostname as the domain name when we send outbound SMTP mail. The /tryflags test command lets us request header sender address processing and the /try command lets us process the sender address for the smtp mailer. First, test the existing configuration to see how the address is processed by the default configuration:

```
[root]# sendmail -bt
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> /tryflags HS
> /try smtp craig
Trying header sender address craig for mailer smtp
```

```
canonify          input: craig
Canonify2         input: craig
Canonify2       returns: craig
canonify        returns: craig
1                 input: craig
1               returns: craig
HdrFromSMTP       input: craig
PseudoToReal      input: craig
PseudoToReal    returns: craig
MasqSMTP          input: craig
MasqSMTP        returns: craig < @ *LOCAL* >
MasqHdr           input: craig < @ *LOCAL* >
MasqHdr         returns: craig < @ parrot . foobirds . org . >
HdrFromSMTP     returns: craig < @ parrot . foobirds . org . >
final             input: craig < @ parrot . foobirds . org . >
final           returns: craig @ parrot . foobirds . org
Rcode = 0, addr = craig@parrot.foobirds.org
> ^D
```


NOTE These tests were run with Sendmail 8.11. The output from older versions of Sendmail, which used ruleset numbers instead of names, will look slightly different.

The address returned by ruleset `final`, which is always the last ruleset to process an address, shows us the address that will be used on outbound mail after all of the rulesets have processed the address. With the default configuration, the input address `craig` is converted to `craig@parrot.foobirds.org`.

NOTE Ruleset final is also known as ruleset 4.

Next, run the `sendmail` command with the `-C` option to use the newly created `test.cf` configuration file. The –C option permits you to specify the Sendmail configuration file on the command line.

```
# sendmail -bt -Ctest.cf
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> /tryflags HS
> /try smtp craig
Trying header sender address craig for mailer smtp
canonify           input: craig
Canonify2          input: craig
Canonify2        returns: craig
canonify         returns: craig
1                  input: craig
1                returns: craig
HdrFromSMTP        input: craig
PseudoToReal       input: craig
PseudoToReal     returns: craig
MasqSMTP           input: craig
MasqSMTP         returns: craig < @ *LOCAL* >
MasqHdr            input: craig < @ *LOCAL* >
MasqHdr          returns: craig < @ foobirds . org . >
HdrFromSMTP      returns: craig < @ foobirds . org . >
final              input: craig < @ foobirds . org . >
final            returns: craig @ foobirds . org
Rcode = 0, addr = craig@foobirds.org
> ^D
```

This test tells you that the value entered in the `M` macro is used to rewrite the sender address in the message header. You know this because the only change made to the `sendmail.cf` file was to set a value for `M`, and now the address returned from ruleset `final` is `craig@foobirds.org`. This is just what you wanted.

Don't make changes directly to the `sendmail.cf` file if you can avoid it. If you're called upon to help someone configure Sendmail on a system that doesn't already have the `m4` source file installed, it may be easier to directly edit the `sendmail.cf` file, but only if the change is very small. If you really want to make major Sendmail configuration changes, use `m4` to build your configuration.

A Command Summary

Sendmail reads the `sendmail.cf` file every time it starts up. For that reason, the syntax of the commands in the `sendmail.cf` file is designed to be easily parsed by a machine, but not necessarily easy for a human to read. Table 7.4 summarizes all of the `sendmail.cf` commands.

Table 7.4 The `sendmail.cf` Commands

Command	Syntax	Meaning
Version Level	V*level*[/*vendor*]	Specify the version level.
Define Macro	D*x**value*	Set macro *x* to *value*.
Define Class	C*cword1*[*word2*]...	Set class *c* to *word1 word2*...
Load Class	F*cfile*	Load class *c* from *file*.
Set Option	O *option*=*value*	Set *option* to *value*.
Trusted Users	T*user*	Add *user* to the trusted users.
Set Precedence	P*name*=*number*	Set *name* to precedence *number*.
Define Mailer	M*name*, *field*=*value*, ...	Define mailer *name* with the parameters set by *field* and *value*.
Define Header	H[?*mflag*?]*name*:*format*	Define a header format.
Set Ruleset	S*name*=*number*	Start a ruleset assigning it a *name* and *number*.
Define Rule	R*pattern template*	Rewrite addresses that match *pattern* to *template* format.
Key File	K*name type* [*argument*]	Define database *name*.

This table, and this chapter, can help you read and understand the `sendmail.cf` file. But when it comes to creating that file, you'll build it with the `m4` macro commands covered earlier in this book.

Tell Me Again Why I Use *m4* Macros

A persistent question raised by most Sendmail administrators is, "Why not just edit `sendmail.cf` directly?" After all, is

```
define(`ALIAS_FILE', `/etc/aliases')
```

really any simpler than

```
O AliasFile=/etc/aliases
```

The answer is no, individual `m4` Sendmail macros are not any simpler to read or write than individual `sendmail.cf` commands once you understand the meaning and syntax of the `sendmail.cf` commands. However, `m4` macro configuration files are certainly much shorter and easier to read than the `sendmail.cf` file, and individual `m4` commands often do much more than individual `sendmail.cf` commands. `m4` makes it possible to actual write a configuration from scratch. But you might not need to. Perhaps a sample `sendmail.cf` configuration provided by the Sendmail developers or your Linux vendor would work for you with only a few small changes. In that case, why do I repeatedly insist that you build your configuration with `m4`?

The reason is "because that's the way it's done." Everyone expects the Sendmail configuration to be defined in the `m4` macro configuration file. That is where your colleagues will look for changes when they debug your system. Putting the configuration directly in the `sendmail.cf` file just makes a confusing system more confusing to those who must debug it. Worse yet is putting some changes in the macro configuration and some in `sendmail.cf`. That approach is doomed to failure. Stick with `m4`. It might not be simple, but it is better than the alternative and it is the way Sendmail configuration is done.

In Sum

The `sendmail.cf` file is read by Sendmail every time it starts. `sendmail.cf` is the configuration file that provides Sendmail with:

- information about the local system
- options that define the Sendmail environment
- the format of standard mail headers
- definitions of the available mailers
- instructions on how to prepare a message for a specific mailer

The `sendmail.cf` file is large and complex. But it is always divided into the same seven parts. Understanding the role of each part of the file can help you locate a problem when you are forced to analyze a `sendmail.cf` file.

The commands that make up the `sendmail.cf` file have a terse and arcane syntax. However, there are only 12 different commands and the purpose of most commands is easy to grasp. Additionally, the fixed structure of every command means that the first character on the command line is always the command. This makes it easy to use a tool like `grep` to examine all of the `C` commands or `D` commands in a `sendmail.cf` file if you suspect that a variable is improperly set.

Obsessing over the meaning of every option, variable, and flag is a waste of time. Reduce the complexity of the `sendmail.cf` file by focusing on it at a global level. Use your knowledge of the meaning of the different sections of the `sendmail.cf` file and of the purpose of the different commands to focus down on a problem area. Then use the appendixes of this book as a reference for the specific options, flags, and variables. Attempting to learn all of the details ahead of time wastes time developing a skill you may never need.

The bulk of the `sendmail.cf` file is composed of `R` commands. `R` commands are the topic of our next chapter.

8

Understanding Rewrite Rules

Sendmail is essentially a mail router. It receives mail, analyzes the delivery address of that mail to determine how the mail should be delivered, formats the mail for delivery by the selected mailer, and hands the mail off to the delivery system, which in some cases is Sendmail itself. At the heart of most of these functions are rewrite rules. *Rewrite rules* analyze the delivery address, select the correct mailer, and format mail for delivery. About the only things they don't do is collect inbound mail or transport outbound mail. Mastering Sendmail requires mastering rewrite rules. This chapter will give you all the information you need to read, understand, and—when absolutely necessary—write rewrite rules.

The rules are organized into groups of related rules called *rulesets* that can be called like subroutines by `sendmail.cf` commands. Certain rulesets are used by Sendmail to process specific types of addresses. Before getting into the details of rewrite rule syntax, let's look at rulesets to gain a global view of how rewrite rules are organized and used.

Basic Rulesets

Grouping rewrite rules into rulesets allows related rules to be referenced by a single name or a number. The `S` command marks the beginning of a ruleset and identifies it with a

name, a number, or both. Every rewrite rule following an `S` command is part of that ruleset until another `S` command is encountered that marks the start of another ruleset.

Rulesets can be thought of as subroutines, or functions, designed to process e-mail addresses. They are called from mailer definitions, from individual rewrite rules, from header definitions, or directly by the Sendmail process. Six rulesets are called directly by Sendmail for normal address processing:

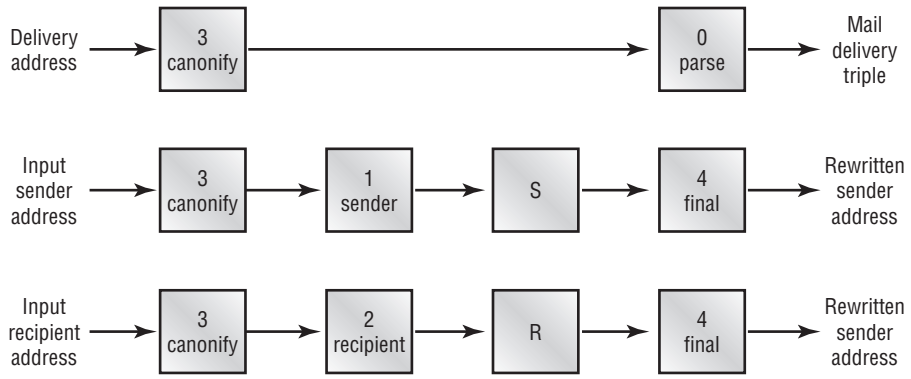
- Ruleset `canonify`, also known as ruleset 3, is called first to prepare all addresses for processing by the other rulesets.
- Ruleset `parse`, also known as ruleset 0, is applied to the mail delivery address to convert it to the (mailer, host, user) triple, which contains the name of the mailer that will deliver the mail, the recipient hostname, and the recipient username. Ruleset `parse` contains the rewrite rules that select which mailer will deliver the message.
- Ruleset `sender`, also known as ruleset 1, is applied to all sender addresses.
- Ruleset `recipient`, also known as ruleset 2, is applied to all recipient addresses.
- Ruleset `final`, also known as ruleset 4, is called last to convert all addresses from internal address formats into external address formats.
- Ruleset `localaddr`, also known as ruleset 5, is applied to local addresses after alias processing is completed.

NOTE Most `sendmail.cf` files do not contain all of these rulesets.

There are three basic types of addresses: delivery addresses, sender addresses, and recipient addresses. A recipient address and a delivery address sound like the same thing, but there is a difference. Think of a mailing list. There can be many recipients for a piece of mail, but mail is delivered to only one person at a time. The recipient address of the one person to which the current piece of mail is being delivered is the delivery address. Different rulesets are used to process the different types of addresses.

Figure 8.1 shows the rulesets that handle each address type. The S and R symbols in Figure 8.1 represent rulesets that have names, just like all normal rulesets, but the S and R ruleset names are defined in the `S` and `R` fields of the mailer definition, as described in Chapter 7, "The `sendmail.cf` File." Each mailer specifies its own S and R rulesets to process sender and recipient addresses just before the message is delivered.

Figure 8.1 Addresses processed by Sendmail rulesets



The rulesets shown in Figure 8.1 and described in the list above are automatically called by Sendmail, but that doesn't mean they necessarily exist in your configuration. Two good examples of this are ruleset 1 (`sender`) and ruleset 2 (`recipient`). By default, these rulesets are empty and thus are not even defined in the `sendmail.cf` file for Sendmail 8.11. (We'll see in Chapter 9, "Special `m4` Configurations," that you can define your own rewrite rules for rulesets 1 and 2, if needed.) The fact that these rulesets are not defined in the `sendmail.cf` file does not cause Sendmail any problems. It simply calls them and goes on to the next ruleset when they are not found.

More Rulesets

The six rulesets described so far are only those called directly by Sendmail. There are many more rulesets defined in the `sendmail.cf` file. For example, the `sendmail.cf` file created by the `redhat.mc` macro configuration has 47 named rulesets. Those other rulesets provide additional address processing. They include those rulesets identified as S and R in Figure 8.1 and those called from inside the `sendmail.cf` file by individual rewrite rules or `H` commands. Rulesets are called using the `$>`*`name`* syntax, where *`name`* is the name or number that identifies the called ruleset. We'll see more of the `$>`*`name`* syntax later when we discuss rewrite rules.

Table 8.1 lists many of the rulesets you'll find in the Rewriting Rules section of your `sendmail.cf` file. It identifies each ruleset by name, and when applicable by number, and provides a short description of the purpose of the ruleset. The rulesets are listed in the order in which they occur in the Rewriting Rules section.

Table 8.1 Rulesets from the Rewriting Rules Section

Name	Number	Purpose
`canonify`	3	Puts addresses in a standard internal format.
`final`	4	Converts addresses to external formats.
`parse`	0	Selects the mailer for a delivery address.
`localaddr`	5	Processes local addresses.
`Mailertable`	90	Matches domain names against the `mailertable`.
`MasqHdr`	93	Masquerades header names.
`MasqEnv`	94	Masquerades envelope names.
`LookUpDomain`		Finds domain names in the `access` database.
`LookUpAddress`		Finds hostnames in the `access` database.
`ParseRecipient`		Converts recipient addresses to the proper address format for relaying.
`check_relay`		Checks relaying for the anti-spam features.
`check_mail`		Checks sender addresses for the anti-spam features.
`check_rcpt`		Checks recipient addresses for the anti-spam features.
`trust_auth`		Tests whether or not the `AUTH` parameter should be trusted.
`tls_client`		Verifies the TLS connection to a client.
`tls_server`		Verifies the TLS connection to a server.

Table 8.1 shows only part of the rulesets found in the Rewriting Rules section. There are several other rulesets that are subroutines of these rulesets or are called by these rulesets to complete their tasks.

- canonify has a subsection named Canonify2, also known as ruleset 96, that is used to obtain canonical hostnames from DNS.
- parse has two subsections named Parse0 and Parse1, and a subroutine named ParseLocal (or ruleset 98) that it calls to handle local addresses.
- Mailertable calls MailerToTriple, which is also known as ruleset 95, to help convert mailertable entries to mail delivery triples, and it uses CanonLocal to put local names from the mailertable into a standard format.
- ParseRecipient uses CanonAddr to put addresses into the standard format, which CanonAddr does by simply calling Parse0 and canonify.
- The bulk of the work of check_relay, check_mail, and check_rcpt is handled by subsections respectively named Basic_check_relay, Basic_check_mail, and Basic_check_rcpt. In turn, Basic_check_rcpt calls RelayAuth to check client authentication when that is required. SearchList is another routine called by check_mail and check_rcpt to process an internal syntax used by these anti-spam features. Recall the {src} class mentioned in Chapter 7; SearchList is where it is used.
- tls_client and tls_server call tls_connection to get the connection verified. tls_connection in turn uses max to determine if the appropriate number of cipher bits were used. Transport layer security is discussed in Chapter 12, "Sendmail Security."

Rulesets within rulesets and rulesets calling rulesets segment the complex task of processing e-mail. This makes the task of processing mail manageable for Sendmail, but it creates a large number of rulesets that in turn create confusion for the system administrator trying to understand what these rulesets do. My advice is: "Don't worry about it." A general idea of what these rulesets do is all that is required for Sendmail mastery. You don't modify the basic rulesets of Sendmail, even to create an advanced custom configuration. Instead, Sendmail provides several empty rulesets as hooks for your modifications:

- sender (ruleset 1) is available for custom processing of sender addresses. See the LOCAL_RULE discussion in Chapter 9.
- recipient (ruleset 2) is available for custom processing of recipient addresses. See the LOCAL_RULE discussion in Chapter 9.
- Local_localaddr is available for custom processing of local addresses before they are processed by localaddr (ruleset 5).
- Local_check_relay is available to customize anti-spam relaying rules. It is called before check_relay. See the discussion of anti-spam rules in Chapter 11, "Stopping Spam."

- `Local_check_mail` is available for custom anti-spam processing of the MAIL FROM: address. It is called before `check_mail`. See the discussion of anti-spam rules in Chapter 11.
- `Local_check_rcpt` is available for custom anti-spam processing of the RCPT TO: address. It is called before `check_rcpt`. See the discussion of anti-spam rules in Chapter 11.
- `Local_trust_auth` is available to customize the `trust_auth` ruleset. See the `AUTH` material in Chapter 12.

These rulesets provide more avenues for customizing Sendmail than you will ever use for any one configuration, even for the most advanced custom configuration. All of these hooks can be accessed through the `m4` macro configuration, so even when custom rewrite rules are required, there is no need to directly edit the `sendmail.cf` file.

Mailer Rulesets

Despite the large number of rulesets found in the Rewriting Rules section, it is not the only place in the `sendmail.cf` file where rulesets are found. The Mailer Definitions section includes the rulesets that are added by the various mailers. The macro configuration that built our sample `sendmail.cf` file had three sets of mailers:

```
MAILER(local)
MAILER(smtp)
MAILER(procmail)
```

These `MAILER` commands added the rulesets listed in Table 8.2 to the Mailer Declarations section of the `sendmail.cf` file. The rulesets are listed in Table 8.2 in the order in which they occur in the Mailer Declarations section. Each ruleset is identified by name and number. The table provides a short description of each ruleset.

Table 8.2 Rulesets Found in the Mailer Declarations Section

Name	Number	Description
`MasqSMTP`	61	Handles rewriting tasks common to sender and envelope masquerading.
`PseudoToReal`	51	Converts pseudo-domains to real domains.
`EnvFromSMTP`	11	Rewrites the envelope sender address.
`EnvToSMTP`	21	Rewrites the envelope recipient address.

Table 8.2 Rulesets Found in the Mailer Declarations Section *(continued)*

Name	Number	Description
HdrFromSMTP	31	Rewrites the header sender address.
MasqRelay	71	Handles masquerading for the relay mailer.
EnvFromL	10	Rewrites the envelope sender for the local mailer.
EnvToL	20	Rewrites the envelope recipient for the local mailer.
HdrFromL	30	Rewrites the header sender for the local mailer.
HdrToL	40	Rewrites the header recipient for the local mailer.
AddDomain	50	Adds the local domain for the always_add_domain feature.

Most of these rulesets deal with rewriting sender and recipient addresses in the envelope and the header. That's to be expected. After all, the S and R parameters of the mailer command (M) identify the rulesets used to rewrite sender addresses and recipient addresses for a specific mailer. It is only natural that these rulesets are included in the Mailer Definitions section of the sendmail.cf file.

Listing 8.1 shows two of these rulesets: EnvToL and HdrFromL. Each ruleset starts with an S command, and ends when the next S command is encountered. Therefore, the EnvToL ruleset contains only one rewrite rule, while the HdrFromL ruleset contains four rules.

Listing 8.1 Two Simple Rulesets

```
#
#  Envelope recipient rewriting
#
SEnvToL=20
R$+ < @ $* >       $: $1               strip host part

#
#  Header sender rewriting
#
SHdrFromL=30
R<@>               $n                  errors to mailer-daemon
R@ <@ $*>          $n                  temporarily bypass Sun bogosity
R$+                $: $>AddDomain $1   add local domain if needed
R$*                $: $>MasqHdr $1     do masquerading
```

Every active line in a ruleset is an R command. The syntax of R commands is complex and difficult to read. Explaining the function and syntax of R commands consumes the rest of this chapter.

Rewrite Rules

Rulesets are composed of individual rewrite rules that parse e-mail addresses from user mail programs and rewrite them into the form required by the mail delivery programs. Each rewrite rule is defined by an R command. The syntax of the R command that was introduced in Chapter 7 is:

```
Rpattern    template    comment
```

The fields in an R command are separated by tab characters. The *comment* field is ignored by the system, but good comments are vital to understanding what's going on. The *pattern* and *template* fields are the heart of this command.

Pattern Matching

Rewrite rules match the input address against the pattern, and if a match is found, rewrite the address in a new format using the rules defined in the template. A rewrite rule may process the same address several times because, after being rewritten, the address is again compared against the pattern. If it still matches, it is rewritten again. The cycle of pattern matching and rewriting continues until the address no longer matches the pattern.

The pattern is defined using variables, classes, literals, and special symbols. The variables, classes, and literals provide the values against which the input is compared, and the symbols define the rules used in matching the pattern. Table 8.3 shows the symbols used for pattern matching.

Table 8.3 Pattern-Matching Symbols

Symbol	Meaning
$@	Match exactly zero tokens.
$*	Match zero or more tokens.
$–	Match exactly one token.
$+	Match one or more tokens.
$*x*	Match all tokens in macro variable *x*.

Table 8.3 Pattern-Matching Symbols *(continued)*

Symbol	Meaning
$=*x*	Match any token in class variable *x*.
$~*x*	Match any token not in class variable *x*.

All of the symbols match some number of tokens. A token is a string of characters delimited by an operator. The operators are the right (**(**) and left (**)**) parentheses, right (**<**) and left (**>**) angle brackets, comma (**,**), semicolon (**;**), backslash (****), quotation mark (**"**), carriage return (**CR**), and line feed (**LF**), plus any characters defined by the `OperatorChars` option. A `grep` of the `sendmail.cf` file for `OperatorChars` shows the additional operator characters are **.**, **:**, **%**, **@**, **!**, **^**, **/**, [,], and **+**.

```
[craig]$ grep 'OperatorChars' /etc/sendmail.cf
O OperatorChars=.:%@!^/[]+
```

Operators also count as tokens when an address is parsed. Assume the following address:

```
sara@hawk.foobirds.org
```

This e-mail address contains seven tokens: `sara`, `@`, `hawk`, `.`, `foobirds`, `.`, and `org`. Three of these tokens, two `.` (dots) and an `@`, are operators. The other four tokens are strings. This address would match the symbol `$+` because it contains more than one token, but it would not match the symbol `$-` because it does not contain *exactly* one token.

The symbols in Table 8.3 are particularly useful when paired with literal values and variables to create more complex patterns—for example:

```
$- @ $- .foobirds.org
```

The sample address `sara@hawk.foobirds.org` matches the pattern because:

- It has exactly one token before the literal `@` that matches the requirement of the `$-` symbol.
- It has an `@` that matches the pattern's literal `@`.
- It has exactly one token after the literal `@` and before the literal `.foobirds.org` that matches the requirement of the second `$-` symbol.
- It has the string `.foobirds.org` that matches the pattern's literal `.foobirds.org`.

`sara@hawk.foobirds.org` matches this pattern, but many other addresses do not. For example, `sara.henson@hawk.foobirds.org` does not match because it has three tokens, `sara`, `.`, and `henson`, before the literal `@`. Therefore, it fails to meet the requirement of

exactly one token specified by the first `$-` symbol. `mandy@sooty.terns.foobirds.org` fails to match the pattern because it has three tokens (`sooty`, `.`, and `terns`) after the literal `@` and before the literal `.foobirds.org`.

Literals are such an important part of pattern matching that Sendmail inserts literal values, such as the angle brackets < and >, into addresses to make them easier to parse. Listing 8.2 shows this.

Listing 8.2 Internal Use of Literal Values

```
[root]# sendmail -bt
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> 3 craig.hunt@ibis.foobirds.org
canonify           input: craig . hunt @ ibis . foobirds . org
Canonify2          input: craig . hunt < @ ibis . foobirds . org >
Canonify2        returns: craig . hunt < @ ibis . foobirds . org . >
canonify         returns: craig . hunt < @ ibis . foobirds . org . >
> ^D
```

Listing 8.2 shows that Sendmail adds literal values to an address when the address is converted to the working format that Sendmail uses internally. The `canonify` ruleset adds angle brackets surrounding the domain name portion of the address. `canonify` calls `Canonify2` to request the canonical form of the hostname from DNS. In this case, `ibis.foobirds.org` is the canonical name of the host, so all `Canonify2` does is return the same name fully qualified to the root. (That's why the hostname has a dot appended.) The three tokens, <, >, and `.`, added by Sendmail are used internally to simplify address parsing. Before the mail is sent, these three tokens will be removed by the `final` ruleset.

NOTE In DNS, the dot at the end of a name is the root domain. Sendmail uses it internally to indicate that a name has been successfully processed by DNS.

About 75 percent of the rewrite rules in the `sendmail.cf` file make use of the inserted tokens by using angle brackets as part of the pattern field. The single rule from ruleset `EnvToL` in Listing 8.1 demonstrate this. That rule contains this pattern:

```
$+ < @ $* >
```

This pattern says to match any address that has one or more tokens (`$+`) before the literal value `< @` and zero or more tokens after that literal value and before the literal value >. The `craig.hunt<@ibis.foobirds.org.>` address matches this pattern. It has three

tokens (craig, ., and hunt) before the literal <@ and six tokens (ibis, ., foobirds, ., org, and .) between the literals <@ and >.

Literals are an important part of patterns but they lack the flexibility needed to create a general purpose configuration that can work on any system. That's where variables come in. In our first example we used the pattern:

```
$- @ $- .foobirds.org
```

The problem with this pattern is that it only works with addresses that have the domain name foobirds.org. The literal .foobirds.org works fine at our site, but isn't much help if we send this configuration to our friends at mammals.org. What we actually wanted to check was whether or not the address had the local domain name. The local domain name is stored by Sendmail in the m variable, so we can use $m in the pattern to match the local domain name. The following pattern is equivalent to the pattern above except that it works on any system:

```
$- @ $- .$m
```

Here we look for addresses that have exactly one token ($-), a literal @, exactly one token ($-), a literal ., and the value return from variable m.

Class variables can also be used in pattern matching. In fact, pattern matching is the only place where class values are useful. The symbols $= and $~ are designed to test whether or not a value from the input address is a member of the class. We can demonstrate this with the simple, although contrived, ruleset. Add the ruleset shown below to the test.cf file we created in Chapter 4:

```
SClassTest
R$+ @ $=w              $@ Found it
R$+ @ $~w              $@ Not in class w
R$*                    $: Wrong format
```

The S command starts the ruleset and names it ClassTest. It contains three R commands. ClassTest expects addresses in the format *user@host*. The pattern in the first rule matches one or more tokens ($+) before a literal @ and any value in class w ($=w). The pattern in the second rule matches one or more tokens ($+) before a literal @ and any value that is *not* in class w ($~w). The pattern in the last line catches everything that falls through to complain that the address didn't contain a literal @. The templates on these rules are contrived examples that will display a message when Sendmail is run in test mode, as it is in Listing 8.3.

Listing 8.3 Testing for Class Values

```
[root]# cat >> test.cf
SClassTest
R$+ @ $=w        $@ Found it
R$+ @ $~w        $@ Not in class w
R$*      $: Wrong format
[root]# sendmail -bt -Ctest.cf
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> $=w
robin.foobirds.org
other.org
wren.foobirds.org
[172.16.12.3]
patient-rights.org
outofbusiness.com
wren
localhost
weRbroke.com
robin
thatplace.com
imaginary.com
> ClassTest christopher@robin
ClassTest          input: christopher @ robin
ClassTest        returns: Found it
> ClassTest sara@hawk
ClassTest          input: sara @ hawk
ClassTest        returns: Not in class w
> ClassTest craig
ClassTest          input: craig
ClassTest        returns: Wrong format
> ^D
```

In Listing 8.3, a `cat` command is used to append the `ClassTest` ruleset to the `test.cf` configuration file. Then the `sendmail` command is run with the `–bt` option and the modified `test.cf` configuration. The contents of class `w` are displayed. The values displayed for class `w` vary from system to system. If you run this test on your own system, use values from your system's class `w`.

In Listing 8.3, three tests of the `ClassTest` ruleset are run. First, we send `ClassTest` the address `christopher@robin`. The ruleset returns the value "Found it." A quick glance at

the contents of class `w` shows that `robin` is indeed in the list. Next we send `ClassTest` the address `sara@hawk`, which returns "Not in class w." Again, a glance at the content of class `w` shows that `hawk` is not in the class. Finally, testing the address `craig` returns "Wrong format" because the address is not in the format *`user@host`*. Using symbols, variables, classes, and literals, patterns can be constructed to match any type of e-mail address.

The patterns used in the `ClassTest` ruleset are realistic, but the templates are contrived. An address goes into a rule and an address comes out. Clearly, the strings `Found it`, `Not in class w`, and `Wrong format` are not legitimate addresses. In the next section we look at how real templates are constructed and how they operate.

Conditional Syntax

Before we leave the topic of pattern matching, the use of conditional syntax in rewrite rules deserves a mention. The "if" (`$?`) "else" (`$|`) syntax can legally be used in rewrite rules. In reality the `$?` symbol is never used in a rewrite rule. The pattern matching of a rewrite rule, by its very nature, is already a conditional. Adding an "if" to an existing conditional test would just increase the complexity of an already complex syntax. The "else" symbol (`$|`) is sometimes used, but it is used as more of an "or" symbol—e.g., `this $| that` could be read as "this or that."

Avoid using the conditional syntax in rewrite rules. Every rule starts with a conditional test. It is better to use two rules, each of which does one thing, than to try to combine multiple tests in a single rule.

Transforming the Address

The template field, from the right-hand side of the rewrite rule, defines the format used for rewriting the address. It is defined with the same things used to define the pattern: literals, variables, and special symbols. Literals in the transformation are written into the new address exactly as shown. Variables are expanded and then written. The symbols perform special functions. Each symbol that can be used in a template and its purpose are shown in Table 8.4.

Table 8.4 Template Symbols

Symbol	Purpose
$*n*	Insert the value from indefinite token *n*.
$:	Terminate this rewrite rule.
$@	Terminate the entire ruleset.
$>*name*	Call the ruleset identified as *name*.
$[*hostname*$]	Convert *hostname* to DNS canonical form.
$(*database-spec*$)	Get the value from a database.

Indefinite Tokens

When an address matches a pattern, the strings from the address that match the symbols are assigned to *indefinite tokens*. The matching strings are called indefinite tokens because they may contain more than one token value. The indefinite tokens are identified numerically according to the relative position in the pattern of the symbol that the string matched. In other words, the indefinite token produced by the match of the first symbol is called $1, the match of the second symbol is called $2, the third is $3, and so on. The $*n* symbol in Table 8.4 represents the use of an indefinite token in the template and the *n* stands for the number of the indefinite token. An indefinite token is expanded and then written to the new address. Indefinite token substitution is essential for flexible address rewriting. Without it, values could not be easily moved from the input address to the rewritten address. The example in Listing 8.4 demonstrates this.

Listing 8.4 Testing Indefinite Token Substitution

```
[root]# cat >> test.cf
STokenTest
R$+ ! $+      $2 @ $1 . $m    convert host!user to user@host.domain
[root]# sendmail -bt -Ctest.cf
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> $m
```

```
foobirds.org
> TokenTest plover!karen.ramsey
TokenTest          input: plover ! karen . ramsey
TokenTest        returns: karen . ramsey @ plover . foobirds . org
> ^D
```

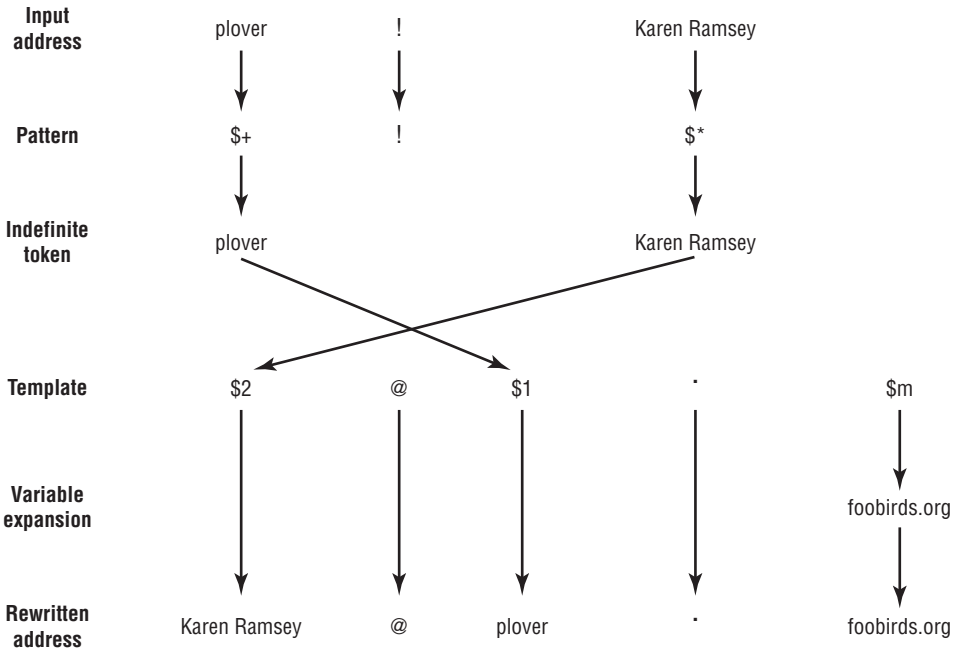
Again we start with the `test.cf` file created in Chapter 4. To that we add a new ruleset we call `TokenTest`, which contains only one rewrite rule. Then we run the `sendmail` command with `–bt` and `–Ctest.cf` to test the new configuration.

When the address `plover!karen.ramsey` matched the pattern `$+!$+`, two indefinite tokens were created. The first is identified as `$1` and contains the single token `plover` that matched the first `$+` symbol. The second indefinite token is `$2` and contains the three tokens, `karen`, `.`, and `ramsey`, that matched the second `$+` symbol. The indefinite tokens created by the pattern matching are then referenced by name (`$1` and `$2`) in the template portion of the `R` command to rewrite the address.

The template contains the indefinite token `$2`, a literal `@`, indefinite token `$1`, a literal dot (`.`), and the variable value `$m`. After the pattern matching, `$2` contains `karen.ramsey` and `$1` contains `plover`. From an earlier discussion of the `m` variable, you known that it contains the name of the domain of which the local system is part. Listing 8.4 shows that `$m` returns `foobirds.org` on the sample system. In Listing 8.4, the input address `plover!karen.ramsey` is rewritten as `karen.ramsey@plover.foobirds.org`.

Figure 8.2 illustrates this specific address rewrite. It shows the tokens derived from the input address, and how those tokens are matched against the pattern. It also shows the indefinite tokens produced by the pattern matching, and how the indefinite tokens, and other values from the transformation, are used to produce the rewritten address.

Figure 8.2 Rewriting an address



Recursion and Flow Control

After rewriting, the address is again compared to the pattern. The address in Figure 8.2 fails to match the pattern the second time through because it no longer contains the literal `!`. Sometimes, however, the recursive nature of rewrite rules is used to create iterative processing. Listing 8.5 shows this with a simple ruleset designed to remove nested angle brackets.

Listing 8.5 The Recursive Nature of Rewrite Rules

```
[root]# cat >> test.cf
SRemoveAngles
R$* < $* >      $1 $2
[root]# sendmail -bt -Ctest.cf
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> RemoveAngles craig<<<@wren>>>
RemoveAngles       input: craig < < < @ wren > > >
RemoveAngles     returns: craig @ wren
> ^D
```

In Listing 8.5, we create a ruleset named `RemoveAngles` that contains only one rule. The pattern in the rule matches any number of tokens (`$*`) before a literal < and any number of tokens (`$*`) between the literals < and >. The template in the rule rewrites the indefinite tokens without the literal angle brackets.

The `sendmail -bt` test in Listing 8.5 shows that the rule works; it removes all of the angle brackets from the address `craig<<<@wren>>>`. Don't assume, however, that it removes all of the angle brackets in one pass. The first time the address matches the pattern it is rewritten as `craig<<@wren>>`. The rewritten address is again compared to the pattern and it again matches. This time it is rewritten as `craig<@wren>`, which again matches the pattern. Finally, it is rewritten as `craig@wren`, which doesn't have the angle brackets required to match the pattern.

Once the pattern no longer matches, no further processing is done by this rewrite rule and the address is passed to the next rule in line. The `RemoveAngles` ruleset from Listing 8.5 contains no other rules so processing stops, but most rulesets have more than one rule. Rules in a ruleset are processed sequentially, although a few symbols can be used to modify this flow.

The recursion built into rewrite rules creates the possibility for infinite loops. The `$@` and the `$:` template symbols are used to control processing and to prevent loops. If the template begins with the `$@` symbol, the entire ruleset is terminated and the remainder of the template is the value returned by the ruleset. Use `$@` to exit a ruleset at a specific rule.

In Listing 8.3, the `$@` symbol was used to control the flow inside the `ClassTest` ruleset. The template in each rule in that ruleset starts with the `$@` symbol, so if a pattern match is found, the template is applied and the ruleset exits. Suppose the `$@` was not used on the first rule in that ruleset. In that case, the test of the address `christopher@robin` would have produced the response "Wrong format" instead of the response "Found it" that we expected. Here's why. The address `christopher@robin` matches the pattern of the first rule, which is `$*@$=w`. Therefore, the address is rewritten to `Found it`. If the `$@` symbol is not used, the address `Found it` is again compared to the pattern `$*@$=w` in the first rule. It doesn't match. The address is then processed by the next rules in line. `Found it` does not match the pattern of the second rule, which is `$*@$~w`. The address `Found it` is therefore passed on to the third rule in line. This time it does match the pattern `$*`, which essentially matches anything that hasn't been caught by the first two rules. The third rule rewrites the address `Found it` into the address `Wrong format`—not, of course, what we wanted. To get the result we want, every rule in ruleset `ClassTest` requires a flow control symbol, even the third rule.

When a template begins with the `$:` symbol, the individual rule is executed only once. In the `ClassTest` ruleset from Listing 8.3, that is exactly what we want to do with the third

rule. At first glance, one might think that flow control is not required for that rule because it is the last rule in the ruleset and thus the ruleset will end after that rule executes. On closer examination the problem is clear: the third rule will never finish executing because it is an infinite loop. The `$*` pattern matches zero or more tokens, meaning it will match anything, even the string `Wrong format`. Thus, the pattern will match the output of the rule. Because the rule recursively processes its own output against the pattern `$*`, which matches anything, a loop will ensue. Sendmail detects loops and complains when one is found, as shown in Listing 8.6.

Listing 8.6 Results of a Tight Loop in the Sendmail Configuration

```
[root]# sendmail -bt -Ctest.cf
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> =SClassTest
R$* @ $=w               $@ Found it
R$* @ $~w               $@ Not in class w
R$*             Wrong format
> ClassTest craig
ClassTest          input: craig
Infinite loop in ruleset ClassTest, rule 3
ClassTest        returns: Wrong format
> ^D
```

In Listing 8.6, `sendmail` is again run with the `–bt` argument. The `=S` command, described in Chapter 10 with other test commands, is used to display the contents of the ruleset `ClassTest`. In this example, the template in the third rule of the ruleset does not start with `$:`. In this case, when `ClassTest` is run with an input address of `craig`, an infinite loop ensues. Sendmail displays an error message stating that an infinite loop was encountered and exactly where the loop occurred.

Loops do not need to be as tight as the one shown in Listing 8.6. A loop can involve multiple rulesets because a ruleset can be called by a rule using the `$>`*`name`* syntax. When the called ruleset finishes processing, it returns a rewritten address to the calling rule. The returned e-mail address is then compared again to the pattern in the calling rule. If it still matches, the ruleset is called again. Use `$:` and `$@` to prevent loops whenever they can occur.

The $>*name* symbol calls ruleset *name* and passes the address defined by the remainder of the template to that ruleset for processing. For example, both rules in the ruleset named CallRulesets, shown below, call other rulesets:

```
SCallRulesets
R$* @ $-                $: $> canonify $1 @ $2
R$*             $: $> final $1
```

The template in the first rule calls ruleset canonify ($>canonify), and passes it the contents of $1, a literal @, and the contents of $2. The template starts with the $: symbol, so the first rule executes only once when the pattern matches. The template in the second rule calls ruleset final ($>final) and passes it the contents of $1. (Because the pattern in the second ruleset includes only one symbol, $1 contains the entire input address.) The second rule will also only execute once because its template starts with $:. Listing 8.7 shows the CallRulesets ruleset in action.

Listing 8.7 Calling Another Ruleset from a Rule

```
[root]# sendmail -bt -Ctest.cf
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> CallRulesets julie@redbreast
CallRulesets       input: julie @ redbreast
canonify           input: julie @ redbreast
Canonify2          input: julie < @ redbreast >
Canonify2        returns: julie < @ robin . foobirds . org . >
canonify         returns: julie < @ robin . foobirds . org . >
final              input: julie < @ robin . foobirds . org . >
final            returns: julie @ robin . foobirds . org
CallRulesets     returns: julie @ robin . foobirds . org
> ^D
```

In Listing 8.7, CallRulesets is passed the address julie@redbreast, which matches the $*@$- pattern of the first rule in the ruleset. That rule calls ruleset canonify and passes it the three tokens julie, @, and redbreast. canonify "focuses" the address by placing angle brackets around the host portion and, in turn, it calls ruleset Canonify2. Canonify2 converts the address to julie<@robin.foobirds.org.>, which is the value that canonify returns to CallRulesets. The second rule in CallRulesets is then executed. The value julie<@robin.foobirds.org.> matches the $* pattern in the rule, so ruleset final is called and passed the address value. final "defocuses" the address and returns the value julie@robin.foobirds.org, which becomes the value returned by CallRuleset.

> ***NOTE*** The words "focus" and "defocus" are used to describe the internal Sendmail processes that mark portions of the address for processing. Generally, this involves enclosing address components in angle brackets.

Transforming Addresses with External Information

In Listing 8.7, `CallRuleset` simply matches the patterns and calls other rulesets to do all of the rewriting. It is also possible to use an external server, such as DNS, or an external database to convert an input address. The `Canonify2` ruleset converts a hostname to the canonical DNS format for that hostname. It does this by querying DNS and using the information it gets in response to that query.

The `$[`*`hostname`*`$]` syntax converts a host's nickname or its IP address to its canonical name by passing the value *`hostname`* to the name server for resolution. Listing 8.8 shows the `$[`*`hostname`*`$]` symbol in action.

Listing 8.8 Retrieving a Canonical Name from DNS

```
[root]# sendmail -bt -Ctest.cf
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> =SDNSTest
R$* @ $+                $: $1 @ $[ $2 $]
> DNSTest julie@redbreast
DNSTest            input: julie @ redbreast
DNSTest          returns: julie @ robin . foobirds . org .
> DNSTest julie@[172.16.5.2]
DNSTest            input: julie @ [ 172 . 16 . 5 . 2 ]
DNSTest          returns: julie @ robin . foobirds . org .
> ^D
```

The `test.cf` configuration file in Listing 8.8 contains a very simple ruleset named `DNSTest`, which is displayed by the `=SDNSTest` command. The ruleset has only one rewrite rule. The rule matches any address that contains zero or more tokens, a literal `@`, and one or more tokens. The template in the rule is:

```
$: $1 @ $[ $2 $]
```

The `$:` symbol ensures that the rule runs only once. The `$1` symbol and the literal `@` guarantee that any tokens occurring before the `@` in the input address and the `@` itself are replicated in the output address. The symbols `$[` and `$]` enclose the value passed to DNS, which is the second indefinite token created by the pattern match. `$2` includes all of the tokens after the literal `@` in the input address.

In Listing 8.8, the first value passed to the rule is `julie@redbreast`. After the pattern match, `$1` contains `julie` and `$2` contains `redbreast`. The DNS query for `redbreast` returns `robin.foobirds.org` because the name server has a `CNAME` record for `redbreast` that indicates that `robin` is its canonical name.

The second test is even more interesting because it demonstrates that e-mail can be addressed with an IP address instead of a hostname. That test passes the address `julie@[172.16.5.2]` to the `DNSTest` ruleset. Clearly 172.16.5.2 is not a hostname; it is an IP address. In this case DNS is asked to return the canonical name for the address. If DNS has a `PTR` record for the address, the address can be mapped back to a name. In this case, it does have the `PTR` record, so the query for 172.16.5.2 returns the canonical name `robin.foobirds.org`.

> ***TIP*** Not sure about DNS `CNAME` records and `PTR` records? See *Linux DNS Server Administration* by Craig Hunt (Sybex, 2000), which is also part of the Craig Hunt Linux Library.

In the same way that a host name or address is used to look up a canonical name in the name server database, the `$(`*`database-spec`*`$)` syntax uses a key to retrieve information from a database. This is a more generalized database retrieval syntax than the one that returns canonical hostnames, and it is more complex to use. To use an external database to transform an address in a rewrite rule, include the database in the template part of a rule with the following syntax:

```
$(map key [$@argument...] [$:default] $)
```

`map` is the name assigned to the database by a `K` command. Like mailer names, map names are arbitrary names only used inside of the `sendmail.cf` file. The map name used in the rewrite rule template must match the name assigned to the database by the `K` command. Because most `K` commands are the result of the `m4 FEATURE` commands used to create the configuration, the map names are the same on most Linux systems. (See Chapter 7 for a description of the `K` command syntax.)

`key` is the value used to index into the database. The value returned from the database for this key is used to rewrite the input address. If no value is returned, the input address is changed to the key unless a default value is provided using the `$:`*`default`* syntax.

An *`argument`* is a value passed to the database program along with the key. Multiple arguments can be used, but each argument must start with `$@`. The *`argument`* modifies the value returned to Sendmail. Arguments are referenced inside the database as `%`*`n`*, where *`n`* is a digit that indicates the order in which the argument appears in the string of arguments, when multiple arguments are used. Argument `%0` is the key, `%1` is the first argument, `%2`

is the second argument, and so on. An example will make the use of arguments clear. Assume the following input address:

```
rebafro@eagle
```

Further, assume the following database with the internal Sendmail name of "hubs":

```
hawk     %1<@mailhub.aol.com>
eagle    %1<@mailhub.yahoo.com>
dove     %1<@mailhub.excite.com>
```

Finally, assume the following rewrite rule:

```
R$+@$-     $(hubs $2 $@ $1 $)
```

The input address `rebafro@eagle` matches the pattern because it has one or more tokens (`rebafro`) before the literal `@` and exactly one token (`eagle`) after it. The pattern match creates two indefinite tokens. The template calls the database `hubs` and passes it token `$2` as the key. The template also contains `$@ $1` that says that token `$1`, which contains `rebafro`, is passed to the database as an argument. The database program uses the key `eagle` to retrieve `%1@mailhub.yahoo.com`, then uses the argument `rebafro` to replace `%1`, and returns `rebafro@mailhub.yahoo.com` to Sendmail.

Before a database can be used, it must be defined in the configuration. This is done with the `K` command. To define the `hubs` database file used in the example above, we might enter the following command in the `sendmail.cf` file:

```
Khubs hash /etc/mail/hubs
```

The sample `hubs` database is shown only to illustrate the syntax used to access a database from a rewrite rule's template. In reality, there are already more databases available for Sendmail than you will ever use without creating any of your own. (See Chapter 6, "Using Sendmail Databases.") It is far more likely that you will use one of the databases that come with Sendmail than that you will create one of your own. Listing 8.9 demonstrates the database syntax using the standard `virtusertable` database we created in Chapter 6.

Listing 8.9 Accessing a Database from a Rewrite Rule

```
[root]# cat /etc/mail/virtusertable
info@patient-rights.org  sara@hawk.foobirds.org
@imaginary.com           david@lion.mammals.org
sales@outofbusiness.com  error:nouser User address is not valid
sales@weRbroke.com       error:5.1.5 Destination address invalid
@other.org               %1@local.org
+*@thatplace.com         %2@newplace.com
```

```
[root]# sendmail -bt -Ctest.cf
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> =SDBTest
R$* @ $+                $: $( virtuser @ $2 $@ $1 $: $1 @ $2 $)
> DBTest fred@imaginary.com
DBTest             input: fred @ imaginary . com
DBTest           returns: david @ lion . mammals . org
> DBTest jim@other.org
DBTest             input: jim @ other . org
DBTest           returns: jim @ local . org
> DBTest info@patient-rights.org
DBTest             input: info @ patient-rights . org
DBTest           returns: info @ patient-rights . org
> ^D
```

Listing 8.9 opens with a `cat` command to show the contents of the `virtusertable` on this sample system. Then `sendmail -bt` is run and the `=SDBTest` command is used to show that the ruleset named `DBTest` contains only one rule. The pattern in the rule matches any address that contains zero or more tokens (`$*`), a literal `@`, and one or more tokens (`$+`). The pattern is simple; the template is the interesting part. It contains the following components:

`$:` Ensures that the rule executes only once.

`$(` Marks the start of the database specification.

`virtuser` Is the standard map name for the `virtusertable` inside the `sendmail.cf` file.

`@ $2` Is the key used to look up a value in the `virtusertable`. It is a literal `@` followed by the value obtained from indefinite token `$2`. Thus, this template will match only keys that start with an `@` in the database.

`$@ $1` Is the `%1` argument passed to the database. The value obtained from indefinite token `$1` is the value of the argument.

`$: $1 @ $2` Is the default value used if no match is found in the database. In this case, the rule will return `$1@$2` if no match is found. If a default was not specified, the key, which in this case is `@$2`, would be returned if no match is found in the database.

`$)` Marks the end of the database specification.

The tests in Listing 8.9 show the effect the database has on different addresses. The first test passes `DBTest` the address `fred@imaginary.com`, which matches the `$*@$+` pattern. The pattern puts `fred` in indefinite token `$1` and `imaginary.com` in indefinite token `$2`.

The template uses a literal `@` plus the values from `$2` (`@imaginary.com`) as the key. The database returns `david@lion.mammals.org` as the value for that key—just what you would expect from looking at the `cat` of `virtusertable`.

The second test demonstrates the use of arguments. It passes the address `jim@other.org` to `DBTest` and gets `jim@local.org` in response. The key `@other.org` matches the value `%1@local.org`. The `$1` token is the argument, so `%1` is rewritten to `jim`, and the final value returned by the ruleset is `jim@local.org`.

The final test illustrates the use of the default value. The third test passes `DBTest` the address `info@patient-rights.org`. A quick look at the `cat` of `virtusertable` shows that `info@patient-rights.org` is a valid key and that `sara@hawk.foobirds.org` is the value assigned to that key. But `DBTest` does not return the value `sara@hawk.foobirds.org`. Here's why. `info@patient-rights.org` matches the pattern `$*@$+`. The template then uses `@$2`, which in this case is `@patient-rights.org`, as the key. `@patient-rights.org`, which is missing the string `info` before the `@`, is not a key found in this database. When a key is not found in a database, the template returns either the value defined as the default or, if no default is defined, the key. In this case, if no default were defined the value returned would be `@patient-rights.org`. However, a default was defined as `$: $1@$2`, so the value returned is `info@patient-rights.org`—the original address. Using a default is particularly important in a database like `virtusertable`, which uses different key formats. By returning the original address when a match is not found, the address can be passed on to the next rule in line for more processing. A database like `virtusertable`, which uses multiple key formats, is normally searched by a series of related rules that try all of the key formats. If `DBTest` contained another rule that used the entire input address as the key, `info@patient-rights.org` would return `sara@hawk.foobirds.org`.

The `virtusertable` used in the examples takes an input address as a key and returns a different address as the value, in most cases. However, two of the values in the `virtusertable` start with the word `error` and do not appear to be e-mail addresses. They aren't. They are values that can be used in a mailer triple, which is a special type of rewrite rule template used in ruleset 0 (ruleset `parse`).

Special Ruleset 0 Rewrite Rules

There is a special rewrite rule syntax that is only used in ruleset 0. Ruleset 0 defines the triple (mailer, host, user) that specifies the mail delivery program, the recipient host, and the recipient user. The special template syntax used to do this is:

```
$# mailer $@ host $: user
```

mailer is a valid mailer name defined by an `M` command. *host* is the hostname of the system that will handle this mail, and *user* is the address of the e-mail recipient. An example of this syntax taken from the sample `sendmail.cf` file is:

```
R$* < @$* > $*    $#esmtp $@ $2 $: $1 < @ $2 > $3   user@host.domain
```

The comment `user@host.domain` at the end of this rule implies that the pattern will match addresses of that format. That's almost true. The addresses have already been through the `canonify` ruleset before they reach ruleset 0, so the input address will be "focused" with angle brackets. For example, the e-mail address `kathy<@wren.foobirds.org>` would match the pattern and be processed by this rule. The address matches the pattern `$*<@$*>$*` because:

- The address has zero or more tokens (the token `kathy`) that match the first `$*` symbol.
- The address has a literal `<@`.
- The address has one or more tokens (the five tokens `wren.foobirds.org`) that match the requirement of the second `$*` symbol.
- The address has a literal `>`.
- The address has zero or more—in this case, zero—tokens that match the requirement of the last `$*` symbol.

This pattern match produces two indefinite tokens. Indefinite token `$1` contains `kathy` and `$2` contains `wren.foobirds.org`. No other matches occurred, so `$3` is empty. These indefinite tokens are used to rewrite the address into the following triple:

```
$#esmtp $@ wren.foobirds.org $: kathy<@wren.foobirds.org>
```

The components of this triple are:

`$#esmtp` `esmtp` is the internal name of the mailer that delivers the message.

`$@ wren.foobirds.org` `wren.foobirds.org` is the recipient host.

`$: kathy<@wren.foobirds.org>` `kathy<@wren.foobirds.org>` is the recipient user.

The mail delivery triple is just that—three pieces of information needed to deliver the mail, including the mailer name, the host, and the e-mail address. The mail delivery triple is created in ruleset 0. Sometimes, however, a template that looks like a mail delivery triple is used for another purpose. These variations on the mail delivery triple can appear in any ruleset.

Mailer Triple Variations

There are a few variations on the mailer triple syntax that are also used in the templates of some rules. Two of these variations use only the "mailer" component.

`$#OK` Indicates that the input address passed a security test. For example, the address is permitted to relay mail.

`$#discard` Indicates that the input address failed some security test and that the e-mail message should be discarded.

NOTE Neither `OK`, `discard`, nor `error`, which is discussed in a second, are declared in `M` commands like real mailers. But the Sendmail documentation refers to them as "mailers" and so do we.

The `$#OK` and `$#discard` mailers are used in spam control and security. You will see more of them in later chapters. The `$#discard` mailer silently discards the mail and does not return an error message to the sender. The `$#error` mailer is another mailer that handles undeliverable mail, but unlike `$#discard`, it does return an error message to the sender. The template syntax used with the `$#error` mailer is more complex than the syntax of either `$#OK` or `$#discard`. That syntax is shown below:

```
$#error $@dsn-code $:message
```

To properly process an error message, the mailer must be `$#error`. The `$:message` field contains the text of the error message that you wish to send. The `$@dsn-code` field is optional. If it is provided, it appears before the *`message`* and must contain a valid DSN error code as defined by RFC 1893 ("Mail System Status Codes") or a valid Sendmail keyword. Table 8.5 lists the valid Sendmail error code keywords and their meanings.

Table 8.5 Sendmail Error Code Keywords

Keyword	Meaning
`config`	An internal configuration error or routing loop was detected.
`nohost`	The host portion of the sender or recipient address is invalid.
`nouser`	The user portion of the sender or recipient address is invalid.
`protocol`	Network delivery failed.

Table 8.5 Sendmail Error Code Keywords *(continued)*

Keyword	Meaning
`tempfail`	A temporary failure was detected.
`unavailable`	A delivery resource is not available.
`usage`	The syntax of the delivery address is bad.

An error message using an error keyword would look something like the following:

```
R<@$+>      $#error $@nouser $:"user address required"
```

This works, but it is not the recommended format. In fact, not a single error message in the `sendmail.cf` file delivered with Sendmail 8.11.0 uses the keyword format. The preferred format is to use a DSN code in place of the keyword. The codes are clearly defined in an Internet standard and are understood by all mailers. DSN codes are composed of three dot-separated components:

`class` Provides a broad classification of the status. Three values are defined for *`class`* in the RFC: 2 means success, 4 means temporary failure, and 5 means permanent failure.

`subject` Classifies the error messages as relating to one of eight categories:

0 (Undefined) The specific category cannot be determined.

1 (Addressing) A problem was encountered with the address.

2 (Mailbox) A problem was encountered with the delivery mailbox.

3 (Mail system) The destination mail delivery system is having a problem.

4 (Network) The network infrastructure is having a problem.

5 (Protocol) A protocol problem was encountered.

6 (Content) The message content caused a translation error.

7 (Security) A security problem was reported.

`detail` Provides the details of the specific error. The *`detail`* value is only meaningful in context of the subject code. For example *`x`*`.1.1` means a bad destination user address and *`x`*`.1.2` means a bad destination host address, while *`x`*`.2.1` means the mailbox is disabled and *`x`*`.2.2` means the mailbox is full. There are far too many detail codes to list here. See RFC 1893 for a full list.

If the error message shown above were rewritten to use the preferred DSN format, it would be:

```
R<@$+>      $#error$@5.1.1$:"user address required"
```

This rule returns the DSN code 5.1.1 and the message "user address required" when the address matches the pattern. The DSN code has a `5` in the *`class`* field, meaning it is a permanent failure; a `1` in the *`subject`* field, meaning it is an addressing failure; and a `1` in the *`detail`* field, meaning that, given the subject value of 1, it is a bad user address.

Error codes and the error syntax can be confusing. We return to this subject again in later chapters when we look at advanced configuration options, spam control, and security.

In Sum

The bulk of the work done by Sendmail is done by rewrite rules. Correspondingly, rewrite rules make up the bulk of the `sendmail.cf` file. The rewrite rules occur in both the Rewriting Rules section and the Mailer Definitions section of the `sendmail.cf` file.

A rewrite rule matches an input address against a pattern composed of literals, variables, and special symbols. If the address matches the pattern, it is rewritten by the rule using a template that is also composed of literals, variables, and special symbols.

The syntax and usage of rewrite rules are complex, and very little can be done to filter out this complexity when rewrite rules are examined in detail. However, it is not always necessary to understand all of the details of an individual rule to know what the rules are doing.

Related rewrite rules are grouped together into rulesets. The purpose of each ruleset is described in this chapter. It is not necessary to know the function of every rule in the `Canonify2` ruleset to know that it asks DNS for canonical hostnames. When it is necessary to understand the function of a single rule, the comment provided with the rule may provide all the understanding you need. Finally, if detailed understanding of a specific rule is necessary, the description of rewrite rule syntax in this chapter will provide all of the information you need to decipher the command.

Generally, there is no need to read the individual rules that already exist in the `sendmail.cf` file. Understanding the purpose of the rulesets is all you need to understand the functioning of the configuration. The real purpose of understanding the details of rewrite rule syntax is to write your own rules. It is rarely necessary for you to do so, but it is part of advanced configuration, as we will see in Chapter 9 and in some of the later chapters.

9

Special *m4* Configurations

Ten percent of the `sendmail.cf` options handles ninety percent of the configurations. The average Sendmail server can operate with the configuration provided by the Linux vendor, with little or no change. But not every server is average. Some systems require special options to handle special configuration requirements. `m4` provides a plethora of configuration options to satisfy any need. Appendix A, "`m4` Macro Command Reference," lists them all. This chapter helps you make sense of these options by organizing them into topics.

This chapter is something of a laundry list because it contains a few largely unrelated topics. I originally planned to title this chapter "Advanced `m4` Configurations," but the truth is that there is nothing more advanced about these configuration options than there is about any others. The options used later in this book for spam control and security are at least as complex as any options discussed in this chapter. The real relationship among the topics in this chapter is that they are configuration options that are needed only in special circumstances. You'll probably discover that you don't need to use most of them, but you'll want to know something about all of them. In this chapter, you'll learn the advantages and the disadvantages of these options to better decide which ones are right for you.

One common thread that links many of the topics in this chapter is that they relate to the special needs of your enterprise. `m4` configuration commands that are specific to your network or domain logically are placed in the `DOMAIN` file. This chapter makes extensive use of the `DOMAIN` file.

Using the *DOMAIN* File

At the conclusion of Chapter 5, "Understanding a Vendor's Configuration," the `redhat.mc` file was rewritten to take advantage of the structure inherent in the Sendmail `m4` configuration directory. In Listing 5.6, the large `redhat.mc` file was divided into three files: a macro control file named `redhat811.mc`, an `OSTYPE` file named `redhat7.0.m4`, and a `DOMAIN` file named `foobirds.m4`. Traditionally, the macro control file selects configuration components, the `OSTYPE` file configures operating system–specific values, and the `DOMAIN` file holds all configuration options that are specific to your network or domain. In the first few sections of this chapter, we stick to the traditional use of these files by making our changes to the `foobirds.m4` file, which is shown in Listing 9.1.

Listing 9.1 A Sample `DOMAIN` File

```
[root]# cat ../domain/foobirds.m4
VERSIONID(`Settings for the foobirds.org domain')dnl
define(`confFORWARD_PATH',
   `$z/.forward.$w+$h:$z/.forward+$h:$z/.forward.$w:$z/.
forward')dnl
define(`confUSERDB_SPEC', `/etc/mail/userdb.db')dnl
FEATURE(always_add_domain)dnl
FEATURE(`access_db')dnl
FEATURE(`blacklist_recipients')dnl
FEATURE(`redirect')dnl
FEATURE(`use_cw_file')dnl
EXPOSED_USER(`root')
[root]# m4 ../m4/cf.m4 redhat811.mc > plain.cf
[root]# cp ../domain/foobirds.m4 ../domain/old-foobirds.m4
```

All of the commands in this file are explained in Chapter 5, and for the most part these existing commands don't have anything to do with the topics covered in this chapter. We process `redhat811.mc`, which is the macro control file that uses this `DOMAIN` file, through `m4` to create `plain.cf`. That will be the baseline `sendmail.cf` file against which we can compare our changes. At the end of Listing 9.1, the original `DOMAIN` file is copied to `old-foobirds.m4`. That provides a backup file in case we don't like the changes we make in the next few sections, and an original against which we can compare the changes. These originals will be an important part of the test that helps us determine the impact of each additional configuration command.

NOTE Most system administrators follow the lead of the vendors and put the entire Sendmail configuration in the macro control file. This has the advantages and disadvantages inherent in having all of the configuration commands in one file. We use the `DOMAIN` file in this chapter primarily to illustrate its traditional role and to show that the vendor's way of doing things is not the only way. Choose the configuration format that you like best. They both work.

The laundry list of topics covered in this chapter needs to start somewhere. Let's start with address masquerading. Of all the special configuration options discussed in this chapter, it is the one I use most often.

Address Masquerading

We played with address masquerading in Chapter 7, "The `sendmail.cf` File," by storing a value in the `sendmail.cf` variable `M`. The value in `M` replaced the hostname portion of the sender address in all outbound mail. In Sendmail parlance, the address is "masqueraded."

Addresses are masqueraded to hide the real name of the host that was the source of the mail. This is done when the real hostname should not be advertised to the outside world. The reasons you might not want to advertise real hostnames vary:

- Perhaps the source host does not collect its own inbound mail.
- Perhaps the firewall does not permit inbound mail to the source host.
- Perhaps your organization uses a standard address format across all hosts.
- Perhaps your security group does not want the names of internal hosts advertised to the outside world.

All of these are legitimate reasons for masquerading addresses. Of course, when you decide to use masquerading, you don't configure it by editing the `sendmail.cf` file to set the `M` variable. Instead, use the `m4` configuration commands designed for masquerading.

Enabling Masquerading

Use the `MASQUERADE_AS` macro to enable masquerading. For example, to enable masquerading as `foobirds.org`, put the following command in the macro configuration:

```
MASQUERADE_AS(`foobirds.org')
```

The name provided in the `MASQUERADE_AS` command should be a valid, canonical DNS name. Often, it is a domain name, instead of a hostname, when masquerading is being used to create a simplified, standard addressing format for the entire enterprise.

The effect of the MASQUERADE_AS command shown above is the same as setting the sendmail.cf M variable to foobirds.org. In fact, the only thing that MASQUERADE_AS does is set a value for M. Listing 9.2 demonstrates this fact.

Listing 9.2 The Impact of MASQUERADE_AS on sendmail.cf

```
[root]# diff ../domain/old-foobirds.m4 ../domain/foobirds.m4
8a9
> MASQUERADE_AS(`foobirds.org')dnl
[root]# m4 ../m4/cf.m4 redhat8ll.mc > masquerade.cf
[root]# diff plain.cf masquerade.cf
128c128
< DM
---
> DMfoobirds.org
```

In Listing 9.2, the first diff command shows that the only difference between the two DOMAIN files is that the new file has a MASQUERADE_AS command that is not found in old-foobirds.m4. The new file is processed through m4 to build Sendmail configurations. The plain.cf configuration file was created in Listing 9.1. Listing 9.2 creates the configuration file named masquerade.cf. The second diff compares the contents of these two files. Where the plain.cf file stores no value in M, the masquerade.cf file stores foobirds.org in M. This is the only difference between these configurations and is the only change that the MASQUERADE_AS command makes.

From the testing we did in Chapter 7, we know that storing a value in M causes Sendmail to rewrite the host portion of header sender addresses to the value found in M. There are some limitations. The value in M is used to rewrite the address only if the input address has no host part or the host part from the input address is found in class w. Additionally, masquerading is only applied to the header sender address. The sendmail –bt tests in Listing 9.3 demonstrates these effects.

Listing 9.3 Testing the Default MASQUERADE_AS Settings

```
[root]# sendmail -bt -Cmasquerade.cf
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> $=w
wren.foobirds.org
[172.16.12.3]
wren
localhost
> /tryflags HS
```

```
> /try esmtp craig@wren.foobirds.org
Trying header sender address craig@wren.foobirds.org for mailer esmtp
canonify           input: craig @ wren . foobirds . org
... Many lines deleted ...
final            returns: craig @ foobirds . org
Rcode = 0, addr = craig@foobirds.org
> /try esmtp craig@hawk.foobirds.org
Trying header sender address craig@hawk.foobirds.org for mailer esmtp
canonify           input: craig @ hawk . foobirds . org
... Many lines deleted ...
final            returns: craig @ hawk . foobirds . org
Rcode = 0, addr = craig@hawk.foobirds.org
> /tryflags ES
> /try esmtp craig@wren.foobirds.org
Trying envelope sender address craig@wren.foobirds.org for mailer esmtp
canonify           input: craig @ wren . foobirds . org
... Many lines deleted ...
final            returns: craig @ wren . foobirds . org
Rcode = 0, addr = craig@wren.foobirds.org
> ^D
```

Listing 9.3 is heavily edited to keep it to a reasonable length, but the key elements that show the default masquerade settings are there. First, we display the contents of class `w` to show that it contains only four values; these are the only four names that will be masqueraded. Then we use the `/tryflags` command to request processing for the header sender (`HS`) address. The first test uses the `/try` command to process the address `craig@wren.foobirds.org` for the `esmtp` mailer. The address is rewritten to `craig@foobirds.org`, showing that this configuration masquerades `wren.foobirds.org` as `foobirds.org` in the header sender address. Next, we process `craig@hawk.foobirds.org` as the header sender address for the `esmtp` mail. This time the address is not masqueraded. The reason is that `hawk.foobirds.org` is not a value in class `w`. Finally, the address `craig@wren.foobirds.org` is processed again. But this time, the `/tryflags` are set to request envelope sender (`ES`) processing. Even though the address is in class `w`, it is not masqueraded because it is an envelope address.

Masquerade Options

The default settings of masquerading only header sender addresses and only for hostnames identified in class `w` are usually adequate. In general, the purpose of masquerading addresses is to provide the correct reply address to the remote user. The user normally sees only the header addresses; the envelope addresses are used in the SMTP protocol exchanges. Thus, header sender masquerading is usually sufficient.

If header sender address masquerading isn't sufficient for your configuration, there are two features available to extend masquerading to other types of addresses. These are:

`FEATURE(masquerade-envelope)` This feature causes Sendmail to masquerade envelope sender addresses. If this feature had been set, the third test in Listing 9.2 would have resulted in `wren.foobirds.org` being masqueraded as `foobirds.org` in the envelope sender address. This feature is useful if masquerading is being done to satisfy the security people. They like to be thorough!

`FEATURE(allmasquerade)` This feature causes Sendmail to masquerade recipient addresses. Generally, this is not a good idea. Masquerading is intended for hiding source addresses on outbound mail. Changing the address on inbound mail does not make much sense, as the user of a local system already knows the real name of that system. Additionally, adding a masqueraded hostname to an inbound address can cause the mail to bypass the alias process. Don't use the `allmasquerade` feature.

As mentioned above, the second limitation of the default masquerade settings is that only hosts identified in class `w` are masqueraded. This default makes sense, because the server masquerading the mail is often the server that will accept inbound mail. A server accepts mail for local delivery only for hosts in class `w`. Limiting masquerading to systems in class `w` creates a balance between how inbound mail and outbound mail are handled. But this only makes sense when the system masquerading the mail also collects the mail for every system that it masquerades. That is not always the case. A mail relay server may relay outbound mail and yet have no role in collecting inbound mail. There are some `m4` macros and features that allow you to create a more flexible configuration.

Class `M` holds a list of hostnames that should be masqueraded. The values stored in class `M` are added to those in class `w` for masquerading. Values in class `M` are not, however, equivalent to values in class `w` because hostnames listed in class `M` are not aliases for the local host. Class `M` is used only for masquerading. The local system will not accept mail addressed to hosts in class `M` as local mail. Class `M` provides a finer level of control by permitting masquerading without granting any other type of access.

The `limited_masquerade` feature further refines your control over masquerading. By default, values in both class `w` and class `M` are masqueraded. To limit masquerading to *only* those values defined in class `M`, use the `limited_masquerade` feature. When masquerading is enabled, masquerading local host aliases is the logical thing to do, but class `w` can hold more than just local host aliases. In Chapter 6, "Using Sendmail Databases," we added virtual domain names to class `w`. You may not want to masquerade virtual domain names in outbound mail because you want external customers to believe that the virtual domains are real domains. In Listing 6.11, we created a virtual domain named `bridal-gowns.com` and stored it in class `w`. Outbound mail from `bridal-gowns.com` is masqueraded as mail

from foobirds.org if MASQUERADE_AS(`foobirds.org') is used with the default settings. But if FEATURE(`limited_masquerade') is also used, the mail goes out as mail from bridal-gowns.com, unless you explicitly add bridal-gowns.com to class M.

Use MASQUERADE_DOMAIN to add individual values to class M. For example, to add hawk.foobirds.org to class M, add the following m4 macro to the macro configuration file:

```
MASQUERADE_DOMAIN(`hawk.foobirds.org')
```

The MASQUERADE_DOMAIN macro is most useful when only a few values need to be added to class M and when those few values change very infrequently. Use the MASQUERADE_DOMAIN_FILE macro to load class M from a file when you have more than a few domain names that you wish to masquerade. Assume that you wanted to load class M from a file named /etc/mail/masquerade-domain-names. You could add the following m4 macro to the macro configuration file:

```
MASQUERADE_DOMAIN_FILE(`/etc/mail/masquerade-domain-names')
```

As the macro name MASQUERADE_DOMAIN implies, the values stored in class M do not have to be hostnames; they can be full domain names. But by default, the hostname portion of the input address must exactly match a value in class w or class M to be rewritten to the masquerade value. Thus, if class M contains terns.foobirds.org, the input address kirstan@terns.foobirds.org is rewritten but the address kirstan@sooty.terns.foobirds.org is *not* rewritten. This means that hosts in a domain are not masqueraded even if the name of the domain is found in class w or class M. Use FEATURE(`masquerade_entire_domain') to change this default behavior so that every component of a domain defined in class w or class M is masqueraded. If masquerade_entire_domain is specified and class M contains terns.foobirds.org, the input address kirstan@terns.foobirds.org is rewritten and so is the address kirstan@sooty.terns.foobirds.org. Listing 9.4 illustrates the effect that these various options have on masquerading.

Listing 9.4 Testing Special Masquerade Options

```
[root]# diff ../domain/old-foobirds.m4 ../domain/foobirds.m4
8a9,12
> MASQUERADE_AS(`foobirds.org')dnl
> MASQUERADE_DOMAIN(`foobirds.org')dnl
> FEATURE(`limited_masquerade')dnl
> FEATURE(`masquerade_entire_domain')dnl
[root]# m4 ../m4/cf.m4 redhat8l1.mc > masquerade.cf
[root]# sendmail -bt -Cmasquerade.cf
```

```
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> $=w
wren.foobirds.org
[172.16.12.3]
patient-rights.org
outofbusiness.com
wren
localhost
imaginary.com
> /tryflags HS
> /try esmtp fred@imaginary.com
canonify           input: fred @ imaginary . com
... Many lines deleted ...
final             returns: fred @ imaginary . com
Rcode = 75, addr = fred@imaginary.com
> $=M
foobirds.org
> /try esmtp sara@hawk.foobirds.org
Trying header sender address sara@hawk.foobirds.org for mailer esmtp
canonify           input: sara @ hawk . foobirds . org
... Many lines deleted ...
final             returns: sara @ foobirds . org
Rcode = 0, addr = sara@foobirds.org
> ^D
```

Listing 9.4 opens with a `diff` command that shows the four `m4` macros added to the `foobirds.m4` configuration file. The four macros tell Sendmail to:

- Masquerade the host portion of outgoing addresses as `foobirds.org`.
- Store the value `foobirds.org` in class `M`.
- Only masquerade addresses if the host portion of the address matches the value in class `M`.
- Treat the value in class `M` as a domain and masquerade any hostname within that domain.

The new `test.mc` file is processed through `m4` to create a Sendmail configuration file named `masquerade.cf`. The `sendmail` command is run with the `–bt` option to enter test mode and with the `–C` option to load the new `masquerade.cf` configuration file. In test mode, the contents of class `w` is displayed, the `/tryflags` are set to `HS` to request header sender address processing, and the address `fred@imaginary.com` is processed for the `esmtp` mailer. (`imaginary.com` is one of the virtual domains we created in Chapter 6.) The

address is not masqueraded, even though the host portion of the address is contained in class w and masquerading is enabled. This test shows the effect of the limited_masquerade feature, which limits masquerading to values stored in class M and ignores values defined in class w.

Next, the contents of class M are displayed. It contains foobirds.org, which is the value we stored in class M with the MASQUERADE_DOMAIN macro. The address sara@hawk.foobirds.org is processed as a header sender address for the esmtp mailer. This time the address is masqueraded as sara@foobirds.org. We know that this is not because hawk.foobirds.org is in class w—it's not, and even if it was, class w is not being masqueraded. Additionally, hawk.foobirds.org is not in class M. The only value in class M is foobirds.org. The reason that hawk.foobirds.org is masqueraded is that this host is part of the foobirds.org domain and the masquerade_entire_domain option has been selected. Masquerading all of the hosts within a domain is very useful, particularly when a single mail server handles the mail for an entire domain.

Sometimes, of course, you want to masquerade most of the hosts in a domain, but not every host. In those cases, it is often simplest to use the masquerade_entire_domain feature to include the bulk of the domain's systems and then use the MASQUERADE_EXCEPTION macro to exclude the individual hosts that you don't want to masquerade. The configuration shown in Listing 9.4 masquerades every host in the foobirds.org domain. Assume that you wanted to masquerade every host except www.foobirds.org. You could add the following macro to the configuration shown in Listing 9.4 to accomplish this:

```
MASQUERADE_EXCEPTION(`www.foobirds.org')
```

Another exception to masquerading is created for special usernames. Class E contains the list of usernames that override masquerading. When the user portion of the input address contains a value found in class E, the host portion of the address is not masqueraded—even if the host portion of the address is listed in class w or class M. The usernames in class E are those names that are not unique among the systems being masqueraded. For example, every system has a root user and many have a postmaster account. If mail from root@wren.foobirds.org is masqueraded as mail from root@foobirds.org and mail from root@ibis.foobirds.org is also masqueraded as root@foobirds.org, there is no way for the mail server to determine the correct host when the recipient replies to root@foobirds.org. Placing the username root in class E prevents this problem. Use the EXPOSED_USER macro to add values to class E. The original old-foobirds.m4 file already had an EXPOSED_USER macro for root because it was derived from the redhat.mc file, which had this macro. The following two lines add both root and postmaster to class E:

```
EXPOSED_USER(root)
EXPOSED_USER(postmaster)
```

The EXPOSED_USER macro is not the only way to handle duplicate usernames. The macro works well for names like root, which have a special meaning and are found on all Linux systems, but it may not be the solution you want when the duplicated names are the logon names of real users. Instead of skipping masquerading for every user who has a duplicated name, you may want to replace the username portion of the outbound address. Rewriting usernames is our next topic.

Masquerading Usernames

Transforming the user portion of an outbound address requires a database. Unlike hosts that can be masqueraded as a single value, each username requires a unique value. The user database and the `genericstable`, both described in Chapter 6, can be used to rewrite usernames. The user database, usually named `/etc/mail/userdb.db`, handles both inbound and outbound addresses—duplicating functions performed by the `aliases` database and the `genericstable`. The user database does not work very well with masquerading. For that reason, it is not covered here. See Chapter 6 for details of the user database. The `genericstable`, on the other hand, is an excellent corollary to masquerading. The `genericstable` handles the user portion of the outbound address while masquerading handles the host portion.

The input address passed to the `genericstable` for processing must either have no host portion or a host portion that matches a value in class `G`. Use the GENERICS_DOMAIN macro to add individual values in class `G`. Class `G` performs the same function for the `genericstable` as class `M` does for masquerading. To configure the `genericstable` to be compatible with masquerading, class `G` should contain the same values as class `M`.

If you plan to add more than a few values to class `G`, load class `G` from a file using the GENERICS_DOMAIN_FILE macro. Use the same file for class `G` that you use for class `M` if you want to make the `genericstable` compatible with masquerading. For example, you might have the following two macros in your configuration if you wanted to masquerade usernames on exactly the same systems that you masquerade hostnames:

```
MASQUERADE_DOMAIN_FILE(`/etc/mail/masquerade-domain-names')
GENERICS_DOMAIN_FILE(`/etc/mail/masquerade-domain-names')
```

Also like values in class `M`, values in class `G` require an exact match. Use the `generics_entire_domain` feature to override this default behavior. The `generics_entire domain` feature acts exactly like the `masquerade_entire_domain` feature described in the previous section. When `generics_entire_domain` is used, the values in class `G` are treated as domain names and any host within those domains is considered a match for class `G`. Listing 9.5 shows the effect of the `genericstable` on output addresses.

Listing 9.5 Using `genericstable` to Masquerade Usernames

```
[root]# cat /etc/mail/generic-names
craig   craig.hunt
kathy   kathy.mccafferty
sara    sara.henson
david   david.craig
becky   rebecca.fro
[root]# makemap hash genericstable < generic-names
[root]# diff ../domain/old-foobirds.m4 ../domain/foobirds.m4
8a9,12
> MASQUERADE_AS(`foobirds.org')dnl
> MASQUERADE_DOMAIN(`foobirds.org')dnl
> FEATURE(`limited_masquerade')dnl
> FEATURE(`masquerade_entire_domain')dnl
9a14,16
> FEATURE(`genericstable')dnl
> GENERICS_DOMAIN(`foobirds.org')dnl
> FEATURE(`generics_entire_domain')dnl
[root]# m4 ../m4/cf.m4 redhat811.mc > generics.cf
[root]# sendmail -bt -Cgenerics.cf
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
Enter <ruleset> <address>
> /tryflags HS
> /try esmtp kathy@hawk.foobirds.org
Trying header sender address kathy@hawk.foobirds.org for mailer esmtp
canonify           input: kathy @ hawk . foobirds . org
... Many lines deleted ...
final            returns: kathy . mccafferty @ foobirds . org
Rcode = 0, addr = kathy.mccafferty@foobirds.org
> /try esmtp sara@patient-rights.org
Trying header sender address sara@patient-rights.org for mailer esmtp
canonify           input: sara @ patient-rights . org
... Many lines deleted ...
final            returns: sara @ patient-rights . org
Rcode = 75, addr = sara@patient-rights.org
> ^D
```

Listing 9.5 shows the contents of the `genericstable`. It also shows the `m4` macros added to the configuration for masquerading and for the `genericstable`. The `genericstable` feature adds support for the `genericstable` to the Sendmail configuration. The `GENERICS_DOMAIN` macro and the `generics_entire_domain` feature parallel the

MASQUERADE_DOMAIN macro and the masquerade_entire_domain feature, allowing the genericstable to work with masquerading.

The two sendmail -bt tests show the impact that these configuration choices have on output addresses. In both tests, we are processing header sender addresses for the esmtp mailer. The first input address is kathy@hawk.foobirds.org. It is rewritten to kathy.mccafferty@foobirds.org. Masquerading rewrote the host portion of the address and the genericstable rewrote the user portion. The address was rewritten because hawk.foobirds.org is a host in the domain foobirds.org, which is identified in both class M and class G.

The second address is sara@patient-rights.org. sara is a valid key in the genericstable, and patient-rights.org is a value found in class w. However, in this case the address is not rewritten because the configuration tells Sendmail to rewrite only addresses that are part of the domain identified in class M and class G.

The example in Listing 9.5 is very realistic. Many sites rewrite usernames to full names, and they usually do it while masquerading the hostname of the address. This provides the simple *first.last@domain* addressing that many organizations prefer. And it does it without interfering with virtual domains.

Masquerading hostnames and usernames both involve rewriting input addresses. An even more direct, though much more rarely used, method for rewriting addresses is to create your own rewrite rules. That is our next topic.

Writing Local Rules

It is not necessary to directly edit the sendmail.cf file to add "raw" sendmail.cf configuration commands to the file. Sendmail provides several m4 macros for inserting text directly into sendmail.cf.

The LOCAL_CONFIG macro marks the beginning of text inserted into sendmail.cf at the end of the Local Info section. LOCAL_CONFIG allows you to define variables, classes, or databases. Because all of the standard variables, classes, and databases are created or modified by m4 commands, the LOCAL_CONFIG command is needed only to create private variables, classes, or databases. Listing 9.5 shows a comment, a D command, a second comment, and a K command that are to be added to the end of the Local Info section of the sendmail.cf file.

Listing 9.6 A LOCAL_CONFIG Example

```
LOCAL_CONFIG
### Store a host name in variable A
DAns.foobirds.org
### Define a special NIS database
Knishosts nis -m hosts.byname
```

Listing 9.6 assumes that A is a private variable and that nishosts is a private database. The LOCAL_CONFIG example in Listing 9.6 is contrived, but it shows the format used by all of the macros covered in this section. Each macro is a keyword that marks the start of a variable-length block of text. The block of text ends when the next m4 macro is encountered. The variation between the macros covered in this section is that each one inserts the text into a different part of the sendmail.cf file.

The MAILER_DEFINITIONS macro is used to define a mailer and add it to the Mailer Definitions section of the sendmail.cf file. The mailer is defined using the M command described in Chapter 7. If any special rulesets are required by the new mailer, they are also defined in the text that follows the MAILER_DEFINITIONS macro.

Rewrite rules, and even entire rulesets, can be added to the Rewriting Rules section of the sendmail.cf file. Use the LOCAL_RULESETS macro to add an entire ruleset. The first line following the LOCAL_RULESETS macro is a sendmail.cf S command that defines the name of the new ruleset. This is followed by the rewrite rules that make up the ruleset. Most often LOCAL_RULESETS are used for spam filtering or security. We cover the LOCAL_RULESETS macro in Chapter 11, "Stopping Spam."

To add individual rules to rulesets 0, 1, 2, or 3, use the LOCAL_RULE_*n* macro. The *n* in the name of this macro is the number of the ruleset to which the rules should be added. Listing 9.7 shows rules being added to ruleset 1, which is also called the sender ruleset.

Listing 9.7 Creating and Testing Additions to Ruleset 1

```
[root]# diff ../domain/old-foobirds.m4 ../domain/foobirds.m4
8a9
> MASQUERADE_AS(`foobirds.org')dnl
9a11,13
> FEATURE(`genericstable')dnl
> LOCAL_RULE_1
> R$- < @ $=w . >       $: $( generics $1 $: $1 $) < @ $2 .>
[root]# m4 ../m4/cf.m4 redhat8l1.mc > local-rule1.cf
[root]# sendmail -bt -C local-rule1.cf
ADDRESS TEST MODE (ruleset 3 NOT automatically invoked)
```

```
Enter <ruleset> <address>
> =S1
R$- < @ $=w . >        $: $( genericstable $1 $: $1 $) < @ $2 . >
> $=G
> $=w
wren.foobirds.org
[172.16.12.3]
wren
localhost
[127.0.0.1]
> /tryflags HS
> /try esmtp craig@wren
Trying header sender address craig@wren for mailer esmtp
canonify           input: craig @ wren
Canonify2          input: craig < @ wren >
Canonify2        returns: craig < @ wren . foobirds . org . >
canonify         returns: craig < @ wren . foobirds . org . >
sender             input: craig < @ wren . foobirds . org . >
sender           returns: craig . hunt < @ wren . foobirds . org . >
... Many lines deleted ...
final            returns: craig . hunt @ foobirds . org
Rcode = 0, addr = craig.hunt@foobirds.org
> ^D
```

NOTE As noted in Chapter 8, "Understanding Rewrite Rules," ruleset 1 is applied to all sender addresses after ruleset 3 (`canonify`). Yet ruleset 1 is, by default, empty. It is only used if you add rules to the ruleset using the `LOCAL_RULE_1` macro.

In Listing 9.7, the `diff` command shows that this version of the `foobirds.m4` file has both masquerading and the `genericstable` enabled with default values, meaning that addresses matching class `w` and class `M` will be masqueraded and addresses matching class `G` will be processed by the `genericstable`. By default, the values in class `w` are not processed by the `genericstable`. Assume that you *want* to process addresses that match class `w` through the `genericstable` using your own rewrite rules. We accomplish this in Listing 9.7 by adding a single rule to ruleset 1.

The `sendmail -bt` test first shows that ruleset 1 contains only the rule that we added. The `$=G` command shows that class `G` is empty, and the `$=w` command shows the five values in class `w`. The address `craig@wren` is then processed as a header sender address for the

esmtp mail. Despite the fact that wren is not in class G, the user portion of the address is rewritten using the genericstable because craig@wren matches the pattern in our new rewrite rule.

LOCAL_RULE_*n* allows you to specify whether the rules you enter are added to ruleset 0, 1, 2, or 3. The LOCAL_NET_CONFIG macro adds your rewrite rules to ruleset 0, specifically to the Parse1 ruleset used by ruleset 0. Rules added by the LOCAL_NET_CONFIG macro have a very specific purpose—they are used to select mail for delivery through local network services before the mail is sent to a relay server. For example, assume that you want to send all of your mail through a relay server except for mail to your local domain. You could add the following to your configuration:

```
LOCAL_NET_CONFIG
R$+ < @ $* $m . >       $#esmtp $@ $2.$m. $: $1 < @ $2.$m. >
```

The template of this rule is a standard mailer triple that takes addresses that match the pattern, formats them, and hands them to the esmtp mailer for delivery. The pattern matches addresses that have one or more tokens ($+), a literal <@, zero or more tokens ($*), the value found in variable m, and a literal .>. The m variable holds the local domain name. If m equals foobirds.org, the address craig<@foobirds.org.> matches the pattern and is sent to esmtp for delivery, but the address marylee<@library.org.> does not match and falls through to the next rule. If the SMART_HOST relay is defined, the next rule sends this mail to that relay for delivery. Thus, the LOCAL_NET_CONFIG macro gives you a means of short-circuiting SMART_HOST relay processing for some addresses.

The LOCAL_NET_CONFIG macro is used only when your local system is a client of a mail relay server. The m4 macros that you use to configure your system as a relay client are our next topic.

Configuring a Relay Client

Linux systems support all of the features of Sendmail. Even a desktop Linux system is usually configured as a Sendmail server that directly collects and directly delivers mail for the system's users. In special cases, this standard configuration might not be what you want; you may want to route all mail through an external server. For example, if the desktop system is behind a firewall that blocks all incoming and outgoing mail except through an approved server, you may need to configure your Linux system to use that server for all mail. The nullclient feature creates this type of configuration. Listing 9.8 shows a complete nullclient configuration and the effect this configuration has on the sendmail.cf file.

Listing 9.8 A Sample `nullclient` Configuration

```
[root]$ cat client-only.mc
OSTYPE(linux)
FEATURE(`nullclient', `wren.foobirds.org')
[root]# m4 ../m4/cf.m4 client-only.mc > client-only.cf
[root]# grep 'wren' client-only.cf
DSwren.foobirds.org
DHwren.foobirds.org
DMwren.foobirds.org
```

In this case, we don't use a `DOMAIN` file. Instead, we replace the entire configuration with the `client-only.mc` macro configuration file that contains only two lines. Unlike all of the other macro control files we have created in this book, `client-only.mc` does not even contain a `MAILER` command. The two lines in the file are a required `OSTYPE` command to specify that we're running Linux and the `FEATURE` command that creates the `nullclient` configuration. The `nullclient` feature requires an argument to identify the external server. In Listing 9.8, the remote server is identified as `wren.foobirds.org`.

When the small `client-only.mc` file is processed through `m4` to produce the `client-only.cf` file, you might be surprised to find that this configuration file is no smaller than any other `sendmail.cf` file. The `nullclient` feature does not produce a radically different configuration. What it does is store the value from the argument field in the `S`, `H`, and `M` variables. `S`, `H`, and `M` direct how mail is processed in the `nullclient` configuration.

You're familiar with the `M` variable from the discussion of masquerading. The argument associated with the `nullclient` feature is used as the masquerade value so that all mail sent from the client is masqueraded as if it came from the external server.

The `S` variable holds the name of the `SMART_HOST` relay. The `SMART_HOST` is the server used for all outbound mail. The `H` variable holds the name of the `MAIL_HUB` server that collects all inbound mail, even mail addressed from one local user to another local user. The role of the `MAIL_HUB` is particularly surprising because local mail is not actually handled locally: the mail is sent to the `MAIL_HUB`. If `H` is set to a value, ruleset `localaddr` (ruleset 5) sends the mail to the host identified by variable `H` even if the mail is addressed to a local user.

WARNING The `nullclient` configuration creates the possibility of mail routing loops. If an alias or `.forward` file on the `MAIL_HUB` forwards mail back to the client, the client might send the mail right back to the `MAIL_HUB`, kicking off a mail loop. Don't forward mail from a `MAIL_HUB` to its clients. It is safest for the clients to download mail using a separate tool, such as IMAP.

The nullclient feature is a simple way to create a client-only Sendmail configuration. But like many simple solutions, it lacks flexibility. With nullclient, SMART_HOST and MAIL_HUB are set to the same value. That might not be what you want. You may not even want to use both a SMART_HOST and a MAIL_HUB. Two define commands can be used to build the client configuration the way you want it.

define(SMART_HOST, *mailer:server*) The SMART_HOST option allows you to identify the external server that should be used for outbound mail from the client. The optional *mailer* value can be used to specify the mailer used to relay mail to the external server. Sensibly enough, the relay mailer is used to relay mail to the external server if no *mailer* value is provided with the SMART_HOST option. The value provided to the SMART_HOST option is stored in variable S exactly as it is entered—i.e., *mailer:server* or just *server*.

define(MAIL_HUB, *mailer:server*) The MAIL_HUB option identifies the external server that the client uses for inbound mail. Again, an optional *mailer* can be specified, and if it isn't, the relay mailer is used to relay the mail to the server. The value specified for MAIL_HUB is written to variable H exactly as entered.

NOTE In addition to added flexibility, an advantage of using SMART_HOST and MAIL_HUB as opposed to nullclient is that you can select the mailer you want to use. If you use the *mailer:server* format with nullclient, the *mailer:server* value is written to S, H, and M, creating an invalid masquerade value.

When MAIL_HUB is used, mail for all local users is sent to the MAIL_HUB. This might not be what you want. For example, you might not want to send mail addressed to root to the MAIL_HUB for delivery. Use the LOCAL_USER macro to identify local users whose mail should be delivered locally even when a MAIL_HUB is defined. As an example, the following command prevents mail addressed to root from being sent to the MAIL_HUB for delivery:

```
LOCAL_USER(root)
```

The LOCAL_USER macro adds values to class L. There is no macro that loads class L from a file. If you want to load class L from a file, you must use a sendmail.cf F command to do so. Assume that you have a file named /etc/mail/local-user that contains a list of users whose mail should not be sent to the MAIL_HUB. You could add the following to your macro configuration to load the file into class L:

```
LOCAL_CONFIG
FL/etc/mail/local-users
```

Conversely, there may be users whose mail should be sent to the MAIL_HUB even though those users are not really local users. The idea of "apparently local" users requires some

explanation. When Sendmail is asked to deliver mail to an address that contains a user part but no host part, it assumes the address is the name of a local user. It verifies this through the aliasing process by checking whether or not the name is a local `login` name or a valid alias. If it is not either one of these things, the name is not considered local and is rejected. The name appeared to be local but it wasn't—it was an apparently local name. It is possible to configure Sendmail to send mail addressed to apparently local users to a relay server. Use the LUSER_RELAY macro to define the server if you want to do this. The following command would forward all apparently local users to the server `wren.foobirds.org` for processing:

```
LUSER_RELAY(wren.foobirds.org)
```

An LUSER_RELAY is most useful in an organization where every user has a unique username. When that is the case, mail can be addressed to the unique username of any user in the entire organization without adding the host part of the address. The Sendmail client detects that the address is apparently local, and sends the mail to the LUSER_RELAY. The relay server must then know how to deliver the mail to the correct user.

One other macro that you will occasionally see discussed for local mail relay is the LOCAL_RELAY macro. You should ignore it. This is a deprecated macro that has been superseded by the MAIL_HUB macro. LOCAL_RELAY should not be used in your configuration.

Finally, there are special relay servers for non-SMTP mail. These are:

`define(UUCP_RELAY, mailer:server)` The *`server`* is the name of the system that handles UUCP mail for all UUCP sites that are not directly connected to the local host. The *`mailer`* defaults to `relay`. It is very common to send UUCP mail from the client to the server using SMTP, which is the protocol used by the `relay` mailer. The server then forwards the mail on through UUCP. The argument provided to the UUCP_RELAY option is stored in the `sendmail.cf` variable `Y`.

`define(FAX_RELAY, mailer:server)` The FAX_RELAY option identifies the server used to deliver mail addressed to the pseudo-domain `.FAX`, which is obviously an external fax server. With this option set, users can address mail to a fax machine by using the syntax expected by the external fax server and the `.FAX` domain. *`server`* is the name of the external fax server and *`mailer`* is the mailer used to reach that server. *`mailer`* defaults to `relay`. The argument of the FAX_RELAY option is stored in the `sendmail.cf` variable `F`.

`define(DECNET_RELAY, mailer:server)` The DECNET_RELAY option identifies the mail gateway to a DECNET network. DECNET is an outdated network that was used by Digital Equipment corporation mini-computers. The argument of the DECNET_RELAY option is stored in the `sendmail.cf` variable `C`.

`define(BITNET_RELAY, mailer:server)` The `BITNET_RELAY` option identifies a mail gateway to the BITNET network. BITNET is an outdated network that connected IBM mainframes in the days before IBM provided TCP/IP software. The argument of the `BITNET_RELAY` option is stored in the `sendmail.cf` variable `B`.

The three options `LOCAL_RELAY`, `DECNET_RELAY`, and `BITNET_RELAY` are never used because the commands or the networks they apply to are outdated. The `UUCP_RELAY` and the `FAX_RELAY` options are rarely used, because it is difficult to find anyone today who has only a fax machine or a UUCP connection and cannot receive SMTP mail from the Internet. The `LUSER_RELAY` is rarely used. There is little demand for it because users expect to add the *`@host`* part to e-mail addresses, and thus do not demand anything else. The configuration of a relay client comes down to just the `SMART_HOST` and `MAIL_HUB` options. Despite all of the possible options, client-side relay configuration is fairly simple. At most, one value is set for an outbound server and one is set for an inbound server.

The server side of relaying is much more complex than the client side. The client simply points to the server that will handle the mail. The server must decide if it wants to handle the mail and how to deliver the mail once it accepts it. Configuring a system as a relay server has become an issue of security and spam control. We will cover the server side of relaying in Chapter 11.

In Sum

This chapter concludes Part 3, "Advanced Configuration," with a look at some of the special `m4` configurations that can be used to customize Sendmail for your environment. Most of the configurations we looked at in this chapter fit well as part of the `DOMAIN` file because they relate to something that is special about your domain or your network.

We started by taking a look at address masquerading, which is the Sendmail feature that rewrites the host part of the sender address to a standard value for all outbound mail. Masquerading is simple to enable with the `MASQUERADE_AS` macro, but then there are eight different masquerading options available for your configuration. As you have seen before, Sendmail takes a simple idea and makes it complex by providing an array of choices. Don't get me wrong. Choice is great. It is what makes Sendmail so powerful and flexible, but it does add complexity. Attack the complexity by starting with the simple `MASQUERADE_AS` configuration. Run a series of tests to see if it gives you what you need. Then, using this book as a reference, add the features you think you want, testing as you go, until you get what you really need.

Masquerading the username portion of an e-mail address is generally related to host address masquerading. There are a couple of different ways this can be done, but the

`genericstable` is a good choice. The `genericstable` also has a range of configuration options, but selecting the correct options is easy once the masquerade configuration has been finalized. You want to masquerade the user portion of the address when you masquerade the host portion. Once you have created the masquerading configuration, simply replicate that configuration for the `genericstable`.

Masquerading and databases are one way to rewrite addresses, but they are not the only way. Addresses can also be directly rewritten using custom rewrite rules. `m4` provides several macros for inserting rewrite rules and their supporting configuration variables into the `sendmail.cf` file. There is no way to really reduce the complexity of rewrite rules. Do not attempt to write your own rules unless you understand what you are doing.

In addition to the various techniques for rewriting addresses, which usually apply to servers that are handling their own mail, we looked at the `m4` configuration options that are used to create a mail relay client. `m4` provides ten different relay options. Of these, only two are commonly used. `SMART_HOST` identifies the server that handles the client's outbound mail, and `MAIL_HUB` identifies the server that handles the client's inbound mail. Understand this, and you have mastered 99 percent of relay client configuration.

In this section, we have examined the inner workings of the `sendmail.cf` file, the details of rewrite rule syntax, and special `m4` options that rewrite addresses and create relay clients. To help us understand these complex topics and to help us select the correct options, we tested the configurations and observed the effects of the configuration commands. In the next chapter, we will look in detail at the Sendmail test features to better understand what we have been doing during these tests and to better understand how to apply these test tools to other problems. Chapter 10, "Testing Sendmail," opens Part 4, "Maintaining a Healthy Server," which covers the ongoing tasks of troubleshooting, spam control, and security.