A/UX® Network System Administration

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Preface

This guide describes A/UX® network system administration. It includes procedures for setting up, configuring, and administering a computer network.

This guide consists of the following chapters:

- Introduction
- Establishing a Two-System Network
- Initializing NFS
- Adding Yellow Pages Service
- Adding Systems to a Network
- Administering AppleTalk
- Network Design Issues
- Network Management
- Tools for Checking System Status
- Troubleshooting

In addition, this guide includes the following appendixes:

- Implementing a `sendmail` Facility
- Name Server Operations Guide for BIND
- The UUCP System
- Additional Reading

◆ *Note:* The procedures covered in this guide affect multiple computers. For information on setting up and administering single computer systems, see *A/UX Local System Administration*.

Who should read this guide

This guide is for both new and experienced A/UX system administrators.

How to use this guide

You should read the introductory chapter first. Then, if you are setting up a network of multiple machines for the first time, you should go through the guide sequentially. If you have already set up a network and need to add other systems to it, you can skip to Chapter 5, "Adding Systems to a Network." If you are primarily interested in printing capabilities, you can start with Chapter 6, "Administering AppleTalk."

The chapters are arranged with sections explaining separate tasks. Within these sections the actual steps you take to accomplish each task are in boldface text, to separate them from the explanatory text. This should help you when you already know what you want to do and need the instructions for how to do it.

What you should already know

As network administrator you should be an experienced A/UX user. You should have some previous system administrative experience or, at least, be familiar with *A/UX Local System Administration.*

Conventions used in this guide

A/UX guides follow specific conventions. Words that require special emphasis appear in specific fonts or font styles. The following sections describe the conventions used in all A/UX guides.

Keys and key combinations

Certain keys on the keyboard have special names. These modifier and character keys, often used in combination with other keys, perform various functions. In this guide, the names of these keys are in Initial Capital Letters followed by SMALL CAPITAL letters.

The key names are

CAPS LOCK	ESCAPE	SHIFT
COMMAND	LEFT ARROW	TAB
CONTROL	RETURN	UP ARROW
DOWN ARROW	RIGHT ARROW	

For example, suppose you enter

```
Applee
```

instead of

```
Apple
```

To erase the additional *e*, you would position the cursor (or insertion point) to the right of the word and press the DELETE key once.

Sometimes you will see two or more names joined by hyphens. The hyphens indicate that you use two or more keys together to perform a specific function. For example,

Press COMMAND-K

means "Hold down the COMMAND key and press the K key."

Terminology

In A/UX guides, a certain term can represent a specific set of actions. For example, the word *enter* indicates that you type an entry and press the RETURN key. The instruction

Enter `ls`

means "Type `ls` and press the RETURN key."

Here is a list of common terms and the corresponding actions you take.

Term	Action
Choose	Activate a command in a menu. To choose a command from a pull-down menu, click once on the menu title while holding down the mouse button, and drag down until the command is highlighted. Then release the mouse button.
Click	Press and then immediately release the mouse button.
Drag	Position the pointer on an object, then press and hold down the mouse button while moving the mouse. Release the mouse button when the object reaches the desired position on the screen.
Enter	Type the letter or letters and press the RETURN key.
Press	Type a *single* key *without* pressing the RETURN key. Or position the pointer on an object and hold down the mouse button.
Select	Position the pointer on a selectable object and click the mouse button.
Type	Type an entry *without* pressing the RETURN key.

The `Courier` font

Throughout A/UX guides, words that you see on the screen or that you must type exactly as shown are in the `Courier` font.

For example, suppose you see the instruction

Type `date` on the command line and press RETURN.

The word `date` is in the `Courier` font to indicate that you must type it.

Suppose you then read this explanation:

Once you type `date` and press RETURN, you'll see something like this:

```
Tues Oct 17 17:04:00 PDT 1989
```

In this case, `Courier` is used to represent exactly what appears on the screen.

All A/UX manual page names are also shown in the `Courier` font. For example, the entry `ls`(1) indicates that `ls` is the name of a manual page.

Font styles

Words that you must replace with a value appropriate to a particular set of circumstances appear in *italics*. For example, if you see

`cat` *filename*

replace the italicized word with the name of the file you wish to view. If you want to view the contents of a file named `Elvis`, type the word `Elvis` in place of *filename*. In other words, enter

```
cat Elvis
```

New terms appear in **boldface** where they are defined.

A/UX command syntax

A/UX commands follow a specific command syntax. A typical A/UX command has this form:
`command` [*flag-option*] [*argument*]...

The following table outlines the elements of an A/UX command.

Element	Description
`command`	The command name.
flag-option	One or more optional arguments that modify the command. Most flag options have the form [-*opt*...], where *opt* is a letter representing an option. Most commands have one or more flag options.
argument	A modification or specification of a command, usually a filename or symbols representing one or more filenames.
[]	Brackets used to enclose an optional item—that is, an item that is not essential for execution of the command.
...	Ellipses used to indicate an argument that can be repeated any number of times.

For example, the `wc` command is used to count lines, words, and characters in a file. Here is the full syntax for that command, including all possible flag options and the optional argument *name*.

`wc` [`-c`] [`-l`] [`-w`] [*name*...]

Thus, you can enter

```
wc -w /Priscilla
```

to count all of the words in the file `/Priscilla`, where `wc` is the name of the command, `-w` is the flag option that instructs the command to count all of the words in the file, and the optional argument `/Priscilla` is the file to be searched.

Command reference notation

A/UX Command Reference, A/UX Programmer's Reference, and *A/UX System Administrator's Reference* contain references for commands, programs, and other related information. Material is organized within these references by section numbers. The standard A/UX cross-reference notation is

cmd (sect)

where *cmd* is the name of the command, file, or other facility; *sect* is the section number where the entry resides.

- Items followed by section numbers (1M), (7), or (8) are listed in *A/UX System Administrator's Reference.*
- Items followed by section numbers (1), (1C), (1G), (1N), and (6) are listed in *A/UX Command Reference.*
- Items followed by section numbers (2), (3), (4), and (5) are listed in *A/UX Programmer's Reference.*

For example,

`cat(1)`

refers to the command `cat`, which is described in Section 1 of *A/UX Command Reference.*

References can be also called up on the screen. Use the `man` command to display pages from reference manuals, known as manual pages, directly on the screen. For example, enter the command

```
man cat
```

to display the manual page for the `cat` command, including its description, syntax, options, and other pertinent information. To exit, press the Space bar until you see a shell prompt, or type `q` at any time to return immediately to your shell prompt.

Cross-referencing

An A/UX guide often refers to information discussed in another guide in the suite. The format for this type of cross-reference is "Chapter Title," *Name of Guide.*

For a complete description of A/UX guides, see *Road Map to A/UX.* This guide contains descriptions of each A/UX guide, part numbers, and ordering information for all the guides in the A/UX documentation suite.

Terminology used in this guide

The following terms are used in this guide:

AppleShare®: Network software based on the AppleTalk® protocols that lets users store and share documents, folders, and applications.

B-NET®: Network software based on the Transmission Control Protocol/Internet Protocol (TCP/IP), also called Internet Protocols. This network software is derived from the networking implementation developed at the University of California at Berkeley and distributed in 4.3BSD. The B-NET software is part of the standard A/UX distribution; you enable it by using the scripts provided, which configure the B-NET software into the kernel. The B-NET software provides several TCP, IP, and UDP-based utilities for the end-user.

client: Depending on the context, a system or process that employs the resources provided to the network by a server.

directory hierarchy: The collection of all files currently available to the system, that is, all files on currently mounted file systems.

export: In NFS, making the local file system(s) of a server system available to certain specified client systems.

file system: A logical device that contains the data structures (directories, files, and inodes, among others) that implement all or part of the directory hierarchy.

host: A machine on the network; often called *local host* and *remote hosts.*

Internet: A group of networks interconnected by intelligent hosts called **Internet forwarders** or **Internet routers.** Because internets can span several networks, the routing of data might involve several intermediate nodes on the way to the destination node.

Internet address: A 4-byte number that contains an Internet network number and a unique host number identifying each host on a network.

Internet broadcast address: An address understood by all hosts on a local network as a special address for broadcast packets.

Internet domain: A hierarchical database of hosts on the Internet.

Internet network number: A 1-, 2-, or 3-byte number that identifies a network. All hosts on that network use the same network number. You can obtain an official Internet network number from SRI International's Network Information Center. To connect with other networks you need an official network number.

master server: In the Yellow Pages software, a designated host that contains the network's master database (including such files as `/etc/passwd`). You can make changes to this database available to all systems by using the Yellow Pages.

netmask: A 32-bit string containing binary 1's and 0's. The 1's in the netmask define the "network part" of the Internet address, and the 0's define the "host part."

protocol: A well-known set of conventions (for representing data, checking it, transmitting it, and so forth) that must be implemented at both ends of a connection before any communication can take place.

server: Depending on the context a system or process that provides resources to the network.

slave server: A system that serves copies of the Yellow Pages databases obtained from the master server.

TCP/IP: A suite of networking protocols developed for the U.S. Department of Defense that specify the details of how computers communicate.

Yellow Pages domain: A concept used by the Yellow Pages to group hosts on the network. Using multiple domains can be a useful security or administrative measure in large network installations.

◆ *Note:* Most commands are available in two forms, the UNIX-style command-line form, and the Macintosh dialog box form called "Commando." (See *A/UX Essentials* for a detailed description of Commando.) The Commando interface is useful for checking options and understanding the format of a particular command, but it can lead to many extra steps when working with networking commands. You might want to use Commando to check the available arguments for a few selected commands and then use the command-line form for most of your networking programs.

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Chapter 1 **Introduction**

This guide provides step-by-step instructions for setting up, maintaining, and troubleshooting A/UX® network software. Here is a list of the network software included with A/UX:

B-NET® is network software based on the Transmission Control Protocol/Internet Protocol (TCP/IP), also called Internet Protocols. This network software is derived from the networking implementation developed at the University of California at Berkeley and distributed in 4.3BSD. The B-NET software is part of the standard A/UX distribution; you enable it by using the scripts provided, which configure the B-NET software into the kernel. The B-NET software provides several TCP, IP, and UDP-based utilities for the end-user.

NFS® (Network File System) is a facility developed and licensed by Sun Microsystems that allows you to export data to remote systems. NFS requires the B-NET software to run. Like the B-NET software, NFS is part of the standard A/UX distribution; you can configure it into the kernel by using the scripts provided. (The networking modules are included automatically when you configure NFS.) NFS provides transparent remote file access for end-users and their processes.

Yellow Pages is a distributed database service developed and licensed by Sun Microsystems that provides several key administrative files to Yellow Pages clients. Yellow Pages are a network administration tool and require a B-NET kernel to run.

AppleTalk® is Apple's simple and flexible way to interconnect computers and peripheral devices. With A/UX you can configure your system to print on a LaserWriter® or an ImageWriter® II on an AppleTalk and a TCP/IP (EtherTalk™) network.

◆ *Note:* In addition to NFS, A/UX users can access AppleShare® file servers (thus becoming AppleShare clients) via LocalTalk™ or EtherTalk networks. See your AppleShare owner's manual for more information.

A/UX also supports the following BSD networking features:

Subnets are a BSD feature that allow a single Internet network number to support multiple networks within an organization (such as a school or company).

`newconfig` is an A/UX program that installs drivers and other software into the kernel. This program allows you to configure your network in a variety of ways (see `newconfig`(1M) for argument options). For instance, you can set up your kernel to run NFS by calling `newconfig nfs`. The `newconfig` program also removes drivers from the kernel; you can call `newconfig nonet` to remove networking capabilities from your system.

The `newconfig` program can take many arguments simultaneously. You can set up the type of kernel you want (B-NET or NFS), Yellow Pages service, AppleTalk capabilities, and other drivers. For example, you can set up your kernel for TCP/IP services with NFS and for AppleTalk and also include the capability of the Macintosh® Sound chip with `newconfig nfs appletalk snd`. In this manual each driver or piece of networking software is discussed separately, and the code examples show only the argument currently under discussion. You can, however, decide which services you want to install and run `newconfig` once with all the arguments.

Internet domains are part of the 4.3BSD BIND (Berkeley Internet Name Domain) distribution. The domain server `named` software provides Internet host names and addresses to domain clients (that is, systems using the `resolver` software). A/UX provides both the `named` and the `resolver` codes.

The **Serial Line Internet Protocol** (`slip`) is a program that lets you attach a serial line to the TCP/IP network. The `slip` program lets you use B-NET programs, such as `rlogin`, `rcp`, and `telnet`, without requiring the Ethernet hardware. See `slip`(1N), and "Establishing the `slip` Environment" in Chapter 2 for more information.

Chapter 2 **Establishing a Two-System Network**

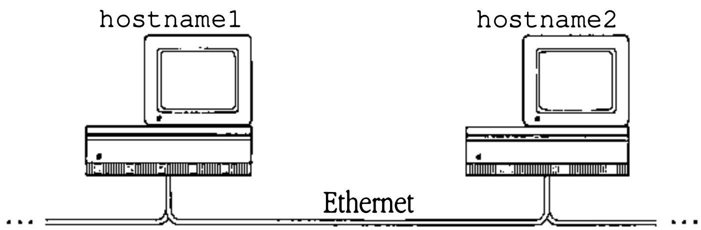
This chapter presents step-by-step instructions for establishing a two-host TCP/IP network of A/UX machines. After you have completed these steps, the machines you have connected by Ethernet or serial line will be able to communicate. Although a complex network may be your goal, it is easier to make a small network and then expand it than to install the larger network at the beginning. After you have established a two-system network, you can enlarge it to include printers, other CPUs, shared file systems, and so on. Instructions for expanding the network are provided in later chapters. The key topics discussed in this chapter are

- Prerequisites to running B-NET
- Preliminary steps
- Installing a kernel
- Adding another system to the network
- Testing network communication
- Establishing the `slip` environment

Overview

The simplest network you can set up consists of two computers connected by a cable, usually an Ethernet cable (see Figure 2-1). Each computer runs software that allows communication between systems.

■ **Figure 2-1** A two-system network



◆ *Note:* If you do not have Ethernet hardware, you can use the `slip`(1N) program to allow the serial lines on your A/UX machine to connect with the network. If you plan to use `slip`, you must build either a B-NET or an NFS kernel. Follow the directions in this chapter to build a networking kernel; ignore the details specific to the Ethernet hardware. Then follow the instructions in "Establishing the `slip` Environment," later in this chapter.

Prerequisites to running B-NET

The A/UX operating system includes all the software needed for the TCP/IP network (B-NET) and the Network File System facility (NFS). Before you run B-NET or NFS you must supply required information in system files, configure system files to start programs automatically (**daemons**), run installation scripts, and reboot with a new A/UX kernel.

A/UX machines require the following hardware to communicate with each other by using Ethernet:

- an Ethernet card in each computer
- regular or thin variety coaxial Ethernet cable
- transceivers and transceiver cable (required for regular Ethernet cable only)
- terminators

Instructions for Ethernet hardware installation are not included in this guide. See the documentation that accompanies your Ethernet hardware.

A/UX machines require the following hardware to communicate with each other by using `slip`

- serial cable for direct connection, or
- a modem

Preliminary steps

After installing the necessary network hardware, you need to obtain information for each machine, including the Internet address and netmask. If you have installed an Ethernet card from a third-party source, refer to your vendor's documentation for instructions on the information you must supply.

Before you set up the network, the system's **host** name and **Yellow Pages domain** name are set to default values. These values are called `localhost` and `localdomain`, respectively. You will need to change these values later, when prompted for your own names during an installation script. See "Choosing a Host Name" for information about the system's host name and Yellow Pages domain name.

If you have an Apple® EtherTalk card installed, the installation script will also prompt you for the following information:

- Internet address
- Internet broadcast address
- netmask

◆ *Note:* If you are using an EtherTalk card on a LocalTalk network, this information is not required.

The information you enter in response to these prompts is stored in the A/UX network information files described in the next section. See "Obtaining an Internet Address," "Determining the Internet Broadcast Address," and "Determining the Netmask" for more information about these prompts.

If you are establishing a `slip` connection and do not have an Ethernet card installed, you are not prompted for these three items. You need to edit certain files to contain this information, as described in "Establishing the `slip` Environment."

A/UX network information files

The A/UX standard distribution uses the files shown in Table 2-1 to store the required network information.

◆ *Note:* These files appear *after* you run `newconfig`(1M).

■ **Table 2-1** A/UX network information files

Information	A/UX system file
host name	`/etc/HOSTNAME` (1st field)
domain name	`/etc/HOSTNAME` (2nd field)
Ethernet logical unit number	`/etc/NETADDRS` (1st field)
Internet address	`/etc/NETADDRS` (2nd field)
Internet broadcast address	`/etc/NETADDRS` (3rd field)
netmask	`/etc/NETADDRS` (4th field)

See "Installing a Kernel" for more information about the prompts displayed when you reboot the system.

You can generate the prompts again to change the system's host name, Internet address, and other system settings by removing the `/etc/HOSTNAME` or `/etc/NETADDRS` files and rebooting. Or you can change the system's host name and Internet address by editing these files with a text editor and rebooting.

Choosing a host name

Every network machine must have a name. Yours has been set up with the default names mentioned earlier. The host name you choose must be no longer than 31 characters; should not include metacharacters such as `!`, `\`, `?`, or `*`; and must be unique on your network. The host name is public and used by everyone on the network to access files, write to users, and so forth.

The two machines set up on the network in this chapter are referred to as `hostname1` and `hostname2`.

◆ *Note:* If you intend to use NFS and the Yellow Pages, you should also determine the correct Yellow Pages domain name for each machine. If you are not sure what domain name to use, you can enter a string (the same host name restrictions apply) and change the domain name later, either temporarily, by using the `domainname` command, or permanently, by editing the second field of `/etc/HOSTNAME` and rebooting. However, do not use the `domainname` command to change your domain name if the Yellow Pages daemons are running on your machine. If this is your situation, first kill the Yellow Pages daemons, and then use the `domainname` command and restart the Yellow Pages daemons if you want to change your domain name temporarily. See Chapter 4, "Adding Yellow Pages Service," for more information about domains.

Obtaining an Internet address

Machines are linked via networks, which themselves may be linked to a larger wide-area network (WAN). For such a system to work, every network must have a unique Internet address. In a local area network that exists separately and never connects with another network, it doesn't matter if local network addresses duplicate addresses on another network. However, if such a local network is connected with another network, a duplicate address will cause mass confusion in the network software. If you are sure your network will never connect with another network on the Internet, you can construct your own network numbers as described in the note at the end of this section. However, if your site may want to communicate on the Internet, you need to obtain a unique network number and construct your Internet addresses from it.

An **Internet address** is a 4-byte number and is divided into class A, class B, and class C network numbers as shown in Table 2-2. The network number identifies the network itself, and the unique host number appended to it identifies each host on the network.

■ **Table 2-2** Internet addresses

Network class	Number of bytes in network number	Range of numbers in first byte (in decimal)	Number of bytes in host number
A	1	1–126	3
B	2	128–191	2
C	3	192–223	1

Note that 0 and numbers over 223 are reserved for special purposes and should not be assigned to specific hosts on the network. The number 127 is reserved for the loopback driver.

Internet numbers are assigned by a clearinghouse run by SRI International in Menlo Park, California. To obtain a unique network number for your site, call "Hostmaster" at

(800) 235-3155

You will be assigned a network number such as

```
192.3
```

Because the value of the first byte is within the range 192 to 223, this example is a class C network number. You may be assigned a class A, class B, or class C network number. Unless there is more than one physical Ethernet at your site, or you are integrating a `slip` connection into an existing Ethernet, you should use the same network number for all hosts on the network. See "Routing and Forwarding" in Chapter 7 for information about using more than one distinct network number at a site.

After you have been assigned a network number, assign Internet addresses to machines on your network by appending a unique host number to your network number. If you are using a class C network number, the "network part" of the address is three bytes and the "host part" of the address is one byte.

To avoid confusing the host address with a broadcast address (see "Determining the Internet Broadcast Address"), make sure that the bytes in the host field do not all contain 0's or 1's. For example, do not assign `192.33.20.0` or `192.33.255` as an Internet address.

For example, if your network number is `192.33.20`, you can assign host numbers `.1` and `.2` to two hosts as follows:

```
192.33.20.1 hostname1
192.33.20.2 hostname2
```

These numbers indicate that the two machines are on the same network, but they are uniquely identified by the host part (second part) of the number.

◆ *Note:* If time is limited, you can use "dummy" numbers until you receive your Internet network number (but *do not* connect your network to other networks). These dummy numbers should follow the conventions just described; that is, the network number must be the same for each machine on the network, and the host number must be unique for each machine on the network. A dummy class B network number should be of the form
X.Y.n.m

where *X* and *Y* are the network part of the address (and are the same for all hosts on the network) and *n* and *m* are host numbers that (together) are unique for each host on the network. *Do not connect your network(s) to another network without first obtaining an official network number.*

Determining the Internet broadcast address

The **Internet broadcast address** is understood by all hosts on a local network as a special address for broadcast packets. The Internet broadcast address is defined as the Internet address with a host part of all binary 1's (or decimal 255). This is the broadcast method used by A/UX and by 4.3BSD.

◆ *Note:* The old broadcast address used by 4.2BSD was an Internet address with a host part of 0.

A/UX allows you to set the broadcast address by responding to prompts when you create an NFS or B-NET kernel.

For example, if the network number is

```
192.33.20
```

and all systems on the network use the standard broadcast address of all binary 1's, the broadcast address you should enter at the prompt is

```
192.33.20.255
```

since 255 decimal is equivalent to eight binary 1's (one byte).

Determining the netmask

The **netmask** is a 32-bit string containing binary 1's and 0's. The 1's in the netmask define the network part of the Internet address, and the 0's define the host part of the Internet address. If you are setting up a simple two-system network of Macintosh II or Macintosh IIx computers, you may not need to redefine the network part of the systems' Internet address. For example, if you are using a class B network number, the netmask

```
0xffff0000
```

specifies that the first two bytes make up the network part of the address and the last two bytes make up the host part. (That is, for a class B network number you do not redefine the network part of the address.) This is the default setup; to create a subnet you will need to mark off additional bits.

See "Subnets" in Chapter 7 for more information about using netmasks in a homogeneous environment of Macintosh computers. See the additional documentation listed in Appendix D under "Related RFCs" for information about subnets, netmasks, and broadcasts in general.

Installing a kernel

To run B-NET or NFS software you must create a kernel containing the appropriate software. A B-NET kernel will run only B-NET, but an NFS kernel will run both B-NET and NFS. The only advantage of making a B-NET kernel (assuming you never plan to run NFS) is one of memory size; a B-NET kernel uses less memory than an NFS kernel.

Installation steps

The following is a summary of the kernel installation procedure. After installing the network hardware, follow these steps:

1. **Log in as the root user.**
2. **Choose CommandShell from the Apple menu.**
3. **Run the `newconfig` program with either `nfs`, `bnet` or `slip`.**

   (See "Overview of the A/UX Network Software" in Chapter 1 for a discussion of `newconfig`; also see `newconfig`(1M) for a full list of options.)

4. **`newconfig` builds the kernel for you and prompts you for several kinds of information.**

   The actual prompts that appear on your screen depend on the kernel you are booting and answers you may have given to prompts during previous configurations.

   ```
   Do you want this machine to be a Yellow Pages client
   (default n)?
   ```

5. **Answer no for now.**

   You will see a message stating that `newconfig` is building the kernel, and that it may take a while.

   If your machine already has an `/etc/exports` file (or if you answered yes to the last prompt) and you're installing NFS, the `/etc/nfsd` entry in `/etc/inittab` will be enabled automatically.

   If you are creating an NFS kernel and your machine doesn't have an `/etc/hostname` file, you will see this prompt:

   ```
   Please enter a hostname (it must be unique):
   ```

   (This prompt will not appear if you've already edited your `/etc/hosts` file.)

6. **Enter the system's host name.**

   (See "Choosing a Host Name," earlier in this chapter, for restrictions and naming conventions.)

   The following prompt appears:

   ```
   Please enter a domainname:
   ```

7. **Enter a domain name for your machine.**

   (See "Yellow Pages Domains" in Chapter 4 for an explanation of domains.)

   If you do not intend to use the Yellow Pages, enter any string that is no longer than 31 characters and does not include metacharacters such as `!`, \, `?`, `*`, or RETURN. Host and domain names are stored in the `/etc/HOSTNAME` file, which is read by the hostname command when `/etc/startup.d/ae6` is called by `/etc/startup`. The `/etc/startup` script is run by `/etc/sysinitrc` at boot time.

   If you don't know the answer to any of the above questions, or if you want to escape from the process of building the kernel, press CONTROL-C. Your kernel and all affected configuration files will be restored to their original state.

   If you have created a B-NET or NFS kernel with `slip` and you don't have the Ethernet hardware, you won't see any of the prompts shown in the rest of this section. In this case skip to the section "Establishing a `slip` Environment." Then, to add another system to your network, follow the directions in "Adding Another System to the Network."

The queries in the following steps will appear when you run `newconfig` after adding a new Ethernet card, when you reboot after moving your Ethernet card to a different slot, or if you've deleted your `/etc/NETADDRS` file.

◆ *Note:* If you remove your Ethernet card, you must edit your `/etc/inittab` file to set `nfs0 - nfs8` and `net4 - net0` to off. Or you can run `newconfig nonet` to remove networking capabilities from your kernel automatically. If you don't make these changes, various NFS or B-NET processes may fail.

As `newconfig` is running, it notices your Ethernet card and prompts you for the Internet address, broadcast address, and netmask associated with the new card:

```
1 Ethernet card(s) installed
ae0: Please enter an Internet address:
```

8. Enter the system's Internet address.

For this sample system, enter

```
192.33.20.1
```

The response is

```
ae0: Please enter an Internet Broadcast address:
```

9. Enter the system's Internet broadcast address.

For this network, enter

```
192.33.20.255
```

(See "Determining the Internet Broadcast Address," earlier in this chapter, for more information.)

The next prompt is

```
ae0: Please enter a netmask [none]:
```

10. A netmask is necessary only if your network uses subnet routing. If you are not setting up subnet routing, press RETURN to accept `none` as the default response. Otherwise, enter the netmask you are using.

For this example, enter

```
0xffff0000
```

Note that you must type the `0x` (hexadecimal) prefix and all eight digits of the netmask. Which number you enter here depends on which broadcast method you are using and on how the network will be configured. See "Determining the Netmask," earlier in this chapter, for more information.

The `/etc/startup.d/ae6` script stores the Internet address, Internet broadcast address, and netmask in `/etc/NETADDRS`. It also appends an entry to the end of `/etc/hosts` with the host name and Internet address and a date stamp in the comment field.

◆ *Note:* If you forced the host name and domain name prompt to appear by removing the `/etc/NETADDRS` file, you may now have duplicate entries for this host *at the same Internet address* in `/etc/hosts`. In most cases these duplicate entries cause no harm. However, if this host is a Yellow Pages master server, be sure to remove these duplicate entries from `/etc/hosts`. Otherwise they may cause inconsistent Yellow Pages behavior.

At this point `newconfig` will edit your `/etc/inittab` file to set up the daemons for the kernel or services you've chosen. (See "Overview of A/UX Network Software" in Chapter 1 for a discussion of `newconfig`.)

11. **Add information about other network hosts to `/etc/hosts` and (if desired) `/etc/hosts.equiv` and `$HOME/.rhosts`.**

    (See "Listing Other Network Hosts" later in this chapter for more information.)

12. **Restart your computer.**

    You can do this from the Finder by choosing Restart from the Special Menu.

Allowing open access (optional)

A host name entry in `/etc/hosts.equiv` allows non–root users from the specified host (who also have an entry in the local `/etc/passwd`) to access the local host remotely by using `rcp`, `remsh`, and `rlogin` without supplying a password.

◆ *Note:* For security reasons a superuser on an equivalent host must supply a password unless the root account is set up (in `/.rhosts`) to allow remote root account access.

To make the system more secure you can use individual `$HOME/.rhosts` files instead of `/etc/hosts.equiv`. See `hosts.equiv`(4), `rlogin`(1N), and also "Network Security" in Chapter 8.

To allow all users (except root users) on another host on the network to use `rcp`, `remsh`, or `rlogin` on `hostname1` without supplying a password:

1. **Open `/etc/hosts.equiv` with a text editor.**

   It may contain a single line for the loopback driver:

   ```
   loop
   ```

2. **Add lines for other hosts; for example,**

   ```
   hostname2
   loop
   ```

Checking your `/etc` files

Use `cat` to check `/etc/inittab`. The `newconfig` program has edited this file, so make sure it looks like the examples listed here. (There will be more lines in the file, but these are the important ones.) Check the status field (shown in bold) on the following lines:

nfs0:2:**wait:**/etc/portmap
net4:2:**wait:**/usr/etc/in.routed
net5:2:**off:**/usr/etc/in.rwhod
net9:2:**respawn:**/etc/inetd

The daemons with a status field other than `off` are enabled.

You do not have to run all the network daemons listed in `/etc/inittab`. In particular, you may want to omit one of the following daemons the first time you bring up your network:

- The `routed` daemon

  net4:2:**wait**:/usr/etc/in.routed

  manages network routing tables but is not necessary on a simple one-cable network. See Chapter 7, "Network Design Issues," for information on multiple networks.

- The `portmap` daemon

  nfs0:2:**wait**:/etc/portmap

  is necessary if you intend to use remote procedure calls (RPCs), as you do with NFS. See the file `/etc/rpc` for a list of RPC services. For networking services, be sure to set the status field to `wait`.

You may also want to leave certain daemons turned off that are off by default. For example, `rwhod` maintains the database used by the optional `rwho` and `ruptime` commands. It broadcasts quite frequently and could cause problems in large or heterogeneous environments. If you have a small environment, though, you can turn the daemon on by editing the line in `/etc/inittab` to look like

net5:2:**once**:/usr/etc/in.rwhod

You may wish to enable `sendmail`. To do this, edit `/etc/inittab` to look like

net8:2:**once**:/usr/lib/sendmail -bd -930m

Next, check `/etc/servers`. If a daemon is listed in this file, it is invoked by `inetd` from `/etc/inittab`. The contents of the file should look like

```
ftp      tcp      /usr/etc/in.ftpd
telnet   tcp      /usr/etc/in.telnetd
shell    tcp      /etc/in.remshd
login    tcp      /etc/in.rlogind
exec     tcp      /usr/etc/in.rexecd
tftp     udp      /usr/etc/in.tftpd
talk     udp      /usr/etc/in.talkd
finger   tcp      /usr/etc/in.fingerd
rpc      udp      /usr/etc/rpc.rstatd      100001      1-2
rpc      udp      /usr/etc/rpc.rwalld      100008      1
rpc      udp      /usr/etc/rpc.mountd      100005      1
rpc      udp      /usr/etc/rpc.rusersd     100002      1-2
rpc      udp      /usr/etc/rpc.sprayd      100012      1
comsat   udp      /etc/comsat
```

Listing other network hosts

You should add information about other network hosts to `/etc/hosts` on `hostname1`.

Open `/etc/hosts` with a text editor. This file already contains the loopback address (in hexadecimal):

```
0x7F.0x00.0x00.0x01  loop  lo  loo localhost
```

Add an entry for at least one system that you will add to this network (in either hexadecimal or decimal numbers); for example,

```
0x7F.0x00.0x00.0x01     loop  lo  loo localhost
192.33.20.1             hostname2
```

See `hosts`(4) in *A/UX Programmer's Reference* for more information about this file. Note that you do not need to add an entry for the address(es) of the local host because this occurs automatically at reboot.

Testing the network software

The simplest test of the network software is to see whether the local system can talk to itself by using the loopback interface. To run this test, enter

```
telnet loop
```

This requests access to a remote login (through the network looped back to itself) on the local system. After a short time you should see the login prompt

```
A/UX Apple Computer, Inc.
login:
```

If this test fails, see Chapter 9, "Tools for Checking System Status," for information on checking the network.

Adding another system to the network

To put `hostname2` on the network, follow these steps:

1. **Log in to `hostname2`.**
2. **Answer the prompt about whether this machine is to be a domain name server.**
3. **Run `newconfig` with the appropriate arguments.**

   `newconfig` will prompt you for your host and Yellow Pages domain names (if you have not already changed them yourself) and for Ethernet information if you have the Ethernet card installed. At this point the `newconfig` program edits your `/etc/inittab` file and builds the kernel for you.

4. **Add information about other network hosts to `/etc/hosts` and (if desired) `/etc/hosts.equiv` and `$HOME/.rhosts`.**

   (See "Listing Other Network Hosts" and "Allowing Open Access (Optional)".)

5. **Restart.**
6. **Check your `/etc/inittab` and `/etc/servers` files, and make any changes you wish.**

   (See "Checking your `/etc` Files.")

Testing network communication

When you have rebooted `hostname2` and tested the network software with the loopback interface, you can use the `ping` command to determine if the network is working.

From `hostname2`, enter

```
/usr/etc/ping hostname1
```

If the network and both hosts are functional, `ping` produces a display similar to

```
64 bytes from 192.33.20.1: icmp_seq=0. time=16. ms
64 bytes from 192.33.20.1: icmp_seq=1. time=16. ms
64 bytes from 192.33.20.1: icmp_seq=2. time=16. ms
64 bytes from 192.33.20.1: icmp_seq=3. time=16. ms
64 bytes from 192.33.20.1: icmp_seq=2. time=16. ms
64 bytes from 192.33.20.1: icmp_seq=3. time=16. ms
```

(*interrupt*)

```
----hostname1 PING Statistics----
6 packets transmitted, 6 packets received, 0% packet loss
round-trip (ms)  min/avg/max = 16/16/16
```

Use the interrupt character (usually CONTROL-C) to stop the output of `ping` once the packets are being returned. The `ping` command prints statistics and exits.

This command works in either direction. You can also enter

```
/usr/etc/ping hostname2
```

from `hostname1`. The resulting display is similar to

```
64 bytes from 128.8.1.2: icmp_seq=0. time=16. ms
64 bytes from 128.8.1.2: icmp_seq=1. time=16. ms
```

(*interrupt*)

```
----hostname2 PING Statistics----
2 packets transmitted, 2 packets received, 0% packet loss
round-trip (ms)  min/avg/max = 16/16/16
```

Remote login

If you have a login account on both hosts, you can log in to one from the other. For example, if you are currently logged in to `hostname1`, use the following `telnet` command to connect to `hostname2`:

```
telnet hostname2
```

If you are prompted for your login name and password on the remote system, the test worked. Just press CONTROL-D at the remote login prompt. If you see the message `Trying...` followed by `Connection timed out.`, the test failed. See Chapters 9 and 10 for more information.

Establishing the `slip` environment

The `slip` program allows serial lines to interface with the TCP/IP network. The `slip` program lets you use a serial line to connect with remote machines without Ethernet hardware. You can set up your machine as either a `slip` client or a `slip` server.

If you want to allow other users to attach their serial lines to the network (by using modems to dial your machine, for example), set up your machine as a `slip` server. After establishing a `slip` connection with your machine, dialin users can use B-NET or NFS network programs to connect to your machine and to other machines connected to yours by the network. Note that both the `slip` server and the `slip` client must run the router `/etc/in.routed` (set up in `/etc/inittab`) to access other hosts transparently.

If you want to access other machines by using `slip`, follow the directions in *A/UX Communications User's Guide* to set up your machine as a `slip` client.

The basic steps to configure your machine as a `slip` server are

1. **Build a networking kernel that includes support for `slip`.**
2. **Modify the `/etc/slip.config` file to contain a host address for each `slip` interface supported by that server.**
3. **Modify the `/etc/hosts` file to contain the Internet address of the `slip` client and `slip` server.**
4. **Modify the `/etc/slip.hosts` file to contain the Internet address and user name of each `slip` client.**
5. **Run `mkslipuser`.**

The subsections that follow explain these steps in more detail.

Building a `slip` kernel

To set up your A/UX machine as a `slip` server, first create a new kernel. See "Installing a Kernel," earlier in this chapter, for instructions.

After creating the networking kernel, modify the `/etc/slip.hosts`, `/etc/hosts`, and `/etc/slip.config` files to include your hostnames. Then run `mkslipuser` to allow dialin users to establish a `slip` connection to your machine.

Configuring the `/etc/slip.config` file

The `/etc/slip.config` file must be configured on the `slip` server to establish `slip` connections between the `slip` server and the `slip` client. The `/etc/slip.config` file must contain a host address for each `slip` interface supported by that server. List host addresses on separate lines; each line configures a separate serial interface.

Here is a sample `/etc/slip.config` file:

```
# slip.config configuration file
# Each line configures a serial line
#
192.33.20.1
192.33.20.254
```

A Macintosh II or Macintosh IIx has two built-in serial interfaces. To use them both for `slip`, you must list host addresses as two separate lines in `/etc/slip.config`. The example shows two `slip` interfaces available for use, each using the same host address.

Configuring the `/etc/hosts` file

You should modify the `/etc/hosts` file on the server so that you can use host names instead of network addresses in your network commands. The `/etc/hosts` file on the server should contain the Internet address of both the `slip` client and the `slip` server. Here is a sample `/etc/hosts` file:

```
0x7F.0x00.0x00.0x01 loop lo loo localhost
128.120.254.3 hostname1 #slip server
192.33.20.253.1 hostname2 #slip client
```

The first line contains the loopback address; this line is always present in the `/etc/hosts` file. The second line is the Internet address and host name of the `slip` server. The third line is the Internet address and host name the client uses to make a `slip` connection.

Configuring the `/etc/slip.hosts` file

You use the `/etc/slip.hosts` file to map user names on `slip` client machines to the Internet addresses of the `slip` clients. The `/etc/slip.hosts` file contains the Internet address used by each `slip` client when that user makes a `slip` connection to the `slip` server. Here is a sample `/etc/slip.hosts` file:

```
# dialup slip.hosts table
# maps user names to host addresses
#
192.33.20.253.1 peter
192.33.20.253.2 sharon
192.33.20.253.3 mike
192.33.20.253.4 linda
```

When the user specified in the second field invokes `slip`, the system uses the Internet address in the first field. Peter's client machine is `hostname2`.

Enabling `slip` on the server

1. **After modifying `/etc/hosts`, `/etc/slip.hosts`, and `/etc/slip.config`, run `mkslipuser` to create the `/etc/slip.user` file.**

   `slip.user` is not ASCII text and cannot be read by humans.

2. **You can use `dslipuser`(1N) to display the contents of the user file and report the number of `slip` users on the system and the number of available `slip` interfaces.**

   Your system is now configured as a `slip` server.

To allow `slip` clients to use host names instead of network names when they establish a `slip` connection to your machine, instruct the users on `slip` client machines to modify their local `/etc/hosts` files to contain the Internet address and host name they use when establishing a `slip` connection. The Internet address and host name of the `slip` server should also be in this file.

Other required network system files

The B-NET software also requires the following files:

`/etc/networks` List the networks available to the system here. For each network, enter a single line with the following information:

network-name network-number aliases

Here is a sample `/etc/networks` file showing two networks available:

```
loopback 127
# Internet networks
#
arpanet 10     arpa
ucb-ether      46    ucbether
```

If you connect to an outside network, this file is normally created from the official network database maintained at the Network Information Center (NIC). You can also assign a name to the network(s) at your own site. Use a text editor to open `/etc/networks` and add a line for your own network; for example,

```
ether-net 192.33.20.1 localnet ournet
```

Network names can contain any printable character other than a field delimiter (blank or tab), a new line, or a comment character (`#`).

`/etc/services`	Information about known services available on the network appears here. These services are called by various network commands. You seldom need to modify this file.
`/etc/protocols`	Information about system protocols used by the network appears here. You modify this file only if the network is joining another network that uses protocols not listed in this file.
`/etc/ftpusers`	Although this file does not require the network software, the A/UX standard distribution contains a root entry. This prevents remote `ftp` users from logging in as root users on the local system.
`/etc/shells`	This file lists which programs `ftp` users may execute as their login shell.

Chapter 3 **Initializing NFS**

This chapter describes intializing the Network File System. The key points covered are:

- Overview of NFS
- Installing NFS on a server machine
- Installing NFS on a client machine

The first part of this chapter describes how to set up a machine as an NFS file server to allow access to its files. The second part of the chapter explains how to set up a machine as an NFS client to mount a server's files remotely. After completing the steps in these two sections, you will have one NFS server and one client. If your goal is to configure a large local area network, you can set up additional servers and clients by repeating the steps described in this chapter.

◆ *Note:* Chapter 2 described how to install a two-system B-NET network. A functioning network is a prerequisite to running NFS. See "Installing a Kernel" in Chapter 2, where there is an option to build the NFS kernel while adding the machine to the network.

Overview of NFS

A **file system** is a logical device that contains the data structures (directories, files, and inodes, among others) that implement all or part of the directory hierarchy. The **directory hierarchy** is the collection of files currently available to the system, that is, all files on currently mounted file systems (see `mount`(1M) in *A/UX System Administrator's Reference*). The general term *hierarchy* is used for the collection of files and subdirectories of a given directory structure; for example, the `/usr` hierarchy contains all files and directories under the `/usr` directory.

◆ *Note:* The current A/UX distribution on an 80-megabyte (MB) hard disk contains only one user-accessible partition: the root file system partition. Thus to **export** a particular directory hierarchy of the root file system and make it available to all client systems, you must first export the entire root file system; then you can export any directory hierarchy you wish. See "Testing NFS with a Temporary Remote Mount," later in this chapter, for more information.

In NFS, a server machine explicitly exports (allows remote access to) its file systems. Any host can function both as a client and a server.

A client machine can remotely mount the exported file system or a hierarchy of that file system by specifying that hierarchy in `/etc/fstab`. When a client system has remotely mounted data from a server, users and processes on the client system can access that data transparently as if it were stored locally. Listing file systems in `/etc/fstab` will cause those systems to be mounted each time you boot the machine. To remotely mount a file system for a single session, you can run

`mount` *hostname*`:`*filesystem directory options*

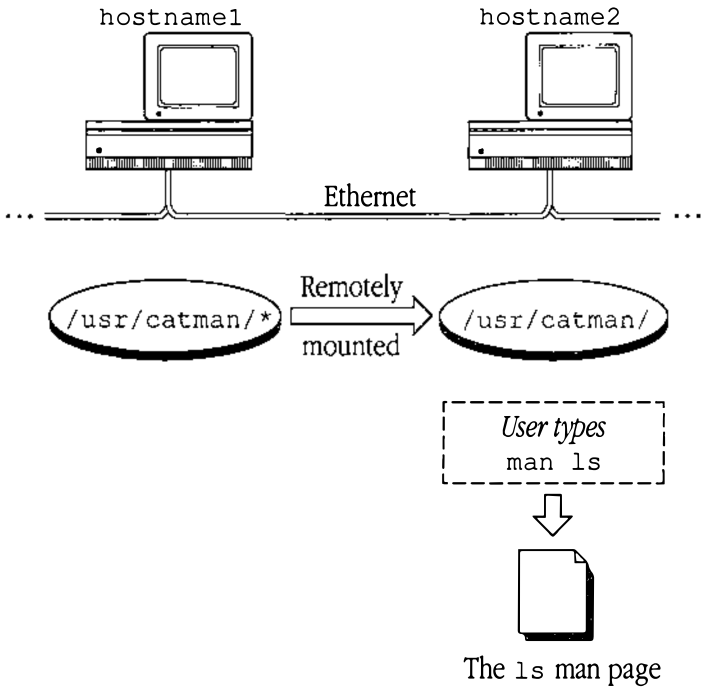
(See `mount`(1M) for a list of the available options.)

For example, in Figure 3-1 `hostname1` is a Macintosh II exporting its root file system to `hostname2`. The machine `hostname2` has remotely mounted the `/usr/catman` hierarchy from `hostname1` on a mount point directory named `/usr/catman`. When a user on `hostname2` enters

```
man ls
```

the `man` command on `hostname2` accesses the online manual page as if it were on the local disk, and the `ls` manual page appears on the user's screen.

■ **Figure 3-1** Remotely mounted manual pages



The NFS service works as follows: A client's `mount` request talks to the server's `mountd` daemon. The daemon checks the client's access permission and, if it is correct, returns a pointer to the requested file system. After the mount is completed, programs needing access to that mount point and below go through the pointer to the server's `nfsd`(1M) daemon by using a remote procedure call (RPC). Client kernel file access requests (delayed-write and read-ahead) are handled by the `biod`(1M) daemons on the client.

Thus, a process on a client machine can directly access files located on the server machine when the following conditions are met:

- The server has exported the file system in which the file is located.
- The client machine has mounted the remote file system on one of its hierarchies.
- The process is owned by a user who has permission to access the file.

Installing NFS on a server machine

It is up to you to decide which machines should be servers. You might want those with larger disks or multiple disks to be the servers, or you may want to share large amounts of data from a particular machine with an entire group and so would designate that machine as an NFS server.

One important criterion in choosing an NFS server is the overall reliability of the server, especially when file systems are mounted with the "hard" option. The "hard" option ensures that a process accessing remote data will not complete until the read or write is successful. If the remote server is down, the process will hang until the remote server returns. (Or you may decide to mount most of your file systems with the "soft" option. See Table 3-1 for more information.)

The following is a list of basic steps for making a machine called `hostname1` an NFS server. The subsections that follow explain the steps in more detail.

1. **If you've already built an NFS kernel, edit your `/etc/exports` file to specify hosts eligible to mount file systems from this server.**

2. **If you haven't already built your kernel, run `newconfig nfs` as described in Chapter 2, this time answering yes to the server query.**

   As discussed in Chapter 2, if your machine already has an `/etc/exports` file, the entry for `/etc/inittab` is automatically turned on to enable NFS serving. However, if you previously built the kernel and answered no to the server prompt, you need to edit your `/etc/inittab` file to change the `nfsd` daemon to `wait`.

3. **Check your `/etc/inittab` file to see that it has set the daemons you wish to have enabled. The following line should appear:**

   ```
   net5:2:wait:/usr/etc/nfsd
   ```

   (See "Checking Your `/etc` Files" in Chapter 2 for explanations of some of the available daemons.)

Adding lines to `/etc/exports`

NFS file servers use the `/etc/exports` file to control which file systems can be mounted by which systems on the network. Entries in `/etc/exports` specify a file system name that can be remotely mounted; the file system name is left-justified and may be followed by a list of host names or netgroup names separated by space or tab characters.

If a host name or netgroup name follows the file system name, export permissions are limited to the host(s) or netgroup(s) specified; otherwise the file system is open to everyone. A number sign (#) anywhere on a line begins a comment to the end of the line. See "Creating a Netgroup File (Optional)" in Chapter 4 for more information about establishing networkwide groups.

Note that on an A/UX NFS server with a single disk you must export the entire root file system. For example,

```
/           # export to everyone
```

or

```
/     hostname2   # export to hostname2
```

After you have exported the root file system, you may want to list specific hierarchies that are resident on the local disk, such as `/usr/catman`. For example,

```
/                 # export to everyone
/usr/catman       # export to everyone
```

Note that the specific reference to `/usr/catman` in `/etc/exports` on an A/UX server is simply an optional convenience to other systems. Listing a hierarchy in `/etc/exports` makes no difference in terms of export permissions once you have exported the root file system in which it is located.

To restrict access to the file system to `hostname2`, edit `/etc/exports` to read

```
/           hostname2 # export to hostname2
/usr/catman hostname2 # export to hostname2
```

To grant open permissions, omit the host name.

Checking for **nfsd** and **rpc.mountd** entries

Use cat to check /etc/inittab to see that the daemons you want turned on are enabled. Using a text editor, make any changes that are necessary.

Make sure that the nfsd entry specifies wait. The file should look like this:

```
nfs0:2:wait:/etc/portmap
nfs4:2:wait:/etc/biod 4
net4:2:wait:/usr/etc/in.routed
net5:2:wait:/usr/etc/nfsd
net9:2:respawn:/etc/inetd
```

The mount daemon, rpc.mountd, must be enabled for NFS to work. The /etc/servers file is listed below, with the required rpc.mountd line printed in bold:

```
ftp   tcp   /usr/etc/in.ftpd
telnet      tcp   /usr/etc/in.telnetd
shell tcp   /etc/in.remshd
login tcp   /etc/in.rlogind
exec  tcp   /usr/etc/in.rexecd
tftp  udp   /usr/etc/in.tftpd
talk  udp   /usr/etc/in.talkd
rpc   udp   /usr/etc/rpc.rstatd     100001      1-2
rpc   udp   /usr/etc/rpc.rwalld     100008      1
rpc   udp   /usr/etc/rpc.mountd     100005      1
```

Be sure that the line printed in bold is listed in the /etc/servers file, in which case inetd invokes rpc.mountd.

Checking that your machine is an NFS server

1. **Check that the appropriate daemons are running by entering**

   ```
   ps -ef | grep nfsd
   ```

   The response should be

   ```
   root     81    1     0 01:27:17 ?      0:02 /etc/nfsd 4
   root     82    1     0 01:27:17 ?      0:02 /etc/nfsd 4
   root     83    1     0 01:27:17 ?      0:02 /etc/nfsd 4
   root     84    1     0 01:27:17 ?      0:02 /etc/nfsd 4
   ```

(The numbers in each column may be different on your system.) If the `nfsd` processes are not running, reboot and check again.

2. **Check that a file system has been exported from this system by using the command**

```
showmount -e
```

With the example file system exports, the response would be

```
export list for hostname1:
/  hostname2
```

Installing NFS on a client machine

To to install NFS on a client machine, follow these steps:

1. **If you have already built an NFS kernel, you are ready.**

   Otherwise make an NFS kernel by following the procedure in "Installing a Kernel" in Chapter 2 and restart A/UX.

2. **Run `newconfig` with the appropriate arguments.**

   (See the explanation of `newconfig` in Chapter 2.)

3. **Answer no to the prompt asking if you want your machine to be an NFS server.**

4. **Check your `/etc/passwd` for a `nobody` entry.**

5. **Check your `/etc/inittab` file to see that it has set the deamons you wish to have enabled.**

6. **Mount the remote file system.**

   If this doesn't work, check that the NFS client service is running on the remote machine. See "Checking That Your Machine is an NFS Client" later in this chapter.

7. **Edit the `/etc/fstab` to mount remote file systems whenever the system is rebooted.**

Checking `/etc/passwd` for a `nobody` entry

For system security reasons, the superuser does not have access permissions on remotely mounted files. This is implemented by mapping UID 0 (`root`) to UID 65534 (unsigned representation of -2 in 2's complement notation) on all client machines. When UID 0 is mapped to UID 65534, the superuser on a client machine has the same permissions on remote files as a user with UID -2. Unless the permissions of the files in the remote file system allow access to "others," the superuser will not be allowed to look at them. See "Network Security" in Chapter 8 for more information.

All NFS client machines (including server machines that will also mount remote file systems) should have a `passwd` entry for `nobody` with UID 65534. To check that such an entry exists enter

```
grep nobody /etc/passwd
```

The response should be

```
nobody:xxxxxxxxxxxxx:65534:65534:NFS generic user:
/tmp:/bin/noshell
```

(This response should appear on one line).

If this line does not appear on the screen, modify `/etc/passwd` to include it.

Checking that your machine is an NFS client

1. **Check that the appropriate daemons are running by entering**

   ```
   ps -ef | grep biod
   ```

   The response should be

   ```
   root     81    1     0 01:27:17 ?       0:02 /etc/biod 4
   root     82    1     0 01:27:17 ?       0:02 /etc/biod 4
   root     83    1     0 01:27:17 ?       0:02 /etc/biod 4
   root     84    1     0 01:27:17 ?       0:02 /etc/biod 4
   ```

   (The numbers in each column may be different on your system.) If the `biod` processes are not running, reboot and check again.

2. **Check that the root file system is correctly exported from the server. On the client machine (`hostname2`), enter the command**

   ```
   showmount -e hostname1
   ```

This command displays the file systems exported from `hostname1`. In this example the resulting display should be

```
export list for hostname1:
/   hostname2
```

Testing NFS with a temporary remote mount

To test that NFS is working properly, you can mount the online manual pages remotely. The manual pages take several megabytes of storage space. To save space you can export this hierarchy from one system to several machines.

When you mount a remote file system on a local machine, you need to specify a **local mount point**. This is a pathname where the information will reside on your local system.

◆ *Note:* Usually you must create a local mount point with open access permissions. The directory should be empty; otherwise its files become obscured, and thereby made inaccessible, by the file system mounted over it. However, a directory named `/usr/catman` often exists on A/UX already. If so you do not need to create a new mount point.

To mount the `/usr/catman` hierarchy remotely from `hostname1`:

1. **Check that the local `/usr/catman` mount point exists and is empty. If it is not empty, back it up and remove its subdirectories by entering**

   ```
   /bin/rm -r /usr/catman/*
   ```

2. **To check permissions on the remote `/usr/catman` hierarchy, enter**

   ```
   remsh hostname1 ls -ld /usr/catman
   ```

   You should see something like

   ```
   drwxr-xr-x 4 bin     bin   15 Mar 31   09:33 /usr/catman
   ```

   (If you have not set up a `hosts.equiv` file, you could get a permission denied error message at this point.)

3. **Check permissions on the local `/usr/catman` mount point.**

   As with local mounts, the mount point directory must have access permissions that are at least as open as those of the remote file system being mounted. In addition, users' UIDs (user IDs) and GIDs (group IDs) must agree across systems. (See Chapter 4 for information on how using the Yellow Pages can facilitate these NFS permission requirements.) In the case of `/usr/catman`, the local `man` command requires that the owner and group of the local mount point directory match those of the remote hierarchy.

   Enter

   ```
   ls -ld /usr/catman
   ```

   You should see something like

   ```
   drwxr-xr-x 4 bin     bin   64 Sep 13 05:06 /usr/catman
   ```

4. **If the permissions check out, enter a `mount` command such as**

   ```
   mount -o soft,ro hostname1:/usr/catman /usr/catman
   ```

   This command mounts the remote file system with the `soft` and `ro` (read-only) options.

   - ◆ *Note:* If the permissions of the topmost directory of the file system you are remotely mounting disallow write permissions for all users, you must mount the hierarchy with the `ro` (read-only) option. (Remember that write permission for the root user is not preserved across the network.) This procedure prevents errors when file access times are updated across the network. These errors would occur whether or not an explicit write was attempted on the hierarchy. See Table 3-1 for more information about `mount` options.

5. **To check that the remote file system is mounted where you expected, enter**

   ```
   mount
   ```

   This command displays the currently mounted file systems. You should see something like

   ```
   /dev/dsk/c0d0s0 on / type 5.2 (rw,noquota)
   hostname1:/usr/catman on /usr/catman type nfs (ro,soft)
   ```

   (You can also use the `df` command to display the currently mounted file systems.)

6. **Test that the manual pages are available by using the `man` command. For example, enter**

   ```
   man ls
   ```

If the test succeeds, the text of the `ls`(1) manual page should appear on your screen. If the test fails, check the default `mount` options (see `mount`(1M) and Chapter 10, "Troubleshooting").

7. **When you have mounted the remote hierarchy successfully, unmount it by entering**

```
umount /usr/catman
```

◆ *Note:* Using the `mount` command from the command line as shown in this section produces a mount that needs to be reentered when the system is rebooted. See "Modifying `/etc/fstab`" for an easier way to mount file systems remotely.

■ **Table 3-1** NFS mount options

NFS mount option	Description
`bg`	If the first mount attempt fails, retry the mount attempt in the background. If the server system is inaccessible, the mount attempt will continue in the background, allowing the client system to be used with local data.
`fg`	If the first mount attempt fails (for example, if the server's mount daemon does not respond), retry the mount attempt in the foreground (default). If a client system attempts to mount a remote file system whose server is inaccessible, the client appears to hang during the mount attempt until the server returns, and then the mount attempt completes as it normally would.
`hard`	Retry request until the server responds (default). If a process is accessing remotely mounted data when a server goes down, the process hangs until the server returns and then completes as it normally would.
`intr`	Allow most commands to be interrupted when a process is accessing remotely mounted data and a server goes down. This can be used to prevent a process from hanging when the server goes down.
`noauto`	To keep an entry from being mounted by a `mount -a` command, use this option on the line with that entry in `/etc/fstab` file.
`port=`*n*	Set the server IP port number to *n* (default=`NFS_PORT`). `NFS_PORT` is defined in `<nfs/nfs.h>`. See RFC 960 in "Related RFCs" in Appendix D for more information about IP port numbers.

[continued]

NFS mount option	Description
`retrans=`*n*	Set the number of NFS retransmissions to *n* (default=4). When *n* retransmissions have been sent with no reply, a soft- mounted file system returns an error on the request and a hard-mounted file system retries the request.
`retry=`*n*	Set the number of mount failure retries to *n* (default=1). The `mount` command attempts each request *n* times before giving up.
`ro`	Read-only. Mount write-protected hierarchies read-only; otherwise errors will occur when access times are updated, even if an explicit write request has not occurred.
`rsize=`*n*	Set the read buffer size to *n* bytes (the default is set by the kernel). The number of bytes in a read request can be set with the `rsize` option.
`rw`	Read/write (default). Allow write requests to the remote file system.
`soft`	Return an error if the server doesn't respond. If a file system is mounted read-only, this option allows the client system to keep running by using only local data when a server system goes down. However, if a process is accessing remotely mounted data when the server goes down, using this option may result in loss of data. It is recommended for use with the `ro` option
`timeo=`*n*	Set the NFS timeout to *n* tenths of a second (default=7). Once the file system is mounted, each NFS request made in the kernel waits *n* tenths of a second for a response. If no response arrives, the timeout is multiplied by two and the request is retransmitted.
`wsize=`*n*	Set the write buffer size to *n* bytes (the default is set by the kernel). The number of bytes in a write request can be set with the `wsize` option. The buffer size varies on different types of machines; for example, if the server is a VAX, `wsize=2048` is required.

Modifying /etc/fstab

If the /etc/mount command is enabled in /etc/inittab, the mount command reads /etc/fstab when the system comes up in multi-user mode.

The /etc/fstab file describes the file systems used by the local machine. The file consists of a number of lines like

```
/dev/dsk/c0d0s0          /           ignore rw       1 1
hostname1:/usr/catman /usr/catman nfs      ro,soft   0 0
```

Fields are separated by blanks or tabs; a number sign (#) as the first nonwhitespace character begins a comment.

- For NFS file systems, the syntax for the first field is

  hostname : *path*

  The *hostname* is always terminated by a colon (:), and *path* is a file system mount point or directory hierarchy below root.

- The second field is the local mount point. In the preceding example, it must be identical to the remote hierarchy pathname so that the local man command will continue to work. In most cases the local mount point can have any pathname you choose. (It must be a fully qualified pathname—one that starts with "/".) The permissions on that mount point must be at least as open as the permissions on the remote hierarchy.
- The third field is the type of file system. This may be 4.2, 5.2, nfs, or ignore. If this field is specified as ignore, the entire line is ignored. This feature allows you to keep in the /etc/fstab file any remote mounts that you do not want to mount routinely when you boot the system.
- The fourth field contains mount options. See Table 3-1, fstab(4), and mount(1M) for more information.
- The fifth field is the dump level (used by dump.bsd(1M)). This field is not used for remote file systems.
- The last field is the fsck pass number. (The value of this field is not used on remote file systems.)

The order of the entries in /etc/fstab is important because fsck, mount, and umount process the file sequentially. A remote file system entry must appear after the entry for the local file system that contains the mount point for the remote file system (if any). See fstab(4) for more information.

Mounting a file system specified in `/etc/fstab`

Once you have modified `/etc/fstab` to include those file systems will be mounted whenever you boot the machine. To mount the remote file systems from the command line, enter

```
mount -atv nfs
```

This command mounts all NFS hierarchies specified in `/etc/fstab` when you boot the client system. Note that if you look in the `/etc/inittab` file on the client machine, you will see the same `mount` line.

If you specify only a directory file system name, or file system type to the `mount` command, `mount` looks in `/etc/fstab` for entries that match the argument. If the entry for `/usr/catman` in `/etc/fstab` is

```
hostname1:/usr/catman /usr/catman nfs     ro,soft     2 2
```

You can also enter the command

```
mount /usr/catman
```

If the `mount` program finds no matching entries, it displays an error message; otherwise it executes the mount indicated in `/etc/fstab`. See `mount`(1M) for more information.

Chapter 4 **Adding Yellow Pages Service**

This chapter discusses adding Yellow Pages service to your machines. The key points covered are:

- Overview of the Yellow Pages
- Installing the Yellow Pages on the master server
- Installing the Yellow Pages on a client system
- Testing Yellow Pages access

The A/UX version of the Yellow Pages is based on Release 3.0 of the Sun Microsystems software. This chapter explains how to set up the Yellow Pages service to distribute essential administrative information, such as the information typically contained in the `/etc/passwd` file.

"Overview of the Yellow Pages" defines the terms used in this chapter and provides useful information about the implementation of Yellow Pages.

"Installing the Yellow Pages on the Master Server" describes how to make a networked system the Yellow Pages master server. This involves starting daemons, setting a domain name, making global copies of the files used to generate the Yellow Pages databases (maps), and creating the Yellow Pages maps.

"Installing the Yellow Pages on a Client System" describes how to set up a system to query the Yellow Pages instead of local files. This involves starting daemons, setting the same domain name used on the master server, and modifying the local files.

Overview of the Yellow Pages

The Yellow Pages are a collection of programs that generate, maintain, and distribute databases (maps). They are generally used to distribute administrative information such as password, group, and host databases across the network, and they generate these maps by default. See "Default Yellow Pages Maps."

Library routines such as `getpwent`(3C) and `getgrent`(3C) have been rewritten to take advantage of the Yellow Pages. If you import binaries that were created in a nonvnode (non-NFS) environment that call such routines, you may have to relink these files for them to work correctly with the Yellow Pages. See Appendix C, "Additional Reading," for a complete description of modified library system calls and subroutines. See also "Modifying `/etc/passwd`" and "Modifying `/etc/group`," for a description of how `getpwent`(3C) and `getgrent`(3C) access the Yellow Pages.

See `ypfiles`(4) for details on the Yellow Pages implementation.

If you do not use the Yellow Pages

If you choose not to use the Yellow Pages, skip the procedures described in this chapter.

Remember that if you are using NFS, user IDs must be unique on all machines on the network, and group IDs must be consistent across systems. The default use of the Yellow Pages is to distribute this information from one source file, which makes it easier to keep user IDs unique and group IDs consistent.

Masters, slaves, and clients

For each Yellow Pages domain, you choose one machine as the Yellow Pages **master server.** This system, a global copy of the master `/etc` files, and all subsequent modification of these files (for example, to add hosts or users to the network) must occur on the master server only.

- ◆ *Note:* If you create or change maps on slave server machines instead of master server machines, you will break the Yellow Pages update algorithm.

See "Default Yellow Pages Maps" for a list of the default files and a description of how the maps are created on the master server.

Since client systems will freeze at the `login` prompt if the Yellow Pages maps are not available, you need to maintain redundant Yellow Pages information. To do this, designate other machines as Yellow Pages servers; these are called **slave servers** because they can receive map changes only through the master server. If the master has propagated all of its maps to the slave server, it doesn't matter which Yellow Pages server process answers a client request; the answer will be the same all over. This allows multiple servers per network, which gives Yellow Pages service a high degree of availability and reliability. If one server becomes unavailable, other servers will take its place. It is very important that the Yellow Pages service be replicated on at least one slave server. Otherwise no one on the network will be able to log in to his or her machine if the Yellow Pages server becomes overloaded or goes down.

The Yellow Pages maps are distributed to any process that requests them from a Yellow Pages **client** machine, that is, any machine that is running the `ypbind` daemon to access the Yellow Pages information. For example, when a process needs to verify user information (such as ownership of a file), that process issues a remote procedure call (RPC) to the Yellow Pages to obtain the information it requires. The Yellow Pages retrieve the information from the first available master or slave server. Because the Yellow Pages use a standard set of access procedures to hide details of data storage, the particular system from which a client process receives information may change at any time.

Default Yellow Pages maps

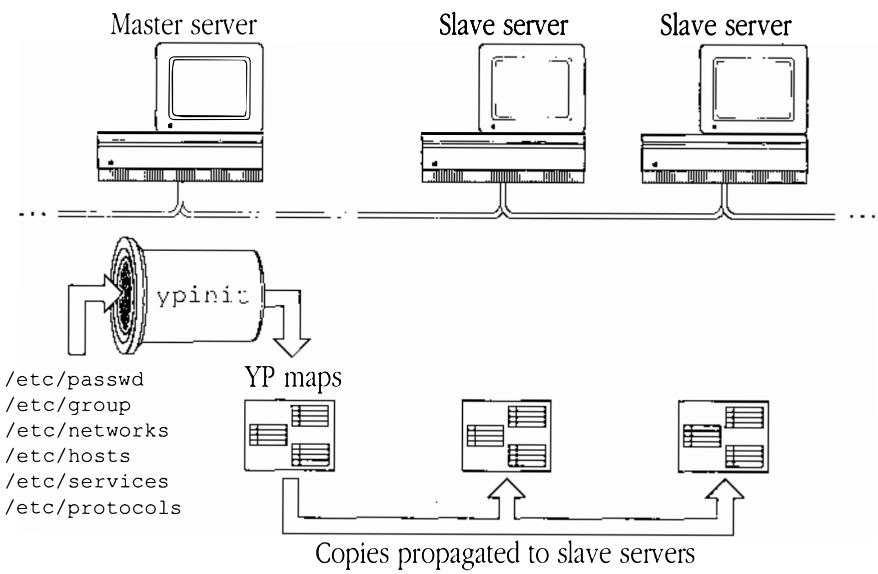
The Yellow Pages maps are created automatically by the shell script `/etc/yp/ypinit` on the master server. After you have set the domain name on the master Yellow Pages server, the `ypinit` command uses it to name a subdirectory of `/etc/yp` that will contain the Yellow Pages maps.

By default, the /etc/yp/ypinit script creates maps from /etc/hosts, /etc/passwd, /etc/group, /etc/networks, /etc/services, /etc/protocols, /etc/ethers, and /etc/netgroup. The /etc/netgroup file can be used to define groups of users that should be permitted to mount certain file systems remotely (see "Creating a Netgroup File (Optional)," later in this chapter).

The ypinit script calls the low-level A/UX utility makedbm, which converts the information in the ASCII files to dbm(3X) database format (a set of keys and associated values). This format is described in dbm(4) and in "Using make on the Default Yellow Pages Maps" in Chapter 8.

Figure 4-1 shows the ypinit program generating dbm-format maps, which are then propagated to Yellow Pages slave servers.

■ **Figure 4-1** Yellow Pages maps



Map names and format

Sun Microsystems wrote the original implementation of the Yellow Pages for Sun workstations, which are BSD-based and therefore have a 255-character filename limit. While the BSD-based UFS file system used as the default root file system in A/UX 2.0 supports these long file names, the System V file system (SVFS) originally supported by A/UX has a 14-character filename limit. Therefore this implementation uses short names for the map files that reside in the `domainname` subdirectory of `/etc/yp` (that is, a subdirectory whose name is the output of the `domainname` command). All the long names (and nicknames, where appropriate) work as usual. Only the filenames change; they will be truncated after the 14th character.

A/UX uses a file named `/etc/yp/names.map` to establish the correspondence between the full map names and the short names, as shown in Table 4-1.

■ **Table 4-1** A/UX short map names

Full map name	A/UX short name	Full map name	A/UX short name
`group.bynumber`	`grp.nr`	`networks.bynumber`	`ntw.nr`
`group.byname`	`grp.nm`	`networks.byname`	`ntw.nm`
`group.bygid`	`grp.g`	`networks.bygid`	`ntw.g`
`group.byuid`	`grp.u`	`networks.byuid`	`ntw.u`
`group.byaddr`	`grp.ad`	`networks.byaddr`	`ntw.ad`
`group.time`	`grp.tm`	`networks.time`	`ntw.tm`
`passwd.bynumber`	`pwd.nr`	`services.bynumber`	`svc.nr`
`passwd.byname`	`pwd.nm`	`services.byname`	`svc.nm`
`passwd.bygid`	`pwd.g`	`services.bygid`	`svc.g`
`passwd.byuid`	`pwd.u`	`services.byuid`	`svc.u`
`passwd.byaddr`	`pwd.ad`	`services.byaddr`	`svc.ad`
`passwd.time`	`pwd.tm`	`services.time`	`svc.tm`
`hosts.bynumber`	`hst.nr`	`protocols.bynumber`	`ptc.nr`
`hosts.byname`	`hst.nm`	`protocols.byname`	`ptc.nm`
`hosts.bygid`	`hst.g`	`protocols.bygid`	`ptc.g`
`hosts.byuid`	`hst.u`	`protocols.byuid`	`ptc.u`
`hosts.byaddr`	`hst.ad`	`protocols.time`	`ptc.tm`
`hosts.time`	`hst.tm`	`netgroup`	`netg`

[continued]

Table 4-1 A/UX short map names [continued]

Full map name	A/UX short name	Full map name	A/UX short name
netgroup.byuser	netg.us	ypdomains	ypdoms
netgroup.byhost	netg.hs	ethers.byaddr	e.ad
netgroup.time	netg.tm	ethers.byname	e.nm
ypmaps	ypmaps	rpc.bynumber	rpc.nr
ypservers	ypsrvs	mail.aliases	m.a

The `makedbm` program adds the filename suffixes `.pag` or `.dir` to the A/UX short name for each map name.

For convenience you may use nicknames for the longer map names with `ypcat`, `ypmatch`, and `ypwhich`. For example, the command

```
ypcat passwd
```

has exactly the same effect as

```
ypcat passwd.byname
```

The nickname-to-map-name correspondence is given by `ypcat -x` and applies to both long and short names (see Table 4-2).

Table 4-2 Map nicknames

Full map name	Map nickname	Full map name	Map nickname
passwd.byname	passwd	hosts.byaddr	hosts
group.byname	group	protocols.bynumber	protocols
networks.byaddr	networks	services.byname	services

Yellow Pages domains

When you run `newconfig` to configure an NFS kernel for the first time, the system prompts you to enter a domain name. When you enter a name in response to the prompt, the name becomes the second field in `/etc/HOSTNAME`. (You can change the system's domain name by editing the second field in `/etc/HOSTNAME` and rebooting.)

The master server needs domain names to create the maps, and the client servers need them to retrieve data from the Yellow Pages. When you are installing the Yellow Pages on the master server, the `ypinit` script uses the domain name as the name of a subdirectory it creates in `/etc/yp`, where the maps are stored. In this sense a domain is a named set of Yellow Pages maps.

Domains also refer collectively to a group of hosts. In this sense all hosts in a domain use the same domain name and access the same set of Yellow Pages maps. Each domain has at least one master server, and clients from one domain cannot access information from another domain. You can define a new domain for a group of hosts to increase security on those hosts.

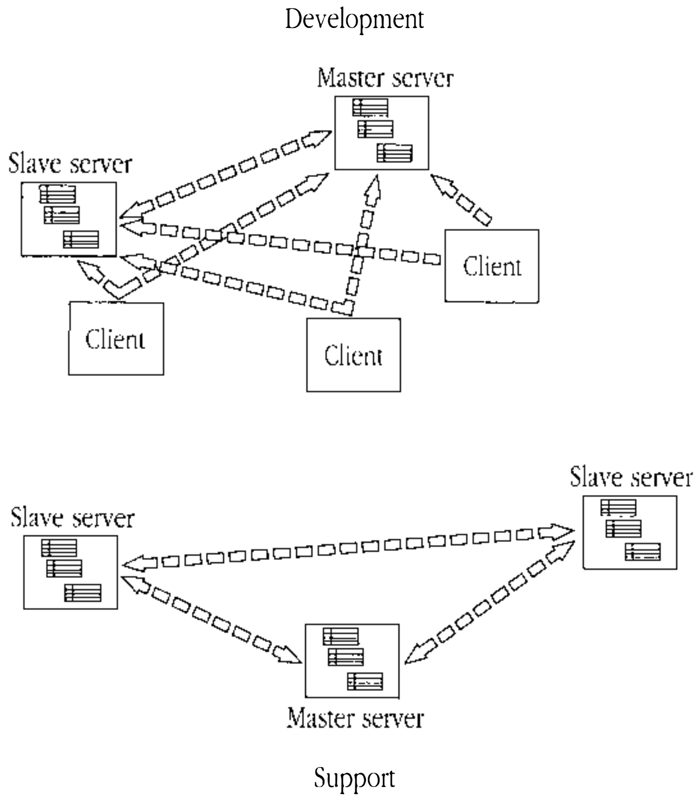
Figure 4-2 shows a network with two Yellow Pages domains named *Development* and *Support.* The master and slave servers both support copies of the Yellow Pages maps and respond to remote procedure calls (RPCs) to retrieve information from the Yellow Pages. The arrows show RPCs retrieving information. Because clients and servers do not "bind" to a particular server, each RPC request may be answered by any of the servers. A server that requests information from the Yellow Pages does not necessarily answer its own request. Clients from one domain can never retrieve information from servers in another domain.

Yellow Pages daemons

There are two daemons in the Yellow Pages system:

- The `ypserv` daemon, which supplies the Yellow Pages databases to querying processes. This daemon must run on each Yellow Pages server machine.
- The `ypbind` daemon, which issues an RPC call to retrieve information from the Yellow Pages maps. This daemon must run on both servers and clients of the Yellow Pages services.

■ **Figure 4-2** Yellow Pages domains



Installing the Yellow Pages on the master server

Complete the following steps to install the master Yellow Pages server. The subsections that follow explain the steps in more detail.

1. **If the domain name set in the second field of `/etc/HOSTNAME` is not correct, edit the file to correct it and reboot to set the correct domain name.**

2. **Create an `/etc/passwd` file that contains entries for all users on the network.**

3. **Create an `/etc/group` file that contains entries for all groups on the network.**
4. **Check that all default files in `/etc` are up to date.**
5. **Run `ypinit -m` to create the Yellow Pages databases.**
6. **Start the Yellow Pages daemons.**
7. **Reboot the system.**

Setting the domain name

1. **Open the `/etc/HOSTNAME` file by using a text editor. To change the domain name, modify the second field.**

   For example, if the file contains

   ```
   hostname1 apple
   ```

   change `apple` to the domain name you have chosen. This will also be the name of the subdirectory of `/etc/yp` that contains the Yellow Pages maps.

2. **Reboot the system.**

   (The system does not read this file until you reboot.)

Creating a global `/etc/passwd`

When you create a global password file on the Yellow Pages master server, the goal is to make each user ID unique to one user and consistent across the network. This condition is required for accurate remote file access.

1. **Copy the password files from other machines on the network; for example,**

   ```
   cd /etc
   rcp hostname2:/etc/passwd passwd.2
   rcp hostname3:/etc/passwd passwd.3
   rcp hostname4:/etc/passwd passwd.4
   rcp hostname5:/etc/passwd passwd.5
   ...
   ```

   (This will work only if you have set up command execution in the `hosts.equiv` file.)

2. **After you have copied all the password files, concatenate them with the local `/etc/passwd` by entering the command**

```
cat passwd* > global.passwd
```

3. **Use a text editor to open `global.passwd`, and edit it as follows:**

- Save the system entries from the local password file.

  These should be the first 10 or 12 entries. It is important to keep these entries in the same order and unmodified. You may want to write them to a separate file while you are modifying the rest of this file and read them back in again when you are finished.

- Delete all other system entries (from password files on other systems).

- When the file contains only user entries, sort the file.

  From `vi`, you can use the `:%!sort` command.

- Eliminate duplicate user entries.

  When you add Yellow Pages to an existing network, you must be sure that each user has a unique user name and UID. At this point you may discover that the same UID is assigned to different users on different systems or different UIDs are used for the same user on different systems. In this case make a record of the entries you delete. You will need to give these users unique networkwide user names and UIDs.

- When you have modified `passwd.global` to contain only one user entry for each user, read in the file containing the local system entries (see step a of this procedure) to the top of the `/etc/passwd` file.

- The password file must also contain the following entries:

  ```
  daemon:xxxxxxxxxxxx:1:1::/:
  nobody:xxxxxxxxxxxx:65534:65534:NFS generic user:
  /tmp:/bin/noshell
  ```

  (The `nobody` entry is on one line in `/etc/passwd`.)

  If these lines do not exist, add them below the system entries you just read in. The `daemon` entry allows file-transfer utilities to work and is required for propagating the Yellow Pages database to the slave servers. Note that earlier entries in `/etc/passwd` will mask later ones with the same UID, so make sure that no earlier entry has UID 1. See "Yellow Pages Security Issues" in Chapter 8 for information on the `nobody` entry and the global password file on the Yellow Pages master server.

- When you have completed this process, save the local password file and move the global password into `/etc/passwd`:

```
cp /etc/passwd /etc/passwd.local
cp /etc/passwd.global /etc/passwd
```

If you changed any UIDs, GIDs, or other environment values, make a note of which machines are affected by the changes and delete the extraneous `passwd.`*n* copies. Be sure to notify users whose UIDs and GIDs you have modified, because these users will not be able to access their files and directories until you perform the procedure described in the following paragraph.

For example, if you have changed Ted Bear's user ID on a system, you need to run `chown` on all his files, or he will not be able to access them. If Ted's previous UID was 400 on this system and you changed it to 125, enter

```
find / -user 400 -exec chown 125 "{}" \;
```

See "Yellow Pages Security Issues" in Chapter 8 if you want to keep a small `/etc/passwd` file on the master server.

Creating a global `/etc/group`

You should now perform a similar procedure on the `/etc/group` file to obtain an `etc/group` file that is consistent across your network.

Checking the default files in `/etc`

The rest of the Yellow Pages default files (see "Default Yellow Pages Maps," earlier in this chapter) should already be complete, but check to make sure they are.

Creating a netgroup file (optional)

Netgroups are networkwide groups of machines and users defined in the `/etc/netgroup` file on the master Yellow Pages server (see `netgroup`(4) for a description of file format and definition of lines and fields). These groups are used for permission checking during remote mount, login, remote login, and remote shell.

The master Yellow Pages server uses `/etc/netgroup` to generate three Yellow Pages maps in the `/etc/yp/`*domainname* directory: `netg`, `netg.us`, and `netg.hs`. If you do not have an `/etc/netgroup` file, these maps will be 0-byte files.

The Yellow Pages map `netg` contains the basic information in `/etc/netgroup`. The two other Yellow Pages maps contain a more specific form of the information to speed the lookup of netgroups given the host or user.

These programs consult the Yellow Pages netgroup maps:

- `login`(1) consults the maps for user classifications if it encounters netgroup names in `/etc/passwd`.
- `mountd`(1M) consults the maps for machine classifications if it encounters netgroup names in `/etc/exports`.
- `rlogin`(1) and `remsh`(1) consult the maps for both machine and user classifications if they encounter netgroup names in `/etc/hosts.equiv` or `.rhosts`.

In this sample `/etc/netgroup` file, the first field is the netgroup name. The following three fields in parentheses indicate the host name, user name, and domain name. Any of the three fields can be empty. An empty field signifies a wildcard. Thus

```
universal (,,)
```

defines a group to which everyone belongs. Field names that begin with something other than a letter, digit, or underscore (such as "-") work in precisely the opposite fashion. For example, in the following `/etc/netgroup` file, `apple` is the domain name. Consider the following entries:

```
justmachines       (h7,-,apple)
justpeople         (-,holly,apple)
```

The machine `h7` belongs to the group `justmachines` in the domain apple, but no users belong to it. Similarly, the user `holly` belongs to the group `justpeople` in the domain `apple`, but no machines belong to it.

Here is another sample `/etc/netgroup` file:

```
#
# Engineering: Everyone has a machine except eric.
# The machine 'h3' is used by all of hardware.
#
engineering hardware software
hardware (h1,alan,apple) (h2,beth,apple) (h3,-,apple)
software (h4,chris,apple) (h5,deborah,apple) (-,eric,apple)
#
# Marketing: Time-sharing on h6
#
marketing   (h6,fran,apple) (h6,greg,apple) (h6,dan,apple)
#
# Others
#
allusers (-,,apple)
allhosts (,-,apple)
```

Based on this sample, the users are classified in groups as follows:

Group	**Users**
`hardware`	`alan, beth`
`software`	`chris, deborah, eric`
`engineering`	`alan, beth, chris, deborah, eric`
`marketing`	`fran, greg, dan`
`allusers`	(every user in the Yellow Pages map `passwd`)
`allhosts`	(no users)

And here is how the machines are classified:

Group	**Users**
`hardware`	`h1, h2, h3`
`software`	`h4, h5`
`engineering`	`h1, h2, h4, h5, h3`
`marketing`	`h6`
`allusers`	(no hosts)
`allhosts`	(all hosts in the map hosts)

Creating the maps: `ypinit -m`

1. **To generate the Yellow Pages maps on the master server, enter**

   ```
   cd /etc/yp
   ypinit -m
   ```

   The `ypinit` program prompts you for information and generates the Yellow Pages maps from `/etc/passwd`, `/etc/group`, `/etc/networks`, `/etc/hosts`, `/etc/services`, `/etc/protocols`, and, if it exists, `/etc/netgroup`.

   The `ypinit -m` command displays the prompt:

   ```
   Do you want this procedure to quit on nonfatal errors?
   ```

2. **(We recommend that you press `y` for yes.)**

   The second inquiry made by the `ypinit` program is

   ```
   At this point we have to construct a list of the hosts that
   will run YP servers. "hostname1" is the list of YP server
   hosts. Please continue to add the names of the other hosts,
   one per line, and when you are finished with the list, type
   CTRL-D.
   ```

3. **If you have this information ready, enter the host names, one to a line. When you are finished, press CONTROL-D.**

   These host names will be included in the `ypsrvs` map. If you need to add or delete slave servers later, reconstruct the `ypsrvs` map as described in "Adding a Yellow Pages Slave Server". If you do not yet know which machines will run as Yellow Pages slave servers, just press CONTROL-D.

4. **The program then lists the server machines again and asks if the list is correct.**

   If it is, press `y` to begin the actual generation of maps (which could take several minutes.)

Starting the Yellow Pages daemons

1 On the master server, start the Yellow Pages daemons `ypserv`, `ypbind`, and `yppasswd`.

To invoke the `ypserv`, `ypbind`, and `yppasswd` daemons, edit `/etc/inittab` to change the status fields (shown in bold) of the following lines from

```
nfs1:2:off:/etc/ypserv
nfs2:2:off:/etc/ypbind
```

to

```
nfs1:2:wait:/etc/ypserv
nfs2:2:wait:/etc/ypbind
```

2. To invoke the `yppasswdd` daemon, add the following line to `/etc/inittab`:

```
nfs9:2:wait:/usr/etc/rpc.yppasswdd /etc/passwd -m passwd
```

This creates a `make` (the `-m` flag) and a `yppush` to occur for every password change on the network. This may cause too much performance degradation on a large network. To avoid this, you can modify this line to read

```
nfs9:2:once:/usr/etc/rpc.yppasswdd /etc/passwd
```

This will update `/etc/passwd` on the master server whenever your system enters multi-user mode but will not modify and propagate the Yellow Pages map. Therefore you need to create a `crontab` entry to perform periodic updates automatically. Rather than having a separate `crontab` entry for each Yellow Pages map, you can group commands to update several maps in a shell script. Examples are in the following files in `/etc/yp`:

```
ypxfr_1d
ypxfr_2d
ypxfr_1h
```

(That is, mnemonically, "yp transfer once per day," "yp transfer twice per day," and "yp transfer once per hour.")

The disadvantage of this approach is that changes made to the master server do not immediately appear throughout the network. That is, database maps may not always be current on the slave servers, and thus users may access incorrect information.

See "Yellow Pages Security Issues" in Chapter 8 for changes you can make to the above `yppasswdd` invocations to keep a restricted-access `passwd` file on the master server.

The `yppasswdd` daemon is invoked on the master Yellow Pages server only. This daemon automatically updates the master's password database when users change their passwords with the `yppasswd` command. (See "Redefining the `passwd` Command" in Chapter 8 for ways to make this change transparent to the user.)

With the database created and the daemons running, the machine is now the Yellow Pages master server. You can use the `ps` command now to verify that the Yellow Pages daemons (`ypserv`, `ypbind`, and `rpc.yppasswdd`) are running. See Chapter 8 for more information about managing the Yellow Pages on the master server.

Adding a Yellow Pages slave server

After you have added a system as a Yellow Pages client on the network, perform the following steps to make it a slave server for the Yellow Pages:

1. **Log in as the root user on the master Yellow Pages server and make sure that the network is working by trying a `ping` or `telnet` command.**
2. **Generate a new set of Yellow Pages maps by entering**

   ```
   cd /etc/yp
   ypinit -m
   ```

   In response, `ypinit -m` displays the prompt

   ```
   Do you want this procedure to quit on nonfatal errors?
   ```

   Press `y` for yes.

   The second request made by the `ypinit` program is

   ```
   At this point we have to construct a list of the hosts that
   will run YP servers. "hostname1" is in the list of YP server
   hosts. Please continue to add the names of the other hosts,
   one per line, and when you are finished with the list, type
   CTRL-D.
   ```

   Type the name of the new system that will be a Yellow Pages slave server, such as

   ```
   hostname3
   ```

   and press CONTROL-D.

This procedure modifies the `ypsvrs` database on the master server. After you have thus informed the master server that there is a new slave server, follow these steps:

1. **Log in as the root user on the new slave server system (`hostname3`) and make sure that the network is working by trying a `ping` or `telnet` command.**

2. **Check the second field of `/etc/HOSTNAME` to make sure that the system is in the same domain as the master server.**

   If these fields are not identical on both systems, use a text editor to enter the master's domain name in the second field of the slave's `/etc/HOSTNAME`. (The field delimiters are blanks or tabs.)

3. **Check that `/etc/passwd` contains the following entry for `daemon`:**

   ```
   daemon:xxxxxxxxxxxx:1:1::/:
   ```

   If this line is not in the slave system's `/etc/passwd`, add it to the password file.

4. **Enter the commands**

   ```
   cd /etc/yp
   ypinit -s hostname1
   ```

   where `hostname1` is the master server (or another Yellow Pages slave server).

   The `ypinit -s` command sets up the Yellow Pages database on the slave Yellow Pages server machine. It will take a while to setup the database. The actual time depends on the size of the maps.

5. **Edit `/etc/inittab` to change the status fields (shown in bold) of the following lines from**

   ```
   nfs1:2:off:/etc/ypserv
   nfs2:2:off:/etc/ypbind
   ```

   to

   ```
   nfs1:2:wait:/etc/ypserv
   nfs2:2:wait:/etc/ypbind
   ```

6. **Restart by choosing Restart from the Finder Special menu.**

The machine is now a Yellow Pages slave server.

Installing the Yellow Pages on a client system

This chapter assumes that the Yellow Pages client is named `hostname2`. To make `hostname2` a client system, complete the steps in this section. The subsections that follow explain the steps in more detail.

1. **If the domain name set in the second field of `/etc/HOSTNAME` is not correct, edit the file to correct it and reboot to set the correct domain name.**

   The domain name on a client system must be the same as the domain name on the server.

2. **Restart the system by going into the finder and choosing Restart from the Special menu.**

Setting the domain name

Open the `/etc/HOSTNAME` file by using a text editor. To change the domain name, modify the second field; for example, if the file contains

```
hostname2  apple
```

change `apple` to the domain name you have chosen. *This domain name must be the same domain name used on the master server.* This will also be the name of the subdirectory of `/etc/yp` that contains the Yellow Pages maps.

Reboot A/UX. (The system does not read this file until you reboot.)

Modifying `/etc/passwd`

When a user program calls the `getpwent` (get password entry) library routine, it reads the local `/etc/passwd` file just as it always does, but it interprets + entries in the password file to mean "interpolate entries from the Yellow Pages database." If the system is a Yellow Pages client (running `ypbind`), a remote procedure call retrieves the entry from the Yellow Pages server. (For example, if you wrote a simple program using `getpwent` to print all entries in your password file, your program would print a virtual password file including all local entries and all entries interpolated from the Yellow Pages database.)

The `/etc/passwd` file is processed sequentially. When a user entry is found, processing stops. For this reason, earlier entries mask later ones, and local entries mask Yellow Pages entries. A Yellow Pages client's `/etc/passwd` file might look like

```
root:wAm0Y4lEnf6:0:1:God:/:/bin/sh
nobody:*:65534:65534::/:
daemon:*:1:1::/:
operator:VyZr6V9:333:20:sys op:/usr2/operator:/bin/csh
+joe:EBd4YJUeS45DA:0:0:Joe Smith:/users/joe:/bin/ksh +::0:0:::
```

These entries include the following:

`root` — To allow `root` to log in and to make all `root` passwords unique on all NFS systems.

`nobody` — To prevent superuser access to remotely mounted files. See "Yellow Pages Security Issues" in Chapter 8 for more information.

`daemon` — To allow file-transfer utilities to work.

`operator` — To allow a dump operator to log in.

primary users — To save the overhead of Yellow Pages access when these users are logging in and to allow these users to log in even if the Yellow Pages are unavailable. Note, however, that their login sessions will still be interrupted if the Yellow Pages are unavailable and the local `/etc/group` file accesses the Yellow Pages. See "Modifying `/etc/group`."

\+ — To call the Yellow Pages. In the sample file above, in the last line,

```
+::0:0:::
```

tells the library routines to use the Yellow Pages rather than give up the search.

◆ *Note:* Do not put such a line in the master server's `/etc/passwd` file, because it allows unrestricted access to the entire domain.

There are four styles of + entries:

+	To insert the entire contents of the Yellow Pages password file at that point.
`+::0:0:::`	To consult the Yellow Pages for any other entries.
+ *name*	To insert the entry (if any) for *name* from the Yellow Pages at that point.

A + *name* entry can have non-null fields; for example,

```
+joe:EBd4YJUeS45DA:0:0:Joe Smith:/users/joe:/bin/ksh
```

where the fields are

name:password:UID:GID:comment:directory:shell

tells the library routines to use the Yellow Pages but to allow the non-null password, comment, directory, or shell fields to override what is contained in that field of the Yellow Pages entry. However, the user UID and GID fields in such an entry are automatically taken from the Yellow Pages.

+@*netgroup*	To insert the entries for all members of *netgroup* at that point.

Modifying `/etc/group`

When a user program calls the `getgrent` (get group entry) library routine, it reads the local `/etc/group` file just as it always does, but it interprets + entries in the password file to mean "interpolate entries from the Yellow Pages database." If the system is a Yellow Pages client (running the `ypbind` daemon), an RPC to the server retrieves the interpolated entry.

However, unlike the processing of the `passwd` file, processing of `/etc/group` does not stop when a match is found; the user program searches the entire file for all possible groups to which a user might belong. If you include a + entry in `/etc/group`, the program searches the entire Yellow Pages group map for every `getgrent` call. Thus, if you use the Yellow Pages for group verification, you can abbreviate the local `/etc/group` file to a single line:

```
+:
```

This escape sequence forces all translation of group names and group IDs to be made via the Yellow Pages service.

◆ *Note:* When you use this escape sequence, the group name and group ID verification process searches the entire Yellow Pages group database to find the correct group and check whether a user belongs to that group. If all Yellow Pages servers on the network are down, the local system will be unavailable to all users (even primary users). If you have the adequate redundancy that using a number of slave servers provides, this should not be a problem. An alternative solution is not to use Yellow Pages service at all but to keep a local `/etc/group` file with no + entries. In this case you should still make sure that the group IDs do not conflict with group IDs on the rest of the network in case you decide later to use the Yellow Pages.

`/etc/hosts` and the other database files

The `/etc/hosts` file does not require any modification on the Yellow Pages client systems. When a user program calls the `gethostbyname` or `gethostbyaddr` library routines, these routines may go to the Yellow Pages before consulting the local `/etc/hosts` file if the system is a Yellow Pages client (running `ypbind`).

If you modify the local `/etc/hosts`, remember that it must contain entries for the local host and the local loopback name. These are accessed at boot time, before the Yellow Pages are available.

For example, the minimal local `/etc/hosts` file for `hostname2` would be

```
192.33.20.1 loop lo loo localhost    #loopback
192.33.20.2 hostname2                #local hostname and address
```

The remaining database files (`/etc/networks`, `/etc/protocols`, `/etc/services`, and `/etc/netgroup` if it exists) are treated exactly as `/etc/hosts` is; if the Yellow Pages are running, the local files are not consulted. Leave these files as they are in case the Yellow Pages become unavailable for any reason.

Starting the Yellow Pages client daemon

The `ypbind` daemon is invoked from `/etc/inittab`. To invoke this daemon:

- **Edit `/etc/inittab` to change the status fields (shown in bold) of the following line from**

  nfs2:2:**off**:/etc/ypbind

  to

  nfs2:2:**wait**:/etc/ypbind

  If you are in single-user mode (and have not previously entered multi-user mode), enter

  ```
  init 2
  ```

  Otherwise, reboot A/UX.

  ◆ *Note:* Make sure there is a Yellow Pages server before putting the client machine in multi-user mode. Otherwise the machine is likely to hang if no Yellow Pages server is available while `ypbind` is running. Use the `ypwhich` command, explained in the next section, to test for this condition.

Testing Yellow Pages access

1. **To see whether the client system recognizes the Yellow Pages server, from the client machine enter**

   ```
   ypwhich
   ```

   The `ypwhich` command returns the host name of the server machine that is currently being used to access the Yellow Pages. The response in the case of the two-system net in this chapter should be

   ```
   hostname1
   ```

   The command

   ```
   ypcat passwd
   ```

   displays the values in the Yellow Pages `passwd` map, which is normally served from the remote host.

To test that all is working as it should be, perform the ultimate test:

2. **Log in to the master Yellow Pages server machine, and create a normal user entry in `/etc/passwd`.**

   Be sure to create a password for this user entry, or the Yellow Pages won't serve the entry.

3. **Propagate this entry to all slave server machines with the commands**

   ```
   /etc/yp/yppush passwd.byname
   /etc/yp/yppush passwd.byuid
   ```

   or, you can log in as the root user on each of the server machines and enter

   ```
   cd /etc/yp
   make passwd
   ```

4. **Log in as this user on any machine running Yellow Pages service within the master server's domain.**

   (For a proper test, this should be any machine but the master server.) If the login is successful, the Yellow Pages are up and running.

Summary of Yellow Pages access policies

`/etc/passwd`	The local file is always consulted. If there are + or – entries, the Yellow Pages password map is also consulted; otherwise the Yellow Pages are not used. Local entries mask analogous Yellow Pages entries.
`/etc/group`	The local file is always consulted. If there are + or – entries, the Yellow Pages group map is also consulted; otherwise, the Yellow Pages are not read.
`/etc/hosts`	The local file is consulted at boot time. After that the Yellow Pages are used before the local file is checked.
`/etc/networks`	The local file is never consulted. The Yellow Pages are used instead.
`/etc/services`	The local file is never consulted. The Yellow Pages are used instead.
`/etc/protocols`	The local file is never consulted. The Yellow Pages are used instead.

`/etc/netgroup`	The local file is never consulted. The Yellow Pages are used instead.
`/etc/ethers`	The local file is never consulted. The Yellow Pages are used instead.
`/etc/hosts.equiv`	The local file is always consulted. If it contains + or – entries whose arguments are netgroups, the Yellow Pages netgroup map is consulted; otherwise the Yellow Pages are not used. See "Yellow Pages Security Issues" in Chapter 8.
`$HOME/.rhosts`	The local file is always consulted. If it contains + or – entries whose arguments are netgroups, the Yellow Pages netgroup map is consulted; otherwise the Yellow Pages are not used. See "Yellow Pages Security Issues" in Chapter 8.

Chapter 5 **Adding Systems to a Network**

This chapter describes how to add systems to a network. If the network is not using the Yellow Pages, you need to copy files manually across the network to inform systems about each other. If the network is using the Yellow Pages, many of the changes can be made on the master server only. The key points covered in this chapter are:

- Adding a system to the network
- Adding NFS systems without the Yellow Pages
- Adding systems by using the Yellow Pages

"Adding a System to the Network" describes how to add a system to a network that is not using the Yellow Pages.

"Adding NFS Systems Without the Yellow Pages" describes how to make NFS systems functional after adding them to the network. Because it is the same procedure described in Chapter 3 it is simply summarized here.

"Adding Systems by Using the Yellow Pages" describes how to use the Yellow Pages to add hosts to the network. If the network is using the Yellow Pages, you will save considerable time by making changes to the master server `/etc/hosts` database and using the Yellow Pages to inform the network about the new host. This section also describes how to add a Yellow Pages client.

Adding a system to the network

When adding a system to an existing network, you should make all the required software changes before enabling the daemons at reboot.

If you are adding a system to a network that is not using the Yellow Pages, you should choose a system that is already on the network as a host machine for network files such as `/etc/hosts`, `/etc/hosts.equiv` (if desired), and `/etc/networks`. This section assumes that the host system is named `hostname1` and the new system is named `hostname3`.

1. **Log in to `hostname1` (a system already on the network), and modify its `/etc/hosts` (and, optionally, `/etc/hosts.equiv`) to include an entry for the new system, `hostname3`.**

2. **Bring up `hostname3`.**

3. **Run the `newconfig` program with the appropriate arguments and answer the prompts.**

   (See `newconfig`(1M) for information about choosing arguments.)

4. **Edit `/etc/inittab` to set up the daemons you wish to have enabled.**

   Also check `/etc/servers` as described in "Checking Your `/etc` Files" in Chapter 2.

4. **Restart by choosing Restart from the Finder Special menu.**

5. **When you are back on `hostname3`, use the `ftp` program to copy `/etc/hosts` from `hostname1` to `/etc/hosts` on `hostname3`.**

   (You use `ftp` instead of `rcp` because, on a properly configured network, `rcp` does not allow the root user to make file transfers across the network.)

   Enter the command

   ```
   ftp 192.33.20.1
   ```

   (where `192.33.20.1` is the Internet address of the host system, `hostname1`). This will display something like

   ```
   Connected to hostname1.
   220 hostname1 FTP server ready.
   Name (hostname1:root): ordinary-user
   331 Password required for ordinary-user.
   ```

(You can also edit the `/etc/hosts` file on `hostname3` to show `192.33.20.1` and then enter the command "`ftp hostname3`".)

After the `Name` prompt, type the user name you would normally use on `hostname1` when you are not logged in as the root user and press RETURN.

The `ftp` utility reads the file `/etc/ftpusers` to determine which users to exclude from the system. It is common practice to ship systems with a `root` entry in this file. If root is in this file, you are excluded from logging in as root, even though you know the root password.

After the `Password` prompt

`Password (hostname1:`*ordinary-user*`):`

type the password and press RETURN.

(The password does not echo on the screen.) The `ftp` utility then prints something like

`230` *ordinary-user* `logged in.`
`ftp>`

6. **At the `ftp>` prompt, enter the command**

   ```
   get /etc/hosts
   ```

   Because you are logged in as the root user on `hostname3`, and because `/etc/hosts` always has read permission for everyone, `ftp` will successfully make the file transfer to `/etc/hosts` on `hostname3`.

   The `get` command will print something like

   ```
   200 PORT command successful.
   150 Opening data connection for /etc/hosts !
      (128.008.001.001) (2147 bytes).
   226 Transfer complete
   local:/etc/hosts remote:/etc/hosts
   2247 bytes received in 0.04 second
   ftp>
   ```

7. **When the file transfer is complete and you see the `ftp>` prompt again, enter**

   ```
   bye
   ```

8. **Log in to your other network systems as a root user and use `rcp` or `ftp` to copy the updated `/etc/hosts` file to all systems that need to communicate with the new system.**

If you want to allow users on the new system access to remote systems without supplying a password, you can modify the `/etc/hosts.equiv` files on the remote systems. Individual users can also accomplish this by creating a `.rhosts` file in their login directories on the remote systems.

Adding NFS systems without the Yellow Pages

This section describes how to add NFS servers and NFS clients that do not use Yellow Pages to your network. The procedure is the same one described in Chapter 3; the information is summarized here for your convenience.

Adding NFS servers

It is up to you to decide which machines should be servers. You might want those with larger disks or multiple disks to be the servers, or you may want to share large amounts of data from a particular machine with an entire group, and so would designate that machine as an NFS server.

One important criterion is the overall reliability of the server, especially when file systems are mounted with the "hard" option. The "hard" option ensures that a process accessing remote data will not complete until the read or write is successful. If the remote server is down, the process will hang until the remote server returns. (Or you may decide to mount most of your file systems with the "soft" option.)

Add the first new system in the network by following the procedure described in "Adding a System to the Network." If you have run the `newconfig` with the `nfs` argument, you can then export the new system's file systems by following these steps:

1. **Edit `/etc/exports` to include a line exporting the root file system (if the system supports a single disk) and any specific hierarchies (if desired) followed by the appropriate list of hosts.**

   For example,

   ```
   /  # export to everyone
   ```

2. **Check that the NFS server daemons are running by entering**

```
ps -ef | grep nfsd
```

The response should be

```
root   81   1   0 01:27:17 ?      0:02 /etc/nfsd 4
root   82   1   0 01:27:17 ?      0:02 /etc/nfsd 4
root   83   1   0 01:27:17 ?      0:02 /etc/nfsd 4
root   84   1   0 01:27:17 ?      0:02 /etc/nfsd 4
```

(The numbers in each column may be different on your system.)

Adding an NFS client

First add the new system to the network by following the procedure described in "Adding a System to the Network." Make sure that an NFS server has an updated copy of `/etc/hosts` so that it can communicate with the new system.

1. **Check that the system can communicate with a file server by entering**

```
ping hostname1
```

(where `hostname1` is a server). The response should be similar to

```
64 bytes from 192.33.20.1: icmp_seq=0. time=16. ms
64 bytes from 192.33.20.1: icmp_seq=1. time=16. ms
64 bytes from 192.33.20.1: icmp_seq=2. time=16. ms
```

(*interrupt*)

```
----hostname1 PING Statistics----
3 packets transmitted, 3 packets received, 0% packet loss
round-trip (ms)      min/avg/max = 16/16/16
```

2. **Check the export permissions on `hostname1`:**

```
showmount -e hostname1
```

If `hostname1` exports to everyone, follow steps 3 through 6 to mount a hierarchy on the new system.

If `hostname1` doesn't export to everyone, log in as the root user on `hostname1` and add the new system's host name to the export list in `/etc/exports`; that is, add the new system's host name, separated by white space from the other host names, to the desired lines in this file. For example, to export the `/usr/catman` hierarchy to the new system `hostname3` modify `/etc/exports` on `hostname1` so that it looks like

```
/   hostname2 hostname3
/usr/catman hostname2 hostname3
```

Now you can follow steps 3 through 6 to add your new system to the network as an NFS client.

3. **Bring up the new system and enter**

   ```
   grep nobody /etc/passwd
   ```

   The response should be

   ```
   nobody:xxxxxxxxxxxxx:65534:65534:NFS generic user:
   /tmp:/bin/noshell
   ```

   (This should appear on one line on the screen.) If this is not the response, modify `/etc/passwd` to include this line.

4. **Edit `/etc/fstab` to add an entry for mounting the remote hierarchy as described in Chapter 3, "Initializing NFS."**

5. **Check that the local mount point you specified in `/etc/fstab` exists, is empty, and has permissions at least as open as those of the remote hierarchy. If the local mount point does not exist, create it with**

   `mkdir` */dir-name*

   and check the permissions as described in "Modifying `/etc/fstab`" in Chapter 3.

6. **Check that the appropriate daemons are running by entering**

   ```
   ps -ef | grep biod
   ```

   The response should be

   ```
   root   81   1   0 01:27:17 ?      0:02 /etc/biod 4
   root   82   1   0 01:27:17 ?      0:02 /etc/biod 4
   root   83   1   0 01:27:17 ?      0:02 /etc/biod 4
   root   84   1   0 01:27:17 ?      0:02 /etc/biod 4
   ```

   (The numbers in each column may be different on your system.)

Adding systems by using the Yellow Pages

This section describes how to add a Yellow Pages client to your network. When add a Yellow Pages client system, you should make all of the system file changes on the master Yellow Pages server alone.

1. **Log in as the root user on the master Yellow Pages server.**

2. **Edit `/etc/hosts` on the master Yellow Pages server, and add an Internet address and host name (and, if you wish, a nickname for the system).**

   For example, if the name of the new system is `hostname5`, use

   ```
   192.33.20.1  hostname5 h5
   ```

3. **Update the Yellow Pages maps by entering**

   ```
   cd /etc/yp
   make
   ```

4. **Log in as the root user on the new system.**

   Unless you have already entered the correct domain name in response to the `domainname` prompt when using newconfig to create the NFS kernel, use a text editor to enter the domain name of the master server in the second field of `/etc/HOSTNAME`. (The field delimiters are blanks or tabs.)

   ```
   hostname5    apple
   ```

   For example, change `apple` to the same domain name used by the master Yellow Pages server.

   If you do not know the domain name, on the master server enter

   ```
   domainname
   ```

5. **Edit `/etc/inittab` to change the status fields (shown in bold) of the following line from**

   nfs2:2:**off**:/etc/ypbind

   to

   nfs2:2:**wait**:/etc/ypbind

6. **Restart the system by choosing Restart from the Finder Special menu.**

   There must be at least one `ypserv` process running on the network before you reboot the client system or the machine will hang during the boot process.

7. **Create home directories for users who should have access to the new system.**

8. **To see whether the client system recognizes the Yellow Pages server, enter** `ypwhich`

   The `ypwhich` command returns the host name of the server machine that is currently being used to access the Yellow Pages.

Chapter 6 **Administering AppleTalk**

This chapter describes the A/UX implementation of the AppleTalk protocols and is designed for network administrators who want to set up an AppleTalk network system. The key points covered in this chapter are:

- The AppleTalk network system and A/UX
- Hardware requirements
- Switching between LocalTalk and EtherTalk
- Using other Ethernet cards
- Using AppleTalk to print in A/UX
- Deinstalling AppleTalk
- Reinstalling AppleTalk
- Reactivating the printer port as a terminal port
- Summary of AppleTalk commands

The AppleTalk network system and A/UX

A network system is a communication environment in which network devices and software observe a common set of rules for communicating. These rules, called network **protocols,** explicitly describe each step in the process of interaction between the network devices.

In AppleTalk networks each protocol governs a different aspect of the communication process, such as how network devices are identified and how data is formatted for transmission. AppleTalk protocols can be implemented on a wide variety of devices and on a wide variety of transmission media. Although all AppleTalk network systems implement the AppleTalk protocols, they do not all use the same transmission standards, media, or connections.

The design of AppleTalk allows you to select the type of network that best meets the needs of your organization while retaining the same AppleTalk services throughout the internet. AppleTalk for A/UX 2.0 supports both low-cost LocalTalk and high-performance Ethernet connections.

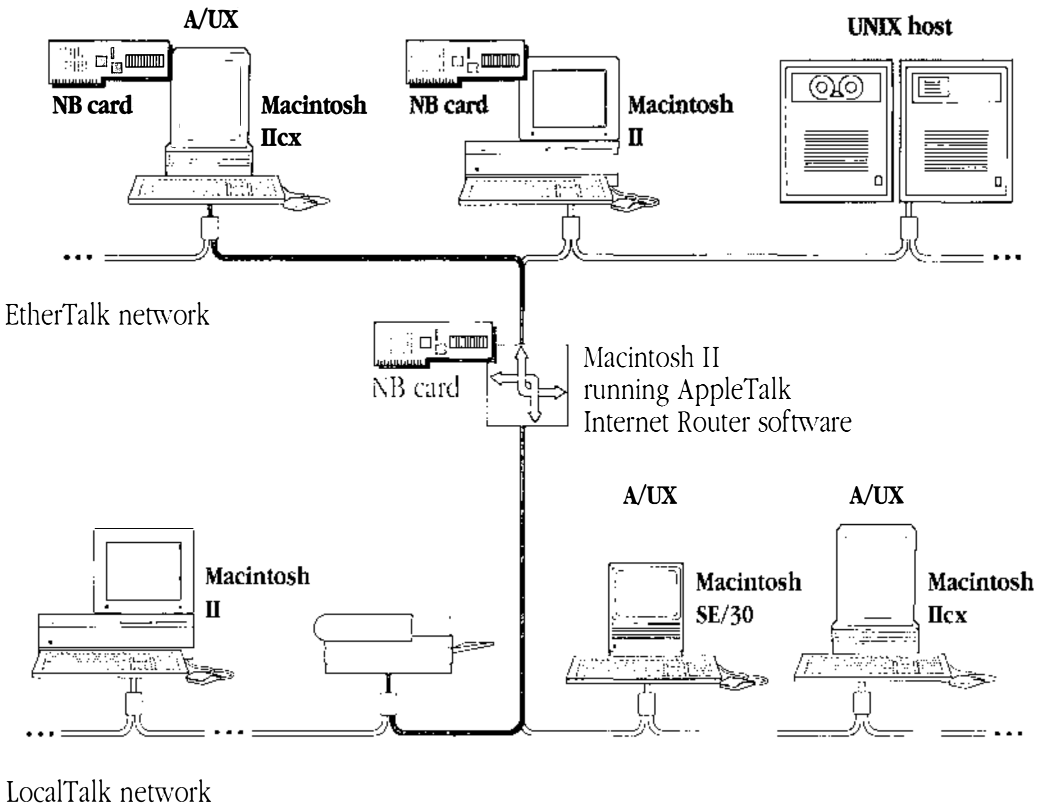
Figure 6-1 illustrates how AppleTalk for A/UX enables you to use an AppleTalk printer from a workstation on an Ethernet network.

AppleTalk for A/UX enables you to connect your A/UX system to a network of computers to share services and devices such as AppleTalk LaserWriters and ImageWriters. AppleTalk for A/UX can work concurrently with B-NET, Network File System (NFS), and Yellow Pages software described in the previous chapters of this manual. In the future it is expected that Apple and third-party vendors will provide additional AppleTalk network service products for A/UX, such as mail and file servers.

Hardware requirements

If you wish to run EtherTalk software on the Macintosh II family of computers, you need an EtherTalk NB card. Third-party Ethernet cards are available for Macintosh SE/30 A/UX systems. EtherTalk and TCP/IP software can use the same card concurrently, so you need only one Ethernet interface card to use both EtherTalk and TCP/IP network services.

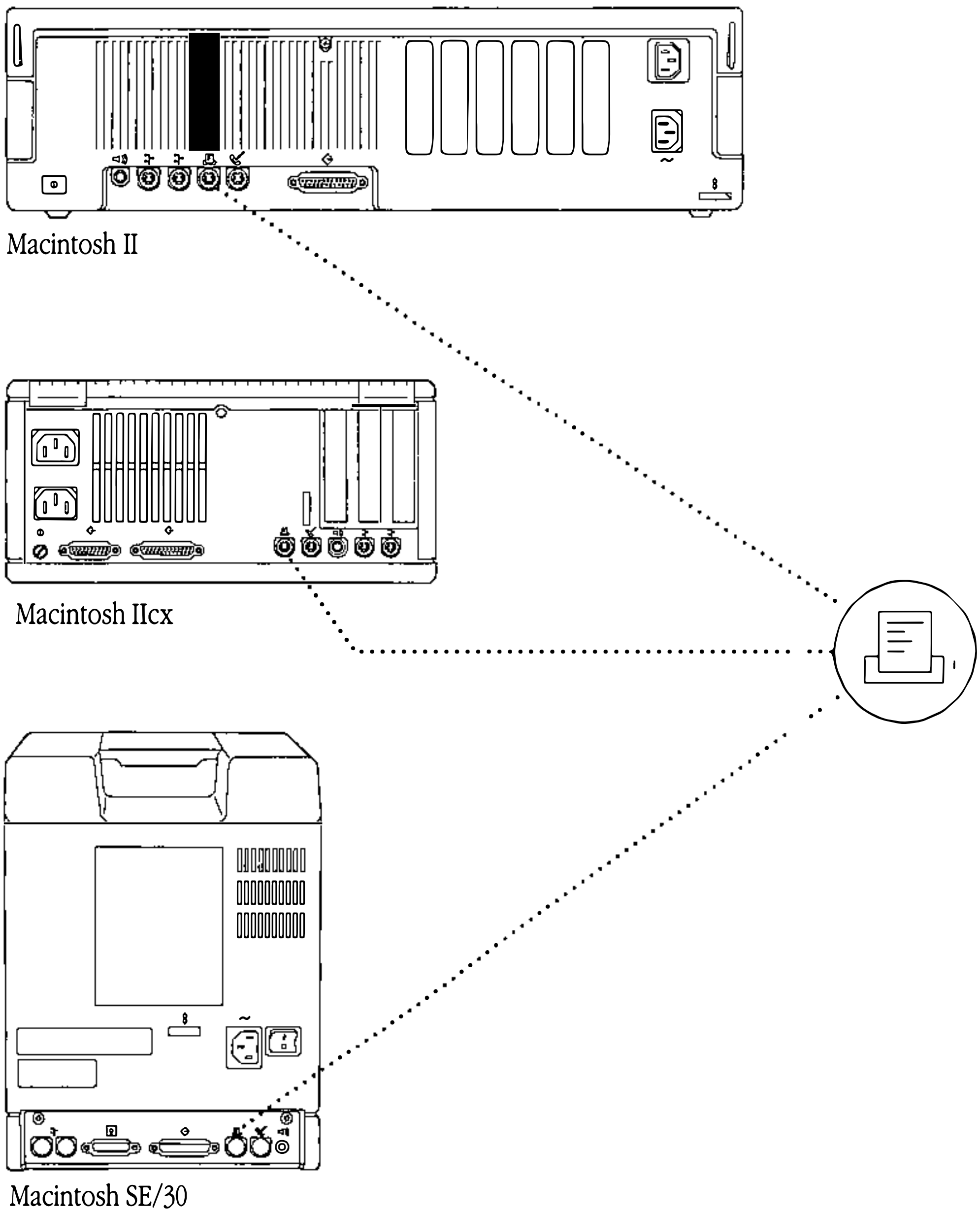
■ **Figure 6-1** AppleTalk printing on Ethernet



If you wish to use LocalTalk for A/UX 2.0, you don't need any additional hardware. LocalTalk software uses the printer port on your machine.

As shown in the Figure 6-2, the LocalTalk software uses the printer port on your machine as a LocalTalk port; the printer port cannot be used as a serial terminal port when LocalTalk is running on your system.

■ **Figure 6-2** LocalTalk printer ports



Switching between LocalTalk and EtherTalk

After you install AppleTalk for A/UX, the system defaults to EtherTalk on interface `ae0`. If there is no EtherTalk NB card, the system defaults to LocalTalk.

Switching from LocalTalk to EtherTalk

If you have an EtherTalk NB card but are currently running LocalTalk, you can manually switch to EtherTalk by following this procedure:

1. **To bring down the EtherTalk interface, enter**

   ```
   /etc/appletalk -d
   ```

2. **Edit the file `/etc/appletalkrc`, changing the line**

   ```
   interface = localtalk0
   ```

   to

   ```
   interface = ethertalk0
   ```

3. **Remove the LocalTalk cable from the printer port on the back of your computer.**

   ▲ **Caution** Make absolutely certain that the LocalTalk cable isn't connected to the printer port when the `getty` process is active. Having the `getty` process active on the printer port with a LocalTalk cable attached can cause problems, including loss of service to other users on the network. ▲

   If you wish to reconfigure the printer port as a serial terminal port, refer to "Deinstalling AppleTalk" later in this chapter.

4. **To bring up the EtherTalk interface, enter**

   ```
   /etc/appletalk -u
   ```

Switching from EtherTalk to LocalTalk

You can manually switch from EtherTalk to LocalTalk by following this procedure:

1. **To bring down the EtherTalk interface, enter**

   ```
   /etc/appletalk -d
   ```

2. **Edit the file `/etc/appletalkrc`, changing the line**

   ```
   interface = ethertalk0
   ```

   to

   ```
   interface = localtalk0
   ```

3. **Make sure the `tty1` line is deactivated.**

   Note that you can skip this step if the `tty1` line is already turned off in the `/etc/inittab` file.

4. **Edit the `/etc/inittab` file, changing the line**

   ```
   01:2:respawn:/etc/getty tty1 at_9600 #port...
   ```

   to

   ```
   01:2:off:/etc/getty tty1 at_9600 #port...
   ```

5. **To remove the unwanted `getty` process on `tty1`, enter**

   ```
   /etc/init q
   ```

   Make sure the LocalTalk cable is securely connected to the printer port on the back of your machine.

6. **To bring up the LocalTalk interface, enter**

   ```
   appletalk -u
   ```

Using other Ethernet cards

AppleTalk works with Ethernet cards other than the EtherTalk NB card as long as the card's driver supports the A/UX 1.1.1 Ethernet driver interface. If you are using one of these cards, the following procedure enables AppleTalk to recognize the card:

1. **Check the file `/etc/appletalkrc` to verify that the "interface" line of the file is**

   ```
   interface=ethertalk0
   ```

2. **To bring down the EtherTalk interface, enter**

   ```
   appletalk -d
   ```

3. **Edit the `ethernet` line of `/etc/appletalkrc` to include the appropriate Ethernet interface name for the board you have installed.**

   You can find this name in the documentation for your Ethernet interface card. For example, if the name of the Ethernet interface for the installed board is `ep0`, change the line to

   ```
   ethernet = ep0
   ```

4. **To bring up the EtherTalk interface on `ep0`, enter**

   ```
   appletalk -u
   ```

Once the `/etc/appletalkrc` file is set up, the interface that file describes comes up each time the system is rebooted.

Using AppleTalk to print in A/UX

A/UX 2.0 provides several methods for printing:

- From a Macintosh application (or Macintosh-like A/UX application such as TextEditor), you can choose Print from the File menu and use the Printer dialog box.
- From CommandShell or from the console application, you can use the `lpr` spooler command.
- From CommandShell or from the console application, you can use the `atprint` command. `atprint` bypasses the spooler and sends output directly to the printer.

With each method, you must first select a default printer by using the Chooser from the Apple menu (or use the `at_cho_prn`(1) command). See *Setting Up Accounts and Peripherals for A/UX* for information about choosing a printer.

◆ *Note:* Your computer is configured with an Laserwriter as the default AppleTalk printer. To use an ImageWriter II as an AppleTalk printer, you need a special conversion kit that allows you to connect an ImageWriter II printer to a LocalTalk cable. (See your Apple representative for details.) Without this kit an ImageWriter II can function only as a serial printer.

Printing files created by a Macintosh application

You can print a file from a Macintosh application just as you normally would from the Macintosh Operating System. Follow these steps:

1. **Print the file you are working on by choosing Print from the File menu.**
2. **When the Printer dialog box appears, click OK to send your file to the printer.**

   If you created a file in a Macintosh application and have since quit that application, you can print the file from CommandShell by clicking the file icon and choosing Print from the File menu. Your file is sent to the printer you selected from the Chooser.

Printing files with `lpr`

You can use the `lpr` spooler command to print files from CommandShell or from the console application. First, to verify that the printer spooler is running, enter

```
/usr/lib/lpc
```

The response should be

```
AppleTalk:
        queuing is enabled
        printing is enabled
        no entries
        no daemon present
```

If the spooler is not running, use the `lpd` command. See `lpd`(1M) in *A/UX System Administrator's Reference* for more information.

To use `lpr` to print files on printers attached to the AppleTalk network, enter
`lpr` *file*

To print formatted `troff` output files on a LaserWriter, use this command:
`troff -Tpsc` *file* `| psdit | lpr`

You can also use the `psroff` command:
`psroff` *file*

`psroff` automatically sends the file through `psdit` and `lpr`.

To use `lpr` to print ASCII files on an ImageWriter, enter
`cat` *file* `| lpr`

See `cat`(1) and `lpr`(1) for more details about these commands. See `/usr/lib/ps` for the Adobe PostScript® programs available with A/UX.

◆ *Note:* You can use `lpr` to print on either an ImageWriter or a LaserWriter. ImageWriter printers expect ASCII input and LaserWriter printers expect PostScript input. If `lpr` receives ASCII input and a user has not specified an ImageWriter as the default printer, the interface file for the AppleTalk printer class runs commands that automatically perform PostScript conversion. See *A/UX Local System Administration* for details.

Printing files with `atprint`

When you use the `atprint` command, data is sent directly to the printer, bypassing the `lpr` spooler. You should use `atprint` if you suspect some problems with the spooler.

To print `troff` output files on a LaserWriter, use the command
`troff -Tpsc` *file* `| psdit | atprint`

To print ASCII text on a LaserWriter, use the command
`enscript -p-` *file* `| atprint`

To print ASCII text on an ImageWriter, use the command
`atprint <` *file*

Deinstalling AppleTalk

To deinstall AppleTalk from your computer, follow these steps:

1. **Log in as the root user.**
2. **Enter**
   `/etc/newconfig noappletalk`

   This command may take several minutes to complete.
3. **If you were using the LocalTalk interface, remove the LocalTalk cable from the printer port in the back of your machine.**

▲ **Caution** Make absolutely certain that the LocalTalk cable isn't connected to the printer port when the `getty` process is active. Having the `getty` process active on the printer port with a LocalTalk cable attached can cause problems, including loss of service to other users on the network. ▲

4. **Restart your system by choosing Restart from the Finder Special menu.**

Reinstalling AppleTalk

To reinstall AppleTalk after deinstalling, follow these steps:

1. **As the root user, enter**
   `newconfig appletalk`

   This command may take a few minutes to complete.
2. **Use the `shutdown` command.**
3. **Restart your system to activate AppleTalk.**

If you have already installed an EtherTalk NB card in your Macintosh, make sure your Ethernet cable is properly attached to your EtherTalk card, and then on system startup AppleTalk for A/UX automatically configures your system for EtherTalk. Your installation is complete.

If you haven't installed an EtherTalk NB card, AppleTalk for A/UX configures your system for LocalTalk using the printer port on the back of your Macintosh and modifies the `tty1` entry in the `/etc/inittab` file to deactivate serial terminal support on the printer port. This message appears on system startup:

```
Starting LocalTalk on printer port
```

Make sure that the LocalTalk cable is properly secured to the printer port on the back of your machine.

Reactivating the printer port as a terminal port

To reactivate the printer port as a terminal port:

1. **Deinstall AppleTalk or switch from LocalTalk to EtherTalk and remove the LocalTalk cable, as described in the previous sections.**
2. **Edit the `etc/inittab` file to change the line**
   ```
   01:2:off:/etc/getty tty1 at_9600 #port ...
   ```
   to
   ```
   01:2:respawn:/etc/getty tty1 at_9600 #port ...
   ```
3. **To start a `getty` process on `tty1`, enter**
   ```
   /etc/init q
   ```
   At this point you have reactivated the printer port as a terminal port and can attach a terminal to it.

▲ **Caution** Make sure the LocalTalk cable isn't connected to the printer port when the `getty` process is active. Having the `getty` process active on the printer port with a LocalTalk cable attached can cause problems, including loss of service to other users on the network. ▲

Summary of AppleTalk commands

`at_cho_prn`	Chooses the system default printer on the AppleTalk network. See `at_cho_prn`(1).
`atlookup`	Looks up network-visible entities (NVEs) registered on the AppleTalk internet. See `atlookup`(1).
`atprint`	Copies data to a remote Printer Access Protocol (PAP) server. See `atprint`(1).
`atstatus`	Returns the status of a PAP server. See `atstatus`(1).
`/etc/appletalk`	Configures and allows you to view AppleTalk network interfaces. See `appletalk`(1M).
`/etc/newconfig`	Prepares for a new kernel configuration. See `newconfig`(1M).

Chapter 7 **Network Design Issues**

This chapter describes various design decisions you need to make when setting up a larger network. It also tells how you use the software supported by A/UX to set up an Internet forwarder machine, configure subnets (supporting only A/UX computers), and add an A/UX system to a larger network that is running the Internet domain software. The key points covered in this chapter are:

- Network design considerations
- Routing and forwarding
- Subnets
- Internet domains

Network design considerations

If you are configuring a large network, you need to consider the physical limitations of the network based on electrical parameters, the number of hosts connected, the total length of the cable, and the physical location of hosts (that is, whether the geographical distribution allows direct Ethernet connections between all hosts on the network). In a large organization, such as a university or a company with more than one building, you need a way of communicating between multiple Ethernet cables. To do this you can

- Obtain a distinct Internet network number for each cable and use Internet forwarders to route between networks. (Note that if these networks connect to the outside world, the internal routing details are propagated to other systems that have no use for this information, resulting in unnecessarily large Internet routing tables.) This is described under "Routing and Forwarding."
- Use a single network number and partition the host address space by assigning subnet numbers to the local area networks. In this case the internal division is not visible to the outside world. See "Subnets."

In a large network you may also want to use the Berkeley Internet Name Domain (BIND) host name and Internet address server, which has been modified slightly in A/UX to accommodate the Yellow Pages. The domain software is part of the 4.3BSD BIND distribution. See Appendix B, "Name Server Operations Guide," and "Related RFCs" in Appendix D for documentation about Internet domains.

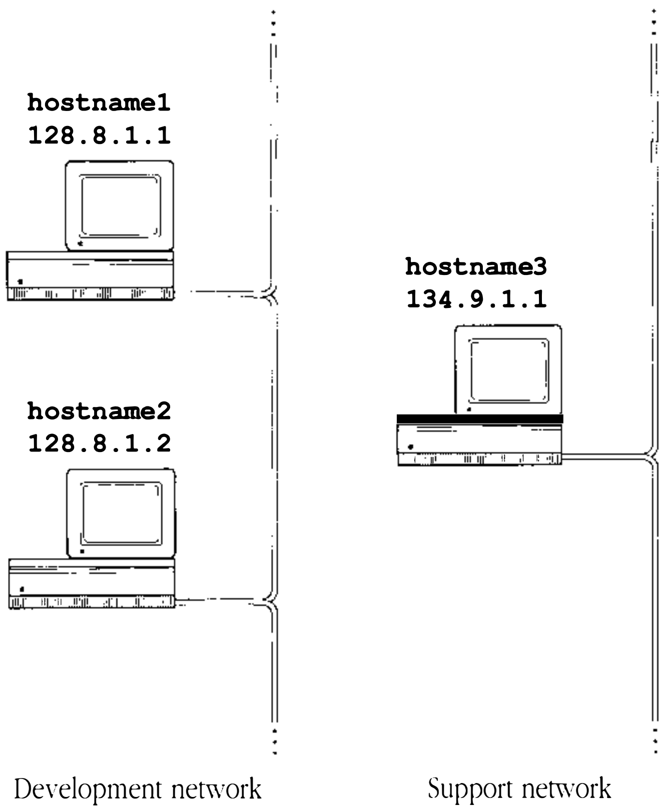
Routing and forwarding

Some organizations have more than one Ethernet and obtain a separate network number on each cable. In this situation you can configure the separate networks to talk to each other by setting up Internet forwarder systems. An Internet forwarder is connected to two separate networks and routes packets between them.

◆ *Note:* If you are setting up multiple Ethernets, or a cluster of networks, all systems should run the `routed` daemon.

This section describes setting up a Macintosh II as an Internet forwarder between two networks. For the purpose of illustration assume the conditions shown in Figure 7-1. The two networks are Development and Support, and they use the network numbers `128.8` and `134.9`, respectively. The Development network currently supports two Macintosh II computers named `hostname1` and `hostname2`. The forwarder system will be `hostname2`. The Support network supports one Macintosh II named `hostname3`. The Internet addresses for each machine are shown in the figure.

■ **Figure 7-1** Two separate networks



To establish a forwarder between the two networks, you need to choose one system on one network (Development network in Figure 7-1) to forward traffic to the other network (Support network in Figure 7-1). Then you need to make the other network able to communicate with the forwarder system.

The forwarder system (`hostname2`) needs two Ethernet cards (one card connected to each network) and two Internet addresses. Systems on the Development network communicate with `hostname` by using an address that begins with the network number `128.8`, and systems on the Support network communicate with `hostname2` by using an address that begins with the network number `134.9`.

To set up `hostname2` as an Internet forwarder system, first install a second Ethernet card into your computer using the directions supplied by the card manufacturer, and connect the cable that came with the card to the second network (see Figure 7-2), and then

1. **Log in as the root user on `hostname2`.**
2. **Choose Restart from the Apple menu.**

   The A/UX Startup copyright dialog and the "Welcome to A/UX" dialog appear.

   As the system is restarting, it notices the new Ethernet card. A CommandShell dialog box appears.

3. **Click OK.**

   Your console window appears with the following prompts:

   ```
   2 Ethernet card(s) installed
   ae1:     Please enter an Internet address:
   ae1:     Please enter an Internet Broadcast address:
   ae1:     Please enter a netmask [none]:
   ```

   ◆ *Note:* Use the DELETE key to edit typing mistakes *before* pressing RETURN.

4. **In response to the first prompts enter the system's address on the Support network.**

   In Figure 7-2, for example, that address is

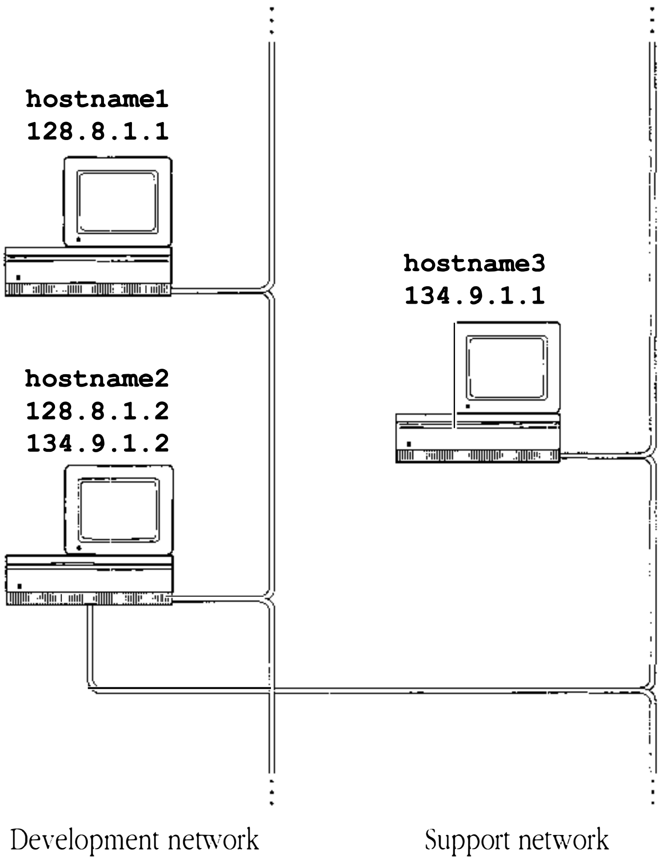
   `134.9.1.2`

5. **Next enter the broadcast address used on the Support network.**

   In Figure 7-2 for example, the broadcast address is

   `134.9.255.255`

■ **Figure 7-2** An Internet forwarder system



Note that the broadcast address on the second Ethernet interface on `hostname2` (the forwarder system) must match the broadcast address of `hostname3`. Before you enter the broadcast address for the new Ethernet card, check the broadcast address on `hostname3` by doing one of the following:

- View `hostname3:/etc/NETADDRS` (the broadcast address and netmask are in the third and fourth fields in this file)
- Enter

  ```
  ifconfig ae0
  ```

  on `hostname3`. This will tell you the broadcast address and netmask.

6. Supply the netmask used on the Support network. For example, 0xffff0000.

All systems on both networks must be running the routing daemon `/etc/in.routed`, which should be set to `wait` in `/etc/inittab`, or you must install static routes manually by using `route`(1M). However, only `hostname2` will broadcast routing updates. The forwarder system broadcasts to the separate networks to let them know about the presence of the other network and routes packets between the two networks; if `hostname1` wants to contact `hostname3`, it communicates through `hostname2`.

◆ *Note:* For each of the Ethernet interfaces on the forwarder system, the broadcast address must agree with the one used by the other system(s) on that network.

Now you need to make `hostname3` able to talk to `hostname2` on the Support network.

1. Log in as the root user on `hostname3`, and open `/etc/hosts` with a text editor.

2. Add an entry for the second Internet address of `hostname2`.

For the example in Figure 7-2, enter

```
134.9.1.2       hostname2 h2            # macII
```

Table 7-1 shows the `/etc/hosts` files on the three systems. (The table includes date lines, which are automatically generated by the system, as well as host information and comment lines, which you would have typed in earlier.)

■ **Table 7-1** `/etc/hosts` on sample networked systems

hostname1	`#Development network`
	`192.33.20.1 hostname1 # Tue Oct 15 01:45:51 PDT 1987`
	`192.33.20.2 hostname2               # macII`

hostname2	`#Development network`
	`192.33.20.1 hostname1               # macII`
	`192.33.20.2 hostname2 # Tue Oct 15 01:45:51 PDT 1987`

hostname3	`#Development network`
	`192.33.20.1 hostname1 localhost     # macII loopback`
	`#Support network`

◆ *Note:* If you forced the host name and domain name prompt to appear by removing the `local loopback` `/etc/NETADDRS` file, you may now have duplicate DT 1987 entries for this host at the same Internet address in `/etc/hosts`. In most cases these duplicate entries cause no harm. However, if this host is a Yellow Pages master server, be sure to remove these duplicate entries from `/etc/hosts`. Otherwise you risk inconsistent Yellow Pages behavior.

Table 7-2 shows the `/etc/NETADDRS` files on the three systems.

■ **Table 7-2** `/etc/NETADDRS` on sample networked systems

hostname1	`0    192.33.20.1 192.33.2155.255` `0xffff0000`

hostname2	`0    192.33.20.2 192.33.2155.255`
	`0xffff0000`
	`1    134.9.1.2 134.9.255.255    0xffff0000`

hostname3	`0    134.9.1.1 134.9.255.255    0xffff0000`

After you have set up the second network, you should modify `/etc/networks` on all systems (or modify it on the master server and use the Yellow Pages) to contain an entry for the new network. Modifying `/etc/networks` is described in "Other Required Network System Files" in Chapter 2.

Subnets

For administrative or technical reasons you may choose to divide the network into several subnets rather than obtaining several unique network numbers. If you use subnets, the internal routing details are not visible to the outside world.

The subnet code is part of the Internet Protocol (IP) module. It allows the standard host field on an Internet address to be split into two parts: a subnet part and a host part, using a 32-bit netmask. The netmask contains binary 1's and 0's. The 1's in the netmask define the network part of the Internet address, and the 0's define the host part.

The actual Internet address for a system does not change (and is therefore consistent for the outside world) the local network interprets it differently.

Because subnets are not visible to the outside world, the network cannot reduce the number of bytes in the network number. For example, on a class B network number, a netmask of `0xffff0000` specifies no subnets, because it uses the class B standard of two bytes of network number and two bytes of host number. To support subnets, you can only *add* significant bits to this default network mask. For example, the netmask

```
0xffffff00
```

allows the third byte (the first byte of the host field of the Internet address) to be used as the subnet number because it adds a byte to the network part of the Internet address.

The procedure for setting up subnets is the same as the procedure described under "Routing and Forwarding" except for the addressing scheme. Figure 7-3 shows three machines on two networks at a site that uses the class B network number

```
128.8
```

All three systems use Internet addresses beginning with `128.8` and a netmask that defines the third byte as part of the network number

```
0xffffff00
```

In Figure 7-3 `hostname2` is set up as a forwarder system with two Ethernet cards and a connection to both networks.

■ **Figure 7-3** Subnets

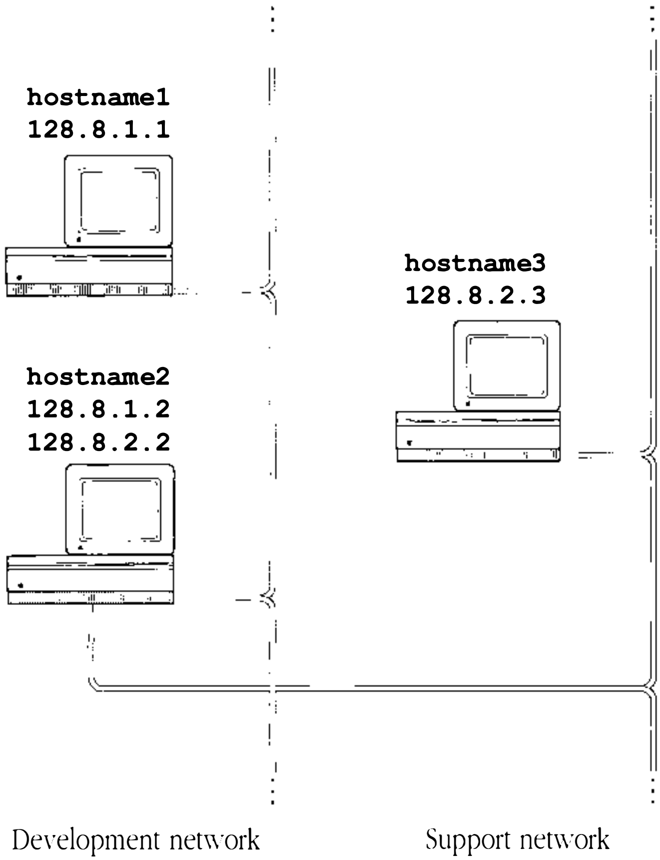


Table 7-3 shows the `/etc/hosts` files on the three subnetted systems.

■ **Table 7-3** `/etc/hosts` on sample subnets

hostname1	`#Development network`
	`192.33.20.1 hostname1 # Tue Oct 15 01:45:51 PDT 1987`
	`192.33.20.2 hostname2                # macII`

hostname2	`#Developmentsnetwork                # macII`
	`192.33.20.1 hostnamelocalhost        # macII loopback`
	`192.33.20.2 hostname2 # Tue Oct 15 01:45:51 PDT 1987`

hostname3	`#Development network`
	`192.33.20.1 hostname13               # macII`
	`#Support network`
	`192.33.21.2 hostname2                # macII`
	`127.0.0.1   loop lo localhost        # local loopback`
	`192.33.21.3 hostname3 # Tue Oct 15 01:45:51 PDT 1987`

Table 7-4 shows the `/etc/NETADDRS` files on the three subnetted systems.

■ **Table 7-4** `/etc/NETADDRS` on sample subnets

hostname1	0	192.33.20.1	192.33.20.255	0xffffff00	
hostname2	0	192.33.20.2	192.33.20.255	0xffffff00	1
		192.33.21.2	192.33.21.255	0xffffff00	
hostname3	0	192.33.21.3	192.33.21.255	0xffffff00	

Subnets and broadcasting

Some daemons broadcast frequently (for example, the `rwho` daemon). If many systems receive broadcast packets with the wrong broadcast address, Ethernet storms with high collision and network traffic rates can result, generally decreasing the efficiency of the network.

In the examples in the preceding section, if both subnets support only Macintosh II computers, you could leave the broadcast address as

```
192.33.255.255
```

on both subnets. Then any broadcast would reach every system on either subnet. See "Related RFCs" in Appendix D for more information.

If the network supports different types of systems, however, you should limit their broadcasts to their own subnet. This method is employed in the examples above. Table 7-5 shows how different netmasks can be used with broadcast addresses.

■ **Table 7-5** Subnets and broadcast addresses

Network class	Netmask	Broadcast address
A	`0xffff0000`	*n1.n2*.255.255
B	`0xffffff00`	*n1.n2.n3*.255
C	`0xfffffff0`	*n1.n2.n3*.15

As Table 7-5 shows, for a class C network number the netmask uses four bits for the subnet number and the same broadcast address. If you use a subnet mask of `0xfffffff0` with a class C network, you can have a total of 14 subnets with 14 hosts on each (0 and all 1's have special meaning, so they're avoided as network, subnet, and host numbers). For a class C network number of `192.11.1` and a netmask of `0xfffffff0` you would have the following Internet addresses as follows:

```
192.11.1.0x11      (host 1 on subnet 1)
192.11.1.0x12      (host 2 on subnet 1)
192.11.1.0x21      (host 1 on subnet 2)
...
```

◆ *Note:* A/UX software allows the `0x` (hexadecimal) notation. Software and hardware from other manufacturers may require the decimal equivalent of the hexadecimal number.

Internet domains

The A/UX software supports Internet domains. For detailed information about Internet domain name servers, see `named`(7); `resolver`(4); Appendix B, "Name Server Operations Guide for BIND;" and the documentation related to Internet domains in "Related RFCs," in Appendix D.

Enabling the resolver software

If you are adding an A/UX system to an existing 4.3BSD network running the BIND distribution, the libraries that query the domain name server are already in place. See `resolver`(3) for more information.

For the system to query a specific Internet name server instead of broadcasting to any local name server, you must create a configuration file named `/etc/resolve.conf` that specifies the desired name server. The required configuration is described in `resolver`(4).

In A/UX a user process sends host name or address queries first to the name server. If the information is not found, the query goes to the Yellow Pages. If the information is not found there, the query goes to the local `/etc/hosts` file. If none of the three sources has the requested information, the query fails.

Chapter 8 **Network Management**

This chapter discusses various topics related to managing your network, including how to increase the security of your network, set up a `sendmail` file on your network, and back up files across the network. This chapter also discusses administration management for a B-NET network, NFS network, and NFS network with the Yellow Pages. The key points covered in this chapter are:

- Network security
- Network user administration
- B-NET administration
- NFS administration
- Yellow Pages administration
- A network mail system

Network security

As network administrator you determine the level of security on your network. This section describes how to make your system a friendly network, how to make your system more secure, and how to address specific security issues associated with B-NET, NFS, and NFS with Yellow Pages networks.

B-NET security issues

Several degrees of network security are possible with the networking software.

A friendly network

If your network is "friendly" (you can trust all the users) you can allow relatively open access to networked machines by specifying all the hosts on the network in the `/etc/hosts` and `/etc/hosts.equiv` files of each machine.

The `/etc/hosts.equiv` file establishes a host "equivalence." Users with entries in the `/etc/passwd` files for two machines can use the `rlogin` command to log in remotely from one system to another without using a password. For example, the `/etc/hosts.equiv` file on `hostname1` might include

```
hostname2
hostname3
hostname4
```

In this case all non–root users who have a legitimate login account on `hostname1` and on the specified machines can log in remotely to `hostname1` from those machines without supplying a password. (See also "The Yellow Pages and `/etc/hosts.equiv`" later in this chapter.)

If user names differ among machines, users may still use `rlogin` by using the `-l` option (see `rlogin`(1N) for more information). Note, however, that `user1` on `hostname2` will be able to log in to `user1`'s account on `hostname1`, even if he or she does not own that account!

Remote login as `root`

Unless you have a very open network environment, you should not allow the superuser on one machine to automatically use `rlogin` as superuser on another machine. If you decide to allow this, you can create a `/.rhosts` file on each machine that specifically names host(s) and `root`; for example,

```
hostname1 root
```

◆ *Note:* Because this further reduces network security, it is not recommended.

A more secure network

To eliminate the open access at the system level you can remove the system's `/etc/hosts.equiv` file. You can then allow specific users access to their own accounts by installing `$HOME/.rhosts` files in their home directories. The format of these files is identical to that of `/etc/hosts.equiv`, but it allows the specified users from the specified hosts to log in to any account listed in that file.

Increasing network security

If you need a secure network system, you may wish to disable the `rlogind`, `remshd`, and `tftpd` daemons, which do not check passwords to authorize users. To do this, edit `/etc/servers` to delete the lines shown in bold:

ftp	tcp	/usr/etc/in.ftpd		
telnet	tcp	/usr/etc/in.telnetd		
shell	**tcp**	**/etc/in.remshd**		
login	**tcp**	**/etc/in.rlogind**		
exec	tcp	/usr/etc/in.rexecd		
tftp	**udp**	**/usr/etc/in.tftpd**		
talk	udp	/usr/etc/in.talkd		
finger	tcp	/usr/etc/in.fingerd		
rpc	udp	/usr/etc/rpc.rstatd	100001	1-2
rpc	udp	/usr/etc/rpc.rwalld	100008	1
rpc	udp	/usr/etc/rpc.mountd	100005	1

NFS security issues

The NFS software currently assumes that you have a friendly network. This section describes security-related issues.

Denying superuser privileges over the network

The following example shows how the root user is treated like an ordinary user when accessing remote file systems.

◆ *Note:* The following example assumes that `/usr` is a remotely mounted file system.

1. **Log in to the local system.**
2. **Check which directories are remotely mounted. Enter the command**

   ```
   mount
   ```

3. **Check the permissions on the remotely mounted directory; for example, if `/usr` is a remotely mounted hierarchy, enter the commands**

   ```
   $ cd /usr/tmp
   $ mkdir test.dir
   $ cd test.dir
   $ ls -ld
   ```

   This will display something like

   ```
   drwxr-x---     4 bin bin   512 Mar 13 14:10 ./
   ```

   Note that these permissions do not allow access to "others."

4. **Use `su` to switch to `root`:**

   ```
   $ su
   Password:
   ```

   and repeat the `ls` command

   ```
   # ls -ld
   #
   ```

Because UID 0 (`root`) has been mapped to UID –2 (`nobody`), the directory will appear empty. Don't panic; the file system still exists. You are simply denied access to it because you are the root user.

◆ *Note:* "Allowing Root Access" describes how to undo the UID 0/UID –2 mapping to allow root superuser access permissions over the network, but *this is not recommended.* (In `/etc/passwd`, the `nobody` entry uses a UID of `65534`—the unsigned representation of –2 in 2's complement notation.)

There are several ways around the problem of no root access on remotely mounted file systems, depending on the security requirements of your network environment. These are described in the next section.

Changing the mode

◆ *Note:* A program that is setuid root will not be able to access remote files or directories unless permissions include "other."

As the root user you cannot change the mode of remotely mounted files. To get around this problem you can use `su` as the owner of the files, or you can log in to the server machine and change the mode of files or directories on the machine where they reside.

For example, a user named `joe` can use `touch` and `chmod` on his own remotely mounted files:

```
$ touch /usr/tmp/test.dir/test1 /usr/tmp/test.dir/test2
$ chmod 777 /usr/tmp/test.dir/test1
$ chmod 700 /usr/tmp/test.dir/test2
$ ls -l /usr/tmp/test.dir/test*
-rwxrwxrwx  1 joe  0 Mar 24 16:12 /usr/tmp/test.dir/test1
-rwx------  1 joe  0 Mar 24 16:12 /usr/tmp/test.dir/test2
```

However, if you are the superuser, the `test2` 700 mode file will not allow any operations, but the `test1` 777 mode will, so the date and time should change.

```
$ su
Password:
# touch /usr/tmp/test.dir/test1
# touch /usr/tmp/test.dir/test2
touch: /usr/tmp/test.dir/test2: Permission denied
# ls -l /usr/tmp/test.dir/test*
-rwxrwxrwx  1 joe  0 Mar 24 16:14 /usr/tmp/test.dir/test1
-rwx------  1 joe  0 Mar 24 16:12 /usr/tmp/test.dir/test2
```

Changing ownership

As the superuser you cannot change ownership of remotely mounted files. For example, if you try to use `chown` on a program named `a.out` (which is setuid root) that is located on a remotely mounted file system, you will see something like

```
$ chmod 4755 /usr/tmp/test.dir/a.out
$ su
Password:
# chown root /usr/tmp/test.dir/a.out
a.out: Not owner
```

Because users cannot execute a `chown` command on a file that is setuid root and because `root` is not treated as the superuser on remote access, there are only two ways to change ownership of remote files. You can log in as the root user (with `login`, `rlogin`, or `telnet`) to the server machine and execute a `chown` command there, or you can use `rcp` to copy the remote file to a file system owned by your machine and make the change in the copy.

Allowing root access

In a very friendly network environment, you may choose to allow root access over the network.

◆ *Note:* This will compromise system security measures for your network and is not recommended if your network requires secure systems.

The following procedure allows you to use `adb` on the A/UX kernel on a server. Note that this works only on a server machine, not on a client.

1. **On the NFS server, change the value of the kernel variable `nobody`.**

2. **Log in as `root` on a running system, and enter**

   ```
   adb -k -w /unix /dev/kmem
   ```

   In response, `adb` should display

   ```
   a.out file = /unix    (COFF format)
   core file  = /dev/kmem
   ready
   ```

3. **Enter**

   ```
   nobody /D
   ```

   The `/` tells `adb` to get the value of `nobody` from, or write it to, kernel memory; the `D` says to print the value in long decimal format. The response should be

   ```
   nobody:   -2
   ```

   If `adb` does not make this response, stop.

   - Press CONTROL-D to exit `adb`.
   - Verify that you have invoked `adb` with the proper flag options and that you have already run `newconfig bnet` or `newconfig nfs` to incorporate the B-NET or NFS modules.
   - Try recreating your kernel with `newconfig` if the problem persists.

4. **If `adb` does respond as above, enter**

   ```
   nobody/W 0
   ```

   This command changes the value of `nobody` in the running memory image of the kernel. You should see the response

   ```
   nobody:   0xFFFFFFFE   =      0x0
   ```

   When you have completed these steps, the currently running kernel will allow root access to NFS clients.

5. **If you want to modify the value of `nobody` on the disk image of the kernel (`/unix`) so that it will be in effect each time the kernel is booted, enter**

   ```
   nobody?W 0
   ```

   instead of

   ```
   nobody/W 0
   ```

The ? tells adb to get the value of nobody from, or write it to, the disk image of the kernel (/unix).

- To check whether the change was written correctly, enter

  ```
  nobody ?D
  ```

  In response, adb should display

  ```
  nobody:     0
  ```

- Press CONTROL-D to exit adb.

◆ *Note:* Be extremely careful when modifying a kernel location. When in doubt, exit with CONTROL-D and do not use the /W or ?W command to write the changes.

Yellow Pages security issues

This section discusses specific steps you can take to enhance the security of your network.

/etc/passwd

The master server's /etc/passwd should contain entries for users who have accounts on all the Yellow Pages client machines. This gives users access to all machines that access the Yellow Pages. If you prefer to use a small password file on the Yellow Pages master server to restrict access to the server, you can install the global password file in a directory other than /etc (in /etc/yp, for example,) and change the line in /etc/inittab that invokes the yppasswdd daemon on the Yellow Pages master server.

Instead of using the line

```
nfs9:2:once:/usr/etc/rpc.yppasswdd /etc/passwd -m passwd
```

you can use the following line (assuming you installed the global password file as /etc/yp/passwd):

```
nfs9:2:once:/usr/etc/rpc.yppasswdd /etc/yp/passwd
-m passwd DIR=/etc/yp
```

(This should appear on one line in /etc/inittab.) This passes a new value for the DIR variable to /etc/yp/Makefile.

The Yellow Pages and /etc/hosts.equiv

The /etc/hosts.equiv and $HOME/.rhosts files are generally used to allow users access to a machine without providing their passwords. However, you may wish to explicitly deny certain groups of users access to a particular Yellow Pages client.

Use the Yellow Pages to modify these files to deny access to all users on particular hosts (defined in the Yellow Pages hosts map) or all hosts and certain users (defined in the Yellow Pages netgroups map).

If a user is entered in both /etc/passwd and $HOME/.rhosts files, B-NET allows that user to use rlogin, rcp, or remsh without providing a password.

Because the Yellow Pages passwd map is global and allows access to most users on the network, you may want to modify /etc/hosts.equiv on certain machines to restrict access by groups of users or all users on certain hosts. You may also want to inform users on these restricted machines that they can modify their $HOME/.rhosts file to allow access.

To modify $HOME/.rhosts files to access the Yellow Pages, use a plus (+) or minus (–) sign and an at symbol (@) followed by the host name or netgroup name. The plus sign allows access; the minus sign denies access.

+@ *trusted-netgroup*
+@ *trusted-host*
-@ *distrusted-netgroup*
-@ *distrusted-host*

For example, if you don't want the administrative department to be able to log in on hostname2, the /etc/hosts.equiv file on hostname2 should contain the line

```
-@admin
```

and the netgroup Yellow Pages database should contain an entry for the admin netgroup followed by the login names of people in that department. See "Creating a Netgroup File (Optional)" in Chapter 4.

◆ *Note:* The root /.rhosts file controls remote root access to the local machine and should be restricted unless you have a very friendly network environment. It is possible to use the same conventions as /etc/hosts.equiv in each user's .rhosts file.

Network user administration

This section describes the procedure for allowing a new user access to (1) a network that does not use the Yellow Pages and (2) a network that does use the Yellow Pages service.

Networked systems without the Yellow Pages

If you have decided not to use the Yellow Pages, the procedure for adding users to a machine on the network is essentially the same as the procedure for adding a user to a single machine. This procedure (described in *A/UX Local System Administration*) should be done on each machine to which the user needs access. Check manually to see that the user's UID and GID are consistent on each machine.

Using the Yellow Pages

This section describes how to

- Add an entry to the master server's `/etc/passwd` file.
- Add an entry to the master server's `/etc/group` file.
- Update the Yellow Pages maps.
- Remove a user from the network.
- Redefine the `passwd` command.

Adding an entry to the master server's password file

To add an entry to the master server's password file,

1. **Log in as the root user on the master server.**
2. **Use `vipw` to edit the global `/etc/passwd` file.**

   This prevents any user or program from accessing `/etc/passwd` while you are editing it.

See `passwd`(4) or "User Administration" in *A/UX Local System Administration* for information about the password file format.

3. **Add an entry for the new user.**

   For example, if the user's name is Mr. Garcia and his login name is `jerry`, add a line like

   ```
   jerry::714:100:Mr. Garcia:/users/jerry:/bin/sh
   ```

4. **Write and exit this file, then assign a password to the user by entering a command like**

   ```
   passwd jerry
   ```

◆ *Note:* You pose a security risk for every machine on the network by not assigning the new account a password before including it in the Yellow Pages maps. Inform the user of the new password, and instruct him or her to change it during the first login.

The command to change a password in the Yellow Pages is

```
yppasswd
```

See "Redefining the `passwd` Command" for various ways of making the Yellow Pages more transparent to the user.

Adding an entry to the master server's group file

To add an entry to the global group file, add the new user's login name to all appropriate groups in the master server's `/etc/group` file.

If the user is to be a member of groups particular to a specific client, also add the user's name to these groups in the client's local `/etc/group` file.

Updating the Yellow Pages maps

To update all the maps that need to be updated:

1. **Change the directory to `/etc/yp` on the master server.**
2. **Enter the command**

   ```
   make
   ```

If you have Yellow Pages slave servers on your network, the updated maps will automatically be propagated to the servers listed in the `ypsrvs` map. See "Yellow Pages Administration" for more information on the `ypsrvs` map and adding slave servers.

Removing a user from the network

A/UX creates files and directories by using the user's UID and GID numbers in the master server's global password file and client group files. If you simply delete a user from the global password file (and client group files), the user's files retain the same UID and GID numbers. If you then assign these numbers to a new user, the new user would inherit ownership of the old user's files.

There are two ways to deal with this problem. You can either

- remove all file and directories belonging to the old user (backing them up if necessary), and then delete the user entry from the global password file and from the client group files;

or, you can

- deny the old user access to the network by changing the user password field in the global password file to a single asterisk (`*`).

We recommend the second method because you don't have to remove files, and you will always know who created those files. (We also recommend that for safety's sake you use `vipw` whenever you edit a password file.)

Whichever method you choose, be sure to remake the Yellow Pages maps by entering

```
cd /etc/yp
make
```

Redefining the `passwd` command

When a user changes his or her password with the `passwd` command, only the entry in the local client's `/etc/passwd` file is changed. However, if you are using the Yellow Pages to handle user accounts, most user entries are not in the local `/etc/passwd` files but are pulled in from the Yellow Pages with a + entry. In this case the `passwd` command displays the error message

```
Changing password for user.
Permission denied.
```

Thus, the `passwd` command is inappropriate, and the user should use the `yppasswd` command instead. Note that `yppasswd` will not work if the password line is not present in the masters server's `/etc/inittab` file.

You may wish to make the `passwd` command inoperable. Some ways to do this are:

- **Save the `/bin/passwd` command under another name; use the `ln -s` command to symbolically link `/bin/passwd` to `/usr/bin/yppasswd`.**
- **Use the `mv` command to save the `/bin/passwd` command under another name, and replace it with the following shell script :**

  ```
  cd /bin
  vi passwd
  echo "Please use yppasswd to change your password."
  echo "If you want to change a local password, use"
  echo "localpasswd"
  ```

  Then type:

  ```
  chmod fx passwd
  ```

  You will now have a prompt that looks like

  ```
  Please use yppasswd to change your password.
  If you want to change a local password, use
  localpasswd.
  ```

  You will need the `/bin/passwd` program to change any local passwords. Therefore you should rename it something familiar, such as `/bin/localpasswd`. Furthermore, be sure to tell all users who have local passwords to use this command to change their passwords.

  ◆ *Note:* `/bin/passwd` must be owned by `root` and must be mode 4755. Thus, you must be the root user when you copy it to save the permissions.

- **Use the `alias` command to map `passwd` to `yppasswd` in the `/etc/cshrc` and `/etc/profile` files.**

  Then, the system will run `yppasswd` when the user gives the `passwd` command.

  In order for this to work, the `/etc/inittab` file on the master server must contain the line

  ```
  nfs9:2:wait:/usr/etc/rpc.yppasswdd /etc/passwd -m passwd
  ```

For `/etc/cshrc`, use the command

```
alias passwd yppasswd
```

For `/etc/profile`, use

```
passwd(){ !
   yppasswd
}
```

B-NET administration

This section describes how to implement a backup strategy for a networked system. For information on administering a network mail system, see "A Network Mail System" at the end of this chapter.

Backing up networked systems

This section describes how to use the utilities `rdump`(1M) and `rrestore`(1M) to back up and restore files residing on a local machine by using a backup device (tape or disk) attached to a remote machine.

The `rdump` utility backs up a file system by directly accessing the raw file system device (for example, `/dev/rdsk/c0d0s0`). This means that `rdump` will not back up remotely mounted file system hierarchies. These hierarchies will be backed up when `rdump` (or `dump.bsd`) is run on the machine where the hierarchy actually resides.

◆ *Note:* Always back up server machines regularly. Should a Yellow Pages master server machine fail, you will need to create a new master server from a recent backup of Yellow Pages maps and files.

Backing up to a remote backup device

The `rdump` command allows you to use the network to make routine backups of a local machine by using a remote machine's backup device.

The `rdump` facility works just like `dump.bsd`; that is, it copies to magnetic media all files changed after a certain date in the file system. You must explicitly tell `rdump` to access the remote machine and tape drive with the syntax

`/etc/rdump` *nf* *host-name*`:`*device*

where *n* is the dump level and *host-name*`:`*device* is the device file corresponding to the backup device on the remote machine. (The `f` key is always required to explicitly specify the device file on the remote machine.)

Consider this example:

```
rdump 0uf hostname1:/dev/rdsk/c0d0s0
```

The `0` flag option causes the entire file system to be dumped. The `u` flag option writes the date of the beginning of the dump on the `/etc/dumpdates` file if the dump completes successfully.

The `rdump` command creates a server (`/etc/rmt`) on the remote machine to control the backup device.

◆ *Note:* If your site uses a custom backup program employing the `stat()` system call to traverse file system trees, your program will not handle symbolic links correctly. Changing all `stat()` calls to `lstat()` calls and recompiling should solve the problem.

See `rdump`(1M), `dump.bsd`(1M), and *A/UX Local System Administration* for more information.

Restoring files from a remote backup device

The `rrestore` command is an incremental file system restore program similar to the standard `restore` command. Like `rdump`, `rrestore` creates a server (`/etc/rmt`) on the remote machine to access the remote backup device and restore files locally.

The `rrestore` command works just like the `restore` command, except that you must explicitly tell the program on which machine the remote backup device resides. The command syntax is

`/etc/rrestore -fi` *host-name*`:`*device*

where *host-name:device* might be, for example

`hostname1:/dev/rdsk/c0d0s0`

The `f` flag option tells `rrestore` to use the next argument as the name of the archive. The `i` flag option allows interactive restoration of files from a dump tape.

After reading in the directory information from the tape, `rrestore` provides a shell-like interface that allows the user to move easily around the directory tree and extract files selectively. The commands for this interface are explained below.

The default for commands accepting an optional argument is the current directory.

`ls` [*arg*] — List the current or specified directory. Append entries that are directories with a `/`. Prefix entries that have been marked for extraction with an `*`. If the verbose key is set, list the inode number of each entry.

`cd` *arg* — Change the current working directory to the specified argument.

`pwd` — Print the full pathname of the current working directory.

`add` [*arg*] — Add the current directory or specified argument to the list of files to be extracted. If a directory is specified, it and all its descendants are added to the extraction list (unless the `h` key is specified on the command line). Prefix files that are on the extraction list with an `*` when they are listed by `ls`.

`delete` [*arg*] — Delete the current directory or specified argument from the list of files to be extracted. If a directory is specified, delete it and all its descendants from the extraction list (unless the `h` key is specified on the command line). The most expedient way to extract most of the files from a directory is to add the directory to the extraction list and then delete files that are not needed.

`extract` — Extract from the dump tape all the files on the extraction list. The `rrestore` command generates a prompt asking which volume you wish to mount. The fastest way to extract a few files is to start with the last volume and work toward the first volume.

`setmodes` — Set the owner, modes, and times for all the directories that have been added to the extraction list. Nothing is extracted from the tape. This is useful for cleaning up after a `restore` command has been aborted prematurely.

`verbose` — Set or disable verbose by pressing `v`, which acts as a toggle. When set the `v` key causes the `ls` command to list the inode numbers of all entries and the `rrestore` command to print information about each file as it is extracted.

`help` — List a summary of the available commands.

`quit` — Exit `rrestore` immediately, even if the extraction list is not empty.

See `rrestore`(1M), `restore`(1M), and *A/UX Local System Administration* for more information.

NFS administration

This section discusses how to administer your NFS system to achieve greater performance, increase throughput, and optimize disk space.

System performance

The first priority of an NFS server is to service I/O requests from client machines. If a file system is exported to several machines, each with multiple users accessing that data, the server machine slows down in the attempt to handle the remote procedure calls. This delay noticeably affects users on the server machine. Performance on the client machine is also affected, but the delay is not as noticeable because the client caches data in its own buffers.

Memory

In theory NFS requires only a small amount more memory than the kernel size (approximately 1 MB) to run. In practice, however, system performance is degraded if processes have to be paged out more often because of insufficient memory. CPU-intensive processes will noticeably slow system response time.

◆ *Note:* For optimal performance we recommend a minimum of 4 MB of memory for NFS servers.

Improving NFS throughput

The NFS daemon `nfsd` runs on an NFS server to handle client file system requests. The NFS daemon `biod` runs on an NFS client to buffer asynchronous block I/O between the client and server. (A machine can be an NFS client without running `biod`, but this could make the client very inefficient.)

If many remote requests are coming in to a server machine, you can run multiple `nfsd` daemons to handle the request bottleneck and thereby increase throughput. You can also increase the number of `biod` daemons running on a client system to improve its throughput.

Of course every running process requires some system overhead, and NFS daemons are no exception to this rule. Running too many NFS daemons can create a bottleneck.

◆ *Note:* Practical experience has shown that by running four `nfsd` daemons on the server and four `biod` daemons on the client produces optimal performance. (A server machine may also be an NFS client.) See `nfsd`(1M) and `biod`(1M). You may wish to edit your `/etc/inittab` file to run fewer `nfsd` or `biod` calls on your machine or server.

Do not remotely mount important executable files

NFS clients should not remotely mount executable files required to boot, talk to the network, or perform indispensable tasks.

▲ **Warning** Never mount important executable files remotely. Files that should not be remotely mounted include `/unix`, `/newconfig`, `/nextunix`, and the `/bin` and `/etc` hierarchies. ▲

Using links to optimize disk space

Because client machines may have a small amount of disk space, you may want to organize disk contents by using links. A **link** is a pointer to a file, which allows the file to appear in two or more places within a file system hierarchy while having only one copy of the actual data on the disk.

Hard links and symbolic links

The A/UX file system provides two kinds of file links: hard and symbolic. **Hard links** work only within a file system; **symbolic links** can be used within or between file systems. Both kinds of links can point to files or directories. Ordinary users can make symbolic links to either files or directories, but only the root user can make a hard link to a directory.

Files and directories sharing a hard link are really the same file because they share the same inode, even though the name of the linked file or directory may differ within the file system hierarchy. A symbolic link is actually a special kind of file (with a unique inode) pointing to the inode of the real file or directory.

Symbolic links were invented to allow linked files to be used across file systems. A/UX allows eight levels of symbolic links and does not limit hard links.

◆ *Note:* When systems run NFS, symbolic links are always resolved on the local system. This means that when remotely mounted file systems contain symbolic links, the actual directories that are pointed to must be either contained in the local directory hierarchy or remotely mounted from the server.

Creating and removing links

To create a hard link to a file, use the `ln` command

`ln` *file link*

For example, assuming `file1` already exists, the commands

```
ln file1 file2
ls -li
```

print something like

```
254 rw-rw-rw- 2 joe doc 29 Mar 14 14:35 file1
254 rw-rw-rw- 2 joe doc 29 Mar 14 14:35 file2
```

where `254` is the inode number, `2` is the number of hard links to this inode, and `29` is the number of bytes in the file.

The `ln` command created `file2`, which shares the same inode (254) with `file1`. Hence modifying `file2` is the same as modifying `file1`.

To create a hard link to a directory (you must be the root user to do this), enter

`ln -f` *directory link*

To remove hard-linked files and directories, use `rm` and `rmdir`.

To create a symbolic link to a file or directory, enter

`ln -s` *file link*

or

`n -s` *directory link*

Assuming directory `dir1` exists, the commands

```
ln -s dir1 dir2
ls -ldi dir1 dir2
```

print something like

```
! 25 drwxrwxr-x   2 joe doc 32 Mar 14 14:35 dir1
427 lrwxrwxrwx    1 joe doc  4 Mar 14 14:35 dir2 -> dir1
```

A symbolic link looks and behaves exactly like a normal file or directory with two exceptions:

- By creating and removing files in a symbolically linked directory you actually create and remove the files in the "real" directory.

- You cannot change the mode on a symbolic link. If you use the `chmod` command on a symbolic link, you actually change the mode on the "real" file or directory, without affecting the mode of the symbolic link.

To remove a symbolic link (whether a file or a directory), use the `rm` command. Modifying a symbolic link modifies the "real" file or directory. Removing a symbolic link removes only the pointer to the file, directory, or other symbolic link.

◆ *Note:* Symbolic links allow up to eight levels of indirection. If you use them frequently, they can turn file systems into a maze. For example, it may be difficult to determine a file's real location if some data is lost and you must restore the data from a backup.

Using NFS and symbolically linked directories

The `/usr` file system contains a number of directories (for example, `/usr/adm`, `/usr/lib/cron`, `/usr/preserve`, `/usr/mail`, `/usr/spool`, and `/usr/tmp`) and programs performing certain functions (administrative functions, time functions, print spoolers, and so on). The programs expect the directories to reside on the local system.

You can share `/usr` over the network and still allow these programs access to the local information they expect by creating "private" directories on the local system and symbolically linking them to the `/usr` directories. For instance, the following sequence of commands creates the local directories in `/private`:

1. **To create the `/private` directory, enter**

```
mkdir /private
chown bin /private; chgrp bin /private
chmod 755 /private
```

2. **To create the `usr` directory below it, enter**

```
mkdir /private/usr
chown bin /private/usr; chgrp bin /private/usr
chmod 755 /private/usr
```

3. **To create `/private/usr/adm`, owned by `adm`, enter**

```
mkdir /private/usr/adm
chown adm /private/usr/adm
chgrp adm /private/usr/adm
chmod 755 /private/usr/adm
```

4. **To create `/private/usr/lib` with the owner and permissions as shown, enter**

```
mkdir /private/usr/lib
chown bin /private/usr/lib
chgrp bin /private/usr/lib
chmod 755 /private/usr/lib
```

5. **To create private directories for `cron`, `preserve`, `spool`, `tmp`, `mail`, and any other directories you need in your local `/usr`, enter**

```
mkdir /private/usr/lib/cron
chown bin /private/usr/lib/cron
chgrp bin /private/usr/lib/cron
chmod 700 /private/usr/lib/cron

mkdir /private/usr/preserve
chown bin /private/usr/preserve
chgrp bin /private/usr/preserve
chmod 755 /private/usr/preserve

mkdir /private/usr/spool
chown bin /private/usr/spool
chgrp bin /private/usr/spool
chmod 755 /private/usr/spool

mkdir /private/usr/tmp
chown bin /private/usr/tmp
chgrp bin /private/usr/tmp
chmod 777 /private/usr/tmp

mkdir /private/usr/mail
chown bin /private/usr/mail
chgrp bin /private/usr/mail
chmod 777 /private/usr/mail
```

6. **After creating these private directories, move the contents of the original directories to the private directories, and create symbolic links to their original location.**

For example, run a shell script such as the following:

```
for i in /usr/adm /usr/lib/cron /usr/preserve \
/usr/spool /usr/tmp /usr/mail
do !     (cd $i ; find . \
  -print | cpio -pduvm /private/$i)
   !     rm -rf $i
   !     ln -s /private/$i $i
done
```

This allows systems to share a remotely mounted `/usr` while functions that you wish to confine to each system (for example, administrative functions, time functions, print spoolers, temporary directories, and so on) are accessed through the symbolic link.

◆ *Note:* If the directory on which a file system is to be mounted is a symbolic link, mount the file system on the directory to which the symbolic link refers rather than on top of the symbolic link itself.

Yellow Pages administration

This section discusses how to administer your system using the Yellow Pages. Topics include how to update and propagate the Yellow Pages maps, how to add a Yellow Pages slave server, and how to use a new master server.

Server system performance

If you have a single Yellow Pages server on the network and all other systems are Yellow Pages clients, performance on the server will suffer, and processes will queue up waiting for UID and GID verifications. This will affect every machine on the network. Slow performance can result in timeouts. For example, the server may be too slow to confirm a user name and password before the `login` program times out.

You can improve overall performance of the Yellow Pages service by designing the network to include more Yellow Pages slave servers. On a small network, with 10 to 15 hosts, a single slave server should be sufficient. However, if additional hosts are added, performance will be improved if you add an additional slave server.

Methods of updating the Yellow Pages maps

You use `make` to update the Yellow Pages maps. After updating the maps, you use `ypxfr` to propagate them.

Using `make` on the default Yellow Pages maps

You can easily change the maps derived from the default Yellow Pages files in `/etc` by editing the ASCII files in `/etc` and running `make` from `/etc/yp` on the master server. (See "Checking the Default Files in `/etc`" in Chapter 4.) This will remake any maps that have a more recent ASCII version and propagate any changed maps. Using `make` is clearly the easiest method of updating the Yellow Pages.

After making any needed changes to the files, enter

```
cd /etc/yp make
```

Using `make` with no arguments creates `dbm` databases for everything that is out of date and then executes `yppush` to notify the master server that there has been a change.

If you use a specific map as an argument to `make` (for example, `make passwd`), only the new `passwd` map is created and propagated to the slave Yellow Pages servers.

Propagation of a Yellow Pages map

Propagating a map means copying it from the master Yellow Pages server to slave Yellow Pages server(s). Initially `ypinit`(1M) copies the maps, as described in "Adding a Slave Server." After a slave server has been initialized, updated maps are transferred from the master server when `ypxfr`(1M) runs on the slave machine. The `ypxfr` program can be run in three different ways:

- periodically by `cron`(1M) on a slave machine
- by the `ypserv`(1M) daemon on a slave machine
- interactively by a user

Periodically by `cron`

Maps have differing rates of change. For example, `protocols.byname` may not change for months, whereas `passwd.byname` may change several times a day in a large organization. A/UX provides sample shell scripts in `/etc/yp` for running `ypxfr` on the various database files: `ypxfr_1h` (once per hour), `ypxfr_1d` (once per day), and `ypxfr_2d` (twice per day). These scripts should be modified for the needs of your site and then entered in the appropriate `crontab`(4) file of each slave server in the domain.

Stagger the execution time to avoid slowing down the master server. If you want to transfer a map from a server other than the master, specify the `-h` flag option to `ypxfr` in the appropriate shell script. You can also use a `crontab` entry to invoke `ypfxr` for maps with unique update requirements.

By `ypserv`

A master server can request that all slave servers within a domain update certain maps. This update request is initiated by the `yppush`(4) command issued from the master machine. The `yppush` command sends a "transfer map" request on the network, and the `ypserv` daemon on each slave responds by executing `ypxfr` to update the requested map. The next subsection gives typical command lines for `yppush` and `ypxfr`.

Interactively by a user

Typically `ypxfr` is run interactively only in exceptional situations. These include setting up a temporary Yellow Pages server to create a test environment or quickly making a Yellow Pages server that has been out of service consistent with the other servers. A typical command line is

`/etc/yp/ypxfr` *map name*

where *map name* is a recognized name or nickname of a Yellow Pages map.

Usually you use `yppush` to invoke `ypxfr` interactively. The `yppush` command invokes `ypxfr` on each slave machine to update a particular Yellow Pages map. A typical use is updating the `passwd.byname` map on all slaves immediately after `yppasswd` is used to change a user password. A typical command line is

`/etc/yppush` *map name*

where *map name* is a recognized name or nickname of a Yellow Pages map.

See Tables 4-1 and 4-2 for lists of valid map names to use with `ypxfr` and `yppush`.

Adding a slave server

This section assumes that the slave server machine is already on your network and running the appropriate network and NFS daemons. Adding a new slave server to a domain involves two basic steps:

1. **On the master server, modify the appropriate host and server databases to include the new slave machine and then propagate the updated databases to the existing slave machines.**
2. **On the new slave server, use `ypinit` to initialize the Yellow Pages databases from the master machine.**

Modifying the master server's databases

To add the new slave host name to the `ypsrvs` database, follow these steps:

1. **Login as the root user on the master server and enter the commands**

   ```
   cd /etc/yp
   makedbm -u `domainname`/ypsrvs > ypsrvs.tmp
   ```

   ◆ *Note:* All Yellow Pages databases are in `dbm`(3X) format. This step makes an ASCII version of the `ypsrv` database in `ypsrvs.tmp`. For more information, see `dbm`(3X) and `makedbm`(1M).

2. **Edit `ypsrvs.tmp`. Initially, your file should look something like**

   ```
   YP_LAST_MODIFIED 0565942409
   YP_MASTER_NAME hostname1
   hostname5
   hostname6
   ```

   Add a line to the end of the file containing the new slave host name.

3. **Enter the commands**

   ```
   makedbm ypsrvs.tmp tmpmap
   mv tmpmap.dir `domainname`/ypsrvs.dir
   mv tmpmap.pag `domainname`/ypsrvs.pag
   ```

   These commands remake the `ypsrvs` database by recreating `ypsrvs.pag` and `ypsrvs.dir`.

4. **To check your work, enter the command**

   ```
   makedbm -u `domainname`/ypsrvs
   ```

   This command should show you a list of all the Yellow Pages servers. If it does not, redo the modification procedures.

5. **When you are sure that the list of Yellow Pages servers is correct, remove the temporary file with the command**

   ```
   rm ypsrvs.tmp
   ```

6. **If `/etc/hosts` does not contain an entry for the new slave server, make one.**

   If the machine is already on the network, the entry should be there and you can skip the remaining steps of this section.

7. **To update the host `hst.nm` and `hst.ad` databases to contain the new slave host name and address, use a text editor to make an entry for the new slave server in `/etc/hosts`.**

   Enter the commands

   ```
   cd /etc/yp
   rm hosts.time
   make hosts
   ```

The file `Makefile` in `/etc/yp` specifies that when `make` is run without a `NOPUSH=1` argument, `yppush`(1) will automatically run to force database updates on the existing slave machines. Removing `hosts.time` ensures that `make` will make a new hosts database.

Initializing databases on the slave server

To initialize the database on the new slave server

1. **Log in as the root user on the new slave server.**
2. **Check the second field of `/etc/HOSTNAME` for the domain name.**

   It must agree with the master machine's domain name. If necessary, use a text editor to change this field to the correct domain name (tabs or blanks are the field separators), and reboot A/UX.

3. **Enter**

   `/etc/yp/ypinit -s` *master name*

   where *master name* is the name of the master server. The `ypinit` command retrieves the Yellow Pages databases from the master server.

4. **In the third field of the `/etc/ypbind` and `/etc/ypserv` entries in `/etc/inittab`, change `off` to `wait`.**

5. **Start the `ypbind` and `ypserv` daemons from the terminal, or simply reboot the slave.**

Using a new master server

When changing master servers, use one of the following two procedures. Use the first when the master is out of service and the second when the master is running and you want to convert it to a slave server.

Old master out of service

The first problem in creating a new master when the old master is not online is getting the slave servers to believe that the new master is actually the new master. This conversion process is inherently an inefficient one because you must make changes to the Yellow Pages database on each slave machine in the old master's domain.

The simplest approach is to convert one of the existing slave machines to the master. The following is a reasonable solution:

1. **Login as the root user on the slave that you are converting to a master.**

2. **Use `ps(1)` to determine the process IDs of `/etc/ypserv` and `/etc/ypbind`.**

3. **Use the `kill(1)` command to terminate these processes.**

   Killing the Yellow Pages daemons ensures that your work will not be undone by normal Yellow Pages update processes (`ypxfr` and `yppush`).

4. **Enter the commands**

```
cd /etc/yp
makedbm -u `domainname`/ypsrvs > ypsrvs.tmp
```

◆ *Note:* All Yellow Pages databases are in `dbm`(3X) format. This step makes an ASCII version of the `ypsrvs` database in `ypsrvs.tmp`. For more information, see `dbm`(3X) and `makedbm`(1M).

5. **Edit `ypsrvs.tmp`. Initially your file should look something like**

```
YP_LAST_MODIFIED 0565942409
YP_MASTER_NAME old master
hostname5
hostname6
old slave
```

Delete the line containing the old slave host name. Change the master's host name in the field following `YP_MASTER_NAME` to the new master's host name. (The field separator is a blank or tab character.) Save the file.

6. **Enter the commands**

```
makedbm ypsrvs.tmp tmpmap
mv tmpmap.dir `domainname`/ypsrvs.dir
mv tmpmap.pag `domainname`/ypsrvs.pag
```

These commands remake the `ypsrvs` database by recreating `ypsrvs.pag` and `ypsrvs.dir`.

7. **To check your work enter the command**

```
makedbm -u `domainname`/ypsrvs
```

This command should show you a list of all the Yellow Pages servers. If it does not, redo the procedure.

8. **When you are sure that the list of Yellow Pages servers is correct, remove the temporary file by entering**

```
rm ypsrvs.tmp
```

9. **On the remaining slave hosts overwrite `/etc/yp/`domainname`/ypsrvs.page` and `/etc/yp/`domainname`/ypsrvs.dir` with the new version you created on this new master host.**

The `ftp` program described in "Adding a System to the Network" in Chapter 5 is a reasonably efficient method of doing this.

10. **Restart the Yellow Pages daemon. Enter**

```
/etc/ypserv
/etc/ypbind
```

11. **Check the Yellow Pages daemon entries in `/etc/inittab` to be sure that the third (colon-separated) fields are set to `wait`.**

    This ensures that the Yellow Pages daemons are started every time your machine enters multi-user mode.

Old master in service

It is easier to change from one master server to another when the old master is still up and running. The trick is to convert the old master to a slave by changing the `ypsrvs` database to a slave database. Since the slave servers believe the old master is still the master server, invoking `yppush` on this machine will propagate the change to the slaves. The slave servers will then respond to the new master server

1. **Log in as the root user on the old master that you are converting to a slave.**
2. **Enter the commands**

```
cd /etc/yp
makedbm -u `domainname`/ypsrvs ypsrvs.tmp
```

- *Note:* All Yellow Pages databases are in `dbm`(3X) format. This step makes an ASCII version of the `ypsrvs` database in `ypsrvs.tmp`. For more information, see `dbm`(3X) and `makedbm`(1M).

3. **Edit `ypsrvs.tmp`.**

   Change the master's host name in the field following `YP_MASTER_NAME` to the host name of the new master server.

   Add the old master's name on a line at the end of the file.

   When you are finished, your file should look something like this:

```
YP_LAST_MODIFIED 0565942409
YP_MASTER_NAME new master
hostname5
hostname6
old master
```

4. **Enter the commands**

```
makedbm ypsrvs.tmp tmpmap
mv tmpmap.dir `domainname`/ypsrvs.dir
mv tmpmap.pag `domainname`/ypsrvs.pag
```

These commands remake the `ypsrvs` database by recreating `ypsrvs.pag` and `ypsrvs.dir`.

5. **To check your work, enter the command**

```
makedbm -u `domainname`/ypsrvs
```

This command should show you a list of all the Yellow Pages servers. If it does not, redo the procedure.

6. **When you are sure that the list of Yellow Pages servers is correct, remove the temporary file by entering**

```
rm ypsrvs.tmp
```

7. **To distribute the data to the other slave servers enter:**

```
/etc/yp/yppush ypsrvs
```

The old master is now running as a slave server, and the other slave servers should respond to the new master. You can now do what you will with the old master.

A network mail system

A/UX 2.0 implements Version 5.61 of the `sendmail` program. See Appendix A "Implementing a `sendmail` Facility" in this document and the `README` file in `/usr/lib/sendmail.conf` for instructions on installing and implementing this new version of `sendmail`.

Chapter 9 **Tools for Checking System Status**

This chapter discusses tools for checking the status of your system. The key points covered in this chapter are:

- Determining network status
- Determining NFS status
- Determining Yellow Pages status

Overview

There are several tools for determining various parameters of the network. Many of these utilities are located in the /etc or /usr/etc directories. If these directories are not included in the value of the PATH variable in root .login or .profile files, add them to the PATH value.

The following utilities are particularly useful in network system administration:

ruptime	Shows host status of local machines. See ruptime(1N).
rwho	Shows who is logged in on local machines. See rwho(1N).
ping	Sends Internet Control Message Protocol (ICMP) ECHO_REQUEST packets to network hosts. See ping(1M).
netstat	Shows network status. See netstat(1N).
df	Reports the mounted file systems and the number of disk blocks. Note that the number of free inodes is shown as zero on remote file systems. This command will hang the client process if a remote file server is down. See df(1).
mount	Shows mounted file systems. Note that this command will not hang the client process if the remote file server is down, whereas the df command will. See mount(1M).
showmount	Shows all remote mounts. See showmount(1M).
nfsstat	Displays statistical information about the network file systems. See nfsstat(1M).
rpcinfo	Reports remote procedure (RPC) call information. See rpcinfo(1M).
domainname	Without an argument, displays the Yellow Pages domain name for the current system. See domainname(1).
ypcat	Displays the values in a Yellow Pages database. See ypcat(1).

`ypmatch`	Displays the value of one or more keys from a Yellow Pages map. See `ypmatch`(1).
`yppoll`	Displays what version of a Yellow Pages map is at a Yellow Pages server host. See `yppoll`(1M).
`ypset`	Changes a map's current Yellow Pages server. See `ypset`(1M).
`ypwhich`	Displays which machine is the Yellow Pages server. See `ypwhich`(1M).

This chapter surveys the use of these commands. See the appropriate manual page entry for full information.

Determining network status

You can use a number of commands to determine the status of your network. This section discusses the `ruptime`, `rwho`, `ping`, and `netstat` commands.

What hosts are up and who is logged in

Use the `ruptime` and `rwho` commands to determine what hosts are up and who is logged into those hosts. However, they rely on the `rwho` daemon, which periodically broadcasts and updates its status list. This daemon causes a lot of overhead if the network is large and different types of systems on the network accept broadcasts differently. To improve efficiency you can turn off `rwhod` on one or more systems on the network. For example, suppose you enter

```
ruptime; rwho
```

on hostname1 and see the response

```
hostname7   down 58+17:09
hostname4   down 55+15:18
hostname3   down 52+17:14
hostname6   down 52+17:01
hostname1   up 0:11
hostname5   down 52+18:04
hostname2   down 52+02:42

holly   hostname1:console Oct 6 18:31
```

This response means either that your machine is the only machine up and running on the network or that your machine is the only one running `rwhod`. If `ruptime` displays

```
no hosts!?!
```

you know that the local host is not running `rwhod`.

Determining if a host is up

The `ping` command is the simplest way of determining whether a host is really up. It uses ICMP's mandatory `ECHO_REQUEST` datagram to elicit a response from a host or gateway.

If `hostname1` is not responding, for example, to an NFS `mount` request, enter

```
ping hostname1
```

from the client machine. In response the system should display something like

```
64 bytes from 128.8.1.1: icmp_seq=0. time=16. ms
64 bytes from 128.8.1.1:  icmp_seq=1. time=16. ms
```

(*interrupt*)

```
----hostname1 PING Statistics----
2 packets transmitted, 2 packets received, 0% packet loss
round-trip (ms)  min/avg/max = 16/16/16
```

if the network and both systems are functioning. You can use the interrupt character (usually CONTROL-C) to cause `ping` to exit and print statistics.

The `ping` command prints

```
no answer from hostname1
```

if `hostname1` is down, or

```
ping: Network is unreachable
```

if the network is not functioning. (In this case check all Ethernet connections.)

When using `ping` to find out why systems are not communicating properly, run it first on the local system. On `hostname1` enter

```
ping hostname1
```

If this prints something similar to

```
64 bytes from 128.8.1.1: icmp_seq=0. time=16. ms
64 bytes from 128.8.1.1:  icmp_seq=1. time=16. ms
```

(*interrupt*)

```
----hostname1 PING Statistics----
2 packets transmitted, 2 packets received, 0% packet loss
round-trip (ms)  min/avg/max = 16/16/16
```

the local network interface is up and running. You can then use `ping` on other systems that are farther and farther away, through forwarder systems, and so on.

Debugging network problems

The `netstat` command is useful for examining the contents of various network-related data structures in a local network running BSD-derived networking software such as B-NET.

For statistics on active interfaces, enter

```
netstat -i
```

The response should be something like

```
Name  Mtu   Network     Address     Ipkts Ierrs Opkts Oerrs Collis
ae0   1500  128.8       hostname1   40506 0     10158 0     0
lo0   1536  loopback-n  loop        1012  0     1012  0     0
```

giving the number of input packets, input errors, output packets, output errors, and collisions, respectively.

With an "interval" argument `netstat -i` displays a running count of statistics related to network interfaces. For example,

```
netstat -i 5
```

displays the statistics detailed above, as well as incremental data every five seconds. The first line of each screen of information contains a summary since the system was last rebooted. Subsequent lines of output show values accumulated over the preceding interval.

If you use

```
netstat -n
```

the system displays the active Internet connections by using Internet addresses rather than host names.

For statistics on active routes, enter

```
netstat -r
```

The response should be similar to

```
Routing tables
Destination    Gateway     Flags   Refcnt  Use   Interface
loop           loop        UH      0       0     lo0
128.8.200      hostname2   UG      0       2228  ae0
128.8.100      hostname1   U       13      1337  ae0
```

(This command will produce a big table on a network with many Internet routers and gateways.)

For information about listening sockets and active connections, enter

```
netstat -a
```

The response should be similar to

```
Active Internet connections (including servers)
Proto Recv-Q Send-Q  Local Address   Foreign Address  (state)
tcp        0      0  hostname1.111   hostname1.1185   CLOSE_WAIT
??? new connections created
tcp        0      0  hostname1.1185 hostname1.111     TIME_WAIT
tcp        0      0  hostname1.1184 hostname1.111     TIME_WAIT
tcp        0      0  hostname1.1183 hostname1.111     TIME_WAIT
tcp        0      0  *.smtp          *.*              LISTEN
tcp        0      0  *.ftp           *.*              LISTEN
tcp        0      0  *.telnet        *.*              LISTEN
tcp        0      0  *.shell         *.*              LISTEN
tcp        0      0  *.login         *.*              LISTEN
```

```
tcp          0      0  *.exec         *.*              LISTEN
tcp          0      0  *.finger                        LISTEN
tcp          0      0  *.111          *.*              LISTEN
udp          0      0  *.1018         *.*
udp          0      0  *.1019         *.*
udp          0      0  *.1020         *.*
udp          0      0  *.1021         *.*
udp          0      0  *.1022         *.*
udp          0      0  *.1023         *.*
udp          0      0  *.tftp         *.*
udp          0      0  *.talk         *.*
udp          0      0  *.1037         *.*
udp          0      0  *.1035         *.*
udp          0      0  *.1033         *.*
udp          0      0  *.biff         *.*
udp          0      0  *.route        *.*
udp          0      0  *.111          *.*
```

Finally, to see statistics on the various protocols enter

```
netstat -s
```

The response should be similar to

```
udp: !
      0 incomplete headers !
      0 bad data length fields !
      0 bad checksums
tcp:
            1989 packets sent
                  614 data packets (19177 bytes)
                  4 data packets (1229 bytes) retransmitted
                  1288 ack-only packets (145 delayed)
                  3 URG only packets
                  9 window probe packets
                  0 window update packets
                  71 control packets
            2148 packets received
                  677 acks (for 19257 bytes)
                  46 duplicate acks
                  0 acks for unsent data
                  565 packets (4520 bytes) received in-sequence
                  1047 completely duplicate packets (1047 bytes)
                  0 packets with some dup. data (0 bytes duped)
                  25 out-of-order packets (0 bytes)
```

```
                0 packets (0 bytes) of data after window
                0 window probes
                1 window update packet
                0 packets received after close
                0 discarded for bad checksums
                0 discarded for bad header offset fields
                0 discarded because packet too short
          24 connection requests
          25 connection accepts
          49 connections established (including accepts)
          47 connections closed (including 1 drop)
          0 embryonic connections dropped
          672 segments updated rtt (of 701 attempts)
          4 retransmit timeouts
                0 connections dropped by rexmit timeout
          0 persist timeouts
          0 keepalive timeouts
                0 keepalive probes sent
                0 connections dropped by keepalive
icmp: !
      165 calls to icmp_error !
      0 errors not generated 'cuz old message was icmp !
      Output histogram: !
            echo reply: 1 !
            destination unreachable: 165 !
            information request reply: 86 !
      0 messages with bad code fields !
      0 messages < minimum length !
      0 bad checksums !
      0 messages with bad length !
      Input histogram: !
            echo reply: 3 !
            echo: 1 !
      87 message responses generated
ip: !
      16020 total packets received !
      0 bad header checksums !
      0 with size smaller than minimum !
      0 with data size < data length !
      0 with header length < data size !
      0 with data length < header length !
      0 fragments received !
      0 fragments dropped (dup or out of space) !
```

```
0 fragments dropped after timeout !
0 packets forwarded !
0 packets not forwardable !
0 redirects sent
```

Determining NFS status

This section describes commands useful in administering NFS. Check the manual page entry for each of these commands for an explanation of all the possible options.

Identifying which file systems are mounted

The `df` command prints the mounted file systems and the number of free disk blocks on each file system. The `df` command reports zero inodes free on the remote file systems. It is not necessarily true that there are no inodes free. The current NFS protocol specification does not include a way to obtain the number of free inodes on the remote system, so the number always appears as 0 on remotely mounted file systems. On the client machine, running `df` without an argument displays something like

```
/      /dev/dsk/c0d0s0   15542 blocks      2358 inodes
/h1    hostname1:/users  22828 blocks      0 inodes
```

The `mount` command without an argument simply prints the mounted file systems and will not hang if the server is down. On the client machine, running `mount` without an argument displays something like

```
/dev/dsk/c0d0s0 on      /     type 5.2 (rw)
hostname1:/users on     /h1   type nfs (rw,soft,noquota)
```

Identifying which clients have mounted systems

On the server machine, the command

```
showmount
```

lists the clients that have remotely mounted a file system from the current system:

```
hostname2
```

The command

```
showmount -e
```

on the server machine lists file systems that are currently exported:

```
/           hostname2
```

On the client machine, the command

```
showmount -e hostname1
```

lists file systems exported by `hostname1`:

```
export list for hostname1:
/     hostname2
```

Determining the status of NFS servers and clients

The `nfsstat` command displays or reinitializes statistical information about NFS and RPC. The `-c` argument gives information about client machines, the `-n` option returns NFS information, and the `-r` option will show you rps information. This is useful in trouble-shooting NFS service and the network. For example, to print NFS client information, enter

```
nfsstat -cn
```

The response should be something like

```
Client nfs:
calls     badcalls   nclget    nclsleep
7644      0          7644      0
null      getattr    setattr   root      lookup    readlink   read
0   0%    225   2%   6   0%    0   0%    992 12%   0   0%     3408 44%
wrcache   write      create    remove    rename    link       symlink
0   0%    2772 36%   60   0%   1   0%    0   0%    0   0%     0   0%
mkdir     rmdir      readdir   fsstat
0   0%    0   0%     177   2%  3   0%
```

Debugging Yellow Pages and `mount` problems

Once you have established that a host is up, you can run `rpcinfo`. The `rpcinfo` command reports information about what RPC programs are being served by the specified host. With the `-p` option, `rpcinfo` probes the portmapper and lists all the RPC programs running. For example, if you are on `hostname2` and enter

```
rpcinfo -p hostname1
```

the response should be

```
program     vers    proto     port
100007       2       udp      1027    ypserv
100007       2       tcp      1030    ypserv
100007       2       udp      1027    ypserv
100007       2       tcp      1030    ypserv
100007       2       tcp      1031    ypbind
100007       2       udp      1035    ypbind
100007       2       tcp      1031    ypbind
100007       2       udp      1035    ypbind
100003       2       udp      2049    nfs
100012       1       udp      1062    sprayd
100008       1       udp      1064    walld
100005       1       udp      1066    mountd
100002       1       udp      1068    rusersd
100002       2       udp      1068    rusersd
100001       1       udp      1071    rstatd
100001       2       udp      1071    rstatd
```

If a remote host is not specified, `rpcinfo` lists the RPC programs registered on the local system. A file called `/etc/rpc` (similar in form to `/etc/services`) lists some of the program numbers and the programs associated with them; for example,

```
rstatd            100001      rstat rup perfmeter
rusersd           100002      rusers
nfs               100003      nfsprog
ypserv            100004      ypprog
mountd            100005      mount showmount
ypbind            100007
walld             100008      rwall shutdown
yppasswdd         100009      yppasswd
etherstatd        100010      etherstat
rquotad           100011      rquotaprog quota rquota
```

```
sprayd              100012      spray
selection_svc       100015      selnsvc
```

The port numbers will be different for each system. In this case the number representing the `rpc.mountd` process is `100005`. (The number `100004` represents the `ypserv` process, and `100007` represents the `ypbind` process.)

You can also use

`rpcinfo -u` *hostname* `nfs 2`

to see if the NFS server on *hostname* can be reached from the local machine.

If the `portmap` daemon is not running, `rpcinfo` will fail and give the message

```
rpcinfo: can't contact portmapper: RPC_SYSTEM_ERROR - !
      Connection refused
```

In this case you should restart the portmapper and kill any RPC daemons that are running (such as `rpc.mountd` and `rpc.rstatd`):

`/etc/portmap`
`kill -9 rpc.daemon.`*PID*

PID is the process number associated with the RPC daemon.

◆ *Note:* This method relies on `init` respawning the `inetd` daemon after it is killed, which it will do if `/etc/inittab` has been modified as shown in Chapter 2, "Establishing a Two-System Network."

Determining Yellow Pages status

This section describes commands useful in administering the Yellow Pages. Check the manual page entry for each of these commands for an explanation of all the possible options.

The domain name

The command

```
domainname
```

displays the name of the current Yellow Pages domain. This is a useful check if your network uses or has access to more than one domain, or if you are not certain that the domain name has been set on a particular machine. If the domain name on a client or slave server system is not consistent with the domain name on the master server, the Yellow Pages will have serious problems.

Determining if Yellow Pages maps have been propagated

The `yppoll` program asks any `ypserv` daemon for the information it holds internally about a single map. Use it to find out if a new version of the database has been propagated to a particular host. For example, the command

```
/etc/yp/yppoll -h hostname1 passwd.byname
```

(where `hostname1` is the Yellow Pages master server) returns the information

```
Map passwd.byname has order number 512391909.
The master server is hostname1.
```

Identifying the server

The binding of Yellow Pages client to Yellow Pages server changes when the network or servers are very busy. Whenever possible, the system stabilizes when all clients get acceptable response time from the Yellow Pages servers. The `ypwhich` command returns the host name of the server machine currently being used to access the Yellow Pages. The command

```
ypwhich
```

displays the name of the Yellow Pages server machine. The answer you get back from `ypwhich` will vary as the Yellow Pages server changes. This is normal.

As long as your client machine gets Yellow Pages service, it doesn't matter where the service comes from. Often a Yellow Pages server machine gets its own Yellow Pages services from another Yellow Pages server on the network.

Examining Yellow Pages maps

The command

```
ypcat passwd
```

displays the values in a specified Yellow Pages map, in this case the `passwd` map. If no map is specified, the response is a usage message.

The `ypmatch` command displays the values associated with one or more keys from the Yellow Pages map specified by either a map name or a map nickname. For example, `passwd` is a nickname for the map named `passwd.byname`. To see a table of map nicknames, enter

```
ypmatch -x
```

The keys you specify must exactly match the capitalization and length of the map values. No pattern matching is available. For example, the command

```
ypmatch hostname1 hosts
```

returns the Internet address of `hostname1` and its aliases. If a key is not matched, a diagnostic message is produced. (See Table 4-2 for an example of a table of Yellow Pages nicknames.)

Chapter 10 **Troubleshooting**

This chapter discusses general error conditions for B-NET, NFS, and Yellow Pages and provides recommended solutions. The chapter also describes symptoms of troubled systems and presents strategies for breaking down the troubleshooting process into manageable steps. The key points discussed in this chapter are:

- Assessing system problems
- Analyzing software problems
- Debugging the network services
- Specific problems in the network environment
- Error messages in the network environment

Overview

Here are a few basic guidelines:

- Always look for specific symptoms. When you first become aware of a system problem, ask yourself: What happened? When? Where? How? Focusing on the answer to these questions will help you assess what's gone wrong.
- Make a note of system maintenance or unusual system behavior that may have occurred near the time of a problem and thus may have somehow contributed to the problem.
- Check for the simplest kind of failure first. Consider more complex problems only when you have eliminated the simple causes of failure.
- Choose the solution that will have the smallest impact on the resources of your machine or your network. (You may be able to avoid rebooting in many cases.)
- If you have to take a machine down temporarily, be aware of what services it provides to other machines and try to warn users of the halted service.

Troubleshooting involves three steps: assessment, analysis, and action. The sections that follow reflect these activities.

Assessing system problems

This section suggests ways to assess system problems.

Keeping a record of system activity

Keep a system log that records maintenance and problems for every machine at your site. This is usually a simple notebook that is accessible to other people if you are unavailable. Don't keep this record online; if the system goes down, you won't be able to read it!

Keep an online record of software changes made on each machine. The method will vary from site to site, but the general idea is to have a log file that all users with root privileges can write to and read to see what's been changed recently on the machine. For example, if you install a new version of a program or of some file or database the system uses regularly, note that fact in the online log. Also note deletions or changes to existing files.

Using a specific description

Get as specific a description as possible of the trouble. Find out who the users are, what machines they are working on, what they were doing when the problem occurred, and anything else relevant or unusual.

If you discover the trouble yourself rather than hearing about it secondhand, you can begin narrowing it down by checking system logs for recent changes or maintenance in the affected area.

Find out if other users or machines are having similar problems. If only one machine has a problem, you can safely assume that the problem is confined to that machine on either the hardware or the software level. If several machines or users have a similar problem, look for a server or network failure.

Determining whether it is a hardware or software problem

Try to determine whether the trouble is related to hardware or software. Sometimes a hardware problem generates the same symptoms as a software problem; this is one area where experience really helps in making diagnoses.

A few symptoms almost always indicate hardware problems:

- Problems that can be described as "the system is dead" are most often related to hardware. It can mean there's no power or no connection whatsoever. When screens or monitors are blank or dark, you may have a power failure within the machine or a bad connection because of a loose plug, a loose or blown fuse, or even a machine that isn't switched on. Check all of these to see if you need to replace parts.

- If a machine suddenly and permanently loses a network connection, there could be a problem with network cabling. (Note *permanently* here, because certain software problems cause degradation of network service.) Has there been any work at your site on the network itself? Network hardware problems are generally harder to pinpoint than other hardware problems. When network hardware fails, it doesn't generate error messages. However, a broken network will interrupt NFS or Yellow Pages service, and you will see an error message from one or both of those services. As a general rule treat NFS or Yellow Pages error messages as if there has been a failure in one of those services. See the appropriate sections in this chapter. If you cannot find a problem with the services or their database files, look for network hardware problems. See "Debugging the Network Hardware" in this chapter.
- Other kinds of hardware problems sometimes show up when machines fail to boot properly, or crash and then fail to boot, with messages that include the words `memory error`. Such messages are rare and usually indicate a bad memory board.
- Occasionally you will see a message in the console window that includes the word `panic` followed by an error message. Panic messages mean that the system has crashed. This sometimes indicates a hardware problem, or possibly even an operating system problem. Copy the error message exactly and save the copy. Attempt to reboot the system if it has not already attempted to reboot on its own. Failure to reboot strongly suggests a hardware problem.
- Another message sometimes seen in the console window is of the form

  `err on dev` *name*

  where *name* is the device name for a particular disk. When the system tries to read a particular disk block and cannot do so, it prints this message. The system then tries to reread the block. Disk errors of this type are common and can be ignored unless they occur in large quantities—many dozens. When there are many such messages, you probably have a bad spot on the disk. It has to be mapped out with the `autorecovery`(8) program.

This list doesn't cover all possibilities. Hardware problems are relatively rare, but it's good to know a bit about the symptoms. When there is a hardware failure, you will probably have to call a hardware technician or a maintenance contract service. These arrangements will vary from site to site and cannot be specifically described here. Know what yours are, and keep necessary phone numbers and names posted in designated places.

It's much more common to have a problem with system software. The remainder of this chapter deals mainly with ways to analyze and fix software problems.

Analyzing software problems

Several kinds of system failure or poor system performance are caused by software running on the system, rather than faulty hardware. If you have determined as best you can that your system hardware is in good working order, you need to look further for the problem. This section guides your search. First it analyzes some common error messages that typically indicate software problems and suggests corrective action. Next it presents symptoms you might encounter and introduces some software tools you can use to identify the type of problem or its location.

Console window error messages

This section contains messages that are usually generated by problems that can be fixed through software alteration; these do not indicate hardware problems. However, a message such as `not responding` may indicate either a software problem or a loose connection, and you should always check your network connections first. On systems running a window package, these messages appear in the console window, disrupting the windows on the screen.

A `filesystem full` message

If a particular file system runs out of space, the system displays messages in the console window of the form

```
fserr: filesystem full
no space on dev name
```

where *name* is the device name of a file system. If the message occurs regularly, you must make space on the device indicated. Usually this means removing unneeded files. Check carefully before removing anything. Make a backup copy of files to be removed if there is *any* possibility they will be needed in the future.

NFS or Yellow Pages messages

Occasionally there will be messages of the form

`yp: server not responding for domain` *domain-name*

or

`NFS: server` *s* `not responding; still trying...`

where *s* is the server's name.

Usually the latter message is quickly followed by the message

`NFS server` *s* `server OK.`

In such cases you can ignore the message; it was probably generated in response to slow communication over a heavily loaded network. However, on rare occasions there will be continuous `server not responding` messages for several minutes. Check the server machine and the network traffic load to make sure nothing is broken. See "Symptoms and Tools for Analysis" and "Debugging the Yellow Pages" later in this chapter. Check the network hardware if you don't discover any abnormalities. See "Debugging the Network Hardware" later in the chapter.

Other messages

The message

`stale NFS file handle`

most often occurs on an NFS client system after the NFS server has been rebooted. If you see this message, unmount the remote file system, kill the `rpc.mountd` process, and then remount the remote file system.

The system also produces other messages, such as

`Random interrupt ignored`

In general you can ignore these messages.

Network error messages

The following messages, which indicate a network problem, may appear at any time. (This list does not cover every possibility.) If the error messages shown appear and the fixes suggested do not solve the problem, proceed to the diagnostic system that follows.

`Connection refused`
: The remote server is not running. Check to see if the remote host is down, if it is up in single-user mode, or if its daemons are down.

`Connection timed out`
: This message usually appears after a a long delay (about two minutes) following the `remsh` or `rlogin` command. Either the remote host is not up (or is extremely busy) or the appropriate daemon is not up. Check to see if the remote host is down or up in single-user mode. This message can also appear if the system in question is small and has very few network buffers. In this case users should try their network commands again later.

`Login incorrect`
: Either the user is trying to use the wrong login name or password, or the `/etc/hosts.equiv` or `.rhosts` file is not set up properly. See `hosts.equiv`(4) in *A/UX Programmer's Reference*. There could also be a corrupt Yellow Pages database; see "Cannot Log In" in the next section.

`m_expand returning 0`
: The system denied a request to allocate memory to use for `mbufs`. Wait a while and see if the condition clears up before rebooting. If this is a continuous problem, you can increase the `mbufs` by using `kconfig`.

`Permission denied`
: The remote system has detected a permissions violation. You can modify either `/etc/hosts.equiv` or `$HOME/.rhosts` on the remote system.

`rcp:`*sys.name*`: No such file or directory`
: The `rcp` program cannot find the file or directory to be copied. This can occur when the remote file system has different paths to users' login directories. This is explained in Chapter 3, "Using B-NET," in *A/UX Communications User's Guide*.

rhost:`Host name for your address unknown`

The remote machine does not know the name and address of the local system. Modify `/etc/hosts` on the master Yellow Pages server and remake the Yellow Pages database.

rhost:`Unknown host`

The local system does not know the name and address of the remote machine. Modify the `/etc/hosts` file on the master Yellow Pages server and remake the Yellow Pages database.

`This machine doesn't exist`

This error message comes only from `talk`.

Symptoms and tools for analysis

This section presents some of the common problems you will encounter and describes tools that help you pinpoint where the problems lie.

Note that troubleshooting is something of an art, and experienced administrators may choose or invent different ways to solve problems. This section gives simple, proven suggestions to help solve known problems, but it is by no means complete. Feel free to invent solutions when you are confident, but be careful not to destroy some things while you're trying to fix others.

When you cannot get something done that involves network services, the problem probably lies in one of the following four areas. They are listed in order of likelihood, with the most likely problem first.

- The network access control policies may not allow the operation (a user or process is trying to access a file system without permission).
- NFS architectural constraints may prevent the operation or cause it to behave unexpectedly. See Chapter 8, "Network Management."
- The client software or hardware may not be working correctly.
- The server software or hardware may not be working correctly.

The following subsections present specific symptoms and probable fixes for these problems in the NFS and Yellow Pages environments.

Cannot reach a machine

If you cannot reach a machine using `rlogin`, `rcp`, or `telnet`, check to see if it's up and running. For example, from `hostname2` enter the command

```
/usr/etc/ping hostname1
```

If `hostname1` is running and reachable, the system returns something similar to

```
64 bytes from 128.8.1.1: icmp_seq=0. time=16. ms
64 bytes from 128.8.1.1: icmp_seq=1. time=16. ms
64 bytes from 128.8.1.1: icmp_seq=2. time=16. ms
64 bytes from 128.8.1.1: icmp_seq=3. time=16. ms
64 bytes from 128.8.1.1: icmp_seq=4. time=16. ms
64 bytes from 128.8.1.1: icmp_seq=5. time=16. ms
```

(*interrupt*)

```
----hostname1 PING Statistics----
6 packets transmitted, 6 packets received, 0% packet loss
round-trip (ms)  min/avg/max = 16/16/16
```

If it doesn't return this, the machine may be down, or there may be a break in network service between the two machines. See `ping`(1M).

To see if the machine is getting Yellow Pages service, type the command

```
ypmatch hostname2 hosts.byname
```

See `ypmatch`(1). This command gives one of three possible responses:

- It may tell you that your machine is not running a `ypbind`. In that case, see "Debugging the Yellow Pages."
- It may tell you that there is no such entry in the database you chose. For example, in the case above the `hosts.byname` database may contain no entry for a particular host. The lack of such an entry would probably make it impossible to connect over the network to the machine in question. In the case of a missing entry in a Yellow Pages database, fix the proper ASCII file on the Yellow Pages master server and then remake the databases from that ASCII file. See "Yellow Pages Administration" in Chapter 8.
- If the entry you request is there, look elsewhere for the problem.

Cannot log in

If you know a user belongs on the system and should have an account but cannot log in, check the Yellow Pages password file database on the master server. When Yellow Pages databases are made automatically on the Yellow Pages master server, bad databases are sometimes generated without an error message. You can use some of the tools mentioned in the preceding section to check Yellow Pages databases. If you have a corrupt database, attempt to remake it on the master server. But before you do, make sure there is enough disk space available on the file system where the Yellow Pages databases are stored. On the target file system, you need twice as much available space as on your largest Yellow Pages database. If remaking the Yellow Pages fills up all the space, the program will quit without an error message and leave partial databases where there should be whole ones. This could be why a known user disappears from the system: He or she has been left out of a truncated password file.

Other Yellow Pages databases may be corrupted in the following way. The password file is the first place you're likely to notice problems, but if a machine is dropped from the host database in the manner just described, you will not be able to communicate with that machine.

Another problem that could cause login failure is a corrupted `/etc/NETADDRS` file. If you hit a cursor key while editing this file, it will place an invisible control character in the file, thereby making Yellow Pages unable to recognize your machine when you next try to log in.

Other problems with the services and netgroup databases could also develop. In general, when login, network communication, or network services problems develop suddenly, check the following in this order:

1. **Make sure that `ypserv` is running on the server and that `ypbind` is running on all machines. See Chapter 4, "Adding Yellow Pages Service," and see "Debugging the Yellow Pages" in this chapter.**
2. **On the master server, check the integrity of all Yellow Pages databases you suspect.**
3. **Try to remake bad databases. Check first to make sure that there is ample disk space.**

A good tool for checking Yellow Pages databases is `yppoll`. Enter

```
/usr/etc/yp/yppoll -h hostname1 hosts.byname
```

where `hostname1` is a Yellow Pages server and `hosts.byname` is a Yellow Pages map name. This will return information about the domain name, the order number of the database, and the name of the master server for the database. If you run `yppoll` before and after you remake a database, you should see an increase in the order number. If the number does not increase, there is a problem. Remember to run `yppoll` on each Yellow Pages server, both slaves and master.

A `Connection timed out` message

You see the message

```
Connection timed out
```

when you try to access an NFS soft-mounted file whose server is dead. See Chapter 3, "Initializing NFS," for an explanation of hard and soft NFS mounts; soft- and hard-mounted file systems act differently. Use the command

```
/usr/etc/rpcinfo -p hostname1
```

(where `hostname1` is a Yellow Pages server) to get information about the state of the NFS server. You may have to fix the server by restarting processes there. See `rpcinfo`(1M) and "Debugging the NFS" in this chapter for a detailed explanation of the steps.

Cannot NFS-mount a file system

This assumes you are not expressly prevented from mounting the file system for security or other reasons; in other words, you have the appropriate privileges to mount the system. Enter the command

```
/usr/etc/showmount -e hostname1
```

where `hostname1` is an NFS server. The output from the `showmount` command shows what file systems are mountable by what machines. If your machine is not shown where you expect it, it must be added to the `/etc/exports` file on the NFS server machine. Only the system administrator (the root user) on the server can make this change. Or if the server machine uses a netgroup database in its `/etc/exports` file, and your machine should be in the database, add your machine name to it and remake the database.

Things work, but slowly

This problem could be due to either a heavy load on the network or CPU-intensive jobs running on your server or client machine. There are several tools for monitoring both network traffic and machine load; the most useful of these for network traffic is `netstat`. See "Debugging Network Problems" in Chapter 9 and `netstat`(1N).

Debugging the network services

This section is divided into five parts. The first three pertain to debugging specific parts of the network: the network hardware, the NFS and the Yellow Pages. The last two parts deal with specific problems that can develop and error messages that can be generated in the network environment.

Debugging the network hardware

From time to time most networks have problems. Always check your network connections first. On networks like Ethernet, a loose cable tap or misplaced transceiver cable can cause severely deteriorated service. The `netstat` program can help you track down hardware malfunctions. In particular look at the `-i` and `-s` options on the man page.

If you believe you have a faulty Ethernet cable, test it to make sure it measures about 50 ohms. See "Hardware Checks" in this section.

If you suspect a `routed` daemon malfunction, you can log its actions—and even all the packet transfers. To create a log file of routing daemon actions, when you start up the daemon, supply a filename such as

```
/etc/in.routed /etc/routerlog
```

Whenever a route is added, deleted, or modified, a log of the action and a history of the previous packets sent and received is printed in the log file. To force full packet tracking specify the `-t` option on the above command line.

◆ *Note:* Beware! On a busy network, the `-t` option will generate almost constant output. See `routed`(1M) in *A/UX System Administrator's Reference* for more detailed information on daemon options.

Even after carefully hooking up your machines, you will sometimes have a problem starting up your network and will get the message

```
Connection timed out
```

when you try to use `rlogin` between machines.

The following subsections describe some suggested corrective actions. After each step test the network again.

Software checks

1. **Check `/etc/hosts` on the Yellow Pages master server machine (or the local host if Yellow Pages is not used on your net) to make sure that the entries are correct and up to date.**

   Make sure a correct copy has been sent to all Yellow Pages slave servers.

2. **Check the accuracy of the information in the `/etc/HOSTNAME` and `/etc/NETADDRS` files.**

3. **Try `rlogin` to your local host or perform the loopback test.**

   Make sure the network daemon `inetd` is running on the machines that want to talk to each other.

   ```
   ps -e | grep inetd
   ```

4. **Use `netstat` with the `-i` option to find out how many packets a machine thinks it is transmitting and receiving on each local network.**

   For example, on a server you may see the input packet count increasing each time a client tries to boot, whereas the output packet count remains steady. This suggests that the server is seeing the request packets from the client but does not respond to them. This might be caused by an incorrect address in `/etc/hosts`. If the input packet count is steady, the machine does not see the packets at all, which suggests a different type of failure, possibly a hardware problem.

Hardware checks

When the power to the host system is on, after a while each transceiver should feel slightly warm to the touch. If a transceiver is cold, it probably isn't receiving power.

This could indicate one of several problems

- a loose connection on either end of the transceiver cable
- a loose connection of the internal Ethernet cable to the Ethernet board
- a faulty cable, transceiver (less likely), or board (even less likely).

To remedy this,

1. **Check all Ethernet coaxial and transceiver cable connections.**
2. **Verify that the network is terminated on both ends.**

   Unscrew one of the terminators and use an ohmmeter to test resistance across the coaxial connector where you just unscrewed the terminator (use the pin "inside" the N-connector for signal and the machine's housing for ground). You should measure about 50 ohms. If you get something other than 50 ohms, your cable may be damaged. This check is particularly pertinent if you use a clamp-on ("vampire clamp") type of transceiver; they tend to short-circuit the Ethernet coaxial cable.

3. **Remove one of the terminators and try operating the network.**

   You should get error messages on every machine like:

   ```
   Ethernet transmission error
   ```

   If a machine continues to give its previous error (`Connection timed out`), it may not be connected correctly to its transceiver. The problem could be loose connections or a faulty connector, cable, transceiver, or Ethernet board.

4. **Try swapping transceivers and transceiver cables. If spare Ethernet boards are available, try swapping boards.**

   Even if there are only two machines on the network, exchanging parts may be informative.

Debugging NFS

The process of locating trouble in an NFS installation is complicated by the fact that the server is not necessarily a UNIX machine.

Remote mount failure: Hard mount versus soft mount

When a remote mount fails because of a problem on the NFS server machine or on the network itself, local programs that access hard-mounted remote files will fail differently from those that access soft-mounted remote files.

Programs accessing hard-mounted remote file systems will keep trying until the server responds again. From the user's point of view, they will simply hang, as if the server machine were very slow. When the server comes back up again, their program will pick up where it left off. If the server crashes while you are attempting to mount its file systems remotely, a hard mount will hang (just like any other program), and you should see the message

`mount:` *host-name*`:/`*directory* `server not responding:`
`RPC_PMAP_FAILURE -`
`RPC_TIMED_OUT`

and some other information, depending on the condition of the server. If you have specified the `bg` option in `/etc/fstab`, `mount` will also print

`mount: backgrounding`
`/`*directory*

You will not be able to interrupt the hanging program, although you can reboot and delete the remote mounts from `/etc/fstab` while in single-user mode.

Programs accessing soft-mounted remote file systems return an error when the server is unreachable. From a user's point of view, an A/UX program accessing a remotely mounted file usually aborts. If that program checks return conditions on file system operations, the user will see the message

```
Connection timed out
```

on the terminal screen. Unfortunately many A/UX programs do not check such return conditions, in which case only the system console window displays a message.

Checking the NFS server

Whether you have used a hard mount or a soft one, if you think the server has crashed, enter the command (on the client machine)

`/usr/etc/rpcinfo -p` *hostname*

(where *hostname* is the server machine) to check if the server is up. If the server is up, this command will list program, version, protocol, and port numbers.

```
program     vers     proto    port
 10004        2        udp    1027   ypserv
 10004        2        tcp    1024   ypserv
 10004        1        udp    1027   ypserv
 10004        1        tcp    1024   ypserv
 10007        2        tcp    1025   ypbind
 10007        2        udp    1035   ypbind
 10007        1        tcp    1025   ypbind
 10007        1        udp    1035   ypbind
 10003        2        udp    2049   nfs
 10012        1        udp    1111   sprayd
 10005        1        udp    1115   mountd
 10008        1        udp    1117   walld
 10002        1        udp    1119   rusersd
 10002        2        udp    1119   rusersd
 10001        1        udp    1122   rstatd
 10001        2        udp    1122   rstatd
 10001        3        udp    1122   rstatd
```

You can also use this command (on the client machine) to check whether the remote `mount` daemon is running:

`/usr/etc/rpcinfo -u` *hostname* `mountd 1`

Here, *hostname* is the server machine. If the server is up and its `mount` daemon is running, your machine displays:

```
program 100005 version 1 ready and waiting
```

If the `rpcinfo` commands fail, log in to the server's console and see if it is OK. If the server is alive but your machine cannot reach it, check the Ethernet connections between your machine and the server.

◆ *Note:* The hardware devices may be physically but not electrically connected. In this case, disconnect and reconnect them.

Checking the NFS client daemons

If the server and network are OK, return to the client machine and use the command

```
ps -ef
```

to check your client daemons. At least a `portmap` daemon and several `biod` daemons should be running.

If the client daemons are running and the server and network connections are OK, check the appropriate subsection.

Debugging the Yellow Pages

This section describes how to troubleshoot and resolve problems associated with the Yellow Pages services.

Checking `ypserv` and `ypbind`

User processes may also hang when the local `ypbind` process is unable to communicate with `ypserv` in the current domain. If commands hang but you can still start new commands, check the system console for a message such as

```
yp: server not responding for domain name.
Still trying
```

where *name* is the domain name. If this problem is common to all or most of the machines on the network, check the Yellow Pages server machines. If everything is OK on the server machines, `ypserv` may not be able to respond to `ypbind` requests within the timeout period. This can be caused by heavy loads on the network or Yellow Pages server machines, in which case the problem will disappear as soon as the load decreases.

If the local system is the only one experiencing the problem, check that at least one Yellow Pages server for your machine's domain is running on your local network. Note that two or more Yellow Pages servers in a domain will improve the availability and response characteristics of Yellow Pages services.

Checking the Yellow Pages server

When you suspect a problem with a Yellow Pages server, first check that all servers are up. If one or more servers are down, reboot the machines. Use the command (on each server machine)

```
ps -ef | grep yp
```

to look for the `ypserv` and `ypbind` processes. If the server's `ypserv` daemon is not running, log in to the server as the root user and restart it by entering

```
/etc/ypserv
```

If the `ypbind` process is not running, restart it by entering

```
/etc/ypbind
```

If the server is up and both `ypserv` and `ypbind` are running, check (on the server) whether `ypserv` is hung, by using the command

```
ypwhich
```

If `ypwhich` returns no answer, the `ypserv` daemon is probably hung. On the server machine, kill it and restart it by entering

```
kill -9 PID
/etc/ypserv
```

If everything is OK on the server machines and both `ypserv` and `ypbind` are running normally, `ypserv` may not be able to respond to `ypbind` requests within the timeout period. This can be caused by a heavy loads on the network or Yellow Pages server hmachines, in which case the problem will disappear as soon as the load decreases. If this occurs often, you should add more Yellow Pages servers to the network to improve the availability and response characteristics of Yellow Pages services.

Checking the Yellow Pages client

First check that `ypbind` is running (as shown in "Checking the Yellow Pages Server"). If it is not running, restart it. If `ypbind` is running, check that the domain name agrees on the client and at least one server machine on the local network. From the client machine use the commands

```
domainname
remsh hostname1 domainname
```

where `hostname1` is a Yellow Pages server. If the Yellow Pages client machine is not behaving properly, this command will probably fail or hang. If they do not agree, edit `/etc/HOSTNAME` and reboot the appropriate system to set the name correctly and then reboot the client system.

If `domainname` agrees on the client and server, check that the remote host you specified is in the local network, not on another accessible network. There must be at least one Yellow Pages server for your machine's domain running on your local network. Using two or more servers improves response time.

Specific problems in the network environment

This section describes how to resolve specific problems that might occur on your network.

Remote mount hangs during boot

If your machine comes up after a boot but hangs when it would normally be doing remote mounts, probably either one or more servers are down or your network connection is bad.

If the server is down, reboot it. If the server machine cannot be rebooted for some reason, reboot the client machine in single-user mode, mount the file system you need to use a text editor, make a copy of `/etc/fstab`, and edit `/etc/fstab` to remove the remote mounts to that server. When you bring the system up in multi-user mode, the problem should disappear.

Processes hang

If processes hang while doing file-related work, the NFS server machine may be down. If your file systems are hard-mounted, you may see this message on the system console:

`NFS server` *hostname* `not responding, still trying`

Here *hostname* is the name of the server machine. This probably reflects a problem with one of your NFS servers or with the Ethernet.

If your machine hangs completely, check the servers from which you have mounted. If one or more of them are down, reboot those systems. When the server comes back up, the client programs will continue automatically, and they will not even know that the server was down. No files should be lost.

If all of the servers are running, check whether other clients using the same servers are having trouble. If the other machines seem to be OK, check the Ethernet connections on the client machine.

If several machines are having problems getting service, the problem is probably with the server. It could be the `nfsd` daemon or the server's network connection. Log in to the server and enter a `ps` command to see if `nfsd` is running and accumulating CPU time. If it is not, you may be able to kill and then restart `nfsd` by entering

`kill -9` *PID1 PID2 PID3 PID4*
`/etc/nfsd 4`

If this does not work, reboot the server.

Processes time out

If processes time out while doing file-related work, the NFS server machine may be down. If your file systems are soft-mounted, you may see an error message on users' terminals. If a soft-mounted server goes down, programs accessing it may report errors, but other work on the system should not be affected.

If all the servers are running, check whether other clients using the same servers are having trouble. If the other machines seem to be OK, check the Ethernet connections on the client and server machines.

If several machines are having problems getting service, the problem is probably with the server's `nfsd` daemon. Log in to the server and enter a `ps` command to see if `nfsd` is running and accumulating CPU time. If it is not, you may be able to kill and then restart `nfsd` by entering

`kill -9` *PID1 PID2 PID3 PID4*
```
/etc/nfsd 4
```

If this does not work, reboot the server.

Things work, but slowly

If access to remote files seems unusually slow, log in to the server and use the `ps` command to check for a daemon that is respawning improperly, a bad TTY line, and so on.

If the server seems OK and other machines are getting a good response, issue the following command on the client machine to make sure the client's block I/O daemons (`biod`) are running:

```
ps -ef | grep biod
```

If the `biod` daemons on the client machine are not running, try to restart them by entering

```
/etc/biod 4
```

To determine whether the `biod` daemons are hung, use the `ps` command as before, and then copy a large remote file and do another `ps` command. If the `biod`s don't accumulate CPU time or if the copy hangs, they are probably hung. Kill the processes and then restart the `biod` daemons. If `biod` is OK, check your Ethernet connection.

On the client machine the command

```
netstat -i
```

will tell you if you are dropping packets. The commands

```
/usr/etc/nfsstat -c
/usr/etc/nfsstat -s
```

can tell if the client (`-c`) or server (`-s`) is doing too much retransmitting. (A retransmission rate of 5 percent is considered high.) Excessive retransmission usually indicates a bad Ethernet board, a bad Ethernet tap, a mismatch between board and tap, or a mismatch between Ethernet boards on the server and client machines.

Yellow Pages errors

Propagation failures can be caused by errors in the databases used by the Yellow Pages themselves. Make sure that all Yellow Pages servers are mentioned in the `ypservers` map. Also make sure that all Yellow Pages servers have entries in the `hst.nm` map in both domains.

Commands hang on Yellow Pages client

When commands hang but the system seems to be OK and you can start new commands, you may see a console message such as

```
yp: server not responding for domain name.
Still trying
```

where *name* is the domain name. This message indicates that the local `ypbind` process is unable to communicate with `ypserv` in the specified domain.

Check that the local `ypbind` process is running (if not, restart it) the local domain name is the same as the domain name on at least one Yellow Pages server on the local network.

Cannot log in

If the Yellow Pages are unavailable on a system, users' passwords may be inaccessible. This usually means that `ypbind` is not running. Check that the local `ypbind` process is running. If it is not, restart it.

If `ypbind` is running, check that at least one `ypserv` process is running in the current domain on the local network.

Yellow Pages commands terminate with a message

Some Yellow Pages commands print more specific error messages. For example, trying the following commands on the client machine produces the following error messages:

```
$ ypcat passwd

ypcat:can't bind to Yellow Pages server for domain name.
Reason: can't communicate with ypbind
```

If any of these symptoms occurs, try a `ps` command such as

```
ps -ef | grep ypbind
```

on the client machine to check for `ypbind`.

If you do not find `ypbind`, restart it by entering

```
/etc/ypbind
```

When you have restarted `ypbind`, the Yellow Pages problems should disappear.

Directory listing reports numbers

If you give an `ls -l` command on a directory that contains files owned by users who are not in the `/etc/passwd` file of the local machine, `ls -l` may return a listing like

```
$ ls -l dir
total 191
-rw-rw-rw-  joe   prog   44   Mar   4     6:08 test1
-rw-rw-rw-  125     12  997   Mar   9     3:00 test2
```

If the `ls -l` reports owners who are not in the local machine's `/etc/passwd` file as numbers rather than names, the Yellow Pages service is probably not working.

Check that the local `ypbind` process is running and that at least one `ypserv` process is accessible in the current domain.

`ypbind` crashes

If `ypbind` crashes almost immediately each time it is started, look for a problem in some other part of the system. Try the command

```
/usr/etc/rpcinfo -p
```

on the client machine to see if the `portmap` daemon is running. It should return a listing like

```
program      vers    proto    port
 10004         2       udp     1027   ypserv
 10004         2       tcp     1024   ypserv
 10004         1       udp     1027   ypserv
 10004         1       tcp     1024   ypserv
 10007         2       tcp     1025   ypbind
 10007         2       udp     1035   ypbind
 10007         1       tcp     1025   ypbind
 10007         1       udp     1035   ypbind
 10003         2       udp     2049   nfs
 10012         1       udp     1111   sprayd
 10005         1       udp     1115   mountd
 10008         1       udp     1117   walld
 10002         1       udp     1119   rusersd
 10002         2       udp     1119   rusersd
 10001         1       udp     1122   rstatd
 10001         2       udp     1122   rstatd
 10001         3       udp     1122   rstatd
```

The port numbers will be different for each system. In this case the number representing the `rpc.mountd` process is `100005`. (The number `100007` represents the `ypbind` process, and `100004` represents the `ypserv` process.)

If the `portmap` daemon is not running, `rpcinfo` will fail and give the message

```
rpcinfo: can't contact portmapper: RPC_SYSTEM_ERROR - !
       Connection refused
```

In this case you should restart the portmapper and then kill any RPC daemons that are running (for example, `rpc.mountd` and `rpc.rstatd`) by entering

```
/etc/portmap
kill -9 PID1 PID2 PID3 PID4
```

◆ *Note:* This method relies on `init` respawning the daemon after it is killed, which it will do if `/etc/inittab` has been modified as shown in Chapter 3, "Initializing NFS."

If `portmap` will not stay up or behaves strangely, look for more fundamental problems. Check the network software. You may be able to talk to the `portmap` daemon on your machine by using the `/usr/etc/rpcinfo` command from another machine that is operating normally. If `ypbind` doesn't show up, reboot the machine.

If `ypbind` is there and changes each time you try to restart `/etc/ypbind`, reboot the system, even if the `portmap` daemon is up.

`ypserv` crashes

If the `ypserv` process crashes almost immediately and will not stay up even with repeated activations, the debugging process is the same as that described in the preceding section, "`ypbind` Crashes."

Error messages in the network environment

`/etc/mtab: No such file or directory`

The mounted file system table is kept in the file `/etc/mtab`. This file must exist before `mount` can succeed. Create `/etc/mtab` (for example, use `touch /etc/mtab`) and try the `mount` command again.

`mount:`*host*`:`*filesystem* `already mounted`

The file system that you are trying to mount is already mounted or there is an incorrect entry for it in `/etc/fstab`.

`mount:`*host*`:`*filesystem* `Block device required`

You probably left off the `rhost` part from the remote `mount` request. The `mount` command assumes that you are doing a local mount unless it sees a colon in the file system name or the file system type is `nfs` in `/etc/fstab`.

`mount:`*host*`:`*filesystem* `not found in /etc/fstab`

If `mount` is called with only a directory or file system name (but not both), it looks in `/etc/fstab` for an entry whose file system or directory field matches the argument. For example, the command

```
mount /rickusr
```

searches `/etc/fstab` for a line that has the directory name field of `/rickusr`. If it finds an entry such as

```
rick:/usr /rickusr nfs rw,hard 0 0
```

it will do the mount as if you typed the full command. This message means that the argument you gave `mount` was not in any of the entries in `/etc/fstab`.

`/etc/fstab: No such file or directory`

The `mount` command tried to look up the name in `/etc/fstab`, but there was no such file.

host`:`*filesystem* `not in hosts database`

Either the Yellow Pages could not find the host name you gave in the remote `mount` command or the Yellow Pages daemon (`ypbind`) is down on your machine. First check the spelling and the placement of the colon in your `mount` call. If it looks OK, make sure that `ypbind` is running by entering

```
ps -ef | grep ypbind
```

Try `remsh` or `rcp` to some other machine. If this also fails, your `ypbind` is probably down or hung. If you get this message for only one host name, it means that the `/etc/hosts` entry on the Yellow Pages server needs to be checked. See "Software Checks."

`mount:Directory path must begin with /`

The second argument to `mount` is the path of the directory to be covered. This must be an absolute path.

`mount:`*host*`:`*filesystem* `server not responding:`
`RPC_PMAP_FAILURE - RPC_TIMED_OUT`

Either the server you are trying to mount from is down, or its portmapper is dead or hung. Try logging in to that machine. If you can log in, try running

`rpcinfo -p` *hostname*

You should get a list of registered program numbers. If you do not get such a list, restart the portmapper. Note that restarting the portmapper requires that you kill and then restart `ypbind` as well. After you have killed the `portmap`, `ypbind`, and `inetd` daemons (by using `kill -9` *PID*), restart them with

```
/etc/portmap
/etc/ypbind
/etc/inetd
```

If you do not want to do this, just reboot the server.

If you cannot use `rlogin` to the server but the server is running, check your Ethernet connection by trying `rlogin` to some other machine, and check the server's Ethernet connection.

`mount:`*host*`:`*filesystem* `server not responding:`
`RPC_PROG_NOT_REGISTERED`

The `mount` got through to the portmapper, but the NFS mount daemon (`rpc.mountd`) was not registered. Go to the server and make sure that `/usr/etc/rpc.mountd` exists and is executable. Look in `/etc/servers` to make sure that there is an entry for `rpc.mountd`. Look in `/etc/inittab` to make sure that `/etc/inetd` is enabled, and check that it's running.

`mount:`*host*`:`*filesystem*`: No such file or directory`

Either the remote directory or the local directory does not exist. Check spelling and try to run `ls` on both directories.

`mount:access denied for` *host*:*file system*

Your machine name is not in the export list for the file system that you want to mount from the server. You can get a list of the server's exported file systems by running

`showmount -e` *hostname*

If the file system you want is not in the list, or if your machine name or netgroup name is not in the user list for the file system, log in to the server and check the `/etc/exports` file for the correct file system entry. A file system name that appears in the `/etc/exports` file but not in the output from `showmount` indicates a failure in `mountd`. Either `mountd` could not parse that line in the file or could not find the file system, or the file system name was not a locally mounted file system. See `exports`(4). If `exports` seems OK, check the server's `ypbind` daemon. It may be down or hung.

`mount:`*host*:*filesystem* `Permission denied`

This message is a generic indication that an attempt to authenticate failed on the server. It could imply that one of several conditions holds. You may not be in the export list (see the preceding message), the server may not figure out who you are (`ypbind` is dead), or the server may not believe that you are who you say you are. For the first two cases check the server's `/etc/exports` and `ypbind`, fix them if necessary, and retry the mount. In the last case change your host name (by using the `hostname` command) and retry the mount.

`mount:`*host*:*filesystem* `Not a directory`

Either the remote path or the local path is not a directory. Check spelling and try to run `ls` on both directories.

`mount:`*host*:*filesystem* `Not owner`

You have to do the mount as the root user on your machine because the mount affects not just you but also the file system for the whole machine.

Miscellaneous problems

If you have problems with remotely mounted directories, errors such as "file not found," files that should be there but don't show up, or failure to connect to directories, it may be caused by bad "date" information on either the client or the server machine. Check that the dates on both machines are reasonable.

AppleTalk troubleshooting

This section discusses general error conditions that affect printing on an AppleTalk network system. First determine whether the error indicates a hardware or software problem.

- To identify hardware problems:

  Check your LocalTalk or Ethernet cabling. See *AppleTalk Personal Network* for information on how to fix cabling problems.

- To identify network software problems:

  Use the `/etc/appletalk -s` command to observe nonzero values and report AppleTalk network statistics. See `appletalk`(1M).

- To identify local software problems:

  Check that the `/dev/appletalk` directory exists. If `/dev/appletalk` does not exist, create a new kernel with the `newconfig appletalk`.

Use the Chooser or `atlookup -z` to verify that zones appear. If the Chooser or the `atlookup` command does not return a zone list in an internet environment, check that the router is up by entering

```
/etc/appletalk -s
```

A router number of zero indicates that the local router is down. Contact your AppleTalk system administrator for assistance.

Make sure that the AppleTalk printer is available. If you attempt to print to an AppleTalk LaserWriter or ImageWriter printer and the request fails, make sure the printer is still available by using `atstatus` to verify its availability.

If the printer to which you wish to send files is not in the list of printers, make sure that you have selected the correct zone and try entering the `at_cho_prn` command again. See `at_cho_prn`(1) for more information. If the printer still doesn't show up, try `atlookup` to see if the printer is network visible.

Appendix A **Implementing a `sendmail` Facility**

This appendix was originally printed as the *Sendmail Installation and Operation Guide Version 5.11,* written by Eric Allman of the Computer Science Research Group at the University of California at Berkeley. It is reproduced here with permission. The key points covered in this appendix are:

- Basic installation
- Normal operations
- Arguments
- Tuning
- The configuration file
- Command line flags
- Configuration options
- Mailer flags
- Other configurations
- Summary of support files

◆ *Note:* The information in this appendix does not necessarily reflect the A/UX implementation of `sendmail`. Specific instructions for installing and operating the version of `sendmail` distributed with A/UX appear in a `README` file located in the `/usr/lib/sendmail.conf` directory.

Introduction

`sendmail` implements a general-purpose internetwork mail-routing facility under the UNIX operating system. It is not tied to any one transport protocol; its function may be likened to a crossbar switch, relaying messages from one domain into another. In the process, it can do a limited amount of message header editing to put the message into a format that is appropriate for the receiving domain. All of this is done under the control of a configuration file.

Because of the flexibility requirements for `sendmail`, the configuration file can seem somewhat unapproachable. However, there are only a few basic configurations for most sites, for which standard configuration files have been supplied. Most other configurations can be built by adjusting an existing configuration file incrementally.

Although `sendmail` is intended to run without the need for monitoring, it has a number of features that may be used to monitor or adjust the operation under unusual circumstances. These features are described in this appendix.

"Basic Installation" describes how to do a basic `sendmail` installation. "Normal Operations" explains the day-to-day information you should know to maintain your mail system. If you have a relatively normal site, these two sections should contain sufficient information for you to install `sendmail` and keep it happy. "Arguments" describes some parameters that may be safely tweaked. "Tuning" has information regarding the command line arguments. "The Configuration File" contains the nitty-gritty information about the configuration file. This section is for masochists and people who must write their own configuration file. The remaining sections of this appendix give a brief but detailed explanation of other features.

The references in this appendix are found in the companion paper *Sendmail—An Internetwork Mail Router*, which provides a basic understanding of how the pieces fit together.

Basic installation

There are two basic steps to installing `sendmail`. The hard part is to build the configuration table. This is a file that `sendmail` reads when it starts up that describes the mailers it knows about, how to parse addresses, how to rewrite the message header, and what the settings are of various options. Although the configuration table is complex, a configuration can usually be built by adjusting an existing off-the-shelf configuration. The second part of installing `sendmail` is actually doing the installation, that is, creating the necessary files, and so on.

This section describes the installation of `sendmail` assuming you can use one of the existing configurations and that the standard installation parameters are acceptable. All pathnames and examples are given from the root of the `sendmail` subtree, normally `/usr/src/usr.lib/sendmail` on 4.3BSD.

Off-the-shelf configurations

Configuration files currently in use at Berkeley are in the directory `cf` of the `sendmail` directory. This directory contains three subdirectories: `cf`, `m4`, and `sitedep`. The directory `cf/m4` contains site-independent `m4`(1) include files that have information common to all configuration files, while `cf/sitedep` contains `m4`(1) include files that have site-specific information in them. These files are used by the master configuration (".mc") in `cf/cf` and produce standard configuration files (with ".cf" suffix) when run through `m4`(1). Three off-the-shelf configurations handle the basic cases:

- Internet sites running the nameserver (or using host tables wherein the fully-qualified domain name of each host is listed first) can use `cf/tcpproto.cf`. For simple sites, you should be able to use this file without modification. This file is not `m4` format.
- UUCP-only sites can use `cf/uucpproto.cf`. This file is not in `m4` format.
- A group of machines at a single site connected by an Ethernet (or other networking that supports TCP/IP) with only one host connected to the outside world via UUCP is represented by two configuration files: `cf/tcpuucpproto.cf` should be installed on the host with outside connections, and `cf/tcpproto.cf` should be installed on all other hosts.

Some configuration will be needed in each of the above cases. Just be sure to correctly fill in the "blanks" a shown in the instructions in the configuration file. Then install the file as `/usr/lib/sendmail.cf`.

If you are running a larger or more complex site, it is to your advantage to read the "READ ME" file in the `cf` subdirectory. This file explains how to use `m4`(1) to automatically create configuration files for non-standard situations.

Installing with the makefile

A makefile exists in the root of the `sendmail` directory that will do all of these steps for a 4.3BSD system. It may have to be slightly tailored for use on other systems.

Before using this makefile, create a symbolic link from `cf` to the directory containing your configuration files. You should also create your configuration file and leave it in the file `cf/`*system*`.cf`, where *system* is the name of your system (that is, what is returned by `hostname`). If you do not have `hostname`, you can use the declaration `HOST=`*system* on the `make` command line. You should also examine the file `md/config.m4` and change the `m4` macros there to reflect any libraries and compilation flags you may need.

The basic installation procedure is to enter

```
make
make install
make installcf
```

in the root directory of the `sendmail` distribution. This will make all binaries and install them in the standard places. The second and third `make` commands must be executed as the superuser (`root`).

Installing by hand

Along with building a configuration file, you will have to install the `sendmail` startup into your system. If you are doing this installation in conjunction with a regular install, these steps will already be complete. Many of these steps will have to be executed as the superuser (`root`).

`/usr/lib/sendmail`

The binary for `sendmail` is located in `/usr/lib`. If it becomes necessary to recompile and reinstall the entire system, the following sequence will do it:

```
cd src
make clean
make install
```

/usr/lib/sendmail.cf

Install the configuration file you created earlier in /usr/lib/sendmail.cf:

```
cp cf/system.cf /usr/lib/sendmail.cf
```

/usr/ucb/newaliases

If you are running delivermail, it is critical that the newaliases command be replaced. This can just be a link to sendmail:

```
rm -f /usr/ucb/newaliases
ln /usr/lib/sendmail /usr/ucb/newaliases
```

/usr/spool/mqueue

Create the directory /usr/spool/mqueue to hold the mail queue. This directory should be mode 755 and owned by root.

/usr/lib/aliases*

The system aliases are held in three files. The file /usr/lib/aliases is the master copy. A sample is given in lib/aliases that includes some aliases that *must* be defined:

```
cp lib/aliases /usr/lib/aliases
```

You should extend this file with any aliases that are appropriate to your system.

Normally, sendmail looks at a version of these files maintained by the dbm(3X) routines. These are stored in /usr/lib/aliases.dir and /usr/lib/aliases.pag. You can initially create these as empty files, but they will have to be initialized promptly. These should be mode 644 if you are running a reasonably relaxed system:

```
cp /dev/null /usr/lib/aliases.dir
cp /dev/null /usr/lib/aliases.pag
chmod 644 /usr/lib/aliases.*
newaliases
```

/usr/lib/sendmail.fc

If you intend to install the frozen version of the configuration file (for quick startup), create the file `/usr/lib/sendmail.fc` and initialize it. This step may be safely skipped.

```
cp /dev/null /usr/lib/sendmail.fc
/usr/lib/sendmail -bz
```

/etc/rc

It will be necessary to start up the `sendmail` daemon when your system reboots. This daemon performs two functions: It listens on the SMTP (Simple Mail Transfer Protocol) socket for connections (to receive mail from a remote system), and it processes the queue periodically to ensure that mail gets delivered when hosts come up.

Add the following lines to `/etc/rc` (or `/etc/rc.local` as appropriate) in the area where it is starting up the daemons:

```
if [ -f /usr/lib/sendmail ]; then !
   (cd /usr/spool/mqueue; rm -f [lnx]f*) !
   /usr/lib/sendmail -bd -q30m & !
   echo -n ' sendmail' >/dev/console
fi
```

The `cd` and `rm` commands ensure that all lock files have been removed; extraneous lock files may be left around if the system goes down in the middle of processing a message. The line that actually invokes `sendmail` has two flags: `-bd` causes it to listen on the SMTP port, and `-q30m` causes it to run the queue every half hour.

If you are not running a version of the UNIX system that supports Berkeley TCP/IP, do not include the `-bd` flag option.

usr/lib/sendmail.hf

This is the help file used by the SMTP `HELP` command. Copy it from `lib/sendmail.hf`:

```
cp lib/sendmail.hf /usr/lib
```

/usr/lib/sendmail.st

If you want to collect statistics about your mail traffic, you should create the file `/usr/lib/sendmail.st`:

```
cp /dev/null /usr/lib/sendmail.st
chmod 666 /usr/lib/sendmail.st
```

This file does not grow. It is printed with the program `aux/mailstats`.

/usr/ucb/newaliases

If `sendmail` is invoked as `newaliases`, it will simulate the `-bi` flag option (that is, it will rebuild the alias database). This should be a link to `/usr/lib/sendmail`.

/usr/ucb/mailq

If `sendmail` is invoked as `mailq`, it will simulate the `-bp` flag option (that is, it will print the contents of the mail queue). This should be a link to `/usr/lib/sendmail`.

Normal operations

This section explains the day-to-day information you should know to maintain your mail system.

Quick configuration startup

A fast version of the configuration file may be set up by using the `-bz` flag option:

```
/usr/lib/sendmail -bz
```

This creates the file `/usr/lib/sendmail.fc` (frozen configuration). This file is an image of `sendmail`'s data space after reading in the configuration file. If this file exists, it is used instead of `/usr/lib/sendmail.cf`. `sendmail.fc` must be rebuilt manually every time `sendmail.cf` is changed.

The frozen configuration file will be ignored if a `-c` flag option is specified or if `sendmail` detects that it is out of date. However, the heuristics are not strong so this should not be trusted.

The mail queue

The mail queue should be processed transparently. However, you may find that manual intervention is sometimes necessary. For example, if a major host is down for a period of time, the queue may become clogged. Although `sendmail` ought to recover gracefully when the host comes up, you may find performance unacceptable in the meantime.

Printing the queue

The contents of the queue can be printed by using the `mailq` command (or by specifying the `-bp` flag option to `sendmail`):

```
mailq
```

This will produce a listing of the queue IDs, the size of the message, the date the message entered the queue, and the sender and recipients.

Format of queue files

All queue files have the form `xf`*AA99999*, where *AA99999* is the ID for this file and *x* is a type. The types are

`d` The data file. The message body (excluding the header) is kept in this file.

`l` The lock file. If this file exists, the job is currently being processed, and a queue run will not process the file. For that reason, an extraneous `lf` file can cause a job to apparently disappear (it will not even time out!).

`n` A file that is created when an ID is being created. This is a separate file to ensure that no mail can ever be destroyed because of a race condition. It should exist for no more than a few milliseconds at any given time.

`q` The queue control file. This file contains the information necessary to process the job.

`t` A temporary file. This is an image of the `qf` file when it is being rebuilt. It should be renamed to a `qf` file very quickly.

`x` A transcript file, existing during the life of a session showing everything that happens during that session.

The `qf` file is structured as a series of lines, each beginning with a code letter. The lines are as follows:

`D` The name of the data file. There may be only one of these lines.

`H` A header definition. There may be any number of these lines. The order is important: They represent the order in the final message. These use the same syntax as header definitions in the configuration file.

`R` A recipient address. This will normally be completely aliased but is actually realiased when the job is processed. There will be one line for each recipient.

`S` The sender address. There may be only one of these lines.

`E` An error address. If any such lines exist, they represent the addresses that should receive error messages.

`T` The job creation time. This is used to compute when to time out the job.

`P` The current message priority. This is used to order the queue. Higher numbers mean lower priorities. The priority changes as the message sits in the queue. The initial priority depends on the message class and the size of the message.

`M` A message. This line is printed by the `mailq` command and is generally used to store status information. It can contain any text.

As an example, the following is a queue file sent to `mckusick@calder` and `wnj`:

```
DdfA13557
Seric
T404261372
P132
Rmckusick@calder
Rwnj
H?D?date: 23-Oct-82 15:49:32-PDT (Sat)
H?F?from: eric (Eric Allman)
H?x?full-name: Eric Allman
Hsubject: this is an example message
Hmessage-id: <8209232249.13557@UCBARPA.BERKELEY.EDU>
Hreceived: by UCBARPA.BERKELEY.EDU (3.227 [10/22/82]) !
   id A13557; 23-Oct-82 15:49:32-PDT (Sat)
HTo: mckusick@calder, wnj
```

This shows the name of the data file, the person who sent the message, the submission time (in seconds since January 1, 1970), the message priority, the message class, the recipients, and the headers for the message.

Forcing the queue

`sendmail` should run the queue automatically at intervals. The algorithm is to read and sort the queue and then attempt to process all jobs in order. When it attempts to run the job, `sendmail` first checks to see if the job is locked. If so, it ignores the job.

There is no attempt to ensure that only one queue processor exists at any time, because there is no guarantee that a job cannot take forever to process. Because of the locking algorithm, it is impossible for one job to freeze the queue. However, an uncooperative recipient host or a program recipient that never returns can accumulate many processes in your system. Unfortunately, there is no way to resolve this without violating the protocol.

In some cases a major host going down for a couple of days can create a prohibitively large queue. This will result in `sendmail` spending an inordinate amount of time sorting the queue. This situation can be fixed by moving the queue to a temporary place and creating a new queue. The old queue can be run later when the offending host returns to service.

To do this move the entire queue directory:

```
cd /usr/spool
mv mqueue omqueue; mkdir mqueue; chmod 755 mqueue
```

You should then kill the existing daemon (because it will still be processing in the old queue directory) and create a new daemon.

To run the old mail queue run the following command:

```
/usr/lib/sendmail -oQ/usr/spool/omqueue -q
```

The `-oQ` flag specifies an alternate queue directory and the `-q` flag says to just run every job in the queue. You can use the `-v` flag option to watch what is going on.

When the queue is finally emptied, you can remove the directory:

```
rmdir /usr/spool/omqueue
```

The alias database

The alias database exists in two forms. One is a text form, maintained in the file `/usr/lib/aliases`. The aliases are of the form

name: *name1*, *name2*, ...

Only local names can be aliased; for example,

```
eric@mit-xx: eric@berkeley.EDU
```

will not have the desired effect. Aliases can be continued by starting any continuation lines with a space or a tab. Blank lines and lines beginning with a number sign (#) are comments.

The second form is processed by the `dbm`(3X) library. This form is in the files `/usr/lib/aliases.dir` and `/usr/lib/aliases.pag`. This is the form that `sendmail` actually uses to resolve aliases. This technique improves performance.

Rebuilding the alias database

The `dbm` version of the database can be rebuilt explicitly by executing the command

```
newaliases
```

This is equivalent to giving `sendmail` the `-bi` flag:

```
/usr/lib/sendmail -bi
```

If the D option is specified in the configuration, sendmail will rebuild the alias database automatically if possible when it is out of date. It will do this under one of the following conditions:

The dbm version of the database is mode 666, or sendmail is running setuid to root.

Autorebuild can be dangerous on heavily loaded machines with large alias files; if it might take more than 5 minutes to rebuild the database, there is a chance that several processes will start the rebuild process simultaneously.

Potential problems

A number of problems can occur with the alias database. They all result from a sendmail process accessing the dbm version while it is only partially built. This can happen under two circumstances: One process accesses the database while another process is rebuilding it, or the process rebuilding the database dies (because it is killed or the system crashes) before completing the rebuild.

sendmail has two techniques to try to relieve these problems. First, it ignores interrupts while rebuilding the database; this avoids the problem of someone aborting the process and leaving a partially rebuilt database. Second, at the end of the rebuild it adds an alias of the form

```
@: @
```

(which is not normally legal). Before sendmail will access the database, it checks to ensure that this entry exists.

◆ *Note:* The a option is required in the configuration for this action to occur. This should normally be specified unless you are running delivermail in parallel with sendmail.

sendmail will wait for this entry to appear, at which point it will force a rebuild itself.

◆ *Note:* The D option must be specified in the configuration file for this operation to occur. If the D option is not specified, a warning message is generated and sendmail continues.

List owners

If an error occurs on sending to a certain address, say *x*, `sendmail` will look for an alias of the form `owner-`*x* to receive the errors. This is typically useful for a mailing list where the submitter of the list has no control over the maintenance of the list itself; in this case the list maintainer would be the owner of the list. For example,

```
unix-wizards: eric@ucbarpa, wnj@monet, !
    nosuchuser, sam@matisse
owner-unix-wizards: eric@ucbarpa
```

would cause `eric@ucbarpa` to get the error that will occur when someone sends to `unix-wizards` because of the inclusion of `nosuchuser` on the list.

Per-user forwarding (`.forward` files)

As an alternative to the alias database, any user may put a file with the name `.forward` in his or her home directory. If this file exists, `sendmail` redirects mail for that user to the list of addresses in the `.forward` file. For example, if the home directory for user `mckusick` has a `.forward` file with contents

```
mckusick@ernie
kirk@calder
```

any mail arriving for `mckusick` will be redirected to the specified accounts.

Special header lines

Several header lines have special interpretations defined by the configuration file. Others have interpretations built into `sendmail` that cannot be changed without changing the code. These built-in header lines are described here.

`Return-receipt-to:`

If this header is sent, a message will be sent to any specified addresses when the final delivery is complete, that is, when successfully delivered to a mailer with the `-l` flag (local delivery) set in the mailer descriptor.

`Errors-to:`

If errors occur anywhere during processing, this header will cause error messages to go to the listed addresses rather than to the sender. This is intended for mailing lists.

`Apparently-to:`

If a message comes in with no recipients listed in the message (in a `To:`, `Cc:`, or `Bcc:` line), `sendmail` will add the `Apparently-To:` header line for any recipients it is aware of. (This is not intended as a standard recipient line to warn any recipients that the list is not complete.)

At least one recipient line is required under RFC 822 (see Appendix D, "Additional Reading" for information on obtaining this document).

Arguments

The complete list of arguments to `sendmail` is described in detail in "Command Line Flags." Some important arguments are described here.

Queue interval

The amount of time between forking a process to run through the queue is defined by the `-q` flag. If you run in mode `f` or `a`, this can be relatively large, because it will be relevant only when a host that was down comes back up. If you run in `q` mode, it should be relatively short because it defines the maximum amount of time that a message can sit in the queue.

Daemon mode

If you allow incoming mail over an IPC connection, you should have a daemon running. This should be set by your `/etc/rc` file by using the `-bd` flag option. The `-bd` flag and the `-q` flag can be combined in one call:

```
/usr/lib/sendmail -bd -q30m
```

Forcing the queue

In some cases you may find that the queue has gotten clogged. You can force a queue run by using the `-q` flag (with no value). It is entertaining to use the `-v` flag (verbose) when this is done to watch what happens:

```
/usr/lib/sendmail -q -v
```

Debugging

A fairly large number of debug flags are built into `sendmail`. Each debug flag has a number and a level, where higher levels mean to print out more information. The convention is that levels greater than 9 are absurd; that is, they print out so much information that you wouldn't normally want to see them except for debugging that particular piece of code. Debug flags are set with the `-d` option:

`-d` *debug-list*

with the syntax:

debug-list:	*debug-option* [, *debug-option*]
debug-option:	*debug-range* [. *debug-level*]
debug-range:	*integer* | *integer* - *integer*
debug-level:	*integer*

For example,

`-d12`	Set flag 12 to level 1.
`-d12.3`	Set flag 12 to level 3.
`-d3-17`	Set flags 3 through 17 to level 1.
`-d3-17.4`	Set flags 3 through 17 to level 4.

For a complete list of the available debug flags, look at the code (they are too dynamic to keep this documentation up to date).

Trying a different configuration file

An alternative configuration file can be specified by using the `-C` flag. For example,

```
/usr/lib/sendmail -Ctest.cf
```

uses the configuration file `test.cf` instead of the default `/usr/lib/sendmail.cf`. If the `-C` flag has no value, it defaults to `sendmail.cf` in the current directory.

Changing the values of options

Options can be overridden by using the `-o` flag. For example,

```
/usr/lib/sendmail -oT2m
```

sets the `T` (timeout) option to two minutes for this run only.

Tuning

You may want to change some of the configuration parameters, depending on the requirements of your site. Most of these are set by using an option in the configuration file. For example, the line `OT3d` sets option `T` to the value `3d` (3 days).

Most of these options default appropriately for most sites. However, sites having very high mail loads may find they need to tune them as appropriate for their mail load. In particular, sites experiencing a large number of small messages, many of which are delivered to many recipients, may find that they need to adjust the parameters dealing with queue priorities.

Timeouts

All time intervals are set by using a scaled syntax. For example, `10m` represents 10 minutes, whereas `2h30m` represents 21/2 hours. The full set of scales is

`s`	seconds
`m`	minutes
`h`	hours
`d`	days
`w`	weeks

Queue interval

The argument to the `-q` flag specifies how often a subdaemon will run the queue. This is typically set to between 15 minutes and 1 hour.

Read timeouts

It is possible to time out when reading the standard input or when reading from a remote SMTP server. Technically this is not acceptable within the published protocols. However, it might be appropriate to set it to something large in certain environments (such as an hour). This will reduce the chance of large numbers of idle daemons piling up on your system. This timeout is set by using the `r` option in the configuration file.

Message timeouts

After sitting in the queue for a few days, a message will time out. This is to ensure that at least the sender is aware of the inability to send a message. The timeout is typically set to 3 days. This timeout is set by using the `T` option in the configuration file.

The time of submission is set in the queue, rather than the amount of time left until the timeout. As a result, you can flush messages that have been hanging for a short period by running the queue with a short message timeout. For example,

```
/usr/lib/sendmail -oT1d -q
```

will run the queue and flush anything that is 1 day old.

Forking during queue runs

By setting the `Y` option, `sendmail` will fork before each individual message while running the queue. This will prevent `sendmail` from consuming large amounts of memory, so it may be useful in memory-poor environments. However, if the `Y` option is not set, `sendmail` will keep track of hosts that are down during a queue run, which can improve performance dramatically.

Queue priorities

Every message is assigned a priority when it is first submitted, consisting of the message size (in bytes) offset by the message class times the *work class factor*, and the number of recipients times the *work recipient factor*.

pri = *size* - (*class* * *wrk*) + (*nrcpt* * *wrkrcpt*)

The priority plus the creation time of the message (in seconds since January 1, 1970) is used to order the queue. Higher numbers for the priority mean that the message will be processed later when running the queue.

The message size is included so that large messages are penalized relative to small messages. The message class allows users to send high-priority messages by including a `Precedence:` field in their message; the value of this field is looked up in the `P` lines of the configuration file. Because the number of recipients affects the amount of load a message presents to the system, this is also included in the priority.

The recipient and class factors can be set in the configuration file by using the `y` and `z` options respectively. They default to 1000 (for the recipient factor) and 1800 (for the class factor). The initial priority is

pri = *size* - (*class* * *z*) + (*nrcpt* * *y*)

(Remember, higher values for this parameter actually mean that the job will be treated with lower priority.)

The priority of a job can also be adjusted each time it is processed (that is, each time an attempt is made to deliver it) by using the *work time factor*, set by the `Z` option. This is added to the priority, so it normally decreases the precedence of the job, on the grounds that jobs that have failed many times will tend to fail again in the future.

Load limiting

With the `x` option `sendmail` can be asked to queue (but not deliver) mail if the system load average gets too high. When the load average exceeds the value of the `x` option, the delivery mode is set to `q` (queue only) if the *queue factor* (`q` option) divided by the difference in the current load average and the `x` option plus 1 exceeds the priority of the message. That is, the message is queued if

$$pri > \frac{QF}{LA - x + 1}$$

The `q` option defaults to 10000, so each point of load average is worth 10000 priority points (bytes + seconds + offsets).

For drastic cases the `x` option defines a load average at which `sendmail` will refuse to accept network connections. Locally generated mail (including incoming UUCP mail) is still accepted.

Delivery mode

`sendmail` can operate in a number of delivery modes set by the `d` configuration option. These modes specify how quickly mail will be delivered. Legal modes are

`i` Deliver interactively (synchronously).

`b` Deliver in the background (asynchronously).

`q` Queue only (don't deliver).

There are trade-offs. Mode `i` passes the maximum amount of information to the sender but is hardly ever necessary. Mode `q` puts the minimum load on your machine but means that delivery may be delayed for up to the queue interval. Mode `b` is probably a good compromise. However, this mode can generate large numbers of processes if you have a mailer that takes a long time to deliver a message.

Log level

The level of logging can be set for `sendmail`. The default with a standard configuration table is level 9. The levels are as follows:

0	No logging.
1	Major problems only.
2	Message collections and failed deliveries.
3	Successful deliveries.
4	Messages being deferred (because of a host being down and so on).
5	Normal message queues.
6	Unusual but benign incidents (for example, trying to process a locked queue file).
9	Log internal queue ID to external message ID mappings. This can be useful for tracing a message as it travels between several hosts.
12	Several messages that are basically only of interest when debugging.
16	Verbose information regarding the queue.

File modes

Some files may have a number of modes. The modes depend on what functionality you want and the level of security you require.

To setuid or not to setuid

`sendmail` can safely be made setuid to `root`. At the point where it is about to execute (see `exec`(2)) a mailer, it checks to see if the UID is 0; if so, it resets the UID and GID to a default (set by the `u` and `g` options). (You can override this by setting the `S` flag for mailers that are trusted and must be called as `root`.) However, this will cause mail processing to be accounted (by using `sar`(1)) to `root` rather than to the user sending the mail.

Should my alias database be writable?

At Berkeley the alias database (`/usr/lib/aliases*`) is mode 644. While this is not as flexible as if the database were mode 666, it avoids potential security problems with a globally writable database.

The database that `sendmail` actually uses is represented by the files `aliases.dir` and `aliases.pag` (both in `/usr/lib`). The mode on these files should match the mode on `/usr/lib/aliases`. If `aliases` is writable and the `dbm` files (`aliases.dir` and `aliases.pag`) are not, users will be unable to make their desired changes to the actual database. However, if `aliases` is read-only and the `dbm` files are writable, a slightly sophisticated user can arrange to steal mail anyway.

If your `dbm` files are not writable by the world or you do not have autorebuild enabled (with the `D` option), you must be careful to reconstruct the alias database each time you change the text version:

```
newaliases
```

If this step is ignored or forgotten, any intended changes will also be ignored or forgotten.

The configuration file

This section describes the configuration file in detail and gives hints on how to write one of your own if you have to.

The syntax of the configuration file is designed to be reasonably easy to parse, because this is done every time `sendmail` starts up, rather than easy for a human to read or write. On the "future project" list is a configuration-file compiler.

An overview of the configuration file is given first, followed by details of the semantics.

Syntax

The configuration file is organized as a series of lines, each of which begins with a single character defining the semantics for the rest of the line. Lines beginning with a space or a tab are continuation lines (although the semantics are not well defined in many places). Blank lines and lines beginning with a number symbol (#) are comments.

R and S: Rewriting rules

The core of address parsing is the rewriting rules. These are an ordered production system. `sendmail` scans through the set of rewriting rules looking for a match on the left side (*ls*) of the rule. When a rule matches, the address is replaced by the right side (*rs*) of the rule.

There are several sets of rewriting rules. Some of the rewriting sets are used internally and must have specific semantics. Other rewriting sets do not have specifically assigned semantics and may be referenced by the mailer definitions or by other rewriting sets.
The syntax of these two commands is as follows:

`F S`*n*

sets the current set of rules being collected to *n*. If you begin a set more than once, it deletes the old definition.

`F R` *ls r comments*

These fields must be separated by at least one tab character; there may be embedded spaces in the fields. *ls* is a pattern that is applied to the input. If it matches, the input is rewritten to *r*. The comments are ignored.

D: Define macro

Macros are named with a single character. These may be selected from the entire ASCII set, but user-defined macros should be selected from the set of uppercase letters only. Lowercase letters and special symbols are used internally.

The syntax for macro definitions is
`D` *xval*

where *x* is the name of the macro and *val* is the value it should have. Macros can be interpolated in most places by using the escape sequence `$`*x*.

C and F: Define classes

Classes of words can be defined to match on the left side of the rewriting rules,where a “word” is a sequence of characters that do not contain characters in the `$o` macro. For example, a class of all local names for this site might be created so that attempts to send to oneself can be eliminated. These can be either defined directly in the configuration file or read in from another file. Classes can be given names from the set of uppercase letters. Lowercase letters and special characters are reserved for system use.

The syntax is

`C`*c word1 word2 . . .*
`F` *c file*

The first form defines the class *c* to match any of the named words. It is permissible to split them among multiple lines; for example, the two forms

```
CHmonet ucbmonet
```

and

```
CHmonet
CHucbmonet
```

are equivalent. The second form reads the elements of the class *c* from *file.*

M: Define mailer

Programs and interfaces to mailers are defined in this line. The syntax is

`M` *name*, {*field=value*} *

where *name* is the name of the mailer (used internally only) and the *field=value* pairs define attributes of the mailer. The fields are

`Path`	the pathname of the mailer
`Flags`	special flags for this mailer
`Sender`	a rewriting set for sender addresses
`Recipient`	a rewriting set for recipient addresses
`Argv`	an argument vector to pass to this mailer
`Eol`	the end-of-line string for this mailer
`Maxsize`	the maximum message length to this mailer

Only the first character of the field name is checked.

H: Define header

The format of the header lines that `sendmail` inserts into the message are defined by the `H` line. The syntax of this line is
`H [ ? ` *mflags* ` ? ]` *hname* `:` *htemplate*

Continuation lines are reflected directly into the outgoing message. *htemplate* is macro-expanded before insertion into the message. If *mflags* (surrounded by question marks) are specified, at least one of the specified flags must be stated in the mailer definition for this header to be automatically output. If one of these headers is in the input, it is reflected to the output regardless of these flags.

Some headers have special semantics that are described in the next section.

O: Set option

A number of random options can be set from a configuration file. Options are represented by single characters. The syntax of this line is
`O` *value*

This sets option `o` to be *value*. Depending on the option, *value* may be a string, an integer, a Boolean (with legal values `t`, `T`, `f`, or `F`; the default is `TRUE`), or a time interval.

T: Define trusted users

Trusted users are those users who are permitted to override the sender address by using the `-f` flag. These typically are `root`, `uucp`, and `network`, but on some users it may be convenient to extend this list to include other users, perhaps to support a separate UUCP login for each host. The syntax of this line is
`T` *user1 user2* . . .

There may be more than one of these lines.

P: Precedence definitions

Values for the `Precedence:` field can be defined by using the `P` control line. The syntax of this field is

`P` *name=num*

When *name* is found in a `Precedence:` field, the message class is set to *num*. Higher numbers mean higher precedence. Numbers less than 0 have the special property that error messages will not be returned. The default precedence is 0. For example, at Berkeley the list of precedences is

```
Pfirst-class=0
Pspecial-delivery=100
Pjunk=-100
```

Semantics

This section describes the semantics of the configuration file.

Special macros and conditionals

Macros are interpolated by using the construct `$`*x*, where *x* is the name of the macro to be interpolated. In particular, lowercase letters are reserved to have special semantics used to pass information in or out of `sendmail`, and some special characters are reserved to provide conditionals, and so on.

The syntax of conditionals is
`$?`*x* *text1* `$|` *text2* `$.`

This interpolates *text1* if the macro `$x` is set, and *text2* otherwise. The `else` clause (`$|`) may be omitted.

The following macros must be defined to transmit information into `sendmail`:

`e`	the SMTP entry message
`j`	the "official" domain name for this site
`l`	the format of the `From` line
`n`	the name of the daemon (for error messages)
`o`	the set of "operators" in addresses
`q`	default format of sender address

The $e macro is printed out when SMTP starts up. The first word must be the $j macro; this should be in RFC 821 format. The $l and $n macros can be considered constants except under very unusual circumstances. The $o macro consists of a list of characters that will be considered tokens and that will separate tokens when doing parsing. For example, if @ were in the $o macro, the input a@b would be scanned as three tokens: a, @, and b. Finally, the $q macro specifies how an address should appear in a message when it is defaulted. For example, at Berkeley these definitions are

```
De$j sendmail $v ready at $b
DnMAILER-DAEMON
DlFrom $g  $d
Do.:%@!^=/
Dq$g$?x ($x)$.
Dj$H.$D
```

An acceptable alternative for the $q macro is "$?x$x $.<$g>. These correspond to the following two formats:

```
eric@Berkeley (Eric Allman)
Eric Allman <eric@Berkeley>
```

Some macros are defined by sendmail for interpolation into argv's for mailers or for other contexts. These macros are

a	the origination date in RFC 822 format
b	the current date in RFC 822 format
c	the hop count
d	the date in UNIX (ctime) format
f	the sender (from) address
g	the sender address relative to the recipient
h	the recipient host
i	the queue ID
p	sendmail's PID
r	the protocol used
s	the sender's host name
t	a numeric representation of the current time
u	the recipient user
v	the version number of sendmail
w	the host name of this site
x	the full name of the sender
z	the home directory of the recipient

There are three types of dates that can be used. The `$a` and `$b` macros are in RFC 822 format; `$a` is the time as extracted from the `Date:` line of the message (if there was one), and `$b` is the current date and time (used for postmarks). If no `Date:` line is found in the incoming message, `$a` is set to the current time. The `$d` macro is equivalent to the `$a` macro in UNIX (`ctime`) format.

The `$f` macro is the ID of the sender as originally determined; when mailing to a specific host, the `$g` macro is set to the address of the sender *relative to the recipient*. For example, if `eric` sends to `bollard@matisse` from the machine `ucbarpa`, the `$f` macro will be `eric` and the `$g` macro will be `eric@ucbarpa`.

The `$x` macro is set to the full name of the sender. This can be determined in several ways. The first way is to pass it as a flag to `sendmail`. The second choice is the value of the `Full-name:` line in the header if it exists, and the third choice is the comment field of a `From:` line. If all of these fail, and if the message is being originated locally, the full name is looked up in the `/etc/passwd` file.

When sending, the `$h`, `$u`, and `$z` macros get set to the host, user, and home directory (if local) of the recipient. The first two are set from the `$@` and `$:` part of the rewriting rules, respectively.

The `$p` and `$t` macros are used to create unique strings (for example, for the `Message-Id:` field). The `$i` macro is set to the queue ID on this host; if put into the time stamp line, it can be extremely useful for tracking messages. The `$v` macro is set to be the version number of `sendmail`; this is normally put in time stamps and has been proven extremely useful for debugging. The `$w` macro is set to the name of this host if it can be determined. The `$c` field is set to the "hop count;" that is, the number of times this message has been processed. This can be determined by using the `-h` flag on the command line or by counting the time stamps in the message.

The `$r` and `$s` fields are set to the protocol used to communicate with `sendmail` and the sending host name; these are not supported in the current version.

Special classes

The class `$=w` is set to be the set of all names this host is known by. This can be used to match local host names.

The left side

The left side of the rewriting rules contains a pattern. Normal words are simply matched directly. Metasyntax is introduced with a dollar sign. The metasymbols are:

`$*`	Match zero or more tokens.
`$+`	Match one or more tokens.
`$-`	Match exactly one token.
`$=`*x*	Match any token in class *x*.
`$~`*x*	Match any token not in class *x*.

If any of these match, they are assigned to the symbol `$`*n* for replacement on the right side, where *n* is the index in *ls*. For example, if *ls*

```
$-:$+
```

is applied to the input

```
UCBARPA:eric
```

the rule will match, and the values passed to *rs* will be

```
$1    UCBARPA
$2    eric
```

The right side

When the left side of a rewriting rule matches, the input is deleted and replaced by the right side. Tokens are copied directly from *rs* unless they begin with a dollar sign. Metasymbols are

`$I`*n*	Substitute indefinite token *n* from *ls*.
`$[`*name*`$]`	Canonicalize *name*.
`$>`*n*	Call rule set *n*.
`$#`*mailer*	Resolve to *mailer*.
`$@`*host*	Specify *host*.
`$:`*user*	Specify *user*.

The `$`*n* syntax substitutes the corresponding value from a `$+`, `$-`, `$*`, `$=`, or `$~` match on *ls*. It may be used anywhere.

A host name enclosed between `$[` and `$]` is looked up by using the `gethostbyaddr`(3N) routines and replaced by the canonical name. For example, `$[csam$]` might become `lbl-csam.arpa` and `$[[128.32.130.2]$]` would become `vangogh.berkeley.edu`.

The `$>` *n* syntax causes the remainder of the line to be substituted as usual and then passed as the argument to rule set *n*. The final value of rule set *n* then becomes the substitution for this rule.

The `$#` syntax should be used only in rule set 0. It causes evaluation of the rule set to terminate immediately and signals to `sendmail` that the address has completely resolved. The complete syntax is
`$#`*mailer*`$@host$:`*user*

This specifies the {*mailer*, *host, user*} triple necessary to direct the mailer. If the mailer is local, the host part may be omitted. The mailer and host must be a single word, but the user may be multipart.

rs may also be preceded by a `$@` or a `$:` to control evaluation. A `$@` prefix causes the rule set to return with the remainder of *"rs"* as the value. A `$:` prefix causes the rule to terminate immediately but the rule set to continue; this can be used to avoid continued application of a rule. The prefix is stripped before continuing.

The `$@` and `$:` prefixes may precede a `$>`. For example,

```
R$+     $:$>7$1
```

matches anything, passes that to rule set 7, and continues; the `$:` is necessary to avoid an infinite loop.

Substitution occurs in the order described; that is, parameters from *ls* are substituted, host names are canonicalized, subroutines are called, and finally `$#`, `$@`, and `$:` are processed.

Semantics of rewriting rule sets

There are five rewriting sets that have specific semantics, as depicted in Figure A-1.

In the figure, D is the sender domain addition, S is the mailer-specific sender rewriting, and R is mailer-specific recipient rewriting.

Rule set 3 should turn the address into canonical form. This form should have the basic syntax *local-part*@*host-domain-spec*

If no @ is specified, the *host-domain-spec* may be appended from the sender address (if the `C` flag is set in the mailer definition corresponding to the `sending` mailer). Rule set 3 is applied by `sendmail` before doing anything with any address.

Rule set 0 is applied after rule set 3 to addresses that are going to specify recipients. It must resolve to a {*mailer*, *host*, *user*} triple. The mailer must be defined in the mailer definitions from the configuration file. The host is defined into the `$h` macro for use in the `argv` expansion of the specified mailer.

Rule sets 1 and 2 are applied to all sender and recipient addresses respectively. They are applied before any specification in the mailer definition. They must never resolve.

Rule set 4 is applied to all addresses in the message. It is typically used to translate internal to external form.

Mailer flags

A number of flags may be associated with each mailer, each identified by a letter of the alphabet. Many of them are assigned semantics internally. These are detailed in the section "Mailer flags" later in this appendix. Any other flags may be used freely to conditionally assign headers to messages destined for particular mailers.

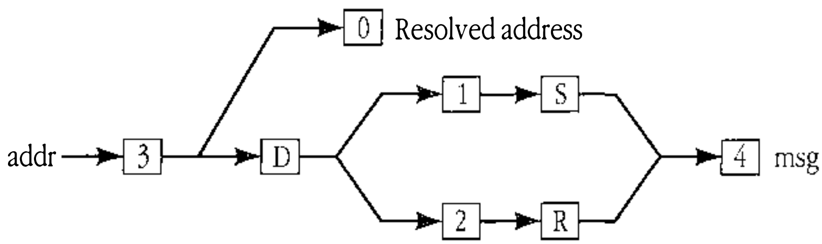
The `error` mailer

The mailer with the special name `error` can be used to generate a user error. The (optional) host field is a numeric exit status to be returned, and the user field is a message to be printed. For example, the entry

```
$#error$:Host unknown in this domain
```

on *rs* of a rule will cause the specified error to be generated if *ls* matches. This mailer is only functional in rule set 0.

■ **Figure A-1** Rewriting set semantics



Building a configuration file from scratch

Building a configuration table from scratch is an extremely difficult job. Fortunately, it is almost never necessary to do so; nearly every situation that may come up can be resolved by changing an existing table. In any case it is critical that you understand what it is that you are trying to do and come up with a philosophy for the configuration table. This section is intended to explain what the real purpose of a configuration table is and to give you some ideas for what your philosophy might be.

What you are trying to do

The configuration table has three main purposes. The first and simplest is to set up the environment for `sendmail`. This involves setting the options, defining a few critical macros, and so on. These are described in other places.

The second purpose is to rewrite addresses in the message. This should typically be done in two phases. The first phase maps addresses in any format into a canonical form. This should be done in rule set 3. The second phase maps this canonical form into the syntax appropriate for the receiving mailer. `sendmail` does this in three subphases. Rule sets 1 and 2 are applied to all sender and recipient addresses respectively. After this you can specify per-mailer rule sets for both sender and recipient addresses; this allows mailer-specific customization. Finally, rule set 4 does any default conversion to external form.

The third purpose of the configuration table is to map addresses into the actual set of instructions necessary to get the message delivered. Rule set 0 must resolve to the internal form, which is in turn used as a pointer to a mailer descriptor. The mailer descriptor describes the interface requirements of the mailer.

Philosophy

The particular philosophy you choose will depend heavily on the size and structure of your organization.

One general point applies to all of the philosophies presented here: It is almost always a mistake to try to do full name resolution. For example, if you are trying to get names of the form `user@host` to the Arpanet, it does not pay to route them to

```
xyzvax!decvax!ucbvax!c70:user@host
```

because you then depend on several links not under your control. The best approach to this problem is to simply forward to `xyzvax!user@host` and let `xyzvax` worry about it from there. In summary, just get the message closer to the destination, rather than determining the full path.

Large site, many hosts: Minimum information

Berkeley is an example of a large site, that is, more than two or three hosts and multiple mail connections. The only reasonable philosophy in this environment is to designate one host as the guru for the site. That host must be able to resolve any piece of mail it receives. The other sites should have the minimum amount of information they can get away with. In addition, any information they have should be hints rather than solid information.

For example, a typical site on the Berkeley local Ethernet is `monet`. When `monet` receives mail for delivery, it checks whether it knows that the destination host is directly reachable; if it is, mail is sent to that host. If it receives mail for an unknown host, it just passes it directly to `ucbvax`, the master host. `ucbvax` may determine that the host name is illegal and reject the message or may be able to make the delivery. However, it is important to note that when a new mail connection is added, the only host that must have its tables updated is `ucbvax`; the others may be updated if convenient, but this is not critical.

This picture is slightly muddied because of network connections that are not actually located on ucbvax. For example, some UUCP connections are currently on ucbarpa. However, monet does not know about this; the information is hidden totally between ucbvax and ucbarpa. Mail going from monet to a UUCP host is transferred via the Ethernet from monet to ucbvax, then via the Ethernet from ucbvax to ucbarpa, and it is then submitted to UUCP. Although this involves some extra hops, it is considered an acceptable trade-off.

An interesting point is that it would be possible to update monet to send appropriate UUCP mail directly to ucbarpa if the load got too high. If monet failed to note a host as connected to ucbarpa, it would go via ucbvax as before, and if monet incorrectly sent a message to ucbarpa, it would still be sent by ucbarpa to ucbvax as before. The only problem that can occur is loops; for example, if ucbarpa thought that ucbvax had the UUCP connection and vice versa. For this reason, updates should always happen to the master host first.

This philosophy results as much from the need to have a single source for the configuration files (typically built using m4(1) or some similar tool) as any logical need. Maintaining more than three separate tables by hand is essentially an impossible job.

Small site: Complete information

A small site (two or three hosts and few external connections) may find it more reasonable to have complete information at each host. This would require that each host know exactly where each network connection is, possibly including the names of each host on that network. As long as the site remains small and the configuration remains relatively static, the update problem will probably not be too great.

Single host

This is in some sense the trivial case. The only big issue is trying to ensure that you don't have to know too much about your environment. For example, if you have a UUCP connection you might find it useful to know about the names of hosts connected directly to you, but this is really not necessary because it may be determined from the syntax.

Relevant issues

The canonical form you use should almost certainly be as specified in the Arpanet protocols RFC 819 and RFC 822. Copies of these RFCs are included on the `sendmail` tape as `doc/rfc819.lpr` and `doc/rfc822.lpr`.

RFC 822 describes the format of the mail message itself. `sendmail` follows this RFC closely, to the extent that many of the standards described in this document cannot be changed without changing the code. In particular, the following characters have special interpretations:

`< > ( ) " \`

Any attempt to use these characters for other than their RFC 822 purpose in addresses is probably doomed to disaster.

RFC 819 describes the specifics of the domain-based addressing. This is touched on in RFC 822 as well. Essentially, each host is given a name that is a right-to-left dot-qualified pseudopath from a distinguished root. The elements of the path need not be physical hosts; the domain is logical rather than physical. For example, at Berkeley one legal host might be `a.CC.Berkeley.EDU`; reading from right to left, `EDU` is a top-level domain comprising educational institutions, `Berkeley` is a logical domain name, `CC` represents the Computer Center (in this case a strictly logical entity), and `a` is a host in the Computer Center.

Beware when reading RFC 819 that there are a number of errors in it.

How to proceed

Once you have decided on a philosophy, it is worth examining the available configuration tables to see if any of them are close enough to your needs to use parts of them. Even under the worst of conditions there is a fair amount of boilerplate that can be collected safely.

The next step is to build rule set 3. This will be the hardest part of the job. Beware of doing too much to the address in this rule set, because anything you do will reflect through to the message. In particular, stripping of local domains is best deferred, because this can leave you with addresses with no domain spec at all. `sendmail` likes to append the sending domain to addresses with no domain, so this can change the semantics of addresses. Also try to avoid fully qualifying domains in this rule set. Although technically legal, this can lead to unpleasantly and unnecessarily long addresses reflected into messages. The Berkeley configuration files define rule set 9 to qualify domain names and strip local domains. This is called from rule set 0 to get all addresses into a cleaner form.

Once you have rule set 3 finished, the other rule sets should be relatively trivial. If you need hints, examine the supplied configuration tables.

Testing the rewriting rules: The `-bt` flag

When you build a configuration table, you can do a certain amount of testing by using the test mode of `sendmail`. For example, you could invoke `sendmail` as

```
sendmail -bt -Ctest.cf
```

which would read the configuration file `test.cf` and enter test mode. In this mode you enter lines of the form

```
rwset address
```

where *rwset* is the rewriting set you want to use and *address* is an address to apply the set to. Test mode shows you the steps it takes as it proceeds, finally showing you the address it ends up with. You may use a comma-separated list of *rwset*s for sequential application of rules to an input; rule set 3 is always applied first. For example,

```
1,21,4 monet:bollard
```

first applies rule set 3 to the input `monet:bollard`. Rule set 1 is then applied to the output of rule set 3, followed similarly by rule sets 21 and 4.

If you need more detail, you can also use the `-d21` flag to turn on more debugging.
For example,

```
sendmail -bt -d21.99
```

turns on an incredible amount of information; a single-word address is probably going to print out several pages' worth of information.

Building mailer descriptions

To add an outgoing mailer to your mail system, you will have to define the characteristics of the mailer.

Each mailer must have an internal name. This can be arbitrary, except that the names `local` and `prog` must be defined.

The pathname of the mailer must be given in the `P` field. If this mailer should be accessed via an IPC connection, use the string `[IPC]` instead.

The `F` field defines the mailer flags. You should specify an `f` or `r` flag to pass the name of the sender as a `-f` or `-r` flag respectively. These flags are only passed if they were passed to `sendmail`, so that mailers that give errors under some circumstances can be placated. If the mailer is not picky, you can just specify `-f$g` in the `argv` template. If the mailer must be called as `root`, the `S` flag should be given; this will not reset the UID before calling the mailer.

◆ *Note:* `sendmail` must be running setuid to `root` for this to work.

If this mailer is local (that is, will perform final delivery rather than another network hop), the `-l` flag should be given. Quote characters (backslashes and double quotation marks) can be stripped from addresses if the `s` flag is specified; if this is not given, they are passed through. If the mailer is capable of sending to more than one user on the same host in a single transaction, the `m` flag should be stated. If this flag is on, the `argv` template containing `$u` will be repeated for each unique user on a given host. The `e` flag will mark the mailer as being expensive, which will cause `sendmail` to defer connection until a queue run.

◆ *Note:* The `c` configuration option must be given for this to be effective.

An unusual case is the `C` flag. This flag applies to the mailer that the message is received from, rather than the mailer being sent to; if set, the domain spec of the sender (that is, the `@host.domain` part) is saved and is appended to any addresses in the message that do not already contain a domain spec. For example, a message of the form

```
From: eric@ucbarpa
To: wnj@monet, mckusick
```

will be modified to

```
From: eric@ucbarpa
To: wnj@monet, mckusick@ucbarpa
```

if and only if the `C` flag is defined in the mailer corresponding to `eric@ucbarpa`.

Other flags are described in "Mailer flags," later in this appendix.

The `S` and `R` fields in the mailer description are per-mailer rewriting sets to be applied to sender and recipient addresses respectively. These are applied after the sending domain is appended and the general rewriting sets (numbers 1 and 2) are applied, but before the output rewrite (rule set 4) is applied. A typical use is to append the current domain to addresses that do not already have a domain. For example, a header of the form

```
From: eric
```

might be changed to be

```
From: eric@ucbarpa
```

or

```
From: ucbvax!eric
```

depending on the domain it is being shipped into. These sets can also be used to do special-purpose output rewriting in cooperation with rule set 4.

The `E` field defines the string to use as an end-of-line indication. A string containing only newline is the default. The usual backslash escapes (`\r`, `\n`, `\f`, `\b`) may be used.

Finally, an `argv` template is given as the `E` field. It may have embedded spaces. If there is no `argv` with a `$u` macro in it, `sendmail` will speak SMTP to the mailer. If the pathname for this mailer is `[IPC]`, the `argv` should be

`IPC $h [` *port* `]`

where *port* is the optional port number to connect to.

For example, the specifications

```
Mlocal, P=/bin/mail, F=rlsm S=10, R=20, A=mail -d $u
Mether, P=[IPC], F=meC, S=11, R=21, A=IPC $h, M=100000
```

specify a mailer to do local delivery and a mailer for Ethernet delivery. The first is called `local`, is located in the file `/bin/mail`, takes a picky `-r` flag, and does local delivery. Quotes should be stripped from addresses, and multiple users can be delivered at once. Rule set 10 should be applied to sender addresses in the message and rule set 20 should be applied to recipient addresses. The `argv` to send to a message will be the word `mail`, the word `-d`, and words containing the name of the receiving user.

◆ *Note:* The A/UX implementation of `sendmail` does not support the `-d` option.

If a `-r` flag is inserted, it will be between the words `mail` and `-d`. The second mailer is called `ether` and should be connected to via an IPC connection. It can handle multiple users at once, connections should be deferred, and any domain from the sender address should be appended to any receiver name without a domain. Sender addresses should be processed by rule set 11 and recipient addresses by rule set 21. There is a 100,000-byte limit on messages passed through this mailer.

Command line flags

Arguments must be presented with flags before addresses. The flags are as follows:

`-f` *addr*	The sender's machine address is *addr*. This flag is ignored unless the real user is listed as a "trusted user" or if *addr* contains an exclamation point (because of certain restrictions in UUCP).
`-r` *addr*	An obsolete form of `-f`.
`-h` *cnt*	Set the hop count to *cnt*. This represents the number of times this message has been processed by `sendmail` (to the extent that it is supported by the underlying networks). *cnt* is incremented during processing, and if it reaches `MAXHOP` (currently 30), `sendmail` throws away the message with an error.
`-F`*name*	Set the full name of this user to *name*.
`-n`	Don't do aliasing or forwarding.
`-t`	Read the header for `To:`, `Cc:`, and `Bcc:` lines, and send to everyone listed in those lists. The `Bcc:` line will be deleted before sending. Any addresses in the argument vector will be deleted from the send list.
`-b`*x*	Set operation mode to *x*. Operation modes are

`m`	Deliver mail (default).
`a`	Run in Arpanet mode.
`s`	Speak SMTP on input side.
`d`	Run as a daemon.
`t`	Run in test mode.
`v`	Just verify addresses; don't collect or deliver.
`i`	Initialize the alias database.
`p`	Print the mail queue.
`z`	Freeze the configuration file.

The special processing for the Arpanet includes reading the `From:` line from the header to find the sender, printing Arpanet-style messages (preceded by three-digit reply codes for compatibility with the FTP protocol [Neigus73, Postel74, Postel77]), and ending lines of error messages with <CRLF>.

`-q` *time*	Try to process the queued mail. If the time is given, `sendmail` will run through the queue at the specified interval to deliver queued mail; otherwise, it only runs once.
`-C` *file*	Use a different configuration file. `sendmail` runs as the invoking user (rather than `root`) when this flag is specified.
`-d` *level*	Set debugging level.
`-o` *xvalue*	Set option *x* to the specified `value`. These options are described in "Configuration Options."

Some options may be specified as primitive flags (provided for compatibility with `delivermail`). These are the `e`, `i`, `m`, and `v` options. In addition, the `f` option may be specified as the `-s` flag.

Configuration options

The following options may be set by using the `-o` flag on the command line or the `O` line in the configuration file. Many of them cannot be specified unless the invoking user is trusted.

`A`*file*	Use *file* as the alias file. If no file is specified, use `aliases` in the current directory.
`a`*N*	If set, wait up to *N* minutes for an `@:@` entry to exist in the alias database before starting up. If it does not appear in *N* minutes, rebuild the database (if the `D` option is also set) or issue a warning.
`B`*c*	Set the blank substitution character to *c*. Unquoted spaces in addresses are replaced by this character.

`c` — If an outgoing mailer is marked as being expensive, don't connect immediately. This requires that queueing be compiled in, because it will depend on a queue-run process to actually send the mail.

`d`*x* — Deliver in mode *x*. Legal modes are

- `i` Deliver interactively (synchronously).
- `b` Deliver in the background (asynchronously).
- `q` Just queue the message (deliver during queue run).

`D` — If set, rebuild the alias database if necessary and possible. If this option is not set, `sendmail` will never rebuild the alias database unless explicitly requested with `-bi`.

`e`*x* — Dispose of errors by using mode *x*. The values for *x* are

- `p` Print error messages (default).
- `q` No messages; just give exit status.
- `m` Mail back errors.
- `w` Write back errors (mail if user is not logged in).
- `e` Mail back errors and give zero exit status always.

`F`*n* — The temporary file mode, in octal. 644 and 600 are good choices.

`f` — Save `From` lines at the front of headers. Normally they are assumed redundant and discarded.

`g`*n* — Set the default GID for mailers to run in to *n*.

`H`*file* — Specify the help file for SMTP.

I — Insist that the BIND name sever be running to resolve host names. If this is not set and the name server is not running, the `/etc/hosts` file will be considered complete. In general, you do not want to set this option if your `/etc/hosts` file does not include all hosts known to you or if you are using the MX (mail forwarding) feature of the BIND name server. The name server will still be consulted even if this option is not set, but `sendmail` will feel free to resort to reading `/etc/hosts` if the name server is not available. Thus, you should *never* set this option if you do not run the name server.

`i`	Ignore dots in incoming messages.
`L`*n*	Set the default log level to *n*.
`M`*xvalue*	Set the macro *x* to *value*. This is intended only for use from the command line.
`m`	Send to me too, even if I am in an alias expansion.
`N`*net-name*	The name of the home network; `ARPA` by default. The argument of an SMTP `HELO` command is checked against *host-name*`.`*net-name* where *host-name* is requested from the kernel for the current connection. If they do not match, `Received:` lines are augmented by the name that is determined in this manner so that messages can be traced accurately.
`o`	Assume that the headers may be in old format; that is, with spaces delimiting names. This turns on an adaptive algorithm: If any recipient address contains a comma, parenthesis, or angle bracket, it will be assumed that commas already exist. If this flag is not on, only commas delimit names. Headers are always output with commas between the names.
`Q`*dir*	Use *dir* as the queue directory.
`q`*factor*	Use *factor* as the multiplier in the map function to decide when to queue jobs rather than run them. This value is divided by the difference between the current load average and the load average limit `x` flag) to determine the maximum message priority that will be sent. Defaults to 10000.
`r`*time*	Read timeout after *time* interval.
`S`*file*	Log statistics in *file*.
`s`	Be "super safe" when running things; that is, always instantiate the queue file, even if you are going to attempt immediate delivery. `sendmail` always instantiates the queue file before returning control to the client under any circumstances.
`T`*time*	Set the queue timeout to *time*. After this interval, messages that have not been successfully sent will be returned to the sender.

`t`*S*`,` *D*	Set the local time zone name to *S* for standard time and *D* for daylight time; this is only used under version 6.
`u`*n*	Set the default UID for mailers to *n*. Mailers without the `S` flag in the mailer definition will run as this user.
`v`	Run in verbose mode.
`x`*LA*	When the system load average exceeds *LA*, just queue messages rather than send them.
`X`*LA*	When the system load average exceeds *LA*, refuse incoming SMTP connections.
`y`*fact*	Add *fact* to the priority (thus *lowering* the priority of the job) for each recipient. This value penalizes jobs with large numbers of recipients.
`Y`	If set, deliver each job that is run from the queue in a separate process. Use this option if you are short of memory, because the default tends to consume considerable amounts of memory while the queue is being processed.
`z`*fact*	Multiply *fact* by the message class (determined by the `Precedence:` field in the user header and the `P` lines in the configuration file) and subtract from the priority. Thus messages with a higher priority will be favored.
`Z`*fact*	Add *fact* to the priority every time a job is processed. Thus each time a job is processed, its priority will be decreased by the indicated value. In most environments this should be positive, because hosts that are down are all too often down for a long time.

Mailer flags

The following flags may be set in the mailer description:

`f` The mailer wants a `-f` from flag, but only if this is a network forward operation (that is, the mailer will give an error if the executing user does not have special permissions).

`r` Same as `f`, but sends a `-r` flag.

`S` Don't reset the UID before calling the mailer. This would be used in a secure environment where `sendmail` ran as `root`. This could be used to avoid forged addresses. This flag is suppressed if given from an unsafe environment (for example, a user's `mail.cf` file).

`n` Do not insert a `From` line on the front of the message.

`l` This mailer is local (that is, final delivery will be performed).

`s` Strip quote characters off of the address before calling the mailer.

`m` This mailer can send to multiple users on the same host in one transaction. When a `$u` macro occurs in the `argv` part of the mailer definition, that field will be repeated as necessary for all qualifying users.

`F` This mailer wants a `From:` header line.

`D` This mailer wants a `Date:` header line.

`M` This mailer wants a `Message-Id:` header line.

`x` This mailer wants a `Full-Name:` header line.

`P` This mailer wants a `Return-Path:` line.

`u` Uppercase should be preserved in user names for this mailer.

`h` Uppercase should be preserved in host names for this mailer.

`A` This is an Arpanet-compatible mailer, and all appropriate modes should be set.

`U` This mailer wants `From` lines with the UUCP-style "`remote from` *host*" on the end.

`e` This mailer is expensive to connect to, so try to avoid connecting normally; any necessary connection will occur during a queue run.

`X` This mailer wants to use the hidden-dot algorithm as specified in RFC 821; basically, any line beginning with a dot will have an extra dot prepended (to be stripped at the other end). This ensures that lines in the message containing a dot will not terminate the message prematurely.

L Limit the line lengths as specified in RFC 821.

P Use the return path in the SMTP `MAIL FROM:` command rather than just the return address. Although this is required in RFC 821, many hosts do not process return paths properly.

I This mailer will be speaking SMTP to another `sendmail`; as such it can use special protocol features. This option is not required (that is, if this option is omitted, the transmission will still operate successfully, although perhaps not as efficiently as possible).

C If mail is received from a mailer with this flag set, any addresses in the header that do not have an at sign (`@`) after being rewritten by rule set 3 will have the `@domain` clause from the sender tacked on. This allows mail with headers of the form

`From:` *usera*`@`*hosta*
`To:` *userb*`@`*hostb*, *userc*

to be rewritten as

`From:` *usera*`@`*hosta*
`To:` *userb*`@`*hostb*, *userc*`@`*hosta*

automatically.

E Escape lines beginning with `From` in the message with a >.

Other configurations

Some configuration changes can be made by recompiling `sendmail`. These are located in two places:

`src/conf.h` Configuration parameters that may be tweaked by the installer are included in `conf.h`.

`src/conf.c` Some special routines and a few variables may be defined in `conf.c`. For the most part these are selected from the settings in `conf.h`.

Parameters in `src/conf.h`

Parameters and compilation options are defined in `conf.h`. Most of these need not normally be tweaked; common parameters are all in `sendmail.cf`. However, the sizes of certain primitive vectors, and so on, are included in this file. The numbers following the parameters are their default value.

`MAXLINE` [1024]
: The maximum line length of any input line. If message lines exceed this length, they will still be processed correctly; however, header lines, configuration file lines, alias lines, and so on, must fit within this limit.

`MAXNAME` [256]
: The maximum length of any name, such as a host or a user name.

`MAXFIELD` [2500]
: The maximum total length of any header field, including continuation lines.

`MAXPV` [40]
: The maximum number of parameters to any mailer. This limits the number of recipients that may be passed in one transaction.

`MAXHOP` [17]
: When a message has been processed more than this number of times, `sendmail` rejects the message on the assumption that there has been an aliasing loop. This can be determined from the `-h` flag or by counting the number of trace fields (that is, `Received:` lines) in the message header.

`MAXATOM` [100]
: The maximum number of atoms (tokens) in a single address. For example, the address `eric@Berkeley` is three atoms.

`MAXMAILERS` [25]
: The maximum number of mailers that may be defined in the configuration file.

`MAXRWSETS` [30]
: The maximum number of rewriting sets that may be defined.

MAXPRIORITIES [25]

The maximum number of values for the Precedence: field that may be defined (by using the P line in sendmail.cf).

MAXTRUST [30]

The maximum number of trusted users that may be defined (by using the T line in sendmail.cf).

MAXUSERENVIRON [40]

The maximum number of items in the user environment that will be passed to subordinate mailers.

QUEUESIZE [600]

The maximum number of entries that will be processed in a single queue run.

Other compilation options specify whether or not specific code should be compiled in:

DBM
If set, the dbm package is used (see dbm(3X)). If not set, a much less efficient algorithm for processing aliases is used.

NDBM
If set, the new version of the dbm library that allows multiple databases will be used. dbm must also be set.

DEBUG
If set, debugging information is compiled in. To get the debugging output, the -d flag must be used.

LOG
If set, the syslog routine in use at some sites is used. This makes an informational log record for each message processed and makes a higher priority log record for internal system errors.

QUEUE
This flag should be set to compile in the queueing code. If this is not set, mailers must accept the mail immediately or it will be returned to the sender.

SMTP
If set, the code to handle user and server SMTP will be compiled in. This is only necessary if your machine has some mailer that speaks SMTP.

DAEMON
If set, code to run a daemon is compiled in. This code is for 4.2 or 4.3BSD.

UGLYUUCP

If you have a UUCP host adjacent to you that is not running a reasonable version of `rmail`, you will have to set this flag to include the "`remote from` *sysname*" information on the `From` line. Otherwise, UUCP gets confused about where the mail came from.

NOTUNIX

If you are not using a UNIX mail format, you can set this flag to turn off special processing of UNIX `From` lines.

NAMED_BIND

Compile in code to use the Berkeley Internet Name Domain (BIND) server to resolve TCP/IP host names.

SETPROCTITLE

If defined, `sendmail` will change its `argv` array to indicate its current status. This can be used in conjunction with the `ps` command to find out just what it's up to.

NO_WILDCARD_MX

Should be set if there are no wildcard MX nameserver records in the local domain. If set, this will enable the use of ANY query types, resulting in better performance. Unfortunately, wildcard MX records in the local domain will mess this up, hence the need for this compilation option.

Configuration in `src/conf.c`

Not all header semantics are defined in the configuration file. Header lines that should be included only by certain mailers (as well as other more obscure semantics) must be specified in the `HdrInfo` table in `conf.c`. This table contains the header name (which should be in all lowercase) and a set of header control flags. The flags are

H_ACHECK Normally when the check is made to see if a header line is compatible with a mailer, `sendmail` will not delete an existing line. If this flag is set, `sendmail` will delete even existing header lines. That is, if this bit is set and the mailer does not have flag bits set that intersect with the required mailer flags in the header definition in `sendmail.cf`, the header line is always deleted.

H_EOH — If this header field is set, treat it like a blank line; that is, it will signal the end of the header and the beginning of the message text.

H_FORCE — Add this header entry even if one existed in the message before. If a header entry does not have this bit set, `sendmail` will not add another header line if a header line of this name already existed. This would normally be used to stamp the message by everyone who handled it.

H_TRACE — If set, this is a time stamp (trace) field. If the number of trace fields in a message exceeds a preset amount, the message is returned on the assumption that it has an aliasing loop.

H_RCPT — If set, this field contains recipient addresses. This is used by the `-t` flag to determine who to send to when it is collecting recipients from the message.

H_FROM — This flag indicates that this field specifies a sender. The order of these fields in the `HdrInfo` table specifies `sendmail`'s preference for which field to return error messages to.

Now look at a sample `HdrInfo` specification:

```
struct hdrinfo   HdrInfo[] =
{ !
            /* originator fields, most to least significant  */ !
      "resent-sender",  H_FROM, !
      "resent-from",    H_FROM, !
      "sender",   H_FROM, !
      "from",     H_FROM, !
      "full-name",   H_ACHECK, !
            /* destination fields */ !
      "to", H_RCPT, !
      "resent-to",   H_RCPT, !
      "cc", H_RCPT, !
            /* message identification and control */ !
      "message",  H_EOH, !
      "text",     H_EOH, !
            /* trace fields */ !
      "received", H_TRACE|H_FORCE, !
      NULL, 0,
};
```

This structure indicates that the `To:`, `Resent-To:`, and `Cc:` fields all specify recipient addresses. Any `Full-Name:` field will be deleted unless the required mailer flag (indicated in the configuration file) is specified. The `Message:` and `Text:` fields will terminate the header; these are specified in new protocols (NBS80) or used by random dissenters around the network world. The `Received:` field will always be added and can be used to trace messages.

There are a couple of important points here. First, header fields are not added automatically just because they are in the `HdrInfo` structure; they must be specified in the configuration file to be added to the message. Any header fields mentioned in the configuration file but not mentioned in the `HdrInfo` structure have default processing performed; that is, they are added unless they were in the message already. Second, the `HdrInfo` structure only specifies cliched processing; certain headers are processed specially by ad hoc code regardless of the status specified in `HdrInfo`. For example, the `Sender:` and `From:` fields are always scanned on Arpanet mail to determine the sender; this is used to perform the return-to-sender function. The `From:` and `Full-Name:` fields are used to determine the full name of the sender if possible; this is stored in the macro `$x` and used in a number of ways.

The file `conf.c` also contains the specification of Arpanet reply codes. These fall into four classifications

```
char  Arpa_Info[]     =     "050";  /* arbitrary info */
char  Arpa_TSyserr[]  =     "455";  /* some (transient) !
                                       system error */
char  Arpa_PSyserr[]  =     "554";  /* some (permanent) !
                                       system error */
char  Arpa_Usrerr[]   =     "554";  /* some (fatal) user !
                                       error */
```

The class `Arpa_Info` is for any information that is not required by the protocol, such as forwarding information. `Arpa_TSyserr` and `Arpa_PSyserr` are printed by the `syserr` routine. `TSyserr` is printed out for transient errors, that is, errors that are likely to go away without explicit action on the part of a system administrator. `PSyserr` is printed for permanent errors. The distinction made is based on the value of `errno`. Finally, `Arpa_Usrerr` is the result of a user error and is generated by the `usrerr` routine. These are generated when the user has specified something wrong, and hence the error is permanent; that is, it will not work simply by resubmitting the request.

If it is necessary to restrict mail through a relay, the `checkcompat` routine can be modified. This routine is called for every recipient address. It can return `TRUE` to indicate that the address is acceptable and mail processing will continue, or it can return `FALSE` to reject the recipient. If it returns `FALSE`, it is up to `checkcompat` to print an error message (by using `usrerr`) saying why the message is rejected. For example, `checkcompat` could read

```
bool
checkcompat(to) !
      register ADDRESS *to;
{ !
      if (MsgSize > 50000 && to->q_mailer != LocalMailer) !
      { !
            usrerr("Message too large for non-local delivery"); !
            NoReturn = TRUE; !
            return (FALSE); !
      } !
      return (TRUE);
}
```

This would reject messages greater than 50000 bytes unless they were local. The `NoReturn` flag can be sent to suppress the return of the actual body of the message in the error return. The use of this routine is highly dependent on the implementation and should be limited.

Configuration in `src/daemon.c`

The file `src/daemon.c` contains routines that are dependent on the local networking environment. The version supplied is specific to 4.3 BSD.

The routine `maphostname` is called to convert strings within `$[...$]` symbols. It can be modified to provide a more sophisticated service; for example, mapping UUCP host names to full paths.

Summary of support files

This is a summary of the support files that `sendmail` creates or generates.

`/usr/lib/sendmail`
: The binary of `sendmail`.

`/usr/bin/newaliases`
: A link to `/usr/lib/sendmail`; causes the alias database to be rebuilt. Running this program is equivalent to giving `sendmail` the `-bi` flag.

`/usr/bin/mailq`
: Prints a listing of the mail queue. This program is equivalent to using the `-bp` flag to `sendmail`.

`/usr/lib/sendmail.cf`
: The configuration file, in textual form.

`/usr/lib/sendmail.fc`
: The configuration file represented as a memory image.

`/usr/lib/sendmail.hf`
: The SMTP help file.

`/usr/lib/sendmail.st`
: A statistics file; need not be present.

`/usr/lib/aliases`
: The textual version of the alias file.

`/usr/lib/aliases.{pag,dir}`
: The alias file in `dbm`(3X) format.

`/usr/spool/mqueue`
: The directory in which the mail queue and temporary files reside.

`/usr/spool/mqueue/qf*`
: Control (queue) files for messages.

`/usr/spool/mqueue/df*`
Data files.

`/usr/spool/mqueue/lf*`
Lock files.

`/usr/spool/mqueue/tf*`
Temporary versions of the `qf` files; used during queue file rebuild.

`/usr/spool/mqueue/nf*`
A file used when creating a unique ID.

`/usr/spool/mqueue/xf*`
A transcript of the current session.

Appendix B **Name Server Operations Guide for BIND**

This appendix was originally printed as the *Name Server Operations Guide for BIND Release 4.8*, written by Kevin J. Dunlap and Michael J. Karels of the Computer Systems Research Group at the University of California at Berkeley. It is reproduced here with permission.

The key points this appendix covers are:

- Building a system with a name server
- Types of server
- Setting up your own domain
- Files
- Domain management

The Berkeley Internet Name Domain (BIND) server implements the DARPA Internet name server for the UNIX operating system. A name server is a network service that enables clients to name resources or objects and share this information with other objects in the network. This in effect is a distributed database system for objects in a computer network. BIND is fully integrated into 4.3BSD network programs for use in storing and retrieving host names and addresses. The system administrator can configure the system to use BIND as a replacement to the original host table lookup of information in the network hosts file `/etc/hosts`. The default configuration for 4.3BSD uses BIND.

Building a system with a name server

BIND is comprised of two parts. One is the user interface called the `resolver`, which consists of a group of routines that reside in the C library `/lib/libc.a`. Second is the actual server called `named`. This is a daemon that runs in the background and services queries on a given network port. The standard port for UDP and TCP is specified in `/etc/services`.

Resolver routines in `libc`

When building your 4.3BSD system you may either build the C library to use the name server resolver routines or use the host table lookup routines to do host name and address resolution. The default resolver for 4.3BSD uses the name server.

Building the C library to use the name server changes the way `gethostbyname`(3N), `gethostbyaddr`(3N), and `sethostent`(3N) do their functions. The name server renders `gethostent`(3N) obsolete, since it has no concept of a next line in the database. These library calls are built with the resolver routines needed to query the name server.

The `resolver` is comprised of a few routines that build query packets and exchange them with the name server.

Before building the C library, set the variable `HOSTLOOKUP` equal to `named` in `/usr/src/lib/libc/Makefile`. You then make and install the C library and compiler and then compile the rest of the 4.3BSD system. For more information see section 6.6 of *Installing and Operating 4.3BSD on the VAX.*

The name server

The basic function of the name server is to provide information about network objects by answering queries. The specifications for this name server are defined in RFC882, RFC883, RFC973, and RFC974. These documents can be found in `/usr/src/etc/named/doc` in 4.3BSD or `ftp`ed from `sri-nic.arpa`. It is also recommended that you read the related manual pages, `named`(1M), `resolver`(3N), and `resolver`(4).

The advantage of using a name server over the host table lookup for host name resolution is to avoid the need for a single centralized clearinghouse for all names. The authority for this information can be delegated to the different organizations on the network responsible for it.

The host table lookup routines require that the master file for the entire network be maintained at a central location by a few people. This works fine for small networks where there are only a few machines and the different organizations responsible for them cooperate. But this does not work well for large networks where machines cross organizational boundaries.

With the name server, the network can be broken into a hierarchy of domains. The name space is organized as a tree according to organizational or administrative boundaries. Each node, called a **domain,** is given a label, and the name of the domain is the concatenation of all the labels of the domains from the root to the current domain, listed from right to left separated by dots. A label need only be unique within its domain. The whole space is partitioned into several areas called **zones,** each starting at a domain and extending down to the leaf domains or to domains where other zones start. Zones usually represent administrative boundaries. An example of a host address for a host at the University of California at Berkeley would look as follows:

```
monet.Berkeley.EDU
```

The top level domain for educational organizations is `EDU`; `Berkeley` is a subdomain of `EDU` and `monet` is the name of the host.

Types of servers

There are several types of server: master, caching, remote, and slave.

Master server

A **master server** for a domain is the authority for that domain. This server maintains all the data corresponding to its domain. Each domain should have at least two master servers, a primary master and some secondary masters to provide backup service if the primary is unavailable or overloaded. A server may be a master for multiple domains, being primary for some domains and secondary for others.

Primary

A **primary master server** is a server that loads its data from a file on disk. This server may also delegate authority to other servers in its domain.

Secondary

A **secondary master server** is a server that is delegated authority and receives its data for a domain from a primary master server. At boot time, the secondary server requests all the data for the given zone from the primary master server. This server then periodically checks with the primary server to see if it needs to update its data.

Caching-only server

All servers are caching servers. This means that the server caches the information that it receives for use until the data expires. A **caching-only server** is a server that is not authoritative for any domain. This server services queries and asks other servers, who have the authority, for the information needed. All servers keep data in their cache until the data expires, based on a time to live field attached to the data when it is received from another server.

Remote server

A **remote server** is an option given to people who would like to use a name server on their workstation or on a machine that has a limited amount of memory and CPU cycles. With this option you can run all of the networking programs that use the name server without the name server running on the local machine. All of the queries are serviced by a name server that is running on another machine on the network.

Slave server

A **slave server** is a server that always forwards queries it cannot satisfy locally to a fixed list of forwarding servers instead of interacting with the master name servers for the root and other domains. The queries to the forwarding servers are recursive queries. There may be one or more forwarding servers, and they are tried in turn until the list is exhausted. A slave and forwarder configuration is typically used when you do not wish all the servers at a given site to be interacting with the rest of the Internet servers. A typical scenario would involve a number of workstations and a departmental time-sharing machine with Internet access. The workstations might be administratively prohibited from having Internet access. To give the workstations the appearance of access to the Internet domain system, the workstations could be slave servers to the time-sharing machine, which would forward the queries and interact with other name servers to resolve the query before returning the answer. An added benefit of using the forwarding feature is that the central machine develops a much more complete cache of information that all the workstations can take advantage of. The use of slave mode and forwarding is discussed further under the description of the named boot file commands.

Setting up your own domain

When setting up a domain that is going to be on a public network, the site administrator should contact the organization in charge of the network and request the appropriate domain registration form. An organization that belongs to multiple networks (such as CSNET, DARPA Internet, and BITNET) should register with only one network.

The contacts are as follows:

DARPA Internet

Sites that are already on the DARPA Internet and need information on setting up a domain should contact `HOSTMASTER@SRI-NIC.ARPA`.You may also want to be placed on the BIND mailing list, which is a mail group for people on the DARPA Internet running BIND. The group discusses future design decisions, operational problems, and other related topics. The address to request being placed on this mailing list is:

`bind-request@ucbarpa.Berkeley.EDU.`

CSNET

A CSNET member organization that has not registered its domain name should contact the CSNET Coordination and Information Center (CIC) for an application and information about setting up a domain.

An organization that already has a registered domain name should keep the CIC informed about how it would like its mail routed. In general the CSNET relay will prefer to send mail via CSNET (as opposed to BITNET or the Internet) if possible. For an organization on multiple networks this may not always be the preferred behavior. The CIC can be reached via electronic mail at `cic@sh.cs.net`, or by phone at (617) 497-2777.

BITNET

If you are on the BITNET and need to set up a domain, contact `INFO@BITNIC`.

Files

The name server uses several files to load its database. This section covers the files and their formats needed for `named`.

Boot file

The boot file is the file that is first read when `named` starts up. This tells the server what type of server it is, which zones it has authority over, and where to get its initial data. The default location for this file is `/etc/named.boot`. However, this can be changed by setting the `BOOTFILE` variable when you compile `named` or by specifying the location on the command line when `named` is started up.

Domain

A default domain may be specified for the name server using a line such as

```
domain        Berkeley-EDU
```

The name server uses this information when it receives a query for a name without a "." that is not known. When it receives one of these queries, it appends the name in the second field to the query name. This is an obsolete facility which will be removed from future releases.

Directory

The directory line specifies the directory in which the name server should run, allowing the other file names in the boot file to use relative pathnames.

```
directory   usr/local/domain
```

If you have more than a couple of named files to be maintained, you may wish to place the named files in a directory such as `/usr/local/domain` and adjust the directory command properly. The main purposes of this command are to make sure `named` is in the proper directory when trying to include files by relative pathnames with `$INCLUDE` and to allow `named` to run in a location that is reasonable to dump core if it feels the urge.

Primary master

The line in the boot file that designates the server as a primary server for a zone looks as follows:

```
primary      Berkeley-EDU ucbhosts
```

The first field specifies that the server is a primary one for the zone stated in the second field. The third field is the name of the file from which the data is read.

Secondary master

The line for a secondary server is similar to the primary except that it lists addresses of other servers (usually primary servers) from which the zone data will be obtained.

```
secondary   Berkeley-EDU      128320101283204 ucbhosts.bak
```

The first field specifies that the server is a secondary master server for the zone stated in the second field. The two network addresses specify the name servers that are primary for the zone. The secondary server gets its data across the network from the listed servers. Each server is tried in the order listed until it successfully receives the data from a listed server. If a filename is present after the list of primary servers, data for the zone will be dumped into that file as a backup. When the server is first started, the data is loaded from the backup file if possible, and a primary server is then consulted to check that the zone is still up-to-date.

Caching-only server

You do not need a special line to designate that a server is a caching server. What denotes a caching-only server is the absence of authority lines, such as `secondary` or `primary` in the boot file.

All servers should have a line as follows in the boot file to prime the name server, `cache`:

```
cache        root-cache
```

All cache files listed will be read in at `named` boot time, any values still valid will be reinstated in the cache, and the root name server information in the cache files will always be used. For information on cache files see the section, "Cache Initialization."

Forwarders

Any server can make use of a forwarder. A **forwarder** is another server capable of processing recursive queries that is willing to try resolving queries on behalf of other systems. The `forwarders` command specifies forwarders by Internet address as follows:

```
forwarders        128320101283204
```

There are two main reasons for wanting to do so. First, the other systems may not have full network access and may be prevented from sending any IP packets into the rest of the network and therefore must rely on a forwarder that does have access to the full net. The second reason is that the forwarder sees a union of all queries as they pass through his server and therefore he builds up a very rich cache of data compared to the cache in a typical workstation name server. In effect the forwarder becomes a metacache that all hosts can benefit from, thereby reducing the total number of queries from that site to the rest of the net.

Slave mode

Slave mode is used if the use of forwarders is the only possible way to resolve queries due to the lack of full net access or to prevent the name server from using other than the listed forwarders. Slave mode is activated by placing the simple command

```
slave
```

in the boot file. If `slave` is used, then you must specify `forwarders`. When in slave mode the server will forward each query to each of the the forwarders until an answer is found or the list of forwarders is exhausted.

Remote server

To set up a host that will use a remote server instead of a local server to answer queries, the file `/etc/resolv.conf` needs to be created. This file designates the name servers on the network that should be sent queries. It is not advisable to create this file if you have a local server running. If this file exists, it is read almost every time `gethostbyname()` or `gethostbyaddr()` is called.

Cache initialization

`root.cache`

The name server needs to know the servers that are the authoritative name servers for the root domain of the network. To do this we have to prime the name server s cache with the addresses of these higher authorities. The location of this file is specified in the boot file. This file uses the Standard Resource Record Format (aka. Masterfile Format) covered later in this appendix.

Domain data files

There are three standard files for specifying the data for a domain. These are `named.local`, `hosts`, and `host.rev`. These files use the Standard Resource Record Format covered later in this appendix.

`named.local`

This file specifies the address for the local loopback interface, better known as `localhost` with the network address `127.0.0.1`. The location of this file is specified in the boot file.

`hosts`

This file contains all the data about the machines in this zone. The location of this file is specified in the boot file.

hosts.rev

This file specifies the IN-ADDR.ARPA domain. This is a special domain for allowing address-to-name mapping. As internet host addresses do not fall within domain boundaries, this special domain was formed to allow inverse mapping. The IN-ADDR.ARPA domain has four labels preceding it. These labels correspond to the four octets of an Internet address. All four octets must be specified even if an octet is zero. The Internet address `128.32.0.4` is located in the domain 4.0.32.128.IN-ADDR.ARPA. This reversal of the address is awkward to read but allows for the natural grouping of hosts in a network.

Standard Resource Record Format

The records in the name server data files are called resource records. The Standard Resource Record Format (RR) is specified in RFC882 and RFC973. The following is a general description of these records:

```
{name}    {ttl} addr-class  Record Type   Record Specific data
```

Resource records have a standard format shown above. The first field is always the name of the domain record, and it must always start in column 1. For some RR s the name may be left blank; in that case it takes on the name of the previous RR. The second field is an optional time-to-live field. This specifies how long this data will be stored in the database. By leaving this field blank the default time to live is specified in the Start Of Authority resource record (see below). The third field is the address class; there are currently two classes: `IN` for Internet addresses and `ANY` for all address classes. The fourth field states the type of the resource record. The fields after that are dependent on the type of the RR. Case is preserved in names and data fields when loaded into the name server. All comparisons and lookups in the name server database are case insensitive.

The following characters have special meanings:

.	A free-standing dot in the name field refers to the current domain.
@	A free-standing @ in the name field denotes the current origin.
..	Two free-standing dots represent the null domain name of the root when used in the name field.

\\X Where X is any character other than a digit (0-9), quotes that character so that its special meaning does not apply. For example, "\\" can be used to place a dot character in a label.

\\DDD Where each D is a digit, is the octet corresponding to the decimal number described by DDD. The resulting octet is assumed to be text and is not checked for special meaning.

( ) Parentheses are used to group data that crosses a line. In effect, line terminations are not recognized within parentheses.

; Semicolon starts a comment; the remainder of the line is ignored.

* An asterisk signifies wildcarding.

Most resource records will have the current origin appended to names if they are not terminated by a period (.). This is useful for appending the current domain name to the data, such as machine names, but may cause problems where you do not want this to happen. A good rule of thumb is that if the name is not in the domain for which you are creating the data file, end the name with a period (.).

$INCLUDE

An include line begins with `$INCLUDE`, starting in column 1, and is followed by a filename. This feature is particularly useful for separating different types of data into multiple files. An example would be:

```
$INCLUDE /usr/named/data/mailboxs
```

The line would be interpreted as a request to load the file `/usr/named/data/mailboxes`. The `$INCLUDE` command does not cause data to be loaded into a different zone or tree. This is simply a way to allow data for a given zone to be organized in separate files. For example, mailbox data might be kept separately from host data, using this mechanism.

$ORIGIN

The origin is a way of changing the origin in a data file. The line starts in column 1, and is followed by a domain origin. This is useful for putting more than one domain in a data file.

SOA: Start of authority

```
name  (ttl)  addr-class  SOA        Origin                  Person in charge
@            IN          SOA        ucbvax.Berkeley.Edu     kjd.ucbvax.Berkeley.Edu. (
                         1.1        ; Serial
                         3600       ; Refresh
                         300        ; Retry
                         3600000    ; Expire
                         3600 )     ; Minimum
```

The start of authority, SOA, record designates the start of a zone. The name is the name of the zone. Origin is the name of the host on which this data file resides. Person in charge is the mailing address for the person responsible for the name server. The serial number is the version number of this data file; this number should be incremented whenever a change is made to the data. The name server cannot handle numbers over 9999 after the decimal point. The refresh indicates how often, in seconds, a secondary name server is to check with the primary name server to see if an update is needed. The retry indicates how long, in seconds, a secondary server is to retry after a failure to check for a refresh. Expire is the upper limit, in seconds, that a secondary name server is to use the data before it expires for lack of getting a refresh. Minimum is the default number of seconds to be used for the time to live field on resource records. There should only be one SOA record per zone.

NS: Name server

```
{name}  {ttl}  addr-class  NS  Name servers name
               IN          NS  ucbarpa.Berkeley.Edu.
```

The name server record, NS, lists a name server responsible for a given domain. The first name field lists the domain that is serviced by the listed name server. There should be one NS record for each primary master server for the domain.

A: Address

```
{name}   {ttl}  addr-class  A  address
ucbarpa         IN          A  128.32.0.4
                IN          A  10.0.0.78
```

The address record, A, lists the address for a given machine. The name field is the machine name, and the address is the network address. There should be one A record for each address of the machine.

HINFO: Host information

{name}	*{ttl}*	*addr-class*	*HINFO*	*Hardware*	*OS*
	ANY	HINFO	VAX-11/780	UNIX	

The host information resource record, `HINFO`, is for host-specific data. This lists the hardware and operating system that are running at the listed host. It should be noted that only a single space separates the hardware info and the operating system info. If you want to include a space in the machine name you must quote the name. Host information is not specific to any address class, so `ANY` may be used for the address class. There should be one `HINFO` record for each host.

WKS: Well-known services

{name}	*{ttl}*	*addr-class*	*WKS*	*address*	*protocol*	*list of services*
		IN	WKS	128.32.0.10	UDP	who route timed domain
		IN	WKS	128.32.0.10	TCP	echo telnet discard sunrpc sftp uucp-path systat daytime netstat qotd nntp link chargen ftp auth time whois mtp pop rje finger smtp supdup hostnames domain name server

The well-known services record, `WKS`, describes the well-known services supported by a particular protocol at a specified address. The list of services and port numbers comes from the list of services specified in `/etc/services`. There should be only one `WKS` record per protocol per address.

CNAME: Canonical name

aliases	*{ttl}*	*addr-class*	*CNAME*	*Canonical name*
ucbmonet		IN	CNAME	monet

The canonical name resource record, `CNAME`, specifies an alias for a canonical name. An alias should be the only record associated with the alias name; all other resource records should be associated with the canonical name and not with the alias. Any resource records that include a domain name as their value (for instance, NS or MX) should list the canonical name, not the alias.

PTR: Domain name pointer

name	*{ttl}*	*addr-class*	*PTR*	*real name*
`7.0`		`IN`	`PTR`	`monet.Berkeley.Edu.`

A domain name pointer record, `PTR`, allows special names to point to some other location in the domain. The above example of a `PTR` record is used in setting up reverse pointers for the special `IN-ADDR.ARPA` domain. This line is from the example `hosts.rev` file. `PTR` names should be unique to the zone.

MB: Mailbox

name	*{ttl}*	*addr-class*	*MB*	*Machine*
`miriam`		`IN`	`MB`	`vineyd.DEC.COM.`

`MB` is the mailbox record. This lists the machine where a user wants to receive mail. The name field is the users login; the machine field denotes the machine to which mail is to be delivered. Mailbox names should be unique to the zone.

MR: Mail rename name

Cname	*{ttl}*	*addr-class*	*MR*	*corresponding MB*
`Postmistress`		`IN`	`MR`	`miriam`

The mail rename records, `MR`, can be used to list aliases for a user. The name field lists the alias for the name listed in the fourth field, which should have a corresponding `MB` record.

MINFO: Mailbox information

Cname	*{ttl}*	*addr-class*	*MINFO*	*requests*	*maintainer*
`BIND`		`IN`	`MINFO`	`BIND-REQUEST`	`kjd.Berkeley.Edu.`

The mail information record, `MINFO`, creates a mail group for a mailing list. This resource record is usually associated with a mail group `mail group`, but may be used with a `mail box` record. The `name` specifies the name of the mailbox. The `xrequests` field is where mail such as requests to be added to a mail group should be sent. The `maintainer` is a mailbox that should receive error messages. This is particularly appropriate for mailing lists when errors in members names should be reported to a person other than the sender.

MG: Mail group member

{mail group name}	*{ttl}*	*addr-class*	*MG*	*member name*
		IN	MG	Bloom

The mail group record, MG, lists members of a mail group. An example for setting up a mailing list is as follows:

Bind	*IN*	*MINFO*	*Bind-Request*	*kjd.Berkeley.Edu.*
	IN	MG	Ralph.Berkeley.Edu.	
	IN	MG	Zhou.Berkeley.Edu.	
	IN	MG	Painter.Berkeley.Edu.	
	IN	MG	Riggle.Berkeley.Edu.	
	IN	MG	Terry.pa.Xerox.Com..	

MX: Mail exchanger

name	*{ttl}*	*addr-class*	*MX*	*preference value*	*mailer exchanger*
Munnari.OZ.AU.		IN	MX	0	Seismo.CSS.GOV.
*.IL.		IN	MX	0	RELAY.CS.NET.

Mail exchanger records, MX, are used to specify a machine that knows how to deliver mail to a machine that is not directly connected to the network. In the first example above `Seismo.CSS.GOV.` is a mail gateway that knows how to deliver mail to `Munnari.OZ.AU.`, but other machines on the network cannot deliver mail directly to Munnari. These two machines may have a private connection or use a different transport medium. The preference value is the order that a mailer should follow when there is more then one way to deliver mail to a single machine. See RFC974 for more detailed information.

Wildcard names containing the character * may be used for mail routing with MX records. There are likely to be servers on the network that simply state that any mail to a domain is to be routed through a relay. In the second example above all mail to hosts in the domain IL is routed through `RELAY.CS.NET`. This is done by creating a wildcard resource record, which states that `*.IL` has an MX of `RELAY.CS.NET`.

Sample files

The following section contains sample files for the name server. This covers sample boot files for the different types of servers and sample domain database files.

Boot file

Primary master server

```
;
; Boot file for Primary Master Name Server
;

; type          domain                     source file or host
; directory     /usr/local/domain
primary         Berkeley.Edu               ucbhosts
primary         32.128.in-addr.arpa        ucbhosts.rev
primary         0.0.127.in-addr.arpa       named.local
cache           .                          root.cache
```

Secondary master server

```
;
; Boot file for Primary Master Name Server
;

; type     domain                 source file or host
;
directory /usr/local/domain
secondary Berkeley.Edu          128.32.0.4 128.32.0.10 ucbhosts.bak
secondary 32.128.in-addr.arpa   128.32.0.4 128.32.0.10 ucbhosts.rev.bak
primary   0.0.127.in-addr.arpa named.local
cache     .                     root.cache
```

Caching-only server

```
;
; Boot file for Caching-only Name Server
;

; type      domain                  source file or host
;
directory   /usr/local/domain
cache       .                       root.cache
primary     0.0.127.in-addr.arpa    /etc/named.local
```

```
/etc/resolv.conf

domain Berkeley.Edu
name server 128.32.0.4
name server 128.32.0.10
```

root.cache

```
;
;
; Initial cache data for root domain servers.
;
.                    99999999   IN   NS   SRI-NIC.ARPA.
                     99999999   IN   NS   NS.NASA.GOV.
                     99999999   IN   NS   TERP.UMD.EDU.
                     99999999   IN   NS   A.ISI.EDU.
                     99999999   IN   NS   BRL-AOS.ARPA.
                     99999999   IN   NS   GUNTER-ADAM.ARPA.
                     99999999   IN   NS   C.NYSER.NET.
; Prep the cache (hotwire the addresses).
SRI-NIC.ARPA.        99999999   IN   A    10.0.0.51
SRI-NIC.ARPA.        99999999   IN   A    26.0.0.73
NS.NASA.GOV.         99999999   IN   A    128.102.16.10
A.ISI.EDU.           99999999   IN   A    26.3.0.103
BRL-AOS.ARPA.        99999999   IN   A    128.20.1.2
BRL-AOS.ARPA.        99999999   IN   A    192.5.25.82
BRL-AOS.ARPA.        99999999   IN   A    192.5.22.82
GUNTER-ADAM.ARPA.    99999999   IN   A    26.1.0.13
C.NYSER.NET.         99999999   IN   A    128.213.5.17
TERP.UMD.EDU.        99999999   IN   A    10.1.0.17
```

named.local

```
@     IN    SOA    ucbvax.Berkeley.Edu. kjd.ucbvax.Berkeley.Edu. (
                   1          ; Serial
                   3600       ; Refresh
                   300        ; Retry
                   3600000    ; Expire
                   3600 )     ; Minimum
      IN    NS     ucbvax.Berkeley.Edu.
1     IN    PTR    localhost.
```

hosts

```
;
;               @(#)ucb-hosts  1.1   (berkeley)  86/02/05
;

@               IN    SOA    ucbvax.Berkeley.Edu. kjd.monet.Berkeley.Edu.
                             1.1      ; Serial
                             10800    ; Refresh
                             1800     ; Retry
                             3600000  ; Expire
                             86400    ; Minimum
                IN    NS     ucbarpa.Berkeley.Edu.
                IN    NS     ucbvax.Berkeley.Edu.
localhost       IN    A      127.1
ucbarpa         IN    A      128.32.4
                IN    A      10.0.0.78
                ANY   HINFO  VAX-11/780 UNIX
arpa            IN    CNAME  ucbarpa
ernie           IN    A      128.32.6
                ANY   HINFO  VAX-11/780 UNIX
ucbernie        IN    CNAME  ernie
monet           IN    A      128.32.7
                IN    A      128.32.130.6
                ANY   HINFO  VAX-11/750 UNIX
ucbmonet        IN    CNAME  monet
ucbvax          IN    A      10.2.0.78
                IN    A      128.32.10
                ANY   HINFO  VAX-11/750 UNIX
                IN    WKS    128.32.0.10 UDP syslog route timed domain
                IN    WKS    128.32.0.10 TCP ( echo telnet
                             discard sunrpc sftp
                             uucp-path systat daytime
                             netstat qotd nntp
                             link chargen ftp
                             auth time whois mtp
                             pop rje finger smtp
                             supdup hostnames
                             domain
                             name server )
vax             IN    CNAME  ucbvax
toybox          IN    A      128.32.131.119
                ANY   HINFO  Pro350 RT11
toybox          IN    MX     0 monet.Berkeley.Edu.
```

```
miriam          ANY   MB     vineyd.DEC.COM.
postmistress    ANY   MR     Miriam
Bind            ANY   MINFO  Bind-Request kjd.Berkeley.Edu.
                ANY   MG     Ralph.Berkeley.Edu.
                ANY   MG     Zhou.Berkeley.Edu.
                ANY   MG     Painter.Berkeley.Edu.
                ANY   MG     Riggle.Berkeley.Edu.
                ANY   MG     Terry.pa.Xerox.Com.
```

host.rev

```
;
;         @(#)ucb-hosts.rev      1.1 (Berkeley)  86/02/05
;

@         IN      SOA      .a+
                           1.1      ; Serial
                           10800    ; Refresh
                           1800     ; Retry
                           3600000  ; Expire
                           86400    ; Minimum
          IN      NS       ucbarpa.Berkeley.Edu.
          IN      NS       ucbvax.Berkeley.Edu.
4.0       IN      PTR      ucbarpa.Berkeley.Edu.
6.0       IN      PTR      ernie.Berkeley.Edu.
7.0       IN      PTR      monet.Berkeley.Edu.
10.0      IN      PTR      ucbvax.Berkeley.Edu.
6.130     IN      PTR      monet.Berkeley.Edu.
```

Domain management

This section contains information for starting, controlling, and debugging `named`.

/etc/rc.local

The host name should be set to the full domain style name in /etc/rc.local by using hostname(1). The following entry should be added to /etc/rc.local to start up named at system boot time:

```
if [ -f /etc/named ]; then
/etc/named [options] & echo -n ' named' >/dev/console
fi
```

This usually directly follows the lines that start syslogd. **Do not** attempt to run named from inetd. This will continuously restart the name server and defeat the purpose of having a cache.

/etc/named.pid

When named is successfully started up, it writes its process ID into the file /etc/named.pid. This is useful to programs that want to send signals to named. The name of this file may be changed by defining PIDFILE to the new name when compiling named.

/etc/hosts

The gethostbyname() library call can detect if named is running. If it is determined that named is not running it will look in /etc/hosts to resolve an address. This option was added to allow ifconfig(8C) to configure the machines local interfaces and to enable a system manager to access the network while the system is in single-user mode. It is advisable to put the local machine's interface addresses and a couple of machine names and address in /etc/hosts so the system manager can use rcp to copy files from another machine when the system is in single-user mode. The format of /etc/host has not changed. See hosts(5) for more information. Since the process of reading /etc/hosts is slow, it is not advised to use this option when the system is in multi-user mode.

Signals

There are several signals that can be sent to the `named` process to have it do tasks without restarting the process.

Reload

`SIGHUP` Causes `named` to read `named.boot` and reload the database. All previously cached data is lost. This is useful when you have made a change to a data file and you want the `named`'s internal database to reflect the change.

Debugging

When `named` is running incorrectly, look first in `/usr/adm/messages` and check for any messages logged by `syslog`. Next send it a signal to see what is happening.

`SIGINT` Dumps the current database and cache to `/usr/tmp/named_dump.db`. This should give you an indication to whether the database was loaded correctly. The name of the dump file may be changed by defining `DUMPFILE` to the new name when compiling `named`.

◆ *Note:* The following two signals only work when `named` is built with `DEBUG` defined.

`SIGUSR1` Turns on debugging. Each following USR1 increments the debug level. The output goes to `/usr/tmp/named.run`. The name of this debug file may be changed by defining `DEBUGFILE` to the new name before compiling `named`.

`SIGUSR2` Turns off debugging completely.

For more detailed debugging, define DEBUG when compiling the resolver routines into `/lib/libc.a`.

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Appendix C **The UUCP System**

This appendix discusses the UUCP system. The key points covered by this appendix are:

- The components of `UUCP`
- Setting up the `L-devices` and `L.sys` files
- Interactive file transfer
- Automatic file transfer
- Security and other tips

Introduction

One of the most important features of A/UX is its ability to transfer information among systems (and among other systems derived from UNIX). The standard communication package, called UUCP (for "UNIX to UNIX copy"), is the mechanism generally used for this function. The UUCP package permits mail, command execution, and file transfers among A/UX computers. These functions are useful whenever related pieces of information and/or users are located on separate computers. For example, mail can be used to communicate with other companies, file transfer can be used to copy programs directly from one computer to another, and remote command execution can be used to print documents on a remote computer that has an attached laser printer.

When two or more computers can communicate, the computers and the communication channels (for instance, telephone lines) between them are considered parts of a computer network. Each computer is a node in the network; the communication channels are network links. Communication between nodes can take place in one of two primary methods: interactive or automated. **Interactive communication** requires a user to log in to the remote system and issue commands to initiate command execution and file transfer. **Automated communication** requires some method by which the local computer can communicate with the remote computer(s) without user intervention.

This appendix describes the many commands, scripts, and spooling directories involved in UUCP and then introduces a step-by-step procedure for setting up UUCP to handle interactive logins and file transfer between UNIX nodes. Next the appendix describes the procedure for setting up mail to a remote UNIX node. It concludes with hints for modifying, expanding, and tightening the security of UUCP on your system.

The components of UUCP

This section discusses the user files and directories used in running UUCP and the system files and directories used in the administration of UUCP.

The files can be grouped in the following categories:

- binary: binary executable files used by UUCP
- script: shell scripts used as commands and for system maintenance
- system: system files also used by UUCP
- `uucp` system: files used by UUCP for system configuration
- statistical: files used by UUCP for storage of statistical information
- sequence: files used for storing sequential number information
- log: files used for logging information on requests and connections
- audit: files used for storing debugging information
- spool: files used to spool requests
- lock: files used to lock UUCP system files and prevent simultaneous updating or accessing
- status: files used to store status of connections to specific systems
- temporary: files used for temporary storage of information
- backup: files used for keeping backups of recent log files

After a discussion of the directories involved, this section focuses on each of these categories and the files that constitute them.

Directories

The following directories are used exclusively by `uucp`.

`/usr/lib/uucp`

Used for storage of UUCP system files that are not temporary. This includes script files run by `cron` and executable binary files that are forked by UUCP processes.

`/usr/spool/uucp`

Used for storage of UUCP files that are temporary. This includes log files and spool files.

`/usr/spool/uucp/.XQTDIR`

Used by `uuxqt` for temporary storage of files used in remote command execution by `uux`.

`/usr/spool/uucppublic`

Reserved for public use when files are sent from one system to another. This directory grants read, write, and execute permission to every user of the system (and for this reason is said to be for public use). All files that are to be sent to the computer should be sent to this directory. Some subdirectories are used for specific purposes.

`/usr/spool/uucppublic/`*user*

Where *user* is a specific user name, used by the system to place files that could not otherwise be transferred because of permission problems.

`/usr/spool/uucppublic/receive`

Along with all of its subdirectories, used exclusively by the programs `uuto` and `uupick`.

`/usr/spool/uucppublic/receive/`*user*

Where *user* is a known user on the system, used to build directories for files from other systems sent by `uuto`.

`/usr/spool/uucppublic/receive/`*user/system*

Where *user* is a known user on the computer and *system* is a remote computer, used to store files sent from *system* to *user* with `uuto`. This is the directory where `uupick` will find files.

Executable files

The following files are the binary executable files used by UUCP for common usage and administration.

`/usr/bin/uucp`

Used to copy files from system to system. Forwarding may be allowed through intermediate nodes. See `uucp`(1C).

`/usr/bin/uulog`
: May be used as a user command or a system maintenance command. As a user command it presents logged information about `uucp` or `uux` requests by either system name or user name. As a maintenance command it appends any temporary log files to the permanent log file. See `uucp`(1C).

`/usr/bin/uuname`
: Used to output either the local node name or a list of the node names of all computers with which the system can communicate. See `uucp`(1C).

`/usr/bin/uustat`
: May be used to display the status of uucp jobs or connections and can be used to cancel certain jobs. See `uustat`(1C).

`/usr/bin/uusub`
: May be used as a user command or a system maintenance command. As a user command, it displays the statistics on `uucp` connections or traffic. As a maintenance command, it flushes the statistics files, adds new systems for statistics gathering, or calls other systems. See `uusub`(1M).

`/usr/bin/uux`
: Execute commands on a remote system and takes care of transferring all files necessary for the command. See `uux`(1C).

`/usr/lib/uucp/uucico`
: Forked by `uucp` or `uux` to call other systems and do all the work. It may be called directly from shell scripts started by `cron` to scan for work needing to be done. It is also executed directly when a remote system logs in.

`/usr/lib/uucp/uuclean`
: Usually called from shell scripts started by `cron` to remove old files from `uucp` directories. See `uuclean`(1M).

`/usr/lib/uucp/uuxqt`
: Forked by `uux` or `uucico` to execute the scripts that `uux` sets up to perform remote command execution.

Script files

The following are script files used as normal commands and files used for system maintenance.

`/usr/bin/uupick`
: Used to pick up files that have been sent to a user from another system via `uuto`. The appropriate public subdirectories are searched, and the user may accept or reject files for copying to another directory. See `uuto`(1C).

`/usr/bin/uuto`
: Used to send files or entire directories via `uucp` to a user on another system. In the case of directories entire subtrees are sent by calling `uucp` repeatedly. See `uuto`(1C).

`/usr/lib/uucp/uushell`
: Used to set the time zone environment variable before executing `uucico`. This will cause log file entries to show the correct time for remotely initiated requests and connections. It should be the login shell for all `uucp` connections.

`/usr/lib/uucp/uudemon.day`
: Started by `cron` every night to perform UUCP maintenance. It is normally used to remove old files from UUCP directories and trim status and statistics files, that is, to eliminate old entries and thus prevent the files from growing too large.

`/usr/lib/uucp/uudemon.hr`
: Started by `cron` every hour to perform UUCP maintenance. It is normally used to append temporary log files to permanent log files and to check for spooled work.

`/usr/lib/uucp/uudemon.wk`
: Started by `cron` every week to perform `uucp` maintenance. It is normally used to store week-old log files and remove two-week-old log files.

The descriptions of the `uudemon` scripts are intended to demonstrate their typical uses. You decide when each of these scripts actually runs via its respective `crontab` entry. You can easily change what these scripts actually do by editing the script files.

A/UX system files

The following system files are used by UUCP.

`/etc/group` Keeps track of group IDs for user names. UUCP uses these user names to allow remote systems to log in.

`/etc/inittab` Generates `gettys` for ports. These `gettys` must be enabled for dialin ports and disabled for dialout ports. See "Dialin and Dialout Ports," later in this appendix.

`/etc/passwd` Keeps track of user names and passwords. UUCP uses these to allow remote systems to log in and transfer files. Both the home directory and the login shell are specified for each user name.

`/usr/spool/cron/crontabs/uucp`
Tells the `cron` process when to schedule the execution of programs. UUCP uses this to schedule hourly, daily, and weekly shell scripts to perform maintenance.

UUCP system files

UUCP uses the following system files for configuration.

`/usr/lib/uucp/ADMIN`
Stores additional information about each system that appears in the `L.sys` file. You can display this description along with the system names by using the command `uuname -v`.

`/usr/lib/uucp/FWDFILE`
Stores a list of system names to which files can be forwarded. These are a subset of the `L.sys` system names and do not restrict the final destination, just the next system in the path. Each line in this file takes the form

system[,*user*,*user*]

where *system* is the name of a system to which a communication can be forwarded, and the optional list of *users* separated by commas represents the login names of users in the system to which the communication can be forwarded.

`/usr/lib/uucp/L-devices`

Stores the names of the ports that are connected to modems or directly to other systems. The file contains the attributes, such as baud rate, of each of these ports. Each line in this file takes the form

type line device speed [*protocol*]

where

type	can be either `DIR`, indicating that the line is directly connected to another system (including modem connections), or `ACU`, indicating that the line uses an automatic calling unit
line	is the device name of the line (for instance `tty0` if the modem is connected to port `/dev/tty0`)
device	is the device name of the `ACU` if one is specified in the *type* field (or a placeholder [`0`])
speed	is the line speed for the connection, as measured in baud
protocol	is an optional field that needs to be filled only if the connection is for a protocol other than the default protocol

A typical entry in the `L-devices` file is:

```
DIR tty0 0 1200
```

`/usr/lib/uucp/L-dialcodes`

Stores dial-code abbreviations for `L.sys`. Each abbreviation is associated with a dial sequence of numbers (typically an area code). Each line in this file takes the form

abbreviation dialing-sequence

where *abbreviation* stands for an arbitrary abbreviation of an area code or telephone exchange number, and *dialing-sequence* stands for the telephone number that should be dialed after the abbreviation.

A typical entry in this file is

```
sfba 415
```

The abbreviation `sfba` stands for San Francisco Bay Area; `415` is the area code.

`/usr/lib/uucp/L.cmds`

Stores a list of command names that `uux` is permitted to execute. If a command name (including `rmail`) is not listed in this file, it cannot be used for remote execution. Each line in this file takes the form

cmd

where *cmd* is the name of any command you want `uux` to be able to execute in your system.

`/usr/lib/uucp/L.sys`

Stores information on connecting to remote systems. Each line represents a way to connect to another system. If more than one line exists for a particular system, the file tries each line sequentially until it makes a connection. Each line in this file takes the form

system time device class phone login

where

system	is the name of the remote system
time	is the time(s) at which that system can be called
device	is either the name of the port (if it is a `DIR` connection) or the keyword `ACU`
class	is the speed of the connection in baud
phone	is the phone number to be called, expressed either in an all-numeric sequence or as an alphabetic abbreviation, and specified in a corresponding line in the `L-dialcodes` file
login	is an *expect-send-expect* sequence as specified in "Automatic File Transfer," later in this appendix

A typical entry in this file is

```
doosy Any tty0 1200 tty0 "" ATDTsfba5551212^M
ogin:-@-ogin:-EOT-ogin:-BREAK-ogin:U_mickeyssword:mouse
```

`/usr/lib/uucp/ORIGFILE`

Stores a list of system names and users from which files can be forwarded. Each entry refers to the system that was the originator of the request and not the most recent system in the path. Each line in this file takes the form

system[,*user*,*user*]

where *system* is the name of a system whose communication the system is willing to forward, and the optional list of *users* separated by commas represents the login names of users in that system whose communication can be forwarded. Note that *system* represents the name of the system that originated the communication, not the name of the last system that forwarded the communication.

`/usr/lib/uucp/USERFILE`

Stores access permissions. These include pathname prefixes that are accessible by local users and remote systems. Remote system login names must appear here with an optional call-back facility. Each line in this file takes the form

[*login*],*system* [c] *path* [*path*]

where *login* is the login name of a user or a remote computer; *system* is the system name of a remote computer; `c` is an optional flag that, as a security measure, requires that the remote computer be called back before any further communication takes place; and *path* is a pathname prefix constraining file access to only those files preceded by the prefix. If the *login* field is empty (a null login), any user can access the specified path.

For an example, the lines

```
root, /
, /usr/spool/uucppublic
```

permit any user at any remote computer to transfer any files from `/usr/spool/uucppublic`, but only a user with the login name of `root` can transfer any file, because all filenames ultimately begin with /.

Statistical files

UUCP uses the following files to store status and statistical information:

`/usr/lib/uucp/L_stat`
: Stores the latest connection status of each remote system. You can display this information by entering the `uustat` command.

`/usr/lib/uucp/L_sub`
: Stores connection statistics for each remote system. You can display this information by entering the `uusub` command.

`/usr/lib/uucp/R_stat`
: Stores the status of each `uucp` request. You can display this information by entering the `uustat` command.

`/usr/lib/uucp/R_sub`
: Stores traffic statistics for each remote system. You can display this information by entering the `uusub` command.

Sequence files

UUCP uses the following files for storing sequence information:

`/usr/lib/uucp/SEQF`
: Stores the sequence number, which is incremented by one for each `uucp` request. This is a four-digit number used in generating the names of the spooled files.

`/usr/lib/uucp/SQFILE`
: Stores a conversation count for remote systems. These systems will be a subset of the systems in `L.sys`. The remote system must also have an entry for your system in its `SQFILE`. If a connection is made but the counts in the two files do not agree, the login attempt fails.

`/usr/lib/uucp/SQTMP`
: Temporarily stores the `SQFILE` used by `uucico`.

Log files

UUCP uses the following files for logging information on UUCP requests and connections.

`/usr/spool/uucp/ERRLOG`
: Logs `uucp` errors generated when `uucico` fails on a file transfer. If you use the `-x` option with `uucico`, the errors do not appear in this file.

`/usr/spool/uucp/LOGDEL`
: Logs files that have been removed. It is used by `uuclean`.

`/usr/spool/uucp/LOGFILE`
: Logs the status of calls and `uucp` requests. During execution of `uucp` requests, log information is normally appended to the file. If more than one `uucp` process is active at a time, the information is logged to temporary files. You can use the `uulog` command to display portions of this file and to append temporary versions to it.

`/usr/spool/uucp/SYSLOG`
: Logs the number of bytes sent and received during each connection and the duration of the connection in seconds.

Audit files

UUCP uses the following files to store debugging information:

`/usr/spool/uucp/AUDIT`
: Stores debugging information from the remote `uucico` process. It is created every time `uucico` is run as a login shell.

`/usr/spool/uucp/AUDIT.`*system*
: Where *system* is the name of a remote computer, stores debugging information when the remote computer calls with `uucico` and the `-x` option.

Spool files

UUCP uses the following files to spool requests for work to be done:

`/usr/spool/uucp/C.`*systemxxdddd*
: Stores information for `uucico` on which system to connect and which source and destination filename to transfer. It is created whenever `uucp` or `uux` is executed.

`/usr/spool/uucp/D.`*systemxxdddd*
: Stores data files for transfer. This file is created when you use the `-c` option with `uucp`.

`/usr/spool/uucp/X.`*systemxxdddd*
: Stores information used to execute remote commands. This file is created prior to running `uuxqt`, which reads it.

In these filenames *system* is the name of the remote computer, *xx* are two ASCII characters representing the priority of the work, and *dddd* is the sequence number from `SEQF`.

Lock files

UUCP uses the following as lock files to prevent simultaneous update of UUCP system files.

`/usr/spool/uucp/LCK..`*system*
: Where *system* is the name of a remote computer, prevents more than one simultaneous connection to that computer. The two dots (`..`) in the name are an integral part of the filename.

`/usr/spool/uucp/LCK..`*ttynn*
: Where *ttynn* is the name of a port used for dialout or direct connection, prevents more than one `uucico` process from using the port at the same time. The two dots (`..`) in the name are an integral part of the filename.

`/usr/spool/uucp/LCK.LOG`
: Prevents simultaneous update of the log files.

/usr/spool/uucp/LCK.LSTAT
: Prevents simultaneous update of L_stat.

/usr/spool/uucp/LCK.LSUB
: Prevents simultaneous update of L_sub.

/usr/spool/uucp/LCK.RSTAT
: Prevents simultaneous update of R_stat.

/usr/spool/uucp/LCK.RSUB
: Prevents simultaneous update of R_sub.

/usr/spool/uucp/LCK.SQ
: Prevents simultaneous update of SQFILE.

/usr/spool/uucp/LCK.SEQL
: Prevents simultaneous update of SEQF.

/usr/spool/uucp/LCK.XQT
: Prevents simultaneous remote command execution by uuxqt (see "Executable Files," earlier in this appendix).

Status files

UUCP uses the following file to store the status of connections to specific systems.

/usr/spool/uucp/STST.*system*
: Where *system* is the name of a remote computer, used to store the status of a connection that fails.

Temporary files

UUCP uses the following files for temporary storage.

`/usr/spool/uucp/LTMP.`*pid*

Stores `LOGFILE` entries temporarily when more than one `uucp` process is executing; *pid* is the process ID. Use the `uulog` command to append these files to `LOGFILE`.

`/usr/spool/uucp/TM.`*pid.ddd*

Temporarily stores these data files until the transfer is complete; *pid* is the process ID, and *ddd* is the number of this file in the current transfer. If the transfer is successful, the file is moved to the correct destination; otherwise, it is removed.

Backup files

UUCP maintenance scripts create the following files to keep backups of recent log files.

`/usr/spool/uucp/Log-WEEK`

Stores `LOGFILE` entries for the current week to date. The shell script `uudemon.day` appends the current `LOGFILE` to `Log-WEEK` every night.

`/usr/spool/uucp/o.Log-WEEK`

Stores the `LOGFILE` entries for the entire previous week. Between `Log-WEEK` and `o.Log-WEEK`, the system will have a backup of one to two weeks of `LOGFILE` entries.

`/usr/spool/uucp/o.SYSLOG`

Stores the `SYSLOG` entries for the entire previous week.

Setting up the `L-devices` and `L.sys` files

You will become familiar with many files as you work with the UUCP system. Two are of particular importance because they affect both interactive and automated file transfers.

The `/usr/lib/uucp/L-devices` file

The `L-devices` file contains information about what devices the computer can use to communicate with the outside world (modem, automatic calling unit, and so on). If you already have a modem on your system, the file should contain information about what port it is attached to. If you don't have a modem attached, you will have to attach one to communicate with other computers. See "Dialin and Dialout Ports," later in this appendix, for a review of how to attach a modem. Each line in the `L-devices` file has the form

type line device speed [*protocol*]

where

type can be either DIR, indicating that the line is directly connected to another system (including modem connections), or ACU, indicating that the line uses an automatic calling unit

line is the device name of the line (such as `tty0` if the modem is connected to port `/dev/tty0`)

device is the device name of the ACU if one is specified in the *type* field (or a placeholder `[0]`)

speed is the line speed for the connection measured in baud

protocol is an optional field that needs to be filled only if the connection is for a protocol other than the default protocol

Consider this entry from an `L-devices` file:

```
DIR tty0 0 1200
```

`tty0` is the name of the port to which the modem is attached. If your modem is attached to another port, substitute its name for `tty0`.

`1200` is the speed, in baud, at which the modem will communicate. If you have a 300/1200 selectable modem, put the two lines

```
DIR tty0 0 1200
DIR tty0 0 300
```

in your `L-devices` file.

The `/usr/lib/uucp/L.sys` file

The `L.sys` file contains information that your system uses to call other computers.

◆ *Note:* The `L.sys` file contains information vital to the security of your neighboring UUCP sites. Keep its permissions closed to reading by unauthorized parties.

A typical `L.sys` file entry is:

```
doosy Any tty0 1200 tty01 "" ATDT5551212^M\ ogin:-@-ogin:-EOT-
ogin:-BREAK-ogin:U_mickey ssword:mouse
```

In this entry `doosy` is the name of the system this entry allows you to call. Every system has a name that identifies it.

`Any` indicates that your system can call `doosy` at any time. You will find out how to restrict these times later. Once again, `tty0` is the port to which the modem is attached, and `1200` is the speed at which the modem will communicate. The second `tty` is a placeholder for a telephone number.

The rest of the line has the form
expect-send-expect-send

where *expect* is what your computer expects the other computer to transmit, and *send* is what your computer will transmit to the remote site. The `"  "` in the example is a null string that will expect nothing. `ATDT5551212^M` is sent to the modem, telling it to dial 555-1212. (This assumes that you are using a Hayes-compatible modem. For any other type, see the modem owner's manual for whatever command would cause the modem to dial the number.)

◆ *Note:* `^M` is CONTROL-M. It is not enough to press CONTROL-M. To enter `^M` into a file when using the `vi` editor, press CONTROL-V. Then press CONTROL-M. This tells the computer to send a carriage return. This is not the same as typing `^m` (caret-m) or UP ARROW-m.

The second *expect* field is then broken up into
expect-send-expect-send-expect-send-expect

In other words, the simplest form of *expect-send-expect-send* for the rest of the line would be `ogin: U_mickey ssword: mouse`. This tells `uucp` to expect a prompt ending with `ogin:`. When it gets the prompt, it sends `U_mickey`. Then it expects `ssword` and replies with `mouse`. The strings `ogin:` and `ssword:` are used because most computers send a string ending in either `Login:` or `login:` to each port. After you enter a login, most computers respond with either `Password` or `password`. Unfortunately, things are not so simple. For instance, this confusing expect string

```
ogin:-@-ogin:-EOT-ogin:-BREAK-ogin:
```

is of this form
expect-send-expect-send-expect-send-expect

It means this: expect `ogin:`; if that does not happen, wait (that's what the `@` means) and expect `ogin:`. If that does not happen, send `EOT`, and so on.

In the login `U_mickey` the `U_` is an ad hoc convention for `uucp` logins, but you need not adhere to it. This login name can be any name on which you and the remote system administrator agree, and it is often the name of the remote system.

While A/UX supports dialing on assorted modems via the `/etc/remote` and `/etc/phones` files, (see `remote`(4) and `phones`(4)), you may wish to dial an unsupported modem.

The following `L.sys` entry shows how to accomplish this with the Apple Personal Modem (APM):

```
foo Any tty0 1200 tty0 "" atdt1234567\r 1200 \r
ogin:-BREAK-ogin: Umine ssword: passwd4foo
```

◆ *Note:* Although these lines have been wrapped onto two lines here, they must appear on a single line in the `L.sys` file.

This entry means that you can call machine `foo` by using `tty0` at `1200` bits per second at any time. UUCP is to expect and send the strings in Table C-1.

■ **Table C-1** Expect-send strings for the Apple Personal Modem

Expect	Send	Comments
`" "`		Don't wait for anything.
	`atdt1234567\r`	Send APM command line.
`1200`		Wait for `CONNECT 1200`
	`\r`	Send a carriage return.
`ogin:-BREAK-ogin:`		Wait for ... login.
		Send a break, if necessary.
	`Ubar`	`foo` knows us as `Ubar`.
`ssword:`		Wait for password.
	`passwd4foo`	Send the password.

Interactive file transfer

At this point you can already start transferring files to and from another system, if the other system is set up so that you can log into it.

To dial out you must make sure that the modem port does not have a `getty` running on it, that is, that it is not working as an incoming modem. To do so establish your modem either as an outgoing modem only or as both a dialout and a dialin modem. To call up the other computer you can use the `cu` command (see Chapter 5, "Using `cu`," in the *A/UX Communications User's Guide*). You can, for instance, enter

`cu -l`*line* `dir`

where *line* is the name of the port to which the modem is attached and `dir` ensures that `cu` uses that line. In this case `cu` looks in the `L-devices` file for the appropriate speed at which to communicate. Once `cu` finds that speed, it informs you by printing the message

`Connected`

on the screen. This means that you are connected to the modem and can now instruct the modem to dial out. For instance, you can dial

```
ATDT5551212
```

if your modem is Hayes compatible. If the computer at the other end of the line is available and a connection can be established, the familiar login prompt will appear on your screen, and you will be able to log in to the other computer.

You can also call up the other system and specify the speed of the connection by entering

`cu -l`line `-s`speed

Once again `cu` looks in the `L-devices` file, this time to check that the requested *speed* for the requested *line* is available. If it is, the `Connected` message appears on your screen as before, and you can log in to the other computer.

You can also use `cu` without specifying either *line* or *speed*, but using *systemname* as found in the `L.sys` file. For instance,

```
cu doosy
```

calls the system `doosy` and goes through the login procedure specified in the `L.sys` file.

Once you are logged in, you can transfer files, one by one, from your local machine to your remote machine by entering

`~%put` *infile* [*outfile*]

where *infile* is the name of the file you are transferring and *outfile* is the name you want it to have in the remote computer. If you do not specify *outfile*, the file transferred will have the same name it has in the local computer.

You can also transfer files from the remote computer to your local one by entering

`~%take` *infile* [*outfile*]

This works exactly as `put` does, but in the reverse direction.

Although `cu` is the simplest method for file transfer between two computers, it has the disadvantage of not providing any error checking.

Automatic file transfer

The UUCP system also provides for an automatic file transfer capability between two computers. Files other than the `L-devices` and `L.sys` files have to be adjusted to permit this automatic transfer to operate properly. The remote computer must be set up to recognize your computer, login name, and password. To receive files from the remote computer, the local computer must also be able to recognize the remote one.

Preparing the systems

The system node name

You must decide on a node name for your system. This is the name other people will put in their `L.sys` file to allow them to call your computer. If you want to change the node name from the current host name for your system, use a text editor to open the `/etc/HOSTNAME` file and change the first field in that file to the new name. When you reboot your system, the new node name will be in effect.

Dialin and dialout ports

You need to modify the `/etc/inittab` file to enable `gettys` for dialin ports and disable them for dialout ports. Depending on your exact needs, you might need a range of differing `/etc/inittab` lines. The following covers most normal cases:

- **Outgoing calls only, at 9600 bits per second:**
  ```
  do:2:off:/etc/getty tty0 at_9600 # Port tty0
  ```
- **Incoming calls only, at 1200 bits per second:**
  ```
  du:2:respawn:/etc/getty tty0 tt_1200 # Port tty0
  ```
- **Calls in both directions, over an Apple Personal Modem.**
  ```
  do:2:wait:/etc/apm_getty tty0 # Set up port
  du:2:respawn:/etc/getty tty0 mo_1200 # Port tty0
  ```

This last case deals with the fact that the Apple Personal Modem (APM) powers up with answering disabled. The `apm_getty` program forces the modem into answering mode.

Generic uucp logins

Your system comes configured with two generic uucp logins:

```
uucp::5:5:UUCP admin:/usr/spool/uucppublic:/usr/lib/uucp/uushell
nuucp::5:5:UUCP admin:/usr/lib/uucp:nuucp:
```

◆ *Note:* Although the first login has been wrapped onto two lines here, it must appear as one long line in the /etc/passwd file.

Both of these uucp logins should be assigned passwords, and both have the same user and group IDs. See "The nuucp Login Environment" later in this appendix for more information.

The nuucp login is for administrative use; when you are working on uucp you should log in as nuucp. Your home directory will be /usr/lib/uucp, and the permissions will be the same as on the uucp login. See "The nuucp Login Environment," later in this appendix, for information on using this login.

The other generic uucp login is uucp. The startup program for this login is /usr/lib/uucp/uushell, a script that establishes the time zone (TZ) variable and calls the uucico program. The startup program for any uucp login except the administrative login nuucp should be uushell.

System-specific uucp logins

It is not a good idea to allow other systems to log in as nuucp. Instead you can set up a unique entry in /etc/passwd and USERFILE for each remote computer that will be calling your system. This allows you to control the access from each of these computers independently. For instance, if the password for one of these is disclosed inadvertently, you can change the password for that system's login and not have to inform the administrators of every computer with which your system connects. Likewise, if one computer calls at the wrong times or ties up the phone line, you can temporarily change the password to stop the problem until you can contact the administrator of the problem system.

The conventional name for a system-specific uucp account is U*xxx*, where *xxx* is the calling machine. For example, a typical set of entries in /etc/passwd might be

```
uucp:SkQs1q/3e1NMo:5:5:UUCP:/usr/spool/uucppublic:
/usr/lib/uucp/uushell
```

```
nuucp:GpBTy2Ls/upXk:5:5:UUCP admin:/usr/lib/uucp:
Ufoo:avxoVAFxOzBTU:uid:5:UUCP for Foo:
/usr/spool/uucppublic:/usr/lib/uucp/uushell
Ubar:4vpPMIds1ZpHk:uid:5:UUCP for Bar:
/usr/spool/uucppublic:/usr/lib/uucp/uushell
```

◆ *Note:* Although three of these sample entries have been wrapped onto two lines, they must all appear on one long line in `/etc/passwd`.

Each system-specific `uucp` account should have a unique UID and the same GID as the generic `uucp` login.

If you have separate entries in `/etc/passwd`, you must have separate entries in `USERFILE`. When a remote system logs in, `USERFILE` is searched for the user name from `/etc/passwd` that was used to log in. The system name in the same entry must either match the system name of the remote computer or be null. See "Controlling Logins and File System Access," later in this appendix.

Receiving mail and files

You now want to make sure that users on the `doosy` system can send mail or files to users on your system. It is assumed that at least one modem port is a dialin port, or that your one modem can serve as both dialout and dialin modem. All you have to do is add an entry in the `/etc/passwd` file on your own system for the system `doosy`. The entry should look like

```
Udoosy::uid:5:UUCP for Doosy:/usr/spool/uucppublic:
/usr/lib/uucp/uushell
```

◆ *Note:* Although this entry has been wrapped onto two lines, it must appear on one long line in `/etc/passwd`.

A machine that logs in as `Udoosy` will not get a normal shell but start up the `uucp` process directly with the program `uushell`, which in turn calls `/usr/lib/uucp/uucico` (UNIX-to-UNIX copy in copy out). Make sure that the user ID (*uid* in the example) is unique in the system and that the group ID is the same as the number in `/etc/group` in the entry for `uucp` (5 in the standard distribution).

Next you must assign a password for the user `Udoosy`. While logged in as the root user, enter

```
passwd Udoosy
```

(You will be asked to enter the password twice, as is usual for password changes.)

To give remote users access to parts of your file system you must modify `/usr/lib/uucp/USERFILE`. A conservative security measure is to force all files to be copied in and out of `/usr/spool/uucppublic`. Note that the permissions on `/usr/spool/uucppublic` must be left open to all users (`777`), for example,

```
drwxrwxrwx 2 uucp uucp 944 Sep 24 08:49 uucppublic
```

Adding the following line to this file will allow all users on the system `doosy` to send you files on `/usr/spool/uucppublic` and to use the mail facility:

```
Udoosy,doosy /usr/spool/uucppublic
```

You must add a specific entry to `/usr/lib/uucp/USERFILE` for each system that is to have `uucp` access to `/usr/spool/uucppublic` on your system. Before your system can send mail and files to the remote computer, you must follow the same procedure on that system to allow your system access permission. See "Controlling Logins and File System Access," later in this appendix for procedures that allow access to specific users or to other directories on your system.

Sending mail or files

To dial out you must make sure that the modem port does not have a `getty` running on it, that is, that it is not working as an incoming modem. To do this you must establish your modem either as an outgoing modem only or as both a dialout and a dialin modem.

Once the modem is able to dial out, you should be able to send mail to a user on the `doosy` system by using the syntax

`mail doosy!`*user*

(When you are using the C shell, a backslash (\) must precede the exclamation point.)

When sending files with the C shell, you can use the notation `~uucp` as shorthand for `/usr/spool/uucppublic`. For example, to send a file named `my.file` to the `uucppublic` directory on a system named `doosy`, a user would enter the following commands from the C shell:

```
cp ./my.file /usr/spool/uucppublic
cd /usr/spool/uucppublic; chmod ugo+r my.file
uucp my.file doosy\!~uucp
```

See "Controlling Logins and File System Access," later in this appendix for procedures that allow access to specific users or to other directories on your system.

Cleaning up

If mail is sent from your computer to `doosy` and from `doosy` to your computer, you must make sure that `uucp` cleans up after itself; that is, that log files do not grow to enormous lengths, and that work spooled but not executed within a certain time (such as a few days or a week), is purged from the spooler. Three shell scripts do this work:

```
/usr/lib/uucp/uudemon.hr
/usr/lib/uucp/uudemon.day
/usr/lib/uucp/uudemon.wk
```

The `/etc/cron` utility runs these scripts on a regular basis; see `cron`(1M). The `cron` utility starts when the system boots. It checks the file `/usr/spool/cron/crontabs/uucp` (which you must create) once every minute to see if it has changed; see `crontab`(1).

- **Create `/usr/spool/cron/crontabs/uucp` as follows:**

```
56 **** /bin/su uucp -c
   "/usr/lib/uucp/uudemon.hr > /dev/null"
0 4 *** /bin/su uucp -c
   "/usr/lib/uucp/uudemon.day > /dev/null"
30 5 ** 1 /bin/su uucp -c
   "/usr/lib/uucp/uudemon.wk > /dev/null"
```

  ◆ *Note:* Although output lines have been wrapped onto two lines here, each must appear as one long line on the screen.

If you no longer want to run uucp, this file must be removed or renamed.

If all has gone well, you now have a functioning remote mail system that cleans up after itself. Not only mail but also uucp and uux should work, because both these utilities use less of the uucp system than mail does. To confirm that everything is working, not just uucp and uux, establish a link with an actual computer. Send mail to a user on the other system, requesting that person to send you a reply. If you receive mail from the person on the remote system, everything is working properly.

If you do not receive a reply within a reasonable time, you should do a few things to find out where the problem lies. First test the modem connections between the two sites by using cu to call up the other system, and ask the other person to call your system with cu. If the cu connection is working properly, check whether the other person received your mail message and whether a response was actually sent. Finally you may have to go back through all the steps described in the preceeding subsections to check that everything was done properly.

Security and other tips

This section details the security features of uucp, some further administrative procedures, and the steps in debugging an improperly functioning UUCP link.

Controlling logins and file system access

If you have separate entries in /etc/passwd for each remote computer that will be calling your system (see "System-Specific uucp Logins," earlier), you must also have separate entries in /usr/spool/uucp/USERFILE. When a remote system logs in, USERFILE is searched for the user name from /etc/passwd that was used to log in. The system name in the same entry must either match the system name of the remote computer or be null. Null system names are not recommended.

An important security feature of `USERFILE` is its ability to restrict access to portions of the file system. For each line in `USERFILE` you can list directories for which remote systems will have access. Remote systems are then given access only to files in the listed directories. By default remote systems have access to `/usr/spool/uucppublic`. The following example shows how to add access to the directory `/usr/doosy` for the remote system `doosy`.

```
Udoosy,doosy /usr/spool/uucppublic,/usr/doosy:
```

To give other users access to parts of your file system, you must modify `/usr/lib/uucp/USERFILE`. The following line in this file will allow all local users to send files and use the mail facility:

```
, /usr/spool/uucppublic
```

The comma is a required part of the syntax. The general format for entries in the `USERFILE` file is

[*system*], [*login*] *directory*

where *system* and *login* specify access permission to the named *system* and *login* names. When no system or user is mentioned, access is granted to all, but the comma that separates them in the general format must remain in place.

As an added security feature of `USERFILE`, you can use the `c` flag to force a call back to the remote computer instead of allowing it to log in to your computer. To use this feature, insert the letter `c` between the first and second entries on the line; for example,

```
Udoosy,doosy c /usr/spool/uucppublic,/usr/doosy
```

Conversation count checking

To improve security further you can require a conversation count check every time a system calls. In other words, both systems must record the number of times they communicate with each other and check whether these counts coincide, as explained below. The file used for this purpose is `/usr/lib/uucp/SQFILE`. Each line in this file contains the name of a system for which you will require the check. To initiate the checking you need only enter the remote system name as a separate line in the file. The administrator of the remote system will have to add your computer's name to the `SQFILE` on that system. After the first call, the line might be

```
doosy 1 10/15-10:15
```

where `doosy` is the name of the other computer, `1` is the conversation count, `10/15` is the date, and `10:15` is the time of the conversation.

From that point on the conversation count will be incremented on these corresponding lines every time these two computers are connected via uucp. If these counts do not match during an attempted call, the conversation will fail. To impersonate another computer you would need to know not only the login name and password but also the conversation count. If a call attempt ever fails because this file is corrupted on one of the two systems, all you have to do is reinitialize the lines (on both systems) so that they contain the system names only.

Controlling file forwarding

The uucp utility can forward files through intermediate nodes to get them to another system. If you plan to allow forwarding through your system (that is, make your system a node in the forwarding chain), and you want some control over this, you have to make entries in /usr/lib/uucp/FWDFILE and /usr/lib/uucp/ORIGFILE. The first file, FWDFILE, contains a list of systems to which you are willing to forward files via uucp. For instance, if you are willing to forward files to the computer doosy from other systems, just add a new line with the name doosy to the file. The second file, ORIGFILE, contains a list of systems and users from which you are willing to forward files. If you are willing to forward files originated in the doosy system by users mark and marian, add

```
doosy,mark,marian
```

If these files do not exist, no restriction applies to forwarding on your system. This means that if you do not have a FWDFILE, you will allow forwarding to all systems to which you connect. Similarly if you do not have an ORIGFILE, you will allow forwarding to originate on any system. To disable forwarding to any other system, create a FWDFILE with no contents (no forwarding permitted to any system). Similarly you can create an ORIGFILE without any contents to prevent any other computers from using your system to forward files.

Controlling remote command execution

Another security feature of uucp is its ability to restrict the execution of remote commands. For uucp to execute remote commands, the names of these commands must be listed in the file /usr/lib/uucp/L.cmds, one command name per line. If you want maximum security, you should include a single line in this file with the command rmail and no other line, so that no other remote commands can be executed. Without the rmail line, local users will not be able to get mail from remote systems.

File permissions

The last security feature is not part of `uucp` itself but involves the file permissions for the UUCP directories, executable files, and administrative files.

In general the public should be denied read permission for most administrative files, especially `/usr/lib/uucp/L.sys`. This requires that the owner of `uucp`'s executable files be the same as the owner of the administrative files, which have setuid permission to access them. It is recommended that all these files be owned by `uucp` and that all the binary executables have the setuid bit set, as shown in the recommendations in this section.

- **The following modes are recommended for directories.**

```
755      /usr/lib/uucp
755      /usr/spool/uucp
777      /usr/spool/uucp/.XQTDIR
777      /usr/spool/uucppublic
777      /usr/spool/uucppublic/receive
```

- **The following modes are recommended for binary files (notice the setuid permissions).**

```
4111     /bin/uucp
4111     /bin/uulog
4111     /bin/uuname
4111     /bin/uustat
4111     /bin/uusub
4111     /bin/uux
4111     /usr/lib/uucp/uucico
4111     /usr/lib/uucp/uuclean
4111     /usr/lib/uucp/uuxqt
```

- **The following modes are recommended for script files.**

```
755      /usr/bin/uupick
755      /usr/bin/uuto
400      /usr/lib/uucp/uudemon.day
400      /usr/lib/uucp/uudemon.hr
400      /usr/lib/uucp/uudemon.wk
755      /usr/lib/uucp/uushell
```

- **The following modes are recommended for `uucp` system files.**

```
444     /usr/lib/uucp/ADMIN
444     /usr/lib/uucp/FWDFILE
444     /usr/lib/uucp/L-devices
444     /usr/lib/uucp/L-dialcodes
444     /usr/lib/uucp/L.cmds
400     /usr/lib/uucp/L.sys
444     /usr/lib/uucp/ORIGFILE
400     /usr/lib/uucp/SQFILE
400     /usr/lib/uucp/USERFILE
```

The `nuucp` login environment

A user login for `nuucp` is set up in the `/etc/passwd` file in the standard distribution. You should always log in as `nuucp` to do UUCP administrative work, because working as the root user can be dangerous and is unnecessary when you deal with UUCP system files.

The administrative login entry in `/etc/passwd` is set up as follows:

```
nuucp::5:5:UUCP admin:/usr/lib/uucp:
```

Note that the directory `/usr/lib/uucp` has been chosen as the home directory and that the default `/bin/sh` is the startup shell. If the startup shell were `/bin/csh` or `/bin/ksh`, that would appear as the last field on the line. Note also that the `nuucp` login has the same user and group ID as the `uucp` login. Because the `uucp` login occurs first in this file, all files created by the `nuucp` administrative login will be owned by `uucp`. This is recommended.

You should assign a password to the `nuucp` login, and you may also create a `.profile` file in `nuucp`'s home directory with some helpful shell procedures as follows:

```
cdlib () { cd /usr/lib/uucp; }
cdpub () { cd /usr/spool/uucppublic; }
cdspl () { cd /usr/spool/uucp; }
poll () { /usr/lib/uucp/uucico -r1 -s$1 &; }
pollx () { /usr/lib/uucp/uucico -r1 -s$1 -x4 &; }
rmstat () { rm -f /usr/spool/uucp/ST*; }
taillog () { tail -f /usr/spool/uucp/LOGFILE; }
```

As you get to know UUCP, you will find out how helpful these procedures can be.

The file `/usr/lib/uucp/ADMIN` consists of a list of systems and their descriptions separated by a tab. The entry for the system `doosy` might look like:

```
doosy 1234 University Avenue,
Sometown, CA
```

Now when you run `uuname` with the `-v` option, the description for `doosy` will also be displayed.

The UUCP commands

```
/bin/uulog
/bin/uustat
/bin/uusub
```

are for administrative as well as general use.

You can use the `uulog` command to display selected portions of `/usr/spool/uucp/LOGFILE`. You may request lines for either a specific system name or a user. For example, to check what has happened with the system `doosy`, enter

```
uulog -sdoosy
```

You can use the `uustat` command to find the job number of a UUCP request and also to cancel a UUCP request. It is recommended that you use this method to terminate UUCP jobs if at all possible. For example, if during a transfer you discover that you have requested the wrong file, you can get the job number by entering

```
uustat -sdoosy
```

The status of requests is displayed in reverse chronological order, so your request is near the top. If the job number is 1234, cancel the request by entering

```
uustat -k1234
```

You can use the `uusub` command to collect and display statistics for the systems with which your system communicates. Before statistics can be collected for a system, `uusub` must first recognize it by adding it to its list. To do this, enter

```
uusub -adoosy
```

You can also use `uusub` to connect to a system. This is usually scheduled by `cron`. If you want to call the `doosy` system every hour on the half hour, the `/usr/spool/cron/crontabs/uucp` entry should look like

```
30 **** /bin/su uucp -c "/bin/uusub -cdoosy > /dev/null"
```

Suggested links

The last issue concerning administration is purely conventional. Instead of using names such as `tty0` in the files `L.sys` and `L-devices`, it is easier to make links in the `/dev` directory to provide alternate names for ports. The naming convention is used for ports that either have direct links to other computers or have modems attached. For instance, if `tty0` is connected to a modem and `tty5` is connected directly to `doosy`, make the following links:

```
ln /dev/tty0 /dev/acu.hayes
ln /dev/tty5 /dev/dir.doosy
```

Then use `acu.hayes` instead of `tty0` in the administrative files and `dir.doosy` instead of `tty5`. This also makes it easier to use `cu` because you don't have to remember the number of the port. See Chapter 5, "Using `cu`" in the *A/UX Communications User's Guide*. If the connection is changed to another port, all you have to do is remove the link to the old port and link the name to the new port. None of the `uucp` administrative files need be modified.

Troubleshooting `uucp`

There are several things you can do if `uucp` is not working properly on your system.

If you have to figure out why `uucp` is not working and fix it without information such as status files or log files, first make sure the port, modem, and phone line are working. You can use the `cu` utility to determine this. See Chapter 5, "Using `cu`" in the *A/UX Communications User's Guide*. The command to check `tty0` is

```
cu -ltty0 dir
```

If you cannot even get the `Connected` message from `cu`, the port probably has the wrong permissions. To correct this, enter

```
chmod 666 /dev/tty0
```

At this point you should be able to communicate with the modem and have it dial up the other system. When you get the login and password prompts, use the login and password in `L.sys`. The remote system should respond with something like

```
Shere=doosy
```

This means you have reached the `uucico` shell on the remote system and you can do no more with `cu`. If you get no response, contact the administrator of the remote system and explain that your `uucp` login is not working.

Once you have established that the port, modem, and phone line are working, test the connection with the command

```
/usr/lib/uucp/uucico -r1 -sdoosy -x4 &
```

◆ *Note:* You should always run this command in the background so you can kill it if it hangs. Do not use the `-9` option of `kill` because `uucp` will not catch the signal and clean up after itself. Instead use `kill` with no options.

To save the debug output in a file, use the `script` program

```
script /usr/lib/uucp/uucico -r1 -sdoosy -x4 &
```

By comparing the debugging output of this command with the *expect-send* sequence in the `L.sys` file, you can usually tell if something is wrong. For instance, if an entry in the `L.sys` file specifies that the password is `foo` but the password that appears in the debugging output is `fee`, you can modify `L.sys` and keep testing until it works. By running the `uucico` command with the `-x9` options, you may generate a lot more debugging output.

A typical problem is finding strange times in the log files. This generally happens because the time zone environment variable is not set correctly. You can avoid this by making sure that `/usr/lib/uucp/uushell` is the startup script for all `uucp` logins. The contents of this script are

```
exec env TZ=PST8PDT /usr/lib/uucp/uucico
```

Make sure that the setting for `TZ` corresponds to your own time zone.

Most problems with `uucp` occur because of incorrect permissions on files. Always check this if `uucp` starts working improperly. See "File Permissions," earlier in this appendix, for specific recommendations about the appropriate permissions for the files used by the UUCP system.

Appendix D **Additional Reading**

This appendix lists additional reading material that you might find helpful. The first section lists relevant online manual pages for information on user commands, administrative commands, subroutines, file formats, and protocols. The next sections list related requests for comments (RFCs) and documentation from the University of California at Berkeley.

The key points covered by this appendix are:

- Related manual page entries
- Related RFCs
- Berkeley documentation

Related manual page entries

The commands, system calls, subroutines, and system files described on the manual pages listed here are either directly related to the networking or NFS/Yellow Pages implementation or are NFS versions of standard UNIX programs. All of the manual page entries listed here can be viewed on the screen by entering

`man` *commandname*

The printed copies of these pages are in *A/UX Command Reference* (Section 1), *A/UX System Administrator's Reference* (Section 1M), and *A/UX Programmer's Reference* (Sections 2, 3, 4, and 5).

User commands

`domainname`(1)	Set or display name of current domain system.
`ftp`(1N)	File transfer program.
`hostid`(1N)	Set or print identifier of current host system.
`hostname`(1N)	Set or print name of current host system.
`netstat`(1N)	Show network status.
`rcp`(1N)	Perform remote file copy.
`remsh`(1N)	Perform remote shell.
`rlogin`(1N)	Perform remote login.
`ruptime`(1N)	Show host status of local machines.
`rusers`(1N)	Show who is logged in on local machines (RPC version).
`rwho`(1N)	Show who is logged in on local machines.
`talk`(1N)	Talk to another user.
`telnet`(1N)	Access the user interface to the TELNET protocol.

ypcat(1)	Print values in a Yellow Pages database.
ypmatch(1)	Print values of one or more keys from a Yellow Pages map.
yppasswd(1)	Change login password in Yellow Pages.
ypwhich(1)	Show which host is the Yellow Pages server or map master.

Administrative commands

ftpd(1M)	Access the DARPA Internet File Transfer Protocol server.
ifconfig(1M)	Configure network interface parameters.
makedbm(1M)	Make a Yellow Pages dbm file (see also ypmake(1M)).
mountd(1M)	Request an NFS mount server if listed in /etc/servers.
nfsd(1M)	Access the NFS daemons.
nfsstat(1M)	Print NFS statistics.
ping(1M)	Send ICMP ECHO_REQUEST packets to network hosts.
portmap(1M)	Use the DARPA port to RPC program number mapper.
remshd(1M)	Use the remote shell server.
rexecd(1M)	Access the remote execution server.
rdump(1M)	Back up to a remote device
rlogind(1M)	Access the remote login server.
route(1M)	Manually manipulate routing tables.
rpcinfo(1M)	Print RPC information.
routed(1M)	Access the network routing daemon.
rrestore(1M)	Restore from remote backup medium.
rstatd(1M)	Use the kernel statistics server.

rusersd(1M)	Access the rusers server.
rwall(1M)	Write to all users over a network.
rwalld(1M)	Access the network wall server.
rwhod(1M)	Access the system status server.
showmount(1M)	Show all remote mounts.
spray(1M)	Use the spray packets.
sprayd(1M)	Use the spray server.
telnetd(1M)	Access the DARPA TELNET protocol server.
tftpd(1M)	Access the DARPA Trivial File Transfer Protocol server.
trpt(1M)	Transliterate protocol trace.
ypinit(1M)	Build and install Yellow Pages database.
ypmake(1M)	Rebuild Yellow Pages database by using /etc/yp/Makefile.
yppasswdd(1M)	Use this server for modifying a Yellow Pages password file.
yppoll(1M)	Print which version of a Yellow Pages map is at a Yellow Pages server host.
yppush(1M)	Force propagation of a changed Yellow Pages map.
ypserv(1M)	Use the Yellow Pages server and binder processes.
ypset(1M)	Point ypbind at a particular server.
ypxfr(1M)	Transfer a Yellow Pages map from a Yellow Pages server to here.

System calls

accept(2N)	Accept connection on a socket.
bind(2N)	Bind name to a socket.
connect(2N)	Initiate connection on a socket.

`fcntl(2)`	Access file control.
`fsmount(2)`	Mount NFS file system.
`getdirentries(2)`	Get directory entries in a file-system-independent format.
`getdomainname(2)`	Get current domain name.
`getdtablesize(2)`	Get descriptor table size.
`gethostid(2N)`	Get/set unique ID of current host.
`gethostname(2N)`	Get/set name of current host.
`getpeername(2N)`	Get name of connected peer.
`getsockname(2N)`	Get socket name.
`getsockopt(2N)`	Get and set options on sockets.
`listen(2N)`	Listen for connections on sockets.
`ocking(2)`	Provide exclusive file regions for reading or writing.
`nfssvc(2)`	Use the NFS daemons.
`readlink(2)`	Read value of a symbolic link.
`recv(2N)`	Receive message from a socket.
`rename(2)`	Change name of a file.
`select(2N)`	Use synchronous I/O multiplexing.
`setregid(2)`	Set real and effective group IDs.
`setreuid(2)`	Set real and effective user IDs.
`send(2N)`	Send message from a socket.
`shutdown(2N)`	Shut down part of a full-duplex connection.
`socket(2N)`	Create endpoint for communication.
`stat(2)`	Get file status.
`statfs(2)`	Get file system statistics.

`symlink(2)`	Make symbolic link to a file.
`truncate(2)`	Truncate file to a specified length.
`uvar(2)`	Return system-specific configuration information.
`wait3(2)`	Wait for child process to stop or terminate.

Subroutines

`bcopy(3N)`	Use bit and byte string operations.
`byteorder(3N)`	Convert values between host and network byte order.
`dbm(3X)`	Access database subroutines.
`directory(3)`	Access directory operations.
`dup2(3N)`	Duplicate descriptor.
`getgrent(3C)`	Obtain group file entry from a group file.
`gethostbyaddr(3N)`	Get network host entry.
`getmntent(3)`	Get file system descriptor file entry.
`getnetgrent(3N)`	Get network group entry.
`getprotoent(3N)`	Get protocol entry.
`getpwent(3C)`	Get password file entry.
`getservent(3N)`	Get service entry.
`inet_addr(3N)`	Use the Internet address manipulation routines.
`initgroups(3)`	Initialize group access list.
`insque(3N)`	Insert/remove element from a queue.
`killpg(3N)`	Send signal to a process group.
`lockf(3C)`	Perform record locking on files.

`ypclnt`(3N)	Access the Yellow Pages libraries.
`rcmd`(3N)	Use the routines for returning a stream to a remote command.
`rexec`(3N)	Return stream to a remote command.
`setuid`(3)	Set user and group IDs.

File formats

`dir`(4)	List the format of System V directories.
`exports`(4)	List NFS file systems being exported and who has permission to mount them.
`fs`(4)	List the format of a System V system volume.
`fstab`(4)	List the static information about file systems.
`group`(4)	Display the group file.
`hosts`(4N)	Access the host name database.
`hosts.equiv`(4)	List trusted hosts.
`inode`(4)	List the format of a System V inode.
`mtab`(4)	Display the mounted file system table.
`netgroup`(4)	List network-wide groups of machines and users.
`networks`(4N)	Access the network name database.
`passwd`(4)	Access the password file.
`protocols`(4N)	Access the protocol name database.
`rmtab`(4)	Display the remotely mounted file system table.
`servers`(4N)	Consulted by network superdaemon `inetd` for list of daemons to start up.
`services`(4N)	Access the service name database.
`ypfiles`(4)	Access the Yellow Pages database and directory structure.

Protocols

`arp(5P)`	Access the Address Resolution Protocol.
`inet(5F)`	Access the Internet protocol family.
`ip(5P)`	Access the Internet Protocol.
`tcp(5P)`	Access the Internet Transmission Control Protocol.
`udp(5P)`	Access the Internet User Datagram Protocol.

Related RFCs

The following requests for comments (RFCs) provide additional information about the networking implementation. You can obtain these documents by writing or telephoning

Network Information Center
SRI International
Menlo Park, CA 94025
(800) 235-3155

TCP	(Internet Transmission Control Protocol) RFC 793, September 1981.
IP	(Internet Protocol) Postel, J., *Internet Protocol,* RFC 791, USC/Information Sciences Institute, September 1981.
ICMP	(Internet Control Message Protocol) Postel, J., *Internet Control Message Protocol,* RFC 792, USC/Information Sciences Institute, September 1981.
IUDP	(Internet User Datagram Protocol) RFC 768, August 1980.
FTP	(File Transfer Protocol) RFC 959, October 1985.
ARP	(Address Resolution Protocol) RFC 826, November 1982.
TELNET	RFC 854, May 1983.

Subnets — Mogul, J., and J. Postel, *Internet Standard Subnetting Procedure,* RFC 950, Stanford University, August 1985.

Mogul, J., *Internet Subnets,* RFC 917, Stanford University, October 1984.

GADS, *Towards an Internet Standard Scheme for Subnetting,* RFC 940, Network Information Center, SRI International, April 1985.

TCP/IP networking

Comer, Douglas, *Internetworking with TCP/IP,* Prentice-Hall, 1988.

Subnets and broadcasting

Mogul, J., *Broadcasting Internet Datagrams,* RFC 919, Stanford University, October 1984.

Mogul, J., Broadcasting Internet Datagrams in the Presence of Subnets, December 1987.

Internet domains — Lottor, M.K., *Domain Administrators Operations Guide,* SRI International, September 1987.

Mockapetris, P., *Domain System Changes and Observations,* RFC 973, January 1986.

Partridge, C., *Mail Routing and the Domain System,* RFC 974, January 1986.

Mockapetris, P., *Domains Names—Concepts and Facilities,* RFC 882, November 1983.

Mockapetris, P., *Domain Names—Implementation Specification,* RFC 883, November 1983.

Network mail — Su, Z., and J. Postel, *The Domain Naming Convention for Internet User Applications*, RFC 819, August 1982.

Postel, J., *Simple Mail Transfer Protocol,* RFC 821, August 1982.

Crocker, D., Standard for the Format of ARPA Internet Text Messages, RFC 822, August 1982.

Network numbers — Reynolds, J., and J. Postel, *Assigned Numbers,* RFC 960, USC/Information Sciences Institute, December 1985.

Berkeley documentation

The following documentation provides additional information about the network mail and Internet domains. To purchase these documents you must be a current USENIX member. Write to:

USENIX Association
P.O. Box 2299
Berkeley, California 94710

`sendmail` Allman, E., *Mail Systems and Addressing in 4.2BSD,* University of California at Berkeley.

Allman, E., *Sendmail—An Internetwork Mail Router*, University of California at Berkeley.

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THE APPLE PUBLISHING SYSTEM

This Apple manual was written, edited, and composed on a desktop publishing system using Apple Macintosh® computers and Microsoft Word software. Proof pages were created on Apple LaserWriter® printers. Final pages were created on the Varityper VT600W imagesetter. Line art was created using Adobe Illustrator. POSTSCRIPT®, the page-description language for the LaserWriter, was developed by Adobe Systems Incorporated.

Text type and display type are Apple's corporate font, a condensed version of ITC Garamond. Bullets are ITC Zapf Dingbats®. Some elements, such as program listings, are set in Apple Courier.

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