RadiSys.

Using OS-9

Version 3.1

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Contents

1 Introduction to OS-9

This chapter introduces the concept of an operating system and explains some of the basic features of OS-9. It includes the following sections:

OVERVIEW OF OS-9

An operating system is the master supervisor of the resources and functions of a computer system. Computer resources consist of the following components:

- memory
- CPU time
- input/output devices such as terminals, disk drives, and printers

OS-9 is a sophisticated operating system for microcomputers. The basic functions of OS-9 are listed below:

- Provide an interface between the computer and the user.
- Manage the input/output (I/O) operations of the system.
- Provide for loading and executing programs.
- Create and manage a system of directories and files.
- Manage timesharing and multi-tasking.
- Allocate memory for various purposes.
- Allocate and manage inter process communication services.

Using OS-9 Functions

There are two basic ways to use the capabilities and functions of OS-9:

1. Utility command set and shell command interpreter

   This method enables you to type OS-9 commands directly on your keyboard.

Refer to the ***Utilities Reference*** for descriptions of all OS-9 utilities.

2. System calls

   System calls are requests made to OS-9 within programs written in assembler or a high-level language. These system calls perform a variety of functions, including those listed below:

   - Load programs into memory.
   - Create new tasks.
   - Create or delete files.
   - Read, write, open, and close files.

   System calls are largely of interest to advanced programmers and are covered in detail in the ***OS-9 Technical Manual***.

   All OS-9 programming languages have statements that cause the program to use OS-9 system calls, often in a hidden manner.

Information Storage

OS-9 stores information in files and directories located on mass-storage devices, such as floppy disks. It provides easy access methods for updating, storing, and retrieving files and directories through standard utilities.

OS-9 organizes all files in directories. A directory is a special file containing the names and locations of each file within it. Directories can also contain files and subdirectories; these subdirectories may contain other files and subdirectories. This method of storage is called a tree structure, or hierarchical organization.

For more information about the file structure, refer to *Chapter 4, The OS-9 File System*.

Multi-Tasking and Multi-User Functions

OS-9 is both a multi-tasking and multi-user operating system. Multitasking and multi-user capabilities tremendously increase the versatility of the operating system. OS-9 is often used as a single-user/multitasking system on small computers. It is also used as a multi-user/multitasking system on larger computer systems.

Multi-Tasking Functions

OS-9 is a multi-tasking operating system. Multi-tasking enables the computer to run many different programs at the same time. By rapidly switching from one program to the next, many times per second, programs appear to run at the same time.

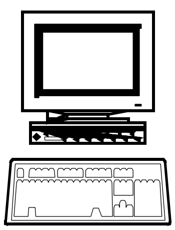
Each program running on the system is called a task, or process. OS-9 enables you to have one or more tasks running in the background while another task runs in the foreground.

A foreground process is a task that requires user interaction. For example, editing a file is a foreground process; you, as a user, are actively modifying it. A program that prompts you for information is also a foreground process because it is a task to which you need to respond.

A background process is a task that does not require user interaction or user attention. For example, printing a text file is a background process because it does not require you, as a user, to supervise the printing process. Therefore, one file may be printing in the background while you edit another file.

A typical multi-tasking environment is described in Figure 1-1.

Figure 1-1. Typical Multitasking Use



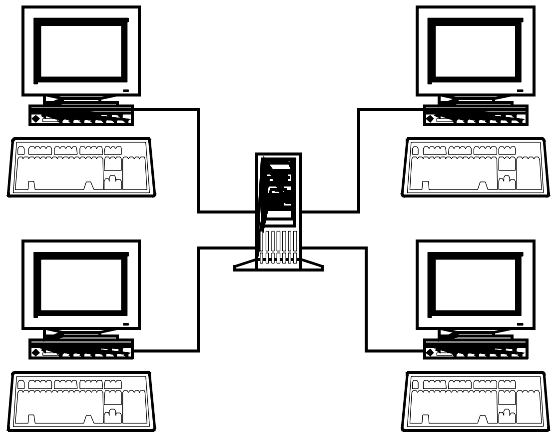
Typical Multitasking Use:

- Editing a file (foreground process)
- Listing a file to a printer (background process)
- Sorting and merging data files (background process)

Multi-User Functions

Multi-user operation is a natural extension of basic multi-tasking functions. It enables several users to work with one computer simultaneously. OS-9 provides security-related timesharing functions that control access to the system and privacy within the system.

Figure 1-2. Multiuser System Configuration



Memory Modules and Modular Software

A unique feature of OS-9 is its support of modular software techniques based on memory modules. Memory modules have the following attributes:

- an efficient use of available disk and memory storage
- the ability to make the system run faster
- the ability to simplify programming jobs
- the ability to easily customize OS-9

All OS-9 programs are kept in the form of one or more "program modules"; program modules contain pure program code. They do not, however, contain variable storage. OS-9 assigns variable storage in a separate block of memory at run-time. Each module has a unique name and can be loaded into memory or stored on disk or tape. OS-9 automatically keeps track of the names and locations of all modules present in memory.

An important characteristic of memory modules is the sharing of one module by several tasks or users at the same time. For example, if four users want to run "umacs" at the same time, only one copy of umacs is loaded into memory. Other operating systems would typically load four copies of umacs into memory, thus requiring 300% more memory than OS-9. This shared module system is completely automatic and usually transparent to the user.

Another advantage of memory modules is that frequently used functions can share common “library” modules. For example, a standard OS-9 module called `csl` provides a wide range of Input/Output (I/O) processing for virtually all programming languages and programs. This eliminates the need for each program to include its own standard I/O package. In addition, you can split large and complex programs into smaller modules that are easier to test.

DEVELOPMENT OPTIONS

OS-9 is a real-time operating system because it can respond quickly enough to interact with people or other computer systems requiring immediate feedback.

For example, a multi-use home entertainment system may involve a user who enters various video selections, an operating system that coordinates the entries with the application programs that fulfill the requests, and a device that displays a menu of the available options or the selected video.

Another example includes a real-time operating system controlling computer resources for data collection, analysis, and corrective action. This type of example can be implemented in missile guidance systems, automated factory tools, and scientific equipment.

OS-9 supports two development options: resident and cross-hosted. Resident development involves using OS-9 both as the operating system for development and as the target development system.

THE MWOS DIRECTORY STRUCTURE

Microware has adopted this general directory structure for all of its products. The MWOS directory structure has the following attributes:

- It provides a consistent directory structure for all development platforms.
- It provides similar development environments for OS-9 and OS-9 for 68K and enables code sharing between the two systems.
- It makes provisions for code and libraries optimized for 32-bit processors.

- It provides a clear division between the development and runtime directory.

- It enables multiple ports from a common set of sources.
- It provides a means to create a disk-based runtime system without modifying makefiles.

About the Directory Structure

The MWOS directory structure lives under the `MWOS` directory. As you descend through the directories, the files become progressively more OS-, CPU-, and hardware-dependent. A simplified model appears in Figure 1-3.

Sources particular to an operating system (such as OS-9 and OS-9 for 68k) are kept in the following location:

```
MWOS/<OS>/SRC
```

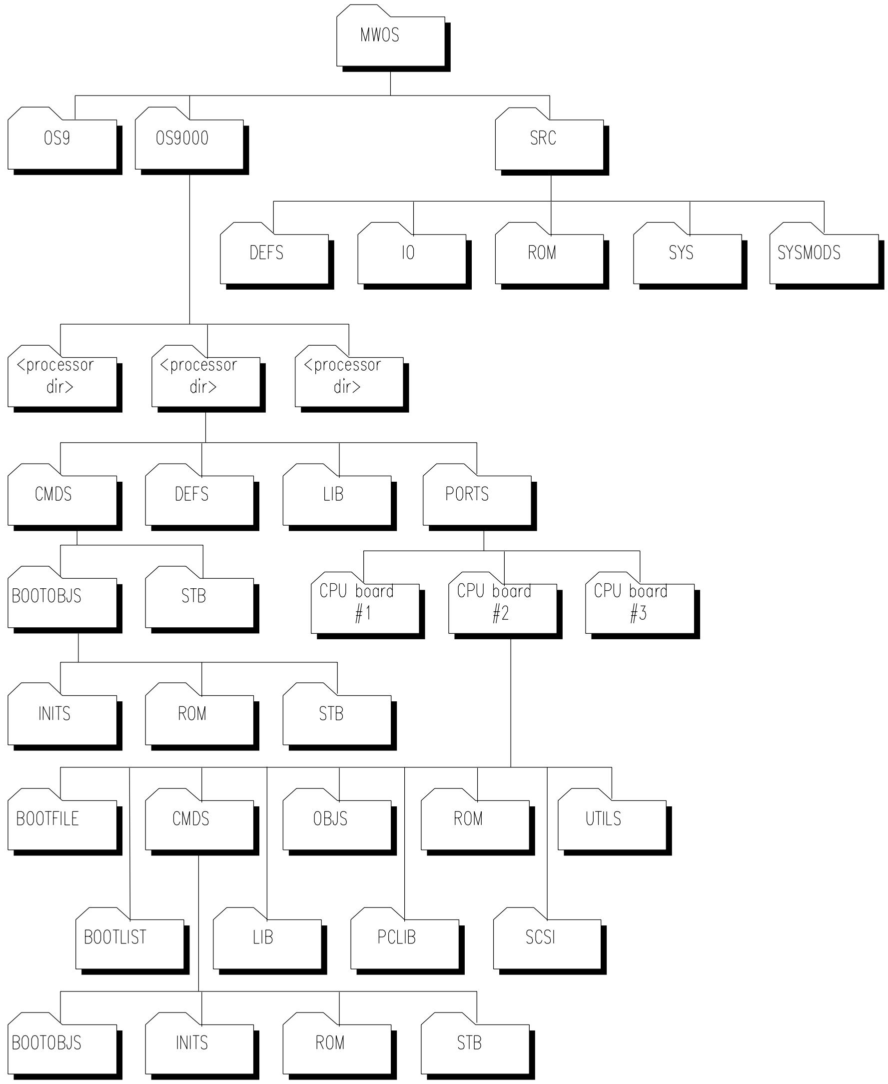
Sources common between all operating systems are located in the following location:

```
MWOS/SRC
```

This logic also applies to C header files and assembler “defs”. Ports for particular boards are kept under the following directories:

```
<OS>/<Processor family>/PORTS
```

Figure 1-3. MWOS File Structure



Development v. Runtime

The MWOS directory structure is oriented specifically towards software development. Whether the development occurs on a resident OS-9 system or a cross-development environment (Windows), once the executable modules have been created you must move them to their final locations on the target machine.

When you are developing an application on a resident development system, moving files may be simple a matter of copying a file from the `MWOS/OS9000/<CPU>/CMDS` directory to the `/H0/CMDS` directory.

Alternatively, it might involve downloading the modules into memory on a small target system, making a boot on a server to boot the target over Ethernet, or creating a set of ROM modules for a fully “ROMed” system.

The root directory on an OS-9 runtime system looks similar to the following illustration:

```
                    Directory of . 17:10:43
   CMDS               ETC               MWOS               SYS
```

`CMDS`	This directory contains all of the sources, header files, and libraries under the `MWOS` directory. Executables are generally found in the `CMDS` directory.
`ETC`	This directory contains network (internet and NFS) databases. At the system administrator's request, these files may also be duplicated in `MWOS`; this would allow the files to be modified and tested prior to being committed for use on the development system.
`MWOS`	This directory contains the operating system files as shown in Figure 1-3.
`SYS`	This directory contains system startup and configuration files, such as `startup`, `password`, and `termcap`.

Other directories may be included in the root directory if the system is used for development (examples include `USR` and `TFTPBOOT`).

The Ultra C/C++ documentation (included with your OS-9 product CD) contains additional information about the MWOS file structure. The sources included in OS-9 for Embedded Systems and Board Level Solutions (BLS) use pathlists for definition and library files that are within the `MWOS` directory structure. They may easily be developed on either resident or Windows environments without requiring modification of their search paths. To ensure your products can be easily migrated to Microware cross- development hosts, you should follow this same approach.

Multiple MWOS Directories

It may sometimes be necessary to have multiple `MWOS` directories on a resident-development machine. For example, if the development machine is running Version 2.1 of OS-9 for the 80386 processor family and a package is purchased to develop code for OS-9 Version 3.0 for the PowerPC processor family, the new package must reside in an separate `MWOS` directory structure. The reason for this is that the two packages have common source files at different revision levels; installing the 3.0 package over the 2.1 package would preclude resident development.

NFS and Other Package Directories

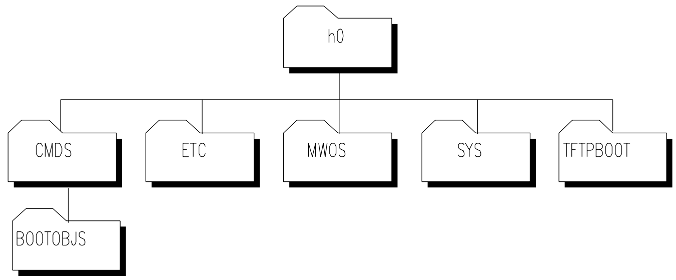
The NFS application and system modules are located in the `CMDS` and `CMDS/BOOTOBJS` directories of your target system. This simplifies the startup procedures for both systems and enables utilities to be loaded as needed without the limitations of long path searching.

The startup procedures for these types of packages enables utilities to be loaded at startup; however, this is not necessary. You may choose to move the system modules to the boot so that no loading is required.

OS-9 SYSTEM DISK DIRECTORIES

Figure 1-4 provides a list of directories commonly distributed with OS-9. They are all contained in the primary directory (the root directory) of your system disk. Each directory is explained in Table 1-1.

Figure 1-4. System Disk Directories



For more information about:

- each utility distributed with OS-9, refer to the *Utilities Reference* manual.
- changing device descriptors, refer to *Chapter 9, OS-9 System Management*.
- the `password` file, refer to *Chapter 6, The Shell*.
- the `login` utility, refer to *Chapter 3, Basic Commands and Functions*.
- the `termcap` file, refer to *Chapter 9, OS-9 System Management*.

Table 1-1. OS-9 System Disk Directories

Directory	Contents of Directory
CMDS	• the standard OS-9 utilities for running the system • additional user-created programs and OS-9 modules to be executed from a shell command line
CMDS/BOOTOBJS	• system modules that are to be loaded after the system is booted If the MWOS directory is not otherwise needed on the target machine, you may choose to keep the modules required for remaking the system boot in this directory.
ETC	• contains the data files used to create the Inetdb and rpcdb configuration modules
MWOS	• OS-9 development directory structure
SYS	• system files and startup scripts for use in bringing up the system, enabling logins, and other files, including: errmsg: text for descriptions of error messages An appendix listing the error messages is included with this manual set. password: a sample password file for timesharing systems The password file contains information such as the user name, password, and initial process for each user. termcap: descriptions of your terminal characteristics

MWOS Directories

Table 1-5 illustrates the MWOS directories. Each directory is explained in Table 1-2.

Figure 1-5. MWOS Directories

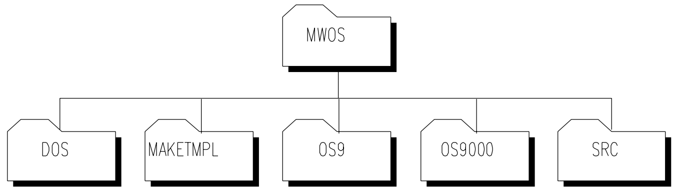


Table 1-2. MWOS Directories

Directory	Contents of Directory
`MAKETMPL`	• a directory for common makefile templates (include files for makefiles)
`OS9000`	• location for all OS-9 object code All OS-9 specific source code, defs files, libraries, processor family code, and ports reside in this directory.
`SRC`	• all sources that are not specific to OS-9 C defs, common I/O systems, user tools, and Dual Ported I/O (DPIO) are examples of code found under the `MWOS/SRC` directory.

MWOS Directories

Table 1-6 illustrates the OS-9 directories. Each directory is explained in Table 1-3.

Figure 1-6. OS-9 Directories

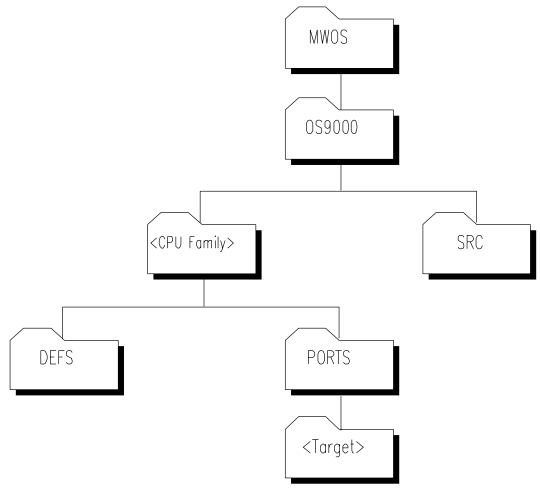


Table 1-3. OS-9 Directories

Directory	Contents of Directory
`<CPU Family>`	• C include files, libraries, and commands specific to OS-9 ports targeting a specific family of processors The processor family-specific objects are deposited in this directory--when built.
`DEFS`	• processor-specific definitions files

Table 1-3. OS-9 Directories (Continued)

Directory	Contents of Directory
`PORTS/<Target>`	• processor-specific information for OS-9 ports--if they target systems based on the specific processor `DEFS` holds processor-specific definition files. `PORTS` holds processor-specific source code, object code, and makefiles.
`SRC`	• the source file for the OS-9 drivers, descriptors, system modules, definitions, and macros This directory is intended to be a source directory containing hardware-specific code, written for reuse from one target to the next. This directory is not intended to be the repository for final object modules that are built from this source, although intermediate object files may be found within its subdirectories.

Each CPU directory has a `PORTS` subdirectory. The ports subdirectory provides directories for a variety of target system boards.

Your distribution package from Microware contains a processor-specific directory in place of the `<CPU Family>` directory shown in <Bold><links>Figure 1-7. MWOS/OS9000/<CPU Family> Directory Structure.

OS9000/<CPU Family> Directories

The MWOS/OS9000/<CPU Family> directory is shown in Figure 1-7. Each directory is explained in Table 1-4.

Figure 1-7. MWOS/OS9000/<CPU Family> Directory Structure

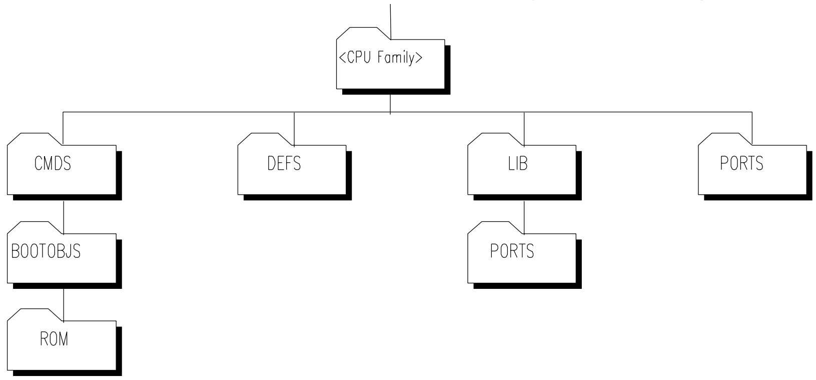


Table 1-4. MWOS/OS9000/<CPU Family> Directories

Directory	Content Summary
<CPU Family>/CMDS	• OS-9 commands and utilities for specific family processors BOOTOBJS contains commands and system modules common to all processors in this family. BOOTOBJS/ROM contains low-level system modules common for all processors in this family.
<CPU Family>/DEFS	• processor-specific definitions files
<CPU Family>/LIB/ROM	• files and libraries (that can be relocated) used to create the low-level module
<CPU Family>/PORTS	• non-specific target port directory examples for this processor family Examples for the 403GA and MVME 1603 specific targets are in the MWOS/OS9000/403 and MWOS/OS9000/603 directories, respectively.

Target Port Directories

The directory structures shown in Figure 1-8 are examples of some of the directories common to most processors. Some directories shown may not be in your software distribution, as your distribution contains the directories specific to your processor.

Figure 1-8. MWOS/OS9000/<CPU>/PORTS/<Target> Directory Structure

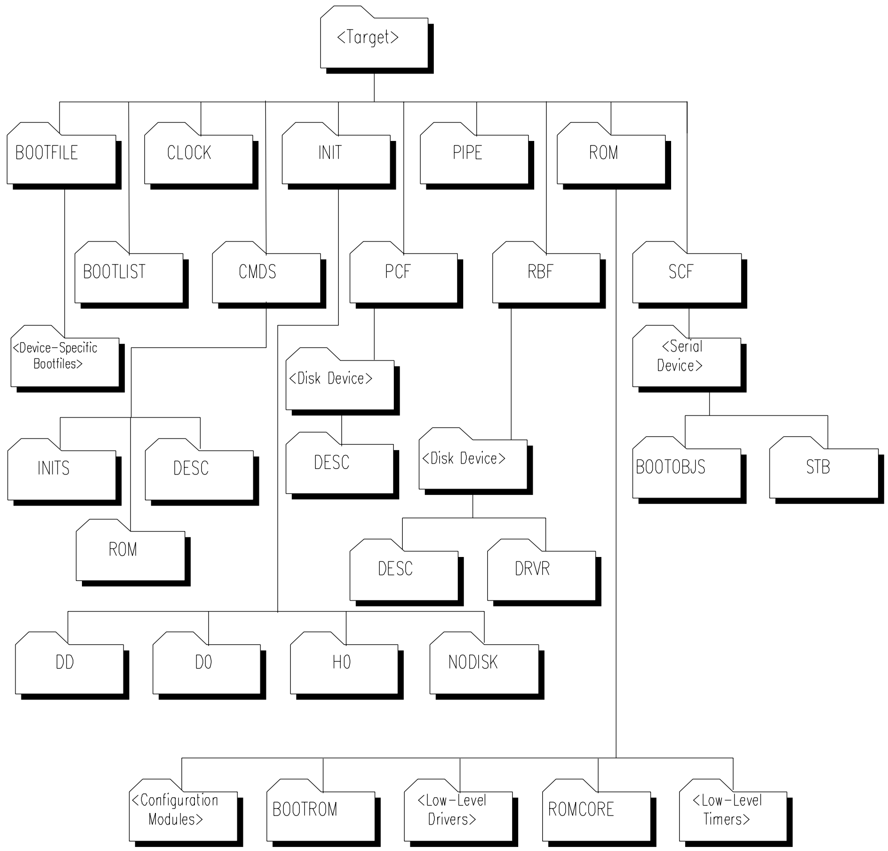


Table 1-5. MWOS/OS9000/<CPU>/PORTS/<Target> Directory Structure

Directory	Content Summary
`BOOTFILE`	driver-specific bootfiles
`BOOTLIST`	system configuration module lists
`CLOCK`	makefiles for building clock modules
`CMDS`	port-specific utilities or commands
	`BOOTOBJS` contains port specific system modules and `BOOTOBJS/ROM` contains port specific bootstrap code and boot modules.

Table 1-5. MWOS/OS9000/<CPU>/PORTS/<Target> Directory Structure (Continued)

Directory	Content Summary
`INIT`	makefiles for building init modules
`PCF`	makefiles for building PC file manager descriptors
`PIPE`	makefiles for building pipe descriptors
`RBF`	makefiles for building random block file descriptors
`ROM`	makefiles for building port specific boot modules. `ROMCORE` contains source code and makefiles for building port specific ROM bootstrap code
`SCF`	makefiles for building serial drivers and descriptors

2 Starting OS-9

This chapter contains procedures for beginning use of OS-9. It includes the following sections:

- Booting OS-9
- Backing Up the System Disk

BOOTING OS-9

Before using OS-9 on your computer, you must “boot” the system. Booting is also called “cold starting” or “bootstrapping”. When you boot the system, the computer reads a portion of the system disk (or CD-ROM) into memory.

Refer to *Chapter 9, OS-9 System Management*, for a description of the directory commonly supplied with OS-9.

If your system is a standard disk-based computer, the system disk contains all of the modules that make up OS-9. The system disk usually contains other files and directories frequently used during normal operations. This includes a directory for each user, a shared command directory, and files used by the system.

When booting OS-9, you should be familiar with two files: `startup` and `sysboot`.

`startup`	is a shell procedure file that is processed immediately after the system starts running. `startup` may contain any legal OS-9 command or program.
`sysboot`	is a file that contains the OS-9 system modules that are read into memory.

The boot procedure depends on the requirements of your specific hardware. The manufacturer supplies detailed instructions outlining the boot procedure for the specific system involved.

Refer to *Chapter 9, OS-9 System Management* for information on changing the startup and sysboot file.

Solutions for Boot Failure

If the system fails to boot, complete any of the following tasks to solve the booting problem:

- Check the hardware setup instructions, especially if you made modifications to your computer.
- Make sure you inserted the disk correctly and try the boot sequence again.

- Make sure you followed the manufacturer's booting instructions.

If the boot sequence fails several times, contact your hardware supplier.

Setting the System Time and Date

When the system boots correctly, a welcome message is displayed, followed by the `setime` prompt. The `setime` utility starts the system clock and enables OS-9 to track the date and time of the creation of the new file. The clock must be running in order to perform multitasking operations.

The `Init` module may command the kernel to automatically start the clock from a battery-backed clock. If the clock is not started and you have a system with a battery-backed clock, type the following command to start the system clock:

```
$ setime -s
```

Otherwise, execute `setime` by typing the following command:

```
$ setime
```

`setime` will then display the following message:

```
yy/mm/dd hh:mm:ss [am/pm]
     Time ?
```

At the prompt, enter the following information:

- year
- month
- day
- hour
- minutes
- seconds
- `am` or `pm` (optional)

If you do not specify `am` or `pm`, `setime` will use the 24-hour clock. For example, 15:20 is the same as 3:20 p.m. The input is one or two digit numbers with a space, colon, semicolon, comma, or slash used as a field delimiter. If you use a semicolon, the entire date string must be within quotes.

For example, to set the time on May 14, 1993 at 1:24 p.m., type any of the alternatives below:

```
93/5/14/1/24/pm
93 05 14 1 24 pm
93,5,14,13,24
93:5:14:13:24
93/5/14/13/24
“93;5;14;13;24"
```

Refer to the following manuals for more information:

- *Utilities Reference* (for more information about `setime` and `date`)
- *Chapter 9, OS-9 System Management* (for more information about the `Init` module and the system clock)

Checking the Date and Time

To find out if the system clock is running or if the date and time is correct, use the `date` utility. For example:

```
$ date
July 2, 1993 Monday 1:25:26pm
```

The System Prompt

Once you set the time and date, the system displays the following prompt:

```
$
```

The dollar sign (`$`) prompt means the operating system is active and waiting for you to enter a command line. This is the default system prompt. This manual uses the `$` prompt for all examples.

For information on changing the system prompt, refer to *Chapter 6, The Shell*.

BACKING UP THE SYSTEM DISK

Before you begin working with OS-9, make a backup of your master system disk. The backup procedure involves making an exact copy of a disk. It is important to have a backup copy of your system disk available in case your system disk becomes damaged; when damaged, the disk becomes unreadable.

Refer to the following documentation for more information:

- *Utilities Reference* (information about `format` and `backup`)
- *Chapter 6, The Shell* (a list of naming conventions used by OS-9)

Before you can back up your system disk, you need a properly formatted disk. OS-9 cannot read from or write to new disks until they have been formatted. The `format` utility initializes new disks for reading and writing. The OS-9 utility that makes copies of disks, `backup`, requires the backup disk to be the same size and format as the original disk.

The following section provides the steps you should take to back up a disk on a typical OS-9 system (booting from a floppy drive (usually called `/d0`)).

If you have a hard disk or are booting from a media other than a floppy disk, refer to *Chapter 9, OS-9 System Management*.

Before formatting your first disk, read the entire section on formatting disks.

The OS-9 system installation contains a menu-driven program, `install`, which optionally partitions and formats the destination drive and copies the OS-9 installation to that drive.

Formatting a Disk

The format of OS-9 system disks vary by the type of disk drive and by manufacturer. Usually, the format is set to the maximum capacity of the disk drive.

Refer to the Basic File System Utilities section in *Chapter 4, The OS-9 File System* for additional information about the format utility.

You can place several parameters on the command line with the `format` command, as shown in Table 2-1.

Table 2-1. Command Line Parameters

Paramete r	Type of disk
`-sd`	single density
`-dd`	double density
`-ss`	single sided
`-ds`	double sided

Refer to your hardware documentation for the maximum capacity of your drives. Also, refer to the label of your system disk for the proper format of your backup copy.

Multiple Drive Format

If your system has two floppy disk drives, place the system disk in one drive and the new disk in the other drive. In multiple drive systems, one drive is normally labeled `/d0` and the other is labeled `/d1`. At the `$` prompt, type `format`, the drive name of the new disk, any desired options, then press the `<Return>` key to enter the command line. For example:

```
$ format /d1 -ds -dd
```

This command line asks the machine to format the disk in the second drive as a double-sided, double-density disk. You should adjust the options to conform to your disk format.

Single Drive Format

If your system has only one disk drive, you must load the `format` utility into memory.

Refer to the Basic File System Utilities section in *Chapter 4, The OS-9 File System* for more information about the load utility.

The `load` utility puts a copy of a program into the computer's memory. To load the `format` utility into memory, type the following command at the `$` prompt:

```
load format
```

Once `format` has been loaded into memory, you can remove your system disk from the drive. OS-9 can execute the copy of `format` residing in memory. You can load and execute any OS-9 utility in this fashion.

Once you have loaded `format`, complete the following steps:

Step 1. Remove the system disk from the drive.

Step 2. Place the disk you are formatting into the drive.

Step 3. Enter the following at the `$` prompt to format the disk:

```
format /d0 -ss -dd
```

This command line specifies the disk should be formatted as a single-sided, double-density disk. Adjust the options as needed to conform to your disk format.

Continuing the Formatting Process

In the case of both single and multiple drive systems, `format` displays the specific disk format settings, followed by a prompt:

```
ready to format <drive name> (y/n/q)?
```

<drive name> is replaced by the name of the device you are trying to format, such as `/d0`.

If the drive name in the prompt is not the name of the drive with the blank disk, type `q` to quit, or you may erase your only system disk.

Complete the following steps to continue the formatting process:

Step 1. If the drive name and parameters in the prompt are correct, type `y` for "yes".

Step 2. If the values in the variable section are not correct, type `n` for "no". `format` then prompts you for the changes to the current values of the options. After the variables have been set, you are queried again as to whether or not you want the disk to be physically formatted. This prompt is not issued for the `-np` option on the command line.

Step 3. If you type `y` at the prompt, you are asked for a name for the disk--unless you specified one with the `-v` option on the command line.

Step 4. You are then asked if you want to perform a physical verification. The physical verification process reads all sectors on the media and marks any bad sectors found as already allocated. This ensures the OS-9 file system does not attempt to use the bad sectors.

Never back up a system disk to a disk having any bad sectors reported by format.

The Backup Procedure

After a disk is formatted, you can run `backup`. The `backup` utility makes an exact copy of the OS-9 system disk. There are other ways to make a copy of a disk, but this is the preferred method. The backup process involves copying the contents of your system disk to a formatted disk.

- During the backup procedure, the system disk is referred to as the *source disk*. The backup disk is called the *destination disk*.
- This procedure makes copies of any disk, not just the system disk.
- It is recommended that you write-protect your source disk when using the backup procedure. This prevents confusion when exchanging the source and destination disks.

`backup` makes two passes:

- The first pass reads a portion of the source disk into a buffer in memory and writes it to the destination disk.

- The second pass verifies everything was copied to the new disk correctly.

Generally, if an error occurs on the first pass, something is wrong with the source disk or the drive it is in.

If an error occurs during the second pass, the problem is with the destination disk. If `backup` repeatedly fails on the second pass, reformat the disk to make sure it has no bad sectors. If the disk reformats correctly, try the back up procedure again.

Multiple Drive Backup

If your system has two floppy disk drives, perform the following steps to make a multiple drive backup:

Step 1. Place the source disk in `/d0`.

Step 2. Place the destination disk in `/d1`.

Step 3. Type `backup` at the `$` prompt.

Step 4. Press the `<Return>` key.

The system assumes you want to backup the disk in `/d0`. It responds to `backup` with the following prompt:

```
ready to BACKUP /D0 to /D1?
```

Step 5. Enter one of the following responses

`y`	Type this key if the correct disks are in the correct drives.
`q`	Type this key if the disks are not in the correct drives. Enter `q` to exit the backup process.

When you type `y`, the system copies all information on the disk in `/d0` onto the disk in `/d1` and returns the `$` prompt.

Single Drive Backup

If your system has a single diskette drive, complete the following steps:

Step 1. Make sure your system disk is in `/d0` and type the following command:

```
load backup
```

Step 2. Take your system disk out of `/d0`, and put your source disk in the disk drive (in this case, it is unnecessary as your system disk is your source disk). Type:

```
backup /d0
```

This tells the system you are performing a single drive backup. The system responds with the following prompt:

```
ready to BACKUP /D0 to /D0?
```

Step 3. Enter one of the following responses

y	Ready to perform the backup.
q	Not ready to perform the backup. You exit the backup procedure when you enter `q`.

If you type `y`, the system begins a series of prompts to complete the backup procedure. This consists of swapping the source and destination disks in the disk drive as prompted by the system.

The first prompt is shown below:

```
ready destination, hit a key
```

Step 4. Remove the source disk from the drive.

Step 5. Insert the destination disk.

Step 6. Press any key to continue the backup procedure.

The next system prompt is shown below:

```
ready source, hit a key
```

Step 7. Remove the destination disk from the drive.

Step 8. Insert the source disk.

Step 9. Press any key to continue the backup procedure.

Step 10. Continue exchanging disks until the backup procedure is completed.

When you have backed up the system disk, store the original disk in a safe place and use the duplicate as your working system disk.

PC-AT system users must perform an additional step to back up the PC-AT system diskette. Refer to the *OS-9 Porting Guide* to find these steps.

3 Basic Commands and Functions

Once your system is up and running, you should begin studying the basic features and utilities of OS-9. This chapter, as well as *Chapter 4, The OS-9 File System*, provide an introduction to OS-9 to get you started.

The information in this chapter helps you get started using the operating system; the most frequently used system commands are discussed. The following sections are included:

- Logging onto a Timesharing System
- Introduction to the Shell
- Using the Keyboard
- Standard OS-9 Utilities
- Using the help Utility
- Using free and mfree

LOGGING ONTO A TIMESHARING SYSTEM

If you are using a single-user system, such as a personal computer, you may skip this section.

Logging onto a multi-user system applies to both “hardwired” and “dial-up” terminals. Until you press the `<Return>` key, idle terminals on multi-user systems do nothing but “beep”. Pressing the `<Return>` key starts the log-on utility called `login`. `login` maintains system security and starts each user with a personalized environment.

For more information about `login` and `tsmon`, refer to the *Utilities Reference* manual.

Once `login` is started, the system requests your user name and the password the system manager assigned to you. The system echoes your user name, but for security purposes your password is not echoed. You are given three attempts to enter a valid user name and password before the program quits.

The following is an example of the `login` procedure:

```
OS-9000/80386 V2.0  80486/PCAT 93/10/24 14:51:12
User Name: smith
Password: [not echoed]
Process #10 logged on  93/10/24 14:51:20
Welcome!
[1]$
```

Depending on how the system is set up, a system-wide message of the day (MOTD) may display on your screen. Typically, you will be set up inside your main working directory; this allows one or more initial programs to run automatically. To log off, simply press the `<Escape>` (end-of-file) key or type `logout` any time your main shell is active.

INTRODUCTION TO THE SHELL

Every operating system has a command interpreter. A command interpreter is a translator between the command you type in and the commands the operating system understands and executes. The command interpreter in
OS-9 is called the “shell”.

The shell provides many functions and options. *Chapter 6, The Shell* exclusively discusses the shell and its features. Refer to that chapter for more detailed information on the shell.

The shell is normally started as part of the system startup sequence on a single user system or after logging onto a timesharing system.

The shell functions in two ways:

1. It accepts interactive commands from your keyboard.
2. It reads a sequence of command lines from a special type of file called a “procedure file” or “script file”. The shell executes each command line in the procedure file as if the command lines had been typed in manually from the keyboard.

When the shell is ready for command input, it displays a $ prompt. This enables you to enter a command line, followed by a carriage return.

The first word of the command line is the name of a command. It may be in upper or lower case. The command may be the name of the following entities:

- an OS-9 utility
- an application program or programming language
- a procedure file

Most commands accept additional parameters or options and some may require them. These parameters or options provide the command and/or the shell with additional information, such as searching file names and directory names. Most options are preceded by a hyphen (-) character. Each parameter is separated by a space character.

Performing a Command Search

The shell follows a special searching sequence for locating the command in memory or on disk. The search sequence is as follows:

1. Current module directory
2. Alternate module directory
3. Subsequent module directory (as specified by the `MDPATH` environment variable)
4. The current execution directory
5. Subsequent execution directory (as specified by the `PATH` environment variable)

Once this sequence is complete, the current data directory is searched for procedure file by the given name. If it cannot find the command you specified, the error `000:216,“file not found”` should be reported.

Below is an example of a simple shell command line:

```
$ list myfile
```

The name of the command is `list`. The file name `myfile` is passed to the `list` command as a parameter.

USING THE KEYBOARD

Most input to OS-9, programming languages, and application programs is line oriented. This means that as you type, the characters are collected, but not sent to the program until you press the `<Return>` key. This gives you a chance to correct typing errors before they are sent to the program.

OS-9 has several line editing features. Each of these features uses control keys generated by pressing the `<Control>` key and some other character key simultaneously.

Line Editing Control Keys

The line editing control keys are listed in Table 3-1.

Table 3-1. Line Editing Control Keys

Key	Function
`<Control>A`	Repeat the previous input line. The last line entered is displayed again, but not executed. The cursor is positioned at the end of the line. You can either enter the line as it is or add more characters to it. You can also edit the line by backspacing and typing over old characters.
`<Control>B`	Move the cursor one space to the left (non-destructive).
`<Control>F`	Move the cursor one space to the right if the cursor is not at the end of the line (non-destructive).
`<Control>H`	Backspace to erase previous characters. Most keyboards have a special `<backspace>` key that can be used directly without using the `<Control>` key.
`<Control>I`	Insert mode toggle key; switch input to insert mode. This enables you to insert characters into an existing input line. Insert mode is terminated by entering `<Control>I` again, another control sequence, or a carriage return.
`<Control>K`	Truncate the line from the current cursor position to the end-of-line. Reset the end-of-line position to the cursor position.
`<Control>L`	Delete the word to the left of the cursor, shift left what is currently right of the cursor, and leave the cursor position on the first character of the deleted word.
`<Control>M`	End-of-record. This has the same effect as a carriage return.
`<Control>P`	Display the current input line again. This is mainly used for hardcopy terminals that cannot erase deleted characters.
`<Control>Q`	Resume the input and output previously stopped by `<Control>S`. The `<Control>Q` function is known as “XON”.

Table 3-1. Line Editing Control Keys (Continued)

Key	Function
`<Control>R`	Delete the word to the right of the cursor, shift left all text that is currently to the right of the deleted word. Leave the cursor at its original position.
`<Control>S`	Halt input and output until `<Control>Q` is entered. The `<Control>S` function is known as “XOFF”. This is a function used by many serial I/O devices, such as printers, to control output speed.
`<Control>W`	Temporarily halt output so you can read the screen before data scrolls off. Output resumes when any other key is pressed. Refer to the section on the page pause feature for more information.
`<Control>X`	Delete the current line.
`<Control>Z`	Move the cursor to the beginning of the current line (non-destructive).
ESCAPE or `<Control>[`	End-of-file. All OS-9 I/O devices, including terminals, are accessed as files. This key simulates the effect of reaching the end of a disk file.

Interrupt Keys

There are two important control keys called interrupt keys. These work differently from the line editing keys because you can use them at any time, not just when a program requests input. They are typically used to halt or alter a running program. These control keys are detailed in Table 3-2.

Table 3-2. Interrupt Keys

Key	Function
`<Control>C`	Send an interrupt signal to the most recent program. This functions differently from program to program. If a program does not make specific interrupt provisions, it aborts the program. If a program has provisions for interrupts, `<Control>C` usually provides a way to stop the current function and return to a master menu or command mode. In the shell you can use `<Control>C` to convert the foreground program to a background program, if the program has not begun I/O to the terminal.
`<Control>E`	Send a program abort signal to the program presently running. In most cases, this key prematurely aborts the current program and returns you to the shell.

The control keys above are the key assignments commonly used in most OS-9 systems. You can, however, change the correspondence between control keys and their functions, so your keys may be different. To redefine the function of control keys, use the `tmode` utility. This command enables you to customize OS-9 to the specific computer's keyboard layout.

For more information about `tmode`, refer to *Chapter 9, OS-9 System Management* or the *Utilities Reference* manual.

The Page Pause Feature

The “page pause” feature stops the scrolling of output on the screen. This is helpful when long lines of output scroll too quickly to be read. OS-9 counts output lines until a full screen has been displayed. It then halts output until you press any key. This is repeated for each screen of output.

In addition, page pause counts a wrapped line as a single line. If the screen is displaying lines that wrap, you may set the page length to a number smaller than 24 so that the page pauses at the bottom of a screen full of information.

You can use `tmode` to turn this feature on and off, or to change the number of lines per screen. The tmode commands are shown in Figure 3-3.

Table 3-3. tmode

Key	Function
`tmode pause`	Turn the page pause mode on.
`tmode nopause`	Turn the page pause mode off.
`tmode page=`*n*	Set the page length to <n> lines, where <n> is the number of lines.

STANDARD OS-9 UTILITIES

OS-9 provides over ninety standard utilities and built-in shell commands. Some of the most commonly used utilities are listed in Figure 3-4.

See the *Utilities Reference* manual for a more detailed explanation of each utility.

Table 3-4. Common OS-9 Utilities

`attr`	`backup`	`build`	`chd`
`chx`	`copy`	`date`	`del`
`deldir`	`dir`	`dsave`	`echo`
`edt`	`format`	`free`	`help`
`kill`	`list`	`makdir`	`merge`
`mfree`	`pd`	`pr`	`procs`
`rename`	`set`	`setime`	`shell`
`wait`			

USING THE HELP UTILITY

The most important command to learn when beginning to use the OS-9 utilities is `help`. The `help` utility is an on-line quick reference. To use this utility, type `help`, a utility name, and a carriage return. The utility function, syntax, and available options are listed.

For example, if you cannot remember the function or syntax of the `backup` utility, you can type `help backup` after the `$` prompt:

```
$ help backup
Syntax: backup [<opts>] [<srcpath> <dstpath>] [<opts>]
Function: backup disks
Options:
     -b=<size> use larger buffer (default is 4k)
     -r      don't exit if read error occurs
     -v      do not verify
$
```

The descriptions are short and precise and using this command is a quick way to find information without looking up the utility in the documentation.

Typing `help` by itself displays the syntax and use of the `help` utility.

This same information is also available by typing the utility name followed by a question mark (`-?`). Each utility has the `-?` option.

USING FREE AND MFREE

During the format procedure, a disk is divided into data blocks of a pre-defined number of bytes. When OS-9 stores a file, the file's contents are stored in physically contiguous blocks. To find out how many blocks are available on the disk, use the `free` utility. This utility displays the amount of unused disk space in number of blocks and bytes. It also displays the disk name, its creation date, and the capacity of the device.

For example:

```
$ free /h1
"OS-9000/68030 Hobbes' Disk" created on: Thu Sep  7
03:37:10 1989
Capacity: 208935 blocks, 102.019 Mbytes
Free: 10 blocks, 0 bytes
Largest Free Block: 3 blocks, 0 bytes
```

`free` uses a 4K buffer by default. To increase the buffer size, use the `-b` option. For example, to use a 10K buffer you could type the following command:

```
$ free -b=10
```

The equal sign (=) is optional. You may also type: `free -b10`.

`mfree` displays the address and size of unused memory available for allocation.

For example:

```
$ mfree
Current total free RAM: 1808.00 K-bytes
```

To learn more about unused memory, use the `-e` option with `mfree`.

For example:

```
$ mfree -e

Minimum allocation size:       4.00 K-bytes
Number of memory segments:   7
Total RAM at startup:       3841.90 K-bytes
Current total free RAM:     1808.00 K-bytes

Free memory map:
    Segment Address         Size of Segment
   -----------------   --------------------------
       $7E000          $1000          4.00 K-bytes
       $8D000          $1000          4.00 K-bytes
       $A3000          $1000          4.00 K-bytes
       $B9000          $1000          4.00 K-bytes
       $CC000          $1BE000     1784.00 K-bytes
       $291000         $1000          4.00 K-bytes
       $296000         $1000          4.00 K-bytes
```

4 The OS-9 File System

This chapter contains a detailed explanation of the tree-structured file and directory system. The following sections are included:

- OS-9 File Storage
- The OS-9 File System
- Current Directories
- Accessing Files and Directories: The Pathlist
- Basic File System Utilities

OS-9 FILE STORAGE

All information stored on an OS-9 computer system is organized into a set of files and directories.

- A file contains data, text, or a program.
- A directory contains names and locations of a file and other subdirectories within it.

This storage structure is hierarchical; it enables you to organize your files by topic, work group, or any other method. When a file is created, its information is stored as an ordered sequence of bytes. These bytes are organized into blocks. A block is a pre-defined group of bytes, anywhere from 256 bytes to 32768 bytes in powers of two. For example, a block may be composed of 512 bytes; every 512 bytes are grouped together as a block.

During the format procedure, each block is marked as “unused” and the allocation map keeps track of each. If a block is in use, it is marked in the allocation map as “in use” at the beginning of each disk. When a block is marked in use, OS-9 moves to the next available set of contiguous blocks and continues storing the information. Each of these sets of blocks is called a “segment”. The size of the segment is determined by the number of contiguous blocks available. When a file is shortened or deleted, the previously used blocks are unmarked in the allocation map and become available for use by another file.

Within a text file, each byte contains one character. Data is written to a file in the order it is provided.   Data is read from a file exactly as it is stored in the file.

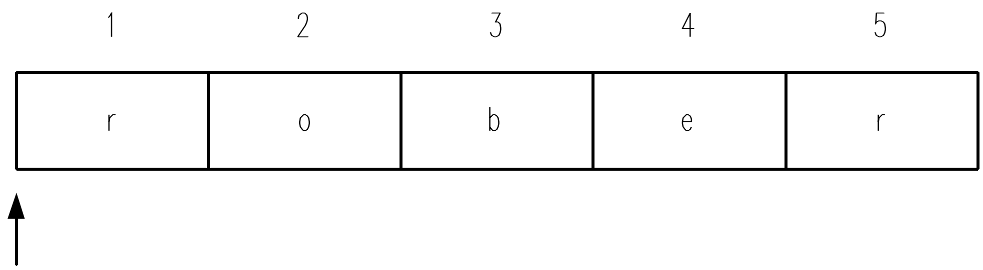
The File Pointer

When a file is created or opened, a file pointer is also created and maintained for it. The file pointer holds the address of the next byte to write or read
(Figure 4-1). As data in the file is read or written, the file pointer is automatically moved. Therefore, successive read or write operations transfer data sequentially (Figure 4-2).

You can use an OS-9 system call, `seek`, to directly access any part of a file by positioning the file pointer to any location in the file. The `seek` system call can be accessed with the C function, `_os_seek`.

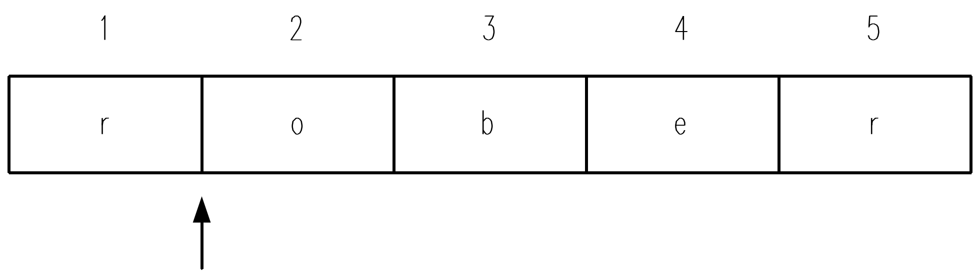
For more information about `_os_seek`, refer to the *Ultra C Library Reference* manual.

Figure 4-1. Pointer Example 1



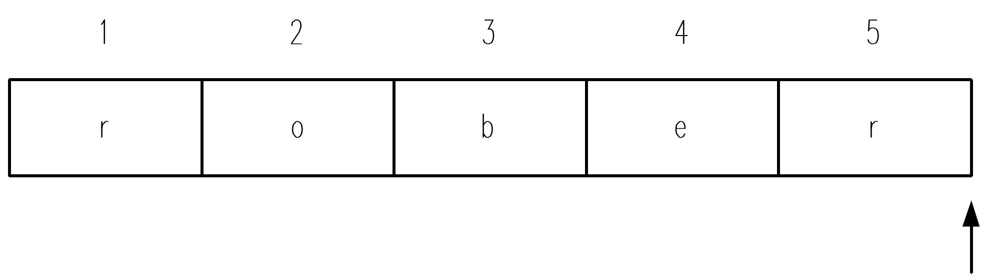
When creating or opening a file, the file pointer is positioned to read from or write to the first component.

Figure 4-2. Pointer Example 2



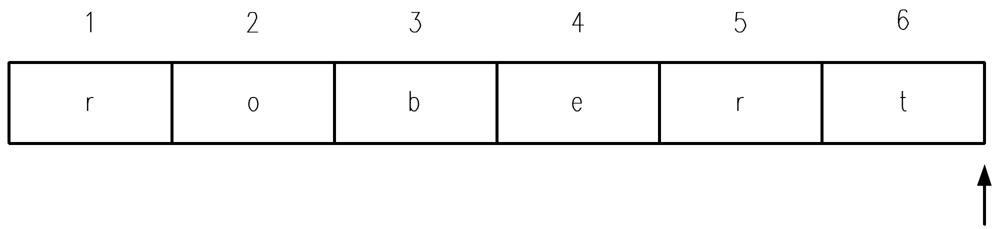
After reading or writing the first component of a file, the file pointer points to the second component.

Figure 4-3. Pointer Example 3



The file pointer points to the current end-of-file (Figure 4-3). Attempting another read operation causes an end-of-file error. Another write operation increases the size of the file.

Figure 4-4. Pointer Example 4



The next write operation adds a new component to the file and moves the file pointer to the new end-of-file (Figure 4-4).

Reading up to the last byte of the file causes the next read operation to return an end-of-file status (Figure 4-3). Attempting to read past the end-of-file mark causes an error. To expand a file, simply write past the previous end of the file (Figure 4-4).

Because all OS-9 files have the same physical organization, you can generally use file manipulation utilities on any file, regardless of its logical use. The main logical types of files used by OS-9 are listed below and are explained in the following sections.

- text files
- executable program module files
- data files
- directories (Directories are the exception and are covered separately.)

Text Files

Text files contain variable length lines of ASCII characters. Each line is terminated by a carriage return (`hex $0D`). Text files typically contain documentation, procedure files, and program source code. You can create text files with any text editor or the `build` utility.

Executable Program Module Files

Executable program modules store programs generated by assemblers and compilers. Each file may contain one or more modules with standard OS-9 module format.

For more information about modules, refer to the *OS-9 Technical Manual*.

Random Access Data Files

A data file is created and used primarily by high-level languages such as C, Pascal, and BASIC. The file is organized as an ordered sequence of records of varying sizes. If each record has exactly the same length, its beginning address within the file can be computed to enable you to access records in any order. OS-9 does not directly deal with records other than providing the basic file manipulation functions high level languages that support random access records require.

File Ownership

When you create a file or directory, OS-9 automatically stores a "group.user" ID with it. The group.user ID is formed from your group number and your user number.

group number	Enable people working on the same project or working in the same department to share a common group identification.
user number	Identify a specific user.

The group.user ID determines file ownership. OS-9 users are divided into three classes, as described in Table 4-1.

Table 4-1. User Classes

Class	Description
owner	any user with the same group and user number as the person who created the file The super-user group (`0.x`) is also considered the owner of the file.
group	any user with the same group number as the person who created the file
public	any person with a group ID differing from the person who created the file

On multi-user systems, the system manager generally assigns the group.user ID for each user. This number is stored in a special file called a password file.

A user with a group.user ID of 0.0 is referred to as a “super user”. A super user can access and manipulate any file or directory on the system regardless of the file’s ownership. On a multi-user system, the super user is generally the system manager, although other people such as group managers or project leaders can also be super users. On single-user systems, users have super user status by default.

Attributes and the File Security System

File use and security are based on file attributes. Each file has ten attributes. These attributes are displayed in a sixteen character listing.

The term “permission” is used when one of the ten possible attribute characters is set. Permission determines who can access a file or directory and how it can be used. If a permission is not valid for the file or directory being examined, a hyphen (`-`) is in its position.

Below is an attribute listing for a file in which all permissions are valid:

```
-o---ewr-ewr-ewr
```

By convention, attributes are read from right to left. They include those shown in Table 4-2.

Table 4-2. File Attributes

Attribute	Abbr	Description
Owner Read	`r`	The owner can read the file. When off, this denies any access to the file.
Owner Write	`w`	The owner can write to the file. When off, this attribute can be used to protect files from being accidentally deleted or modified.
Owner Execute	`e`	The owner can execute the file.
Group Read	`gr`	The group can read the file.
Group Write	`gw`	The group can write to the file.
Group Execute	`ge`	The group can execute the file.
Public Read	`pr`	The public can read the file.
Public Write	`pw`	The public can write to the file.

Table 4-2. File Attributes (Continued)

Attribute	Abbr	Description
Public Execute	`pe`	The public can execute the file.
Exclusive Use	`o`	When set, only one user at a time can open the file.

Directory Attributes

Directories have slightly different attributes from files. Instead of attributes for permission to execute files, directories have attributes for permission to search through directories for files. Below is an attribute listing for a directory in which all permissions are valid:

```
do---swr-swr-swr
```

By convention, directory attributes are also read from right to left. They are listed in Table 4-3.

Table 4-3. Directory Attributes

Attribute	Abbr	Description
Owner Read	`r`	The owner can read the file. When off, this denies any access to the file.
Owner Write	`w`	The owner can write to the file. When off, this attribute can be used to protect files from accidentally being deleted or modified.
Owner Search	`s`	The owner can search the directory for files.
Group Read	`gr`	The group can read the file.
Group Write	`gw`	The group can write to the file.
Group Search	`gs`	The group can search the directory for files.
Public Read	`pr`	The public can read the file.
Public Write	`pw`	The public can write to the file.
Public Search	`ps`	The public can search the directory for files.
Exclusive Use	`o`	When set, only one user at a time can open the file.
Directory	`d`	When set, indicates a directory.

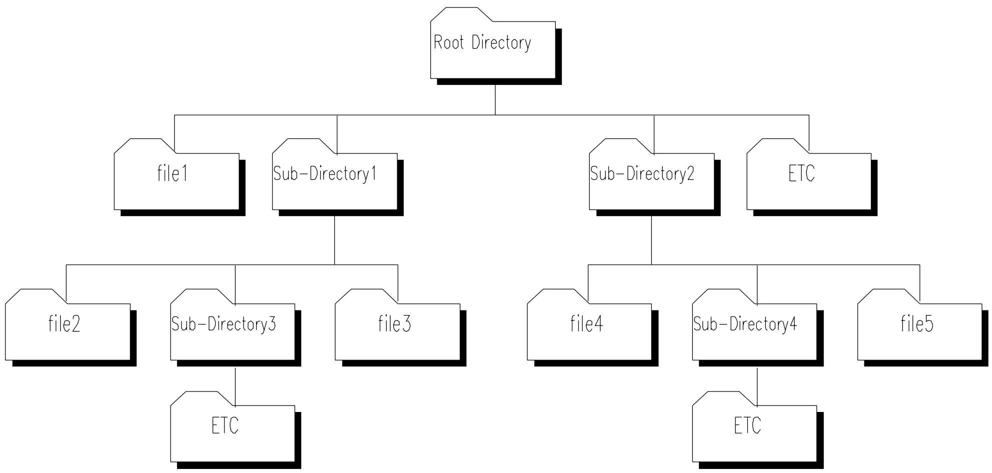
THE OS-9 FILE SYSTEM

OS-9 uses a tree-structured, or hierarchical, organization for its file system on mass storage devices such as disk systems. (Figure 4-5.) Each mass storage device has a master directory, called the root directory.

The root directory is created automatically when a new disk is formatted. It contains the names of the files and the subdirectories on the disk. Every file is listed in a directory by name and each file has a unique name within a directory.

An OS-9 directory can contain both files and subdirectories. Each subdirectory can contain more files and subdirectories. This enables you to embed subdirectories within other subdirectories. The only limit to this division is the amount of available disk space.

Figure 4-5. The File System



With the exception of the root directory, each file and directory in the system has a parent directory. A parent directory is the directory directly above the file or directory being discussed. For example in Figure 4-5, the parent directory of `file2` is `SUB-DIRECTORY1`. Likewise, the parent directory of `SUB-DIRECTORY1` is the root directory.

CURRENT DIRECTORIES

Two working directories are always associated with each user or process. These directories are called the current data directory and the current execution directory.

The following terms are important in the discussion of directories:

- *data directory*: the location in which text files are stored and created
- *execution directory*: the location in which executable files live

This current directory concept enables you to organize your files and keep them separate from other users on the system. The word "current" is used to reflect the idea that you can move through the tree structure of the OS-9 file system to a different directory; this different directory becomes your current data or execution directory.

DIrectories and Single-User Systems

On a single user system, OS-9 chooses the root directory of your system disk as the initial current data directory. The initial current execution directory is the `CMDS` directory. The `CMDS` directory is located in the root directory of the system disk.

Directories and Multi-User Systems

On a multi-user system, the current data and execution directories are established as part of the initial login sequence. When you log in, your initial directories are set up according to your password file entry. A password entry is established for each user on a multi-user system. This entry lists information such as the user's password and current directories.

The execution directory on a multi-user system is usually the `CMDS` directory, which is shared with other users. `CMDS` contains OS-9 utilities and other executable files.

The Home Directory

On typical multi-user systems, all users have their own data directory. Through the `/H0/CMDS` environment variable, each user may also have a private execution directory to avoid conflict with other users.

The private data directory enables you to organize your files by project, function, or any other method without affecting other users' files. The data directory specified in the password file entry is known as the home directory. When you first login to the system, your information is placed in this directory. This can also be accomplished by using the `chd` utility without parameters.

On single user systems, you may establish a home directory by setting the `HOME` environment variable.

For more information about:

- `chd`: Refer to the *Utilities Reference* manual.
- the `HOME` environment variable: Refer to *Chapter 6, The Shell*.

Directory Characteristics

Below are some important characteristics relating to directory files:

- Directories have similar ownership and attributes as other files. However, directories always have the `d` attribute set, and contain attributes that allow for file searching, while files have attributes for executing files.
- Each file name within a directory must be unique. For example, you cannot store two files named `trial` in the same directory. Files may have different names if they are stored in separate directories.
- All files are stored on the same device as the directory in which they are listed.
- You are limited to the number of files you can store in a directory by the amount of free disk space in your system.

ACCESSING FILES AND DIRECTORIES: THE PATHLIST

You can access all files or directories in your current data directory by specifying the name of the file or directory after typing the correct command. In cases where only a file or directory name is given, OS-9 does not look outside your current data directory to find that particular file or directory.

If you want to access a file that does not live in your current data directory or run a program that does not live in your current execution directory, you must either change the current directory or specify a pathlist through the file system for OS-9 to follow.

There are two types of pathlists: full pathlists and relative pathlists. These are explained in the following sections.

Full Pathlists

A full pathlist starts at the root directory and follows the directory names in the list down the file structure to a specific file or directory. A full pathlist must begin with a slash character (`/`). (Slashes separate names within the pathlist.)

The following example is a full pathlist from the root directory, `/d1`, through two subdirectories, `PASCAL` and `TESTS`, to the file `futureval`.

```
/d1/pascal/tests/futureval
```

The example below specifies a path from the root directory, `/h0`, through the `USR` subdirectory, to the `NICHOLLE` subdirectory.

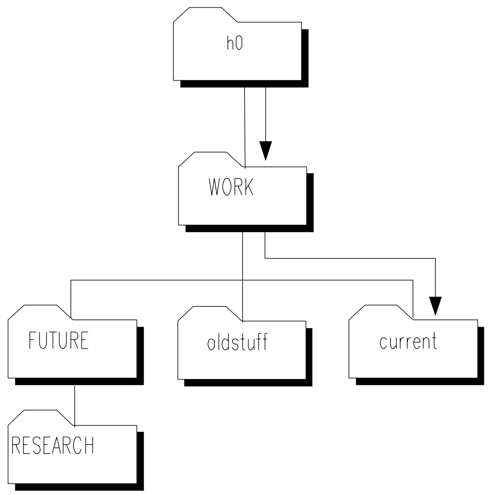
```
/h0/usr/nicholle
```

A full pathlist begins at the root directory regardless of where your current data directory is located. It lists each directory located between the root directory and a specific file or subdirectory.

Example

Suppose your data directory is `RESEARCH`. A full pathlist to `current` would then be `/h0/WORK/current` (as shown in Figure 4-6).

Figure 4-6. Full Pathlist Example



Relative Pathlists

A relative path starts at the current directory and proceeds up or down through the file structure to the specified file or directory. A relative pathlist does not begin with a slash (`/`). (Slashes separate names within a relative pathlist.)

When you use a relative pathlist and the desired destination requires moving up the directory tree, you can use special naming conventions to make moving around the pathlist easier.

- A single period (`.`) refers to the current directory.
- Two periods (`..`) refer to the current directory's parent directory.
- Add a period for each higher directory level.

For example, to specify a directory two levels above the current directory, three periods are required. Four periods refer to a directory three levels above the current directory.

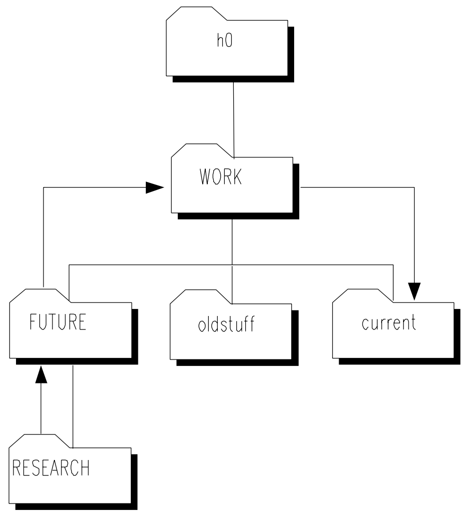
You can also use a Unix-style pathlist such as `../../../`

A relative pathlist begins at your current directory regardless of its location in the overall file structure.

Example

Suppose your data directory is `RESEARCH`. A relative pathlist to `current` would then be `.../current` (as shown in Figure 4-7).

Figure 4-7. Relative Pathlist Example



Using a relative pathlist name substitute does not change the directory's name.

The following example is a relative pathlist that begins in your current directory and goes through the subdirectory `DOC` and `LETTERS` to the file `jim`.

```
DOC/LETTERS/jim
```

The next pathlist goes up to the next directory above your current directory and then through the subdirectory `CHAP` to the file `page`.

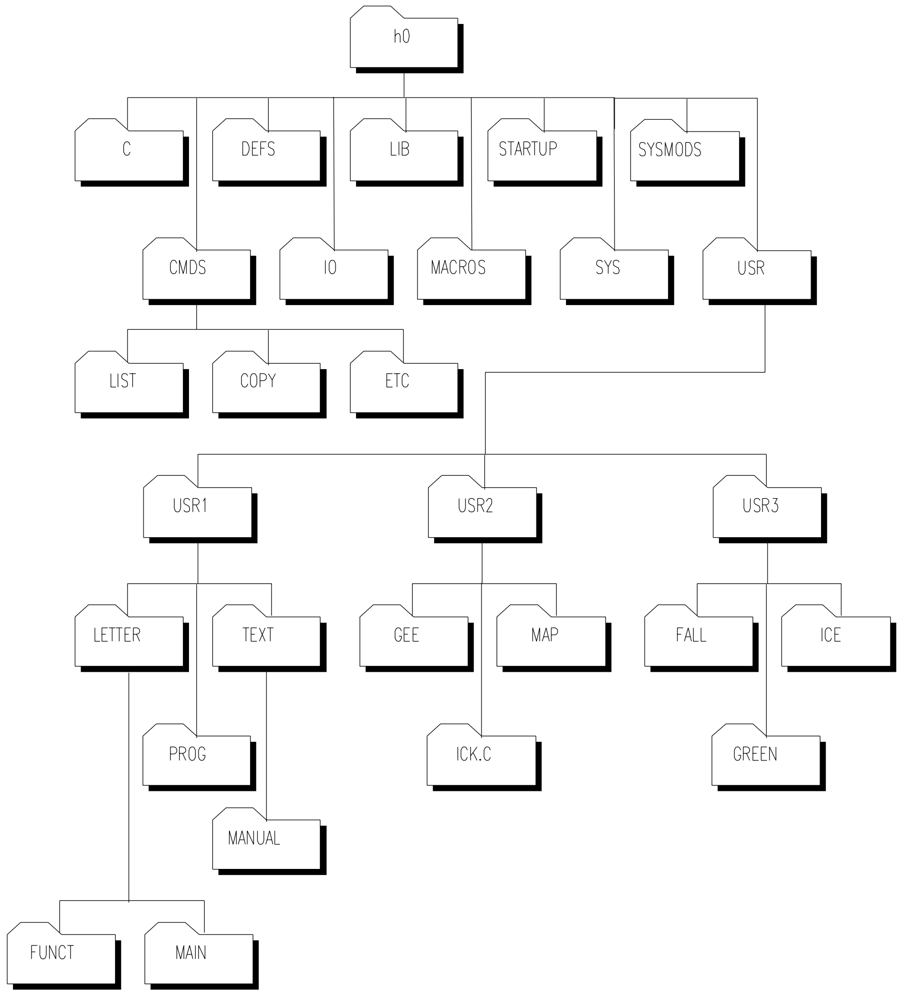
```
../CHAP/page
```

The next pathlist specifies a file within your current directory. No directories are searched other than the current directory.

BASIC FILE SYSTEM UTILITIES

Some OS-9 utility commands manipulate the file system. These utilities include `dir`, `chd`, `chx`, `pd`, `build`, `makdir`, `list`, `copy`, `dsave`, `del`, `deldir`, and `attr`. The given examples refer to an example file system (Figure 4-8).

Figure 4-8. Diagram of a Typical File System



The dir Utility

The `dir` utility displays the contents of a directory. Typing `dir` by itself displays the contents of your current data directory. For the following example, the current data directory is `/h0`. Typing `dir`, as shown in Figure 4-8, results in the following output:

```
$ dir
  directory of .  13:56:58
C        CMDS     DEFS     IO       LIB
MACROS   SYS      SYSMODS  USR      STARTUP
```

To look at directories other than your current data directory, you must either provide a pathlist to the desired directory or change your current data directory.

To display the contents of another directory without changing your current data directory, type `dir` and the pathlist to the directory. For example, if you are in the root directory and you want to see what is in the `DEFS` directory, type the following command:

```
dir defs
```

`dir` now displays the names of the file in the `DEFS` directory. The name `defs` is a relative pathlist. You can type `dir defs` because `DEFS` is in your current data directory. You can also use the full pathlist, `dir /h0/defs` and get the same result.

To display the contents of your current execution directory, type `dir -x`.

dir and Wildcards

Wildcards can be used with `dir` and with most other utilities. OS-9 recognizes two wildcards, as described in Figure 4-4.

Table 4-4. OS-9 Wildcards

Wildcard	Description
An asterisk (*)	An asterisk replaces any number of letter(s), number(s), or special character(s). Consequently, an asterisk by itself expands to include all of the files in a given directory.
A question mark (?)	A question mark replaces a single letter, number, or special character.

For example, the command `dir *` lists the contents of all directories located in the current data directory. The command `dir /h0/cmds/d*` lists all files and directories in the `CMDS` directory beginning with the letter `d`. The command `dir prog_?` lists all files in your current directory having a file name with `prog_` followed by a single character.

For more information on using wildcards, refer to *Chapter 6, The Shell*.

dir Options

`dir` has several options are fully documented in the *Utilities Reference* manual. The `-e` and `-r` options are discussed in this section.

The -e Option

The `-e` option gives an extended directory listing. An extended directory listing displays all files within the specified directory with their attributes, sizes, and the sectors where the files are stored. The following example uses the file structure shown in Figure 4-8.

```
   $ dir usr/bob -e
                          Directory of USR/Bob 12:30:27
    Owner    Last modified    Attributes    Block  Bytecount
Name
   -------   ------------- --------------- ------ --------
- ----
    22.150   89/09/25 1057 --------------wr  12CB0
5744 letter
    22.150   89/09/19 1057 d-------------wr  12CAF
15944 PROG
    22.150   89/09/25 1103 d-------------wr  12C90
11113 TEXT
```

The -r Option

The `-r` option displays the contents of the specified directory and any files contained within its subdirectories. Typing `dir usr/usr1 -r` lists the following output:

```
   Directory of . 12:30:15
     PROG      TEXT      letter
   Directory of PROG 12:30:15
     funct     main
   Directory of TEXT 12:30:15
     manual
```

You can use any `dir` option with another. Typing `dir -er` displays all files within the current data directory, all files within its subdirectories, and provides an extended listing of their attributes and sizes.

The chd and chx Utilities

The `chd` and `chx` utilities enable you to travel around the file system.

- `chd` changes the current data directory.
- `chx` changes the current execution directory.

Using chd

To change your current data directory, type `chd` followed by a full or relative pathlist. For example, if your current data directory is `/h0` and you want your current data directory to be `USR`, type `chd` and the pathlist of `USR`.

- Using a relative pathlist, type the following command:

  `chd usr`
- Using a full pathlist, type the following command:

  `chd /h0/usr`

Your current data directory is now `USR`. When you type `dir`, you should see the contents of `USR`:

```
directory of . 14:04:32
USR1      USR2      USR3
```

To see which files are in the `USR1` directory, type `dir usr1`. Change directories by typing `chd usr1`, then `dir` after the new prompt.

To return to your home directory, which in this case is `/h0`, type `chd` without including a pathlist. After changing the directory, `dir` displays the contents of `/h0`.

Using chx

The `chx` command enables you to redefine an existing directory as a personal execution directory. If you have programs you do not want other users to execute, you may find it useful to define a personal execution directory. To do this, type `chx`, followed by a full or relative pathlist to the directory. When using a relative pathlist with `chx`, note that the pathlist is relative to your current execution directory.

If your current data directory is `USR` and you want to change your current execution directory from `CMDS` to `USR2`, you can type the relative pathlist `chx ../usr/usr2` or the full pathlist `chx /h0/usr/usr2`. When you type a command after you have changed your current execution directory, OS-9 searches `USR2` instead of `CMDS`.

Typing `dir -x` displays the contents of your current execution directory, `USR2`:

```
Directory of .. 20:54:18
map      pics     new.c
```

Navigating through Directory Trees

You can use special naming conventions to move around the file system. Naming conventions are periods specifying the current directories and directories higher in the file structure. Consider the following example:

`.`	refers to the current directory
`..`	refers to the parent directory
`...`	refers to two directory levels higher

When used as the first name in a path, you can use these naming conventions with relative pathlists.

Examples

The following examples relate to the file structure in Figure 4-9. The examples assume your initial current data directory is `PROG`.

- The contents of `PROG` are displayed below. It is functionally the same command as `dir`.

  ```
  dir .
    directory of . 14:04:32
  funct    main
  ```

- The command below displays the contents of `PROG`'s parent directory, `USR1`.

  ```
  dir ..
    directory of ..  14:05:58
  PROG     TEXT     letter
  ```

- The example below displays the contents of `TEXT` by specifying a path starting with the parent directory:

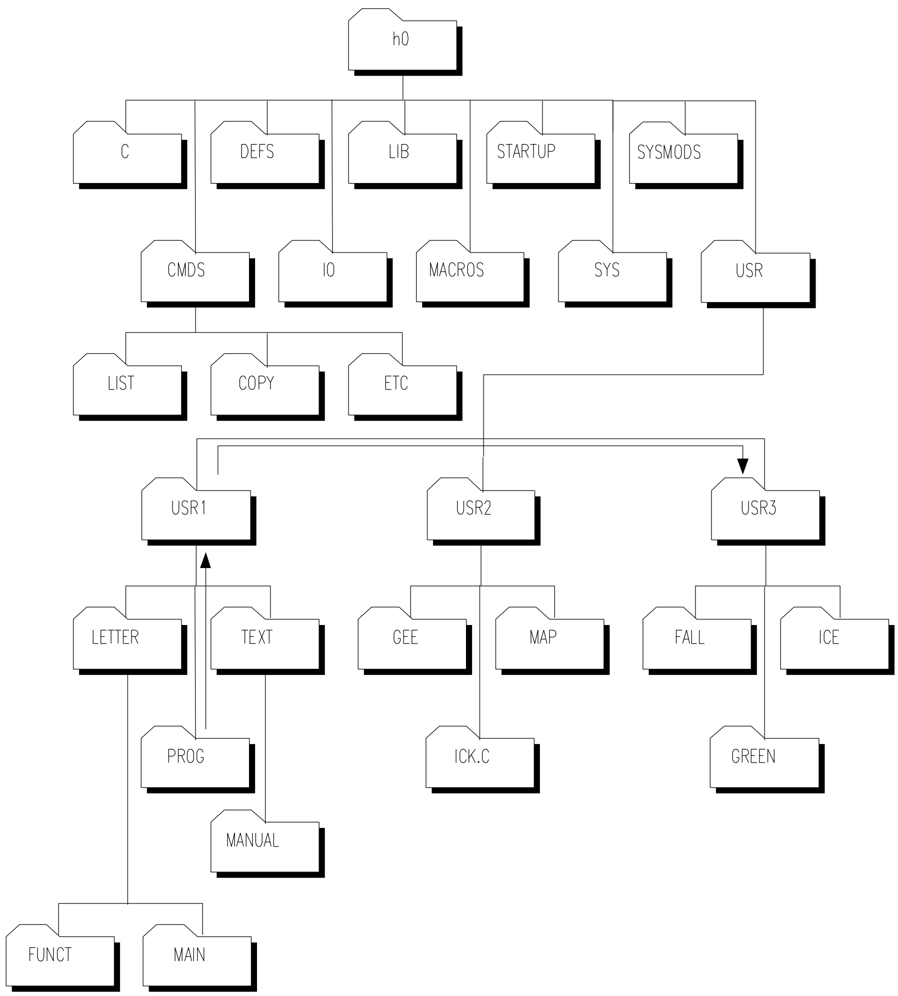
  ```
  dir ../text
     directory of ../text 14:06:47
  manual
  ```

- The following command changes the current data directory from `PROG` to `USR3`:

  ```
  chd .../usr3
  ```

  `USR3` is accessed from `PROG` using the relative path `.../usr3`.

Figure 4-9. Accessing Directories Using a Relative Path



You can use any number of periods (.) to access higher directories. One period is added for each level. An error is not returned if you specify a greater number of directory levels above your current data directory than actually exist. Instead, this indicates the root directory on your system.

For example, the command below displays the contents of the root directory:

```
dir .........
```

This may be helpful if you are not sure how deep into the directory structure you have travelled.

- The following example changes your current data directory from `PROG` to `MACROS`:

  ```
  chd ........./macros
  ```

Using the pd Utility

The `pd` utility displays the complete pathlist from the root directory to your current data directory.

For example (if your current data directory is `USR2`):

```
pd
/h0/USR/USR2
```

While inside your current execution directory, type `pd -x` to display the pathlist to that directory.

Creating New Directories

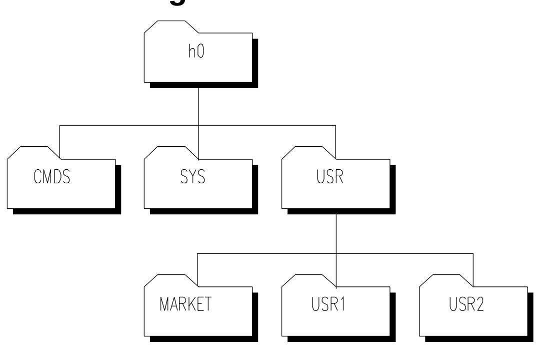
To create new directories, use the `makdir` utility. For example, to create a directory called `MARKET`, type the following command:

```
makdir MARKET
```

`MARKET` now is a new directory in your current directory.

If you want the new directory created somewhere other than in your current directory, you must specify a pathlist. For example, `makdir /h0/usr/MARKET` creates the new directory in `USR`.

Figure 4-10. Creating the /h0/USR/MARKET Directory



Rules for Constructing File Names

When creating files and directories, you must follow certain rules. A file name can contain from one to 43 upper and lower case letters, numbers, and special characters, as listed in Table 4-5. While the file name may begin with any of the following characters or digits, each file name must contain at least one letter or number. Within these limitations, a name can contain any combination of the following examples:

Table 4-5. Characters Allowed in File Names

Description	Example
Upper case letter:	A - Z
Lower case letter:	a - z
Decimal digits:	0 - 9
Underscore:	_
Period:	.
Dollar sign:	$

File names must not contain spaces. Instead, use an underscore (_) or a period (`.`) should be used to improve the readability of file and directory names. OS-9 does not distinguish upper case from lower case letters. For example, the names `FRED` and `fred` are considered the same name.

Typically, directory names are in upper case and file names are in lower case. It is not required, but it helps to easily distinguish directories from files.

Table 4-6 lists are some examples of legal names:

Table 4-6. Legal File Names

`raw.data.2`	`project_review_backup`
`X6809`	`$SHIP.DIR`
`...c`	`12345`

Table 4-7 lists are some examples of illegal names:

Table 4-7. Illegal File Names

Name	Description
`Max*min`	* is not a legal character
`open orders`	name cannot contain a space

File names beginning with a period are not displayed by `dir` unless you use the `-a` option. This enables you to hide files within a directory.

Creating Files

You can create files in many ways. Text files are generally created with the `build` utility, the `edt` utility, or the `µMACS` text editor. These file building tools are provided with the OS-9 package.

Creating Short Text Files

Use the `build` utility to create short text files. To use `build`, type `build`, followed by the name of the file you want to create. `build` responds with a "`?`" prompt, which tells you that `build` is waiting for input. To terminate `build`, type a carriage return at the `?` prompt. Consider the following example:

```
$ build test
? Creating a text file is easy
? when you use the buid utility,
? but you cannot edit files with build.
?
$
```

You cannot edit files with `build`.

Editing Text Files

To create and edit text files, use the `edt` utility. `edt` is a line-oriented text editor with the capability to create and edit source files. To use `edt`, type `edt` and the desired pathlist. `edt` displays a question mark (`?`) prompt and waits for an edit command. If the file is found, `edt` performs the following tasks:

1. Opens the file.
2. Displays the last line of the file.
3. Displays the `?` prompt.

Using µMACS

Most people prefer using µMACS to create and edit files. µMACS is a screen-oriented text editor for creating and modifying text files and programs. Through the use of multiple buffers, µMACS enables you to display different files or different portions of the same file on the same screen. In addition, extensive formatting commands enable you to complete the following tasks:

- Reformat paragraphs with new user-defined margins.
- Transpose characters.
- Capitalize words.
- Change words or sections into upper or lower case.

For more information about µMacs, refer to the *Utilities Reference* manual.

Examining File Attributes

When you create a file using `build` or µMACS, only the owner read and owner write permissions are set. When you create a directory, it initially has all the permissions set except the single user permission.

To examine file attributes, use the `attr` utility. To use this utility, type `attr`, followed by the name of a file. Consider the following example:

```
$ attr newtest
--------------wr
```

The file `newtest` has the permissions set for owner reading and owner writing. Access to this file by anyone other than the owner is denied.

Users with the same group.user ID as the person who created the file are considered owners. However, if the file is created by a group 0 user, only users in the super group can read, write, or execute the file.

If you use `attr` with a list of one or more attribute abbreviations, the file attributes are changed accordingly, provided you have the proper write permission to access the file. You do not need to list the attribute abbreviations in any particular order. The letter `n` preceding an attribute removes that permission.

The following command enables public read and write permission and removes execution permission for both the owner and the public:

```
$ attr newtest -pw -pr -ne -npe
```

The owner always has the right to delete a file, change the user privileges, etc. Users in the same group have the same permissions as the owner.

The directory attribute is somewhat different than the other attributes. It could be dangerous to be able to change directory files to normal files or a normal file to a directory. For this reason, you cannot use `attr` to turn the directory (`d`) attribute on; use `makdir` to turn this attribute on. Furthermore, you can only use `attr` to turn the directory attribute off if the directory is empty.

Listing Files

The `list` utility displays the contents of files. By default, `list` displays the lines of text on your terminal screen. To examine a file, type `list`, followed by the name of the file. For example:

```
$ list test
Creating a text file is easy
when you use the build utility,
but you cannot edit files with build.
$
```

It is important to remember that you cannot list a directory. If you type the command `list USR`, the following error message and error number will be returned:

```
list: can't open "USR".  Error# 000:214.
```

The above message means you cannot access `USR` because it is a directory.

`list` displays text files. All distributed files in `CMDS` are executable program module files. If you try to list the contents of a random access data file or an executable program module file, you see what appears to be random data displayed on your screen. This may also include unprintable characters--such as escape or delete--that could change your terminal's operating parameters. If the operating characteristics of your terminal are affected, try turning the terminal off and on. If this does not re-initialize the terminal, consult your terminal operating manual.

Copying Files

The copy utility makes a duplicate of a file. To copy a file, type `copy`, followed by the name of the file to be copied, followed by the name of the duplicate file. For example:

```
$ copy test newtest
```

If you `list` the file `newtest`, it is an exact copy of `test`.

The file you are copying, as well as the duplicate file, can be located in any directory; these do not have to be in your current data directory. For files located outside of your current data directory, use full or relative pathlists. The following example uses Figure 4-11. The first command copies the file `gee` in the `USR2` directory to a file named `new.info` in the `TEXT` directory:

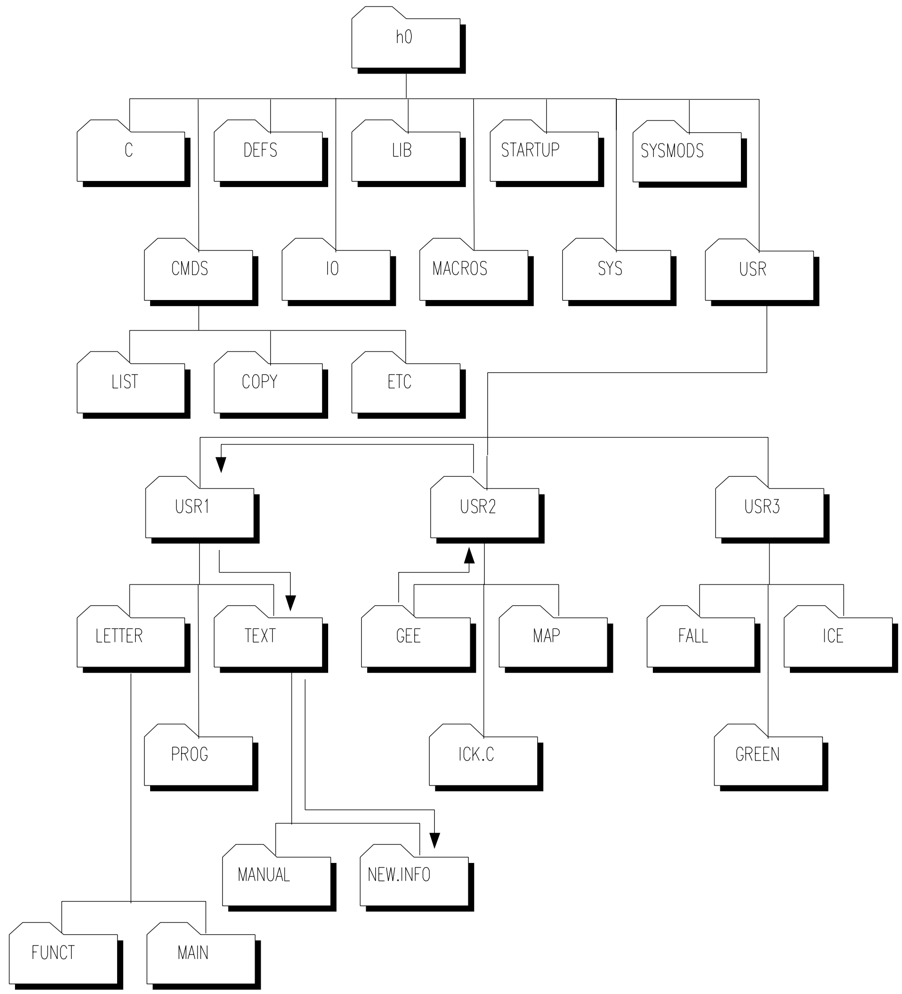
```
copy /h0/usr/usr2/gee /h0/usr/usr1/text/new.info
```

Assuming your data directory is `USR`, the following commands have the same effect:

```
copy /h0/usr/usr2/gee usr1/text/new.info
copy usr2/gee usr1/text/new.info
```

`gee` is copied from `USR2/gee` to `USR1/TEXT/new.info` using the command `copy usr2/gee usr1/text/new.info`.

Figure 4-11. Copying Files



Copying a File into an Existing File

If you try to copy the contents of one file into an existing file, you will receive the following message: `Error #000:218 Tried to create a file that already exists`. If you know the file exists but you want to overwrite it anyway, use the `-r` option. For example, the following command replaces the contents of `green` with the contents of `fall`.

```
$ copy fall green -r
```

When you list the contents of both files, it becomes obvious that they are identical.

Copying Multiple Files

At some point, you may want to copy more than one file at a time into another directory. By using the `-w=<dir>` option of `copy`, you can copy more than one file with a single command. For example, if your current directory is `PROG` and you want to copy all of the files in `PROG` into the `TEXT` directory, you would type the following command line:

```
$ copy * -w=../text
```

This option prints the name of the file after each successful copy. If an error occurs, the prompt `continue (y/n)` is displayed.

Copying Large Files

If you have a large file, the copy procedure may be slow because the system has to perform multiple read and write statements from a small 4K buffer. To make the copy procedure faster when copying large files, use the `-b` option to increase the buffer size. To use the `-b` option, type `copy`, the original file name, the new file name, and `-b=<num>k`.

For example, typing `copy gee mine -b=20k` allocates a 20K buffer for copying the file `gee` into the file `mine`.

For more information about `copy`, refer to the *Utilities Reference* manual.

Using Procedure Files to Copy Files

T the `dsave` utility copies all files and directories within a specified directory by generating a procedure file. The procedure file is either executed later to actually perform the copy or, by specifying the `-e` option, executed immediately.

A procedure file is a special OS-9 file containing OS-9 commands. Each command is specified on a line, one command per line. When the procedure file is executed, the OS-9 commands it contains are executed in the order they are listed in the procedure file.

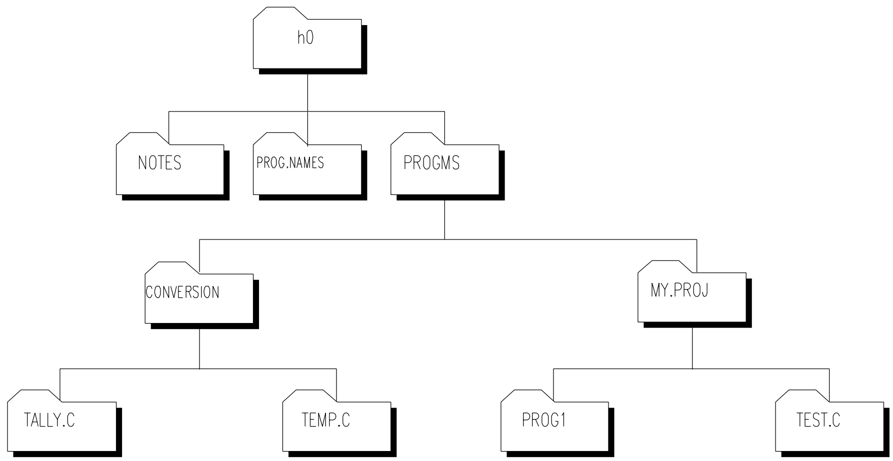
For more information about procedure files, refer to *Chapter 6, The Shell*.

To use the `dsave` utility, type `dsave` followed by the pathlist of the directory into which the files are copied, followed by any options you wish to use.

If no pathlist is specified for the destination, the files are copied to the current data directory when the procedure file is executed. If you do not specify the
`-e` option or redirect the output to a file, `dsave` sends the output to the terminal.

The example below uses the directory structure shown in Figure 4-12.

Figure 4-12. Dsave Example Directory Structure



If `PROGMS` is your current data directory and you type `dsave ../notes`, the following output appears on your screen:

```
$ dsave ../notes
-t
chd ../notes
tmode -w=1 nopause
load copy
makdir MY.PROJ
chd MY.PROJ
copy -b=10 /h0/PROGMS/MY.PROJ/prog1
copy -b=10 /h0/PROGMS/MY.PROJ/test.c
chd ..
makdir CONVERSION
chd CONVERSION
copy -b=10 /h0/PROGMS/CONVERSION/temp.c
copy -b=10 /h0/PROGMS/CONVERSION/tally.c
chd ..
unlink copy
tmode -w=1 pause
$
```

Because the output was not redirected to a procedure file and the `-e` option was not used, the above commands were not executed. They were merely echoed to your screen.

If you now type `dsave ../notes -e`, the commands are again echoed to the screen. However, the contents of the `PROGMS` directory are copied into the `NOTES` directory.

Selectively Copying Multiple Files

You can redirect the output of `dsave` to a file. When you redirect the output, the commands output from `dsave` are essentially captured in a file. You can later execute this file to actually perform the `dsave` operation.

To redirect the output from `dsave` to a file, use the redirection modifier for standard output. The standard output modifier is the greater than (redirect) symbol.

For example, from the `PROGMS` directory, you can redirect the output from `dsave` into a file called `make.bckp` by typing:

```
dsave >make.bckp
```

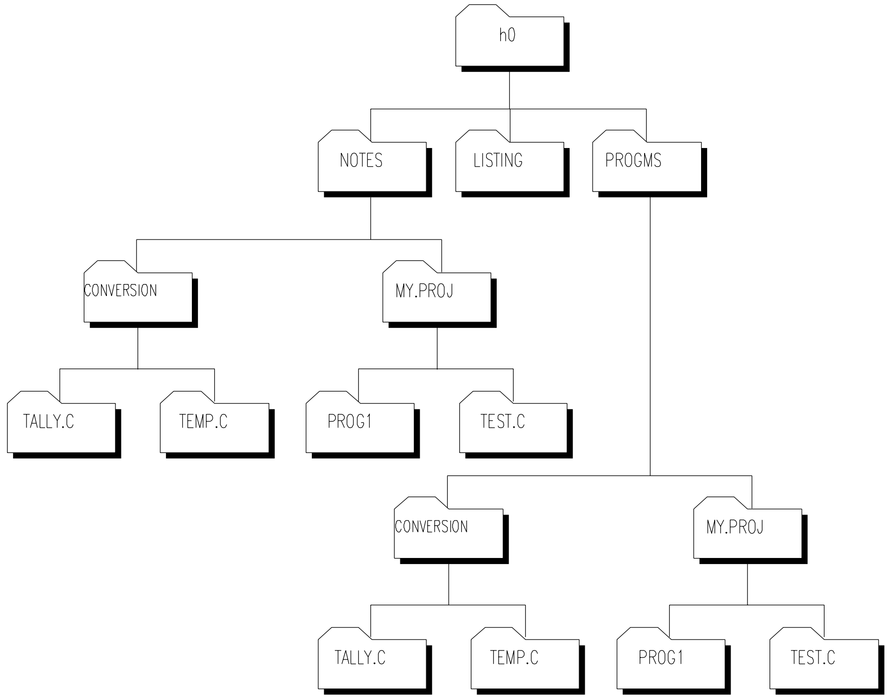
This command creates `make.bckp` in the current data directory. To perform the `dsave`, type `make.bckp` at the command line.

Redirecting the output to a file is helpful when you want to save most, but not all, of the file in the directory or directory being saved. You can edit `make.bckp` before performing the `dsave`. This enables you to save only selected files.

Regardless of how you decide to perform the `dsave`, if `dsave` encounters a directory file, it automatically creates a new directory and changes to that directory before generating `copy` commands for files in the subdirectory.

In the `dsave` example, the directory structure looks like the following diagram when `dsave` has finished:

Figure 4-13. dsave Example Directory Structure



If the current working directory is the root directory of the disk, `dsave` creates a file that backs up the entire disk, file by file. This is useful when you need to copy many files from different format disks or from a floppy disk or a hard disk.

Errors During dsave

If an error occurs during the `dsave` process, the following prompt is displayed:

```
continue (y,n,a,q)?
```

Table 4-8. Responses to dsave Errors.

Response	Indicates you...
`y`	want to continue with `dsave`
`n`	do not want to continue with `dsave`
`a`	want all possible files copied and do not want the prompt displayed on error
`q`	want to exit `dsave`

You can use the `-s` option to turn off the prompt. This skips any file that cannot be copied and continues the `dsave` routine without the error prompt.

Indenting for Directory Levels

When you copy several subdirectories, you can use the `-i` option to indent for directory levels. This helps to keep track of which files are located in which directories.

Keeping Current Directory Backups

You can use `dsave` to keep current directory backups. Use the `-d` or `-d=<date>` options to compare the date of the file to be copied with a file of the same name in the directory where it is to be copied. The `-d` option copies any file with a more recent date. The `-d=<date>` option copies any file with a date more recent than that specified. The following example shows the use of `dsave` with the `-d` option:

```
  $ chd /d0/BACKUP
  $ dir
  Directory of . 14:14:32
   Owner    Last Modified  Attributes Sector Bytecount
Name
  -------   -------------  ---------- ------ --------- ---
-
   12.4     92/11/12 1417   ------wr    20CO     11113
program.c
```

```
    12.4     92/10/05 1601   ------wr    313D      5744
prog.2
   $ chd /d0/WORKFILES
   $ dir
   Directory of . 14:14:32
    Owner    Last Modified  Attributes Sector Bytecount
Name
   -------   -------------  ---------- ------ --------- ---
-
    12.4     92/11/12 1417   ------wr    DODO     11113
program.c
    12.4     92/11/12 1601   ------wr    3458      5780
prog.2
   $ dsave -deb32 /d0/BACKUP
   $ chd /d0/BACKUP
   $ dir
   Directory of . 14:14:32
    Owner    Last Modified  Attributes Sector Bytecount
Name
   -------   -------------  ---------- ------ --------- ---
-
    12.4     92/11/12 1417   ------wr    5990     11113
program.c
    12.4     92/11/12 1601   ------wr    A12B      5780
prog.2
```

Only `prog.2` was copied to the `BACKUP` directory because the date was more recent in the `WORKFILES` directory.

For more information about `dsave`, refer to the *Utilities Reference* manual.

Deleting Files and Directories

Use the `del` and `deldir` utilities to eliminate unwanted file and directories.

- `del` deletes a file.
- `deldir` deletes a directory.

If you no longer need a file, deleting the file frees disk space. You must have permission to write to the file or directory in order to delete it.

Deleting Files

To delete a file, type `del`, followed by the name of the file you want deleted. For example, to delete the file `test` you created with `build`, you would type the following command:

```
del test
```

If you execute `dir`, `test` is no longer displayed.

When deleting files, you may use wildcards. For example, if you have three files, `trial`, `trial1`, and `trial.c` in a directory, you can use the * wildcard in the command to delete all three files.

Use caution when you use wildcards with utilities like `del` and `deldir`. It is easy to unintentionally delete files you want to save.

The `del -p` option displays the following prompt before deleting a file:

```
delete <filename> ? (y,n,a,q)
```

This helps prevent deleting files you want to keep.

Table 4-9. Responses to Del -p Option

Response	Action
y	Delete the file.
n	Do not delete the file.
a	Delete specified files without further prompts.
q	Exit the deleting process.

Deleting Directories

To delete a directory, use the `deldir` utility to delete directories. `deldir` first deletes all the files and directories in the given directory, and then, if no errors occur, finally deletes the directory name. For example:

```
$ deldir USER2
Deleting directory: USER2
Delete, List, or Quit (d, l, or q) ?
```

Table 4-10. Responses to Deldir Command

Response	Action
`d`	Delete the directory.
`l`	List the directory contents.
`q`	Quit without deleting any files.

Do not delete a file or directory unless you are sure you do not need it. Files and directories deleted with the `del` and `deldir` commands are permanently removed.

5 OS-9 Memory Modules

This chapter describes OS-9 memory modules and module directories. The utilities used with modules and module directories are also discussed. The following sections are included:

- OS-9 Memory Modules
- Module Directories

OS-9 MEMORY MODULES

In addition to organizing your programs and other files into a file system, OS-9 manages both the physical assignment of memory to programs and the logical contents of the memory. To do this, OS-9 uses memory modules.

A memory module is a logical, self-contained program, program segment, or collection of data. Any program or file can become a memory module. Modules are created by compiling and linking programs or by creating data modules. Each module must have three parts:

- A module header contains information that describes the module and its use. The information contained in the module header includes the module name, size, type, language, memory requirements, and entry point.
- A module body contains information such as initialization data, program instructions and constant tables.
- A Cyclic Redundancy Check (CRC) value verifies the module integrity.

In addition to a module header, a module body, and a CRC value, a module must also be position-independent and re-entrant. A re-entrant module does not modify itself; this enables two or more processes to use the module simultaneously. A position-independent module does not depend on being loaded at a specific memory location; this enables OS-9 to load the program wherever memory space is available. In many operating systems, you must specify a load address to place the program in memory. OS-9 determines an appropriate load address only when the program is run.

For more information on modules, refer to the *OS-9 Technical Manual.*

Using Memory Modules

Memory modules are extremely useful. They provide efficient use of available disk and memory storage, simplify programming jobs, and enable the system to run faster. In addition, they make it easy to customize and adapt OS-9.

An important characteristic of memory modules is that they can be shred by several tasks or users at the same time. For example, if four users want to run µMACS at the same time, only one copy of the µMACS program module is loaded into memory. Other operating systems typically load four exact copies of µMACS into memory, requiring 300% more memory than if OS-9 were used. In addition, the shared module system is completely automatic and usually transparent to the user.

Also, with memory modules, frequently used functions can share common library modules and you can split large and complex programs into smaller, “testable” modules.

Loading Modules into Memory

Modules can be loaded into memory during the startup procedure or after the system has been accessed. Modules loaded during the startup procedure can be loaded either in bootfile or in the startup file. Both of these methods for loading modules are discussed in the chapter on system management.

Modules necessary for system startup or modules that are used frequently should be loaded during the startup procedure. Loading modules at system startup places them in contiguous spaces of memory; therefore, the memory will be less fragmented.

Modules that are used less frequently can be loaded after the system startup. To load one or more specified modules into memory, type `load`, then the pathlist(s) of the module(s) to be loaded into your current module directory. Pathlists may be relative to your current execution directory. If the module is located in your current execution directory, only the file name is needed after the `load` command:

```
load <file>
```

If `<file>` is not in your execution directory and the shell environment variable `PATH` is defined, `load` searches each directory specified by `PATH` until `<file>` is successfully loaded from a directory. This corresponds to the shell execution search method using the `PATH` environment variable. The names of the modules are added to the module directory. If a module is loaded having the same name as a module already in the current module directory, the module having the highest revision level is kept. The modules are normally loaded from the current execution directory.

Environmental variables are discussed in *Chapter 6, The Shell*.

Module Security

The OS-9 file security mechanism enforces certain requirements regarding owner and access permission when loading modules into a module directory. You must have file access permission to the file loaded. If the file is to be loaded from an execution directory, you must have the execute and read permissions for the file. If the file is to be loaded from a directory other than the execution directory, and the `-d` option is used, only the read permission is required.

You must have module access permission to the module to be loaded. This is different from the file access permission of the file containing the target module. The module owner and access permissions are stored in the module header and can be examined by the `ident` utility. To prevent loading super user programs by ordinary users, OS-9 enforces the following restriction: If the module group ID is zero (super group), then the module can be loaded only if the process group ID or the file group ID is zero.

If you are not the owner of a module and not a super user, the public execute and/or public read access permissions must be set. The module access permissions are divided into three groups: the owner, the group, and the public. Only the owner of the module or the super user can set the module access permissions.

There is one other restriction. You must have write permission for the module directory into which you are loading the module. Module directory attributes are discussed later in this chapter.

The Link Count

When modules are loaded into memory, they are added to the module directory structure. Each directory entry contains the module address and a count of the processes using the module. This count is called the link count.

When a process forks to a primary memory module, the module link count is automatically incremented by one. When the process is finished with the primary module, the link count is automatically decremented.

You can also use the `link` utility to link to a memory module if you want to keep the module in memory. To link to a module, type `link` and the name(s) of the module(s) to be linked. The link count of the specified module is incremented by one each time it is linked.

For example, if you have loaded the module `leap1` into memory, it has a link count of 1. If another user also decides to use `leap1` and links to the memory module, the link count becomes 2.

When you have finished using a module you have linked to with the `link` utility, remove your link to the module by typing `unlink` and the name(s) of the module(s) to be unlinked. The link count is decremented by 1.

In the example above, if you have finished using `leap1`, type the following command:

```
unlink leap1
```

The link count for `leap1` becomes 1 because another user is still using the module.

The link count becomes 0 if the other user decides to unlink from leap1. The module directory entry is deleted and the memory is de-allocated. It is good practice to unlink modules whenever possible to make the most efficient use of available memory resources.

Unless you have explicitly linked to a module using `link`, you do not need to unlink the module

Modules Remaining in Memory

There are three cases when a module is not removed from memory, even if the module's link count reaches `0`:

- Modules have been loaded during system bootstrap.
- The modules being loaded are sticky modules.

- Modules are still in use.

Modules loaded during system bootstrap cannot be unlinked from memory regardless of their link count. It is potentially fatal to your system to unlink memory modules such as the kernel.

A sticky module sticks in the system even when it has a link count of 0. A sticky module is removed from memory only when `unlink` is used to lower the module link count to -1. You can use the `fixmod` utility to make a module sticky. Generally, sticky modules are modules used frequently enough to warrant them staying in the system at all times.

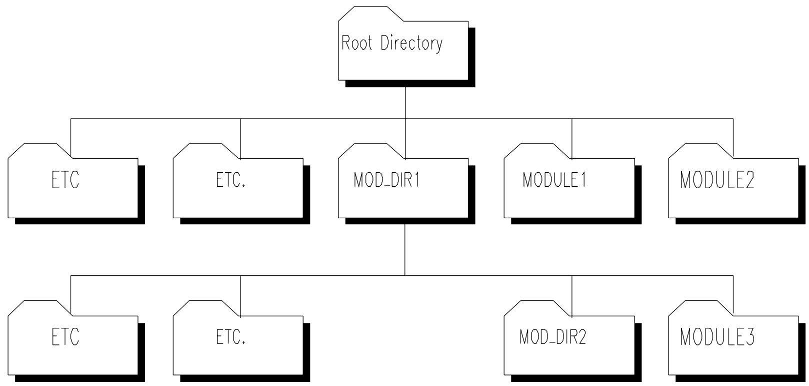
The third case involves modules with their link counts lowered to 0 (or -1 for sticky modules), but are still in use. For example, if one user is using µMACS and another user lowers µMACS' link count to 0, the module stays in memory because the module is still in use.

MODULE DIRECTORIES

OS-9 is unique because memory modules may be arranged in a hierarchical directory structure just like files and directories. Therefore, when you load a module into memory, you must make a decision as to which module directory should contain the module.

Immediately after OS-9 is booted, a single module directory is created in which all of the modules were loaded during system startup--unless either `sysgo` or the `startup` file has been modified to build a memory module directory structure. You may create additional module directories at any time. This enables you to organize modules in memory. Each module directory can contain other module directories.

Figure 5-1. Root Module Directory



The development of new and existing modules is the major advantage of this hierarchical module structure.

OS-9 enables you to load modules into specific directories, even if a module of the same name is loaded into another directory. This means you can make changes to a program and load it into your own module directory. Once in the module directory, the module can be accessed instead of a module with the same name elsewhere in the module directory system. From this directory, you can test and debug the module without affecting other system users.

For example, if you are using a module called `mine` that is loaded into your module directory, another user could be using or developing another `mine` module in a different directory.

Module directories also enable you to load programs into memory without the programs becoming known to the public.

Current Module Directory

Memory module directories are similar to other directories, as you can specify a current module directory. The current module directory is important for accessing memory modules.

For example, when modules are loaded into memory, they are added to the process current module directory. Likewise, when a process forks a new process, OS-9 searches the current module directory for the target module first. If the search fails, OS-9 searches the process' alternate module directories. Failing to find the module in memory, OS-9 attempts to load the target module into the current module directory.

You can set the initial current module directory in your `.login` file. Use the `MDPATH` environment variable in the `.login` file to establish the alternate module directory. You can change the current memory module directory using the `chm` built-in shell command. To change module directory, type `chm` and the pathlist to the new module directory.

You can use full or relative pathlists when specifying module directory pathlists. However, pathlists beginning from the root module directory begin with a single slash (`/`). Pathlists beginning with either two slashes (`//`) or no slash specify the pathlist begins at the current module directory.

For example, the following pathlist begins at the root module directory:

```
chm /user/paul
```

The next two commands both begin at the your current module directory:

```
chm //doc/proj1
chm doc/proj1
```

If the `MDHOME` environment variable is set, typing `chm` with no pathlist changes your current module directory to the directory specified by the `MDHOME` environment variable.

For more information on the `chm` built-in shell command, refer to the *Utilities Reference* manual.

Displaying the Contents of Module Directories

You can display the contents of memory module directories with the `mdir` utility. To see the contents of a particular memory module directory, type `mdir` and the pathlist to the module you want to display. Pathlists may be either full or relative.

For example, to display the contents of the `UTILS` module directory located in the root module directory, type the following command:

```
mdir /utils
```

A screen containing the contents of the `UTILS` folder should display:

```
         Module Directory of /utils
<FILE1>       <FILE2>       <FILE3>       csl       dir
```

To display an extended listing of a module directory, use the `-e` option. The extended listing displays detailed information concerning each module located in the directory. The following is an example of a `mdir -e` command.

```
 mdir //doc -e
```

```
                  Module Directory of //doc
    Addr     Size       Owner     Perm Type Revs  Ed #  Lnk
Module name
  ------ -------- ----------- ---- ---- ---- ----- ----- -
-----------
  36a170    1940    22.148   0333 MDir 0000     0     1
<FILE1>
  2f90f0    7948     7.17    0555 MDir a000     7     2
<FILE2>
  2adda0    1834    0.22    0555 MDir 8001    7     1 RIC
  033a68   45408    22.148   0555 Subr c000    18     7
csl
  318f20   23402     1.169   0555 Prog c001    36     0
dir
```

Memory Module Directory Attributes

You can examine and change module attributes using the `mdattr` utility. To use the `mdattr` utility, type `mdattr` and the module directory pathlist. For example:

```
mdattr leap1
---r---r--wr  leap1
```

Memory module directories can have owner, group, and public attributes. These attributes are each divided into four fields (from right to left):

- read attribute
- write attribute
- reserved
- reserved

The attribute abbreviations are listed in Table 5-1.:

Table 5-1. Attribute Abbreviations

Abbreviation	Means
`r`	owner read permission
`w`	owner write permission
`gr`	group read permission
`gw`	group write permission
`pr`	public read permission
`pw`	public write permission

A module directory with all permissions set looks like similar to that shown below:

```
--wr--wr--wr
```

The first `wr` series is the public read and write permissions. The second is the group read and write permission. The third is the owner read and write permissions. The hyphens (`-`) are place holders for reserved fields.

A permission is changed by giving its abbreviation preceded by a hyphen (`-`). It is turned off by preceding its abbreviation with a hyphen followed by the letter n (`-n`). Permissions not explicitly named are not affected. If no permissions are specified, the current file attributes are printed.

To see the attributes of the module `leap1`, type the following command:

```
$ mdattr leap1
------wr--wr  leap1
```

`leap1` has the group and owner read and write permissions set. To remove the group write permission and add the public read permission to `leap1`, type the following command:

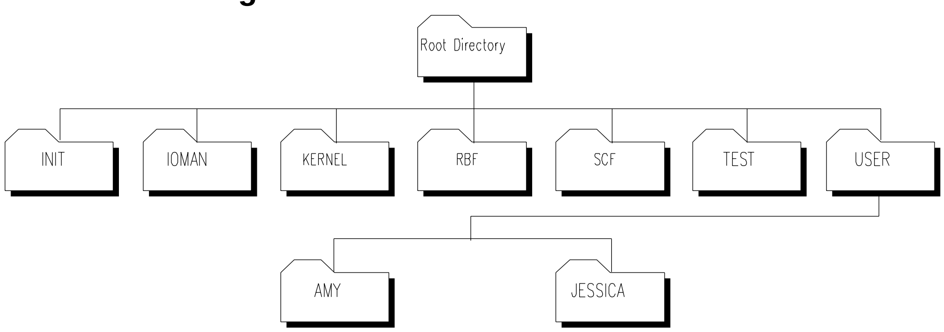
```
$ mdattr leap1 -ngw -pr
---r---r--wr  leap1
```

Creating New Memory Module Directories

To create new memory module directories, use the `makmdir` utility. The `makmdir` utility creates the new module directory in the directory specified. To create a new memory module directory, type `makmdir` followed by the module directory pathlist specifying the new module directory.

The following example uses this memory module directory structure:

Figure 5-2. Before `makmdir` Command

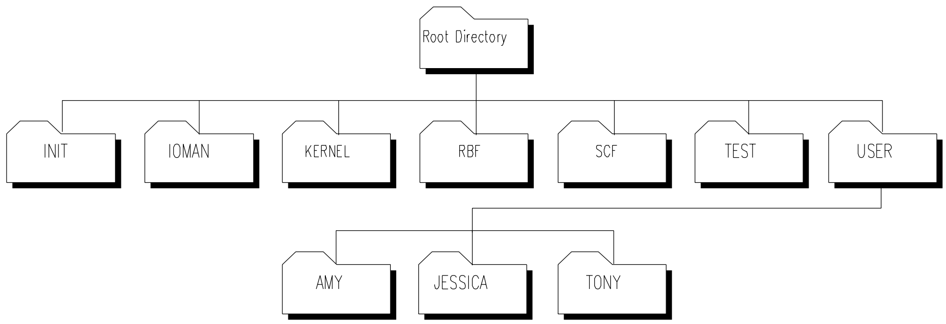


To create the directory TONY in the USER directory, type the following command:

```
makmdir /user/TONY
```

The module directory structure looks like the following figure:

Figure 5-3. After makmdir Command



makmdir creates the new module directory with the read and write permissions set for the owner, group, and public. In addition, makmdir only searches the current module directory for a specified module path when creating a new module directory. The alternate pathlists specified by the MDPATH environment variable are not searched if a specified module path is not found in the current module directory.

For example, if USER is your current module directory and you want to make a new directory in a directory called TEST, OS-9 does not search the alternate module directories for a module directory named TEST.

Deleting Memory Module Directories

You can delete memory module directories using the delmdir utility. To delete a module directory, type delmdir, the pathlist for the module directory, and any desired options.

If the module directory to be deleted contains sub-directories, the sub-directories are also deleted. For example, if the USER directory in the previous example is deleted, the directories AMY, TONY, and JESSICA are also deleted.

delmdir searches only the current module directory for a specified module path when deleting a module directory. The alternate pathlists specified by the MDPATH environment variable are not searched if a specified module path is not found in the current module directory.

Modules within the directory to be deleted or any of its sub-directories must not be in use. If a module in a directory is in use when `delmdir` is called, `delmdir` is not successful. You must also have the appropriate access permissions to a module directory in order to delete it.

6 The Shell

This chapter contains a detailed description of the shell, the OS-9 user interface. It includes the following sections:

THE FUNCTION OF THE SHELL

The shell is the OS-9 command interpreter program. The shell takes the commands you enter and translates them into commands the operating system understands and executes.

The shell also provides an environment that can be configured by the user; this allows you to personalize the way OS-9 works on your system. You can use the shell to change the shell prompt, send error messages to a file, or backup your disk before you log out.

The `shell` command starts the shell program. This command is automatically executed following system startup or after logging on to a timesharing terminal. When the shell is ready for commands, it displays the following prompt:

```
[1]$
```

The `[1]` in the prompt is the history number for that command line. This has been omitted from the rest of the prompts shown in this manual. The command line history is discussed in this chapter.

This prompt indicates the shell is active and waiting for a command from your keyboard. From here you can type a command line followed by a carriage return.

Shell Options

A number of options are available to the shell. By default, some are automatically turned on following startup or log on. The available shell options are listed in Table 6-1.

Table 6-1. Shell Options

Option	Description
`-a`	Echo the command line if it is altered after if is entered. This is the default option.
-c=<num>	Specify the number of previously executed commands the shell should remember. This provides a history of your commands. If <num> is not specified, the default is 40.

Table 6-1. Shell Options (Continued)

Option	Description
`-e=<file>`	Print error messages from `<file>`. If no file is specified, `/dd/SYS/errmsg` is used. Without this option, the shell prints only error numbers with a brief message description. Each error is described in the appendix on error codes in the *OS-9 Technical Manual*.
`-h`	Display the command's history number in front of the command line prompt. This is the default option.
`-l`	The `logout` built-in command is required to terminate the login shell. `<eof>` does not cause the shell to terminate.
`-na`	Does not echo the command line if it is altered after it is entered.
`-nc`	Does not keep track of your command history.
`-ne`	Print no error messages. This is the default option.
`-nh`	Does not display the command's history number.
`-nl`	`<eof>` terminates the login shell. `<eof>` is normally caused by pressing the `<Esc>` key. This is the default option.
`-np`	Does not display the prompt.
`-nq`	Does not keep `assigns` in environment.
`-ns`	Does not save your command history from one login session to the next. This is the default option.
`-nt`	Does not echo input lines. This is the default option.
`-nv`	Turns off verbose mode. This is the default option.
`-nx`	Does not abort process on error.

Table 6-1. Shell Options (Continued)

Option	Description
`-p`	Displays the prompt. The default prompt is a dollar sign (`$`).
`-p=<string>`	Set the current shell prompt equal to `<string>`.
`-q`	Keep `assigns` in environment. This is the default option.
`-s`	Save your command history from one login session to the next. The command history is saved in a `.history` file in your home directory.
`-t`	Echo input lines.
`-v`	Verbose mode: display a message for each directory searched when executing a command.
`-x`	Abort process on error. This is the default option.

You can change shell options with either of two methods. The two methods accomplish the same function.

1. Type the option on the command line or after the `shell` command. For example:
   - `$ -np` turns off the shell prompt.
   - `$ shell -np` creates a new shell that does not prompt. When the new shell is exited, the original shell prompts.
2. Use `set`, a special shell command. To set shell options, type `set`, followed by the options desired. When using the `set` command, a hyphen (`-`) is unnecessary before the letter option. For example:
   - `$ set np` turns off the shell prompt.
   - `$ shell set p` creates a new shell that does not prompt. When the new shell is exited, the original shell prompts.

THE SHELL ENVIRONMENT

The shell maintains a unique list of environment variables for each user on an OS-9 system. These variables affect the operation of the shell or other programs subsequently executed and can be set according to your preference.

All environment variables can be accessed by any process called by the shell or descendant shells. This enables you to use the environment variables as global variables.

If an environment variable is redefined by a subsequent shell, the variable is only redefined for that shell and its descendents. The environment variable is not redefined for the parent shell.

The environment variables shown in Table 6-2 are automatically set up when you log on to a time-sharing system.

Table 6-2. Environment Variables

Variable	Description
`PORT`	The name of the terminal. An example of a valid name is `/t1`. The `tsmon` utility automatically sets up `PORT`.
`HOME`	Your home directory. The home directory is specified in your password file entry and is your current data directory when you first log on the system. This is also the directory used when the command `chd` with no parameter is executed.
`SHELL`	The first process executed upon logging on to the system.
`USER`	The user name you type when prompted by the `login` command.
`PATH`	Specify any number of directories. Directory paths must be separated by a colon (`:`). The shell uses `PATH` as a list of command directory to search when executing a command. If the default commands directory does not include the file or module to be executed, each directory specified by `PATH` is searched until the file/module is found or the list is exhausted.

For single user systems, these variables can be set with the `setenv` command. A procedure file may also be set up with your normal configuration of these variables. This procedure file could then be executed each time you start up your terminal.

Other important environment variables include those shown in Table 6-3:

Table 6-3. Optional Environment Variables

Variable	Description
`MDHOME`	Specify your home module directory. This is the module directory used when executing the command `chm` with no parameter.
`MDPATH`	Specify any number of module directories to search. Module directory paths must be separated by a colon (`:`). The shell uses `MDPATH` as a list of module directories to search when executing a command.
`PROMPT`	Specify the current prompt. By specifying an **at** sign (`@`) as the first character of your prompt, you may easily keep track of how many shells you have running under each other. `@` is used as a replaceable macro for the shell level number. The base level is set by the environment variable `_sh`.

`_sh`	Specify the base level for counting the number of shell levels.
	For example, set the shell prompt to `@howdy:` and `_sh` to 0:
	`$ setenv _sh 0`
	`$ -p="@howdy: "`
	`howdy: shell`
	`1.howdy: shell`
	`2.howdy: eof`
	`1.howdy: eof`
	`howdy:`

`TERM`	Specify the type of terminal being used. `TERM` allows word processors, screen editors, and other screen dependent programs to know what type of terminal configuration is used.

Environment variables are case sensitive. OS-9 cannot recognize a variable if the proper case is not used.

Changing the Shell Environment

Three commands are available for use with environment variables: `setenv`, `unsetenv`, and `printenv`. These variables are only known to the shell in which they are defined and any descendant processes from that shell.

Table 6-4. Environment Variable Commands

Command	Description

`setenv`	Declare the variable and sets its value.
	
	The variable is put in an environment storage area accessed by the shell. For example:
	
	`$ setenv PATH ..:/h0/cmds:/d0/cmds:/dd/cmds`
	`$ setenv _sh 0`
	
	`setenv` does not change the environment of the parent process of the shell from which `setenv` was issued.

`unsetenv`	Clear the value of the variable and removes it from storage. For example:
	
	`$ unsetenv PATH`
	`$ unsetenv _sh`

`printenv`	Print the variables and their values to standard output. For example:
	
	`$ printenv`
	`PATH ..:/h0/cmds:/d0/cmds:/dd/cmds`
	`PROMPT howdy`
	`_sh 0`

These three commands are described in the *Utilities Reference* manual.

Using Environmental Variables as Command Line Parameters

When you use the following syntax, the shell replaces the environment variable with its value:

```
$(<env var>)
```

For example, if `HOME` is set to `/h0/USR/ROB` and you enter the command `dir $(HOME)`, the shell executes the command `dir /h0/USR/ROB`.

This substitution is useful for entire command lines. By using `setenv`, a command line can be assigned to an environment variable:

```
setenv PR "procs -ea"
```

Any time `$(PR)` appears on the command line, the shell automatically substitutes `procs -ea`.

BUILT-IN SHELL COMMANDS

The shell has a special set of commands or option switches built in to the shell. These commands are executed without loading a program and creating a new process. They can be executed regardless of your current execution directory.

The built-in commands and their functions are as listed in Table 6-5.

Table 6-5. Built-in Shell Command

Command	Description
`* <text>`	Indicates a comment: `<text>` is not processed.
`assign`	Allows you to assign commands and strings to a single word for command line substitutions.
`chd <path>`	Change the current data directory to the directory specified by `<path>`.
`chm <path>`	Change the current module directory to the module directory specified by `<path>`.
`chx <path>`	Change the current execution directory to the directory specified by `<path>`.
`ex <name>`	Directly execute the named program. This replaces the shell process with a new execution module.
`hist`	Display the history of your commands.
`kill <proc ID>`	Abort the process specified by `<proc ID>`.

Table 6-5. Built-in Shell Command (Continued)

Command	Description
`logout`	Terminate the current shell. If the login shell is to be terminated, the `.logout` file in the home directory is executed and then the login shell is terminated.
`profile`	Execute a procedure file without forking a child shell.
`set <options>`	Set options for the shell.
`setenv <env var> <value>`	Set an environment variable to a specified value.
`setpr <proc ID> <priority>`	Change the process priority.
`unassign`	Unassign an assignment made with `assign`.
`unsetenv <env var>`	Delete the environment variable from the environment.
`w`	Wait for a child process to terminate.
`wait`	Wait for all child processes to terminate.

SHELL COMMAND LINE PROCESSING

The shell reads and processes command lines one at a time from its input path (usually your keyboard). Each line is first parsed to identify and process any of the following parts that may be present:

Table 6-6. Command Line Parts

Part	Description
keyword	name of a program, procedure file, built-in command, or pathlist
parameters	names of files, programs, values, variables, and constants to be passed to the program being executed
execution modifiers	These modify a program’s execution by redirecting I/O or changing the priority or memory allocation of a process.
separators	When multiple commands are placed on the same command line, separators specify whether they should be executed sequentially or concurrently.

Only the keyword needs to be present for the shell to process a command line. Parameters, execution modifier, and separators are optional. After the keyword has been identified, the shell processes any execution modifiers and separators. Any text not yet processed is assumed to be parameter and is passed to the program called.

The keyword must be the first word in the command line. If the keyword is a built-in command, it is executed immediately. If the keyword is not a built-in command, the shell assumes it is a program name and attempts to locate it. The shell searches for the command in the following sequence:

1. The shell checks the memory to see if the program has already been loaded into the module directory. If it is already in memory, there is no need to load another copy. The shell then calls the program to be executed.

2. If the program is not in memory, your current execution directory is searched. An attempt to load the program is made if it is found. If this fails, the shell tries to execute it as a procedure file. If this fails, the shell attempts the same procedure using the next directory specified in the `PATH` environment variable. This continues until the command is successfully executed or the list of directory is exhausted.

3. Your current data directory is searched. If the specified file is found, it is processed as a procedure file. Procedure files are assumed to contain one or more shell command lines. These command lines are processed by a newly created, or child shell as if they had been typed in manually. After all commands from the procedure files are executed, control returns to the old, or parent shell. Because the commands are processed by the child shell, all built-in commands in the procedure file such as `chd` and `chx` only affect the child shell.

An error is returned if the program is not found. If the program is found and executed, the shell waits until the program terminates. When the program terminates, it reports any errors returned. If there are more input lines, the shell gets the next line and the process is repeated.

This sample command line calls a program:

```
$ prog #12K sourcefile  -l -j >/p
```

In this example:

`prog`	is the keyword.
`#12K`	is a modifier requesting an alternate memory size be assigned to this process. In this case, 12K is used as memory.
`sourcefile -l -j`	are parameters passed to `prog`.
`>`	is a modifier redirecting output to a file or device. In this case, > redirects the output to the printer (`/p`).
`/p`	is the system printer.

Special Command Line Features

In addition to basic command line processing, the shell facilitates the following jobs:

- memory allocation
- I/O redirection, including filter
- process priority
- wildcard pattern matching
- multi-tasking; concurrent execution

These functions are accessed by using execution modifiers, separators, and wildcard characters. The combination of ways you can use these capabilities is virtually unlimited.

Characters comprising execution modifiers, separators, and wildcards are stripped from the part(s) of the command line passed to a program as parameter. Characters cannot be passed as parameters to programs unless contained in quotes.

Table 6-7. Execution Modifiers

Modifier	Description
#	Additional memory size
^	Process priority
>	Redirect output
<	Redirect input
>>	Redirect error output

Table 6-8. Separators

Separator	Description
;	Sequential execution
&	Concurrent execution
+	Concurrent execution
!	Pipe construction for standard output
!!	Pipe construction for standard error
!!!	Pipe construction for both output and error

Table 6-9. Wildcards

Wildcard	Description
*	Matches any character
?	Matches a single character

Execution Modifiers

The shell processes execution modifiers before the program is run. If an error is detected in any of the modifiers, the run is aborted and the error reported.

Additional Memory Size Modifier

Every executable program is converted to machine language for storage. During the conversion process, a module header is created for the program. A module header is part of all executable programs and holds the program's name, size, memory requirements, and other details.

A complete explanation of module headers is available in the *OS-9 Technical Manual*.

When an executable program is processed by the shell, the minimum amount of working memory specified in the program module header is allocated. To increase the default memory size, memory can be assigned in 1K increments using the pound sign modifier (#) followed by a number of allocated kilobytes: `#10k` or `#10`. The shell adds the allocated number of kilobytes to the default listed in the program header.

The increase in memory allocation only affects one command. If you want to increase the allocation for the next command, you must add the modifier (#) again.

Programs written in C use the additional memory for stack space only.

I/O Redirection Modifiers

Redirection modifiers redirect the program's standard I/O paths to alternate file or devices. Usually, programs do not use specific file or device names. This makes the redirection of standard I/O to any file or device fairly simple without altering the program. Programs normally receiving input from a terminal or sending output to a terminal use one or more of these standard I/O paths:

Standard Input Path	Pass data from a keyboard to a program.
Standard Output Path	Pass output data from a program to a display.
Standard Error Path	This can be used for either input or output, depending on the nature of the program using it. This path is commonly used to output routine status messages, such as prompts and errors to the terminal's display. By default, the standard error path uses the same device as the standard output path.

A new process can only be created by an existing process. The new process is known as the “child process”. The process creating the child process is known as the “parent process”. Each child process inherits the standard I/O paths from the parent process.

When the shell creates a new process, it inherits the shell’s standard I/O paths. Upon startup or login, standard input is the terminal keyboard. The standard output and standard error are directed to the display. Consequently, the child process standard input is the keyboard. The child process standard output and standard error are directed to the display.

Below are the three redirection modifiers:

`<`	Redirect the standard input path.
`>`	Redirect the standard output path.
`>>`	Redirect the standard error path.

When you use a redirection modifier on a shell command line, the shell opens the corresponding paths and passes them to the new process as its standard I/O paths. When you use redirection modifiers on a command line, they must be immediately followed by a path describing the file or device to or from which the I/O is to be redirected.

Standard Devices

Each physical input/output device supported by the system must have a unique name within a module directory. Although the device names used on a system are somewhat arbitrary, it has become customary to use the names Microware assigns to standard devices in OS-9 packages. The standard devices are shown in Table 6-10.

Table 6-10. Standard Devices

Device	Description
`term`	Primary system terminal
`t1`, `t2`, etc.	Other serial terminals
`p`	Parallel printer
`p1`	Serial printer
`dd`	Default disk drive
`d0`	Floppy disk drive unit 0
`d1`, `d2`, etc.	Other floppy disk drives

Table 6-10. Standard Devices (Continued)

Device	Description
`h0`, `h1`, etc.	Hard disk drives (format-inhibited)
`h0fmt`, `h1fmt`, etc.	Hard disk drives (format-enabled)
`n0`, `n1`, etc.	Network devices
`mt0`, `mt1`	Tape devices
`r0`	RAM disk

The `h0fmt` and `h1fmt` device descriptors have a bit set allowing you to use the `format` and `os9gen` utilities on them. To avoid accidentally formatting a hard disk, you should use the device names `h0`, `h1`, etc.

Device names may only be used as the first name of a pathlist and must be preceded by a slash (`/`) to indicate the name is an I/O device. If the device is not a mass storage multi-file device like a disk drive, the device name must be the only name in the path. This restriction is true for devices such as terminals and printers.

For example, the standard output of `list` can be redirected to write to the system printer instead of the terminal:

```
$ list correspondence >/p
```

Files referenced by I/O redirection modifier are automatically opened or created and closed as appropriate by the shell. In the below example, the output of `dir` is redirected to the path `/d1/savelisting`:

```
$ dir >/d1/savelisting
```

If `list` is used on the path `/d1/savelisting`, output from `dir` is displayed as follows:

```
$ List /d1/savelisting
   directory of .  10:15:00
file1           myfile          savelisting
```

You can use redirection modifiers before and/or after the program parameter, but you can use each modifier only once in a given command line. Redirection modifiers can be used together to cause more than one of the standard paths to be redirected. For example, `shell <>>>/t1` redirects all three standard paths to `/t1`.

The plus and hyphen characters (+ and -) can be used with output style redirection modifier. The >- modifier redirects output to a file. If the file already exists, the output overwrites it. The >+ modifier adds the output to the end of the file. The following example overwrites `dirfile` with output from the execution directory listing:

```
dir -x >-dirfile
```

The below example adds the listing of `newfile` to the end of `oldfile`.

```
list newfile >+oldfile
```

Spaces must not occur between redirection operators and the device or file path.

Process Priority Modifier

On multi-user systems or when multi-tasking, many processes seem to be simultaneously executed. Actually, OS-9 uses a scheduling algorithm to allocate execution time to active processes.

All active processes are sorted into a queue based on the age of the process. The age is a number between 0 and 65535 based on how long a process has waited for execution and its initial priority.

On a timesharing system, the system manager assigns the initial priority for processes started by each user. This priority for the initial process is listed in the password file. The initial process is usually the shell. On a single user system, processes have their priority set in the `Init` module. All child processes inherit the parent process priority.

When a process enters the active queue, it has an age set to its initial priority. Every time a new active process is submitted for execution, all earlier processes' ages are incremented. The process with the highest age is executed first.

If you want a program to run at a higher priority, use the caret modifier (^). By specifying a higher priority, a process is placed higher in the execution queue. For example:

```
$ format /d1 ^255
```

In this example, the process `format` is assigned a priority of 255. By assigning a lower number, a lower priority can be specified.

Specifying too high of a priority for a process can cause all other processes to be locked out until their ages mature.

For example, if you specify a priority of 2000 for a program and all the other processes have an age of less than 100, your program is the only process executed on the system until either your program terminates or another process' age reaches 2000. If another process' age reaches 2000, it runs once and enters back in the queue at its initial priority. Once again, your program either runs until it terminates or until another process' age reaches 2000.

Wildcard Matching

The shell uses some alternate ways to identify file and directory names. The shell accepts wildcards in the command line. The two recognized wildcard characters are the asterisk (`*`) and the question mark (`?`).

An asterisk (`*`) matches any group of zero or more characters. A question mark (`?`) matches any single character. The shell searches the current data directory or the directory given in a path for matching file names.

For the following examples, a directory containing the following file is used:

```
    directory of FILES  14:45:20

diary         diary2       form       form.backup  forms

login.names   logistics    logs       old          oldstuff

setime.c      shellfacts   sizes      sizes.backup  utils1
```

The command `list log*` lists the contents of `login.names`, `logistics`, and `logs`. The pattern `log*` matches all file names beginning with `log` followed by zero or more characters. The following commands demonstrate the function of this wildcard.

Table 6-11. Commands Using * Wildcards

Command	Result
`list s*`	List all files in the current data directory beginning with `s`: `shellfacts`, `setime.c`, and `sizes`.
`del *`	Delete every file in the current data directory (in this example, `FILES`).
`dir ../*.backup`	List all files in the parent directory ending with `.backup`.
`dir -x d*`	List all files in the current execution directory starting with the letter `d`. This can be helpful if you are unsure of the spelling of a particular utility.

The question mark (`?`) matches any single character in the position where the wildcard character is located. For example, the command line `list log?` only lists the contents of the file `logs`. The following commands demonstrate the function of this wildcard.

Table 6-12. Commands Using ? Wildcards

Command	Result
`del form?`	Delete the file `forms` but not `form`.
`list s????`	List the contents of `sizes`, but not `setime.c` or `shellfacts`.

In both examples, the shell searches only for names with five characters.

Wildcards may also be used together. For example, the command `list *.?` lists any files ending in a period followed by any letter, number or special character, regardless of what comes before the period. In this case, `list *.?` lists the contents of the file `setime.c`.

The shell only attempts to expand a character string containing a wildcard if the character string could be a pathlist. The shell does not expand wildcards used in the keyword of a command line. For example, the shell does not expand the asterisk in the following:

```
d* forms
```

The shell disregards wildcard characters enclosed in double quotes. For example:

```
echo  "*"
```

This echoes an asterisk (`*`) to standard output (usually the terminal). If the double quotes around the asterisk were left out, the shell expands the wildcard to include every file name in the current directory and outputs each name to the terminal.

.You must be careful when using wildcards with utilities such as `del` and `deldir`. Wildcards should not be used with the `-x` or `-z` options of most utilities.

Command Separators

A single shell input line can include more than one command line. These command lines may be executed sequentially or concurrently. Sequential execution causes one program to complete its function and terminate before the next program is allowed to begin execution. Concurrent execution allows several command lines to begin execution and run simultaneously.

Commands can be sequentially executed by separating the command with a semicolon (`;`). Commands can be concurrently executed by separating the commands with an ampersand (`&`) or plus sign (`+`).

Sequential Execution

When one command per line is entered from the keyboard, programs are executed one after another, or sequentially. All programs executed sequentially are individual processes created by the shell. After initiating a sequentially executed program, the shell waits until the program it created terminates. The command line prompt does not return until the program has finished.

For example, the following command lines are executed one after another. The `copy` command is executed first, followed by the `dir` command.

```
$ copy myfile /D1/newfile
$ dir >/p
```

You can specify more than one program on a single shell command line for sequential execution by separating each program name and its parameter from the next one with a semicolon (`;`). For example:

```
$ copy myfile /D1/newfile; dir >/p
```

The shell first executes `copy` and then `dir`. The command line executes exactly as the previous two command lines unless an error occurs.

If an error is returned by any program, subsequent commands on the same line are not executed regardless of the `-nx` option. In all other regards, a semicolon (`;`) and a carriage return act as identical separators.

The following example copies the contents of `oldfile` into `newfile`. When the `copy` command finished, `oldfile` is deleted. Then the contents of `newfile` are listed.

```
$ copy oldfile newfile; del oldfile; list newfile
```

In the next example, the output from `dir` is redirected into `myfile` in the `d1` directory. The output from `list` is then redirected to the printer. Finally, `temp` is deleted.

```
$ dir >/d1/myfile; list temp >/p; del temp
```

Multi-tasking: Concurrent Execution

Programs may be executed concurrently using the ampersand (`&`) or plus sign (`+`) separators. This allows programs to run at the same time as other programs, including the shell. The shell does not wait to complete a process before processing the next command. Concurrent execution is how a background program is started.

Multi-tasking is accomplished by using the concurrent execution separators. The number of programs that can run at the same time is not fixed; it depends upon the amount of free memory in the system and the memory requirements of the specific programs.

Here is an example:

```
$ dir >/P& list file1& copy file1 file2; del temp
```

The `dir`, `list`, and `copy` utilities run concurrently because they were separated by an ampersand (`&`). `del` does not run until `copy` has terminated because sequential execution (`;`) was specified.

By adding an ampersand (`&`) or plus sign (`+`) to the end of a command line, regardless of the type of execution specified, the shell immediately returns command to the keyboard, displays the `$` prompt, and waits for a new command. This frees you from waiting for a process or sequence of processes to terminate.

This is especially useful when making a listing of a long text file on a printer. Instead of waiting for the listing to print to completion, using either of the concurrent execution separators allows you to use your time more efficiently.

The plus sign (`+`) separator allows you to fork a process to run in the background as an orphan process. An orphan process does not have a parent process. This means regardless of how the process terminates, you are not notified. Also, when the `wait` command is executed, the shell does not wait for the process to finish execution. Executing an orphan process is useful for executing non-terminating processes.

For example, you could execute `tsmon` and any networking utilities concurrently using the plus sign separator:

```
$ tsmon /t1 +
```

`tsmon` is started, but your shell is not considered to be the parent process.

If you have several processes running at once, you can display a status summary of all your processes with the procs utility. procs gives you a complete list of your current processes and pertinent information about each process.

The `procs` utility is discussed later in this chapter in the section The procs Utility.

Pipes and Filters

The third kind of separator is the exclamation point (`!`) used to construct “pipelines”. Pipelines consist of two or more concurrent programs whose standard input and/or output paths connect to each other using “pipes”. A pipe is simply a way to connect the output of a process to the input of another process, so the two run as a sequence of process: a pipeline. Pipes are one of the primary means for transferring data from process to process for inter process communications. Pipes are first-in, first-out buffers.

All programs in a pipeline are executed concurrently. The pipes automatically synchronize the programs so the output of one never gets ahead of the input request of the next program in the pipeline. This ensures data cannot flow through a pipeline any faster than the slowest program can process it.

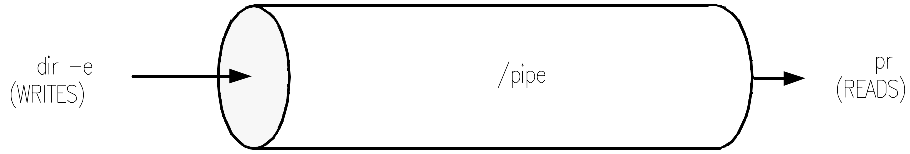
Any program that reads data from standard input can read from a pipe. Any program that writes data to standard output can write data to a pipe. Several utilities are designed so the standard output of one can be piped to the standard input of another. For example:

```
$dir -e ! pr
```

This example causes the standard output of `dir` to be piped to the standard input of the `pr` utility instead of on the terminal screen. `pr` reads the output of `dir` even though `pr` reads standard input by default. `pr` then displays the result.

In Figure 6-1 the standard output of the `dir -e` command is piped to the standard input of the `pr` command through an un-named pipe. The `pr` utility displays the results of the `dir -e` command.

Figure 6-1. Unnamed Pipe



The pr command may be modified with the following options:

- Two exclamation points (!!) pipe the standard error from one program to another.
- Three exclamation points (!!!) pipe both the standard output and standard error from one program to another.

There are two types of pipes used by OS-9: unnamed pipes and named pipes.

Unnamed Pipes

Unnamed pipes are created by the shell when an input line with one or more exclamation point (!) separators is processed. For each exclamation point, the standard output of the program named to the left of the exclamation point is redirected by a pipe to the standard input of the program named to the right of the exclamation point. Individual pipes are created for each exclamation point present. For example:

```
$ update <master_file ! sort !!! write_report >/p
```

In this example, the input for the program update is redirected from master_file.update to the standard input for the program sort. The standard and error output from sort, in turn, become the standard input for the program write_report. Standard output from write_report is redirected to the printer.

Named Pipes

Named pipes are similar to unnamed pipes with one exception: a named pipe works as a holding buffer that can be opened by another process at a different time.

Named pipes are created by re-directing output to /pipe/<file>, where <file> is any legal OS-9 file name. For example:

```
$ list letters >/pipe/letters &
```

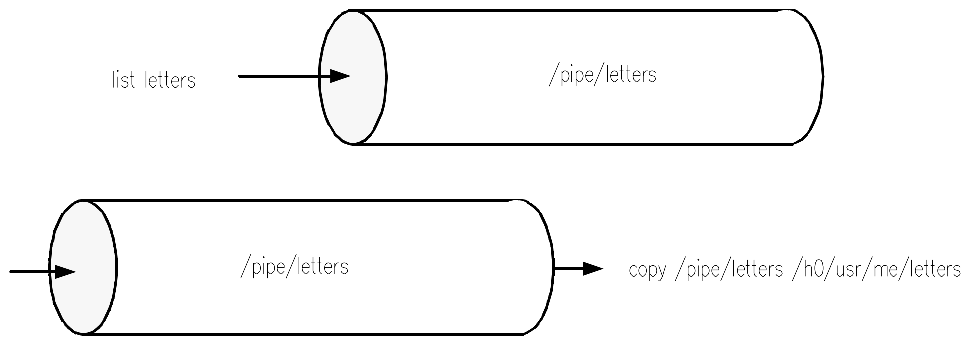
The output from the list command is redirected into a named pipe, /pipe/letters. The information remains in the pipe until it is listed, copied, deleted, or used in some other manner.

In Figure 6-2 the output from the command `list letters` is redirected to the named pipe, `/pipe/letters`. The pipe `/pipe/letters` remains open until the contents are used in some way. In this example, another user could later copy `letters` from the pipe into a file in their own directory by typing a command such as:

```
copy /pipe/letters /h0/usr/me/letters
```

Once the file `/pipe/letters` is copied, the named pipe is deleted.

Figure 6-2. Named Pipes



You can also create named pipes by writing to the named pipe from a program. Named pipes are similar to mass-storage files, except for the limitation to their size. Named pipes have attributes and owners. They may be deleted, copied, or listed using the same syntax you would use to delete, copy, or list a file. You may change the attributes of a named pipe just as you would change the attributes of a file.

`dir` works with `/pipe`. This displays all named pipes in existence. A `dir -e` command may be deceiving. If a named pipe is created by any utility other than `copy`, the default pipe size equals 128 bytes. `copy` expands the size of the pipe to the size of the file. This indicates the first 128 bytes of the output are in the named pipe. However, if the `procs` utility is executed, you see a path remains open to `/pipe`. If you were to `copy` or `list` the pipe, for example, the pipe continues to receive input and passes it to its output path until the input process is finished. When the pipe is empty, the named pipe is deleted automatically.

Some of the most useful applications of pipelines are character set conversion, data compression/decompression, and text file formatting. Programs designed to process data as components of a pipeline are often called filters.

Command Grouping

You can enclose sections of shell input lines in parentheses. This enables you to apply modifier and separators to an entire set of programs. The shell processes them by calling itself recursively as a new process to execute the enclosed program list. For example, the following commands produce the same result:

```
$ (dir /d0; dir /d1) >/p
$ dir /d0 >/p; dir /d1 >/p
```

However, one subtle difference exists. The printer is continuously controlled by one user in the first example, while in the second case, another user could access the printer between the `dir` commands.

You can use command grouping to execute a group of programs sequentially with respect to each other and concurrently with respect to the shell that initiated them. For example:

```
$ (del *.backup; list stuff_* >/p)&
```

This command begins to sequentially delete all files ending in `.backup` and then list to the printer the contents of any files starting with `stuff_`. At the same time a `$` prompt appears, indicating the shell is waiting for a new command.

A useful extension of this form is to construct pipelines consisting of sequential and/or concurrent programs. For example:

```
$ (dir CMDS; dir SYS) ! makeuppercase ! transmit
```

This command line outputs the `dir` listings of `CMDS` and `SYS`, in that order, through a pipe to the program `makeuppercase`. The total output from `makeuppercase` is then piped to the program `transmit`.

It is important to remember that OS-9 processes commands from left to right. In the following example, the `dir` command is executed first, followed by the `procs` and `del` commands located inside the parentheses.

```
$ dir& (procs; del whatever)
```

SHELL PROCEDURE FILES

A procedure file is a text file containing one or more command lines that are identical to command lines manually entered from the keyboard. The shell executes each command line in the exact sequence given in the procedure file.

A simple procedure file might consist of `dir` on one line and `date` on another. When the name of this procedure file is entered from the command line, `dir` is run followed by `date`.

Procedure files have a number of valuable applications:

- eliminating repetitive manual entry of commonly used command sequences
- enabling the computer to execute a lengthy series of programs in the background while the computer is unattended or while you are running other programs in the foreground
- initializing your environment when you first login

You can run procedure file in the background by adding the `&` operator:

```
$ procfile&
+4
```

If a procedure file is run in the background, it should not contain any terminal I/O. Any terminal I/O caused by a background procedure file will minimally cause two or more processes try to control the same I/O path.

Notice the `+4` returned by the shell in the example above. This is the process number assigned to the shell running `procfile`. The same effect could be achieved by using the `<control>C` interrupt:

```
$ procfile
[<control>C is typed]
+4
```

Using `<Control>C` to place a procedure in the background only works if the procedure has not yet performed I/O to the terminal. Another limitation of the `<Control>C` interrupt occurs when the shell has not had time to set up the command for execution. If the shell has not loaded files from the disk, established pipelines, or completed other set-up activities the `<Control>C` causes the shell to abort the operation and return the shell prompt. For this reason, it is usually better to use the ampersand to place a procedure in the background.

OS-9 does not have any limit on the number of procedure files that can be simultaneously executed as long as memory is available.

.Procedure files themselves can cause sequential or concurrent execution of additional procedure files.

Using Parameters with Procedure Files

The shell allows you to pass as many parameters as you wish to a procedure file. These parameters are entered on the command line and replace the variables located within the procedure file.

For example, if you have a procedure file, `files`, you can list the first parameter and delete the second parameter:

```
$ list files
list $(P0)
del $(P1)
```

When you enter `files` and two filenames, the first filename replaces `$(P0)` and the second replaces `$(P1)`:

```
files starter update
```

This command lists the file `starter` to your terminal screen and deletes `update`.

If you add a third filename to the command line, it is ignored unless the variable `$(P2)` is added to the procedure file. If there is a variable `$(P2)`, the third parameter is recognized and used.

The `$(P*)` variable is a concatenation of all the parameters passed to the procedure file. The following example shows a procedure file using the `$(P*)` variable and printing out the environment within the shell.

```
[7]POS: build listfil
? list $(P*)
? printenv
?
[8]POS: listfil data1 data2 data3
This is the first file          Contents of data1
This is the second file         Contents of data2
This is the third file          Contents of data3
PORT=/pks01
HOME=/h0/USR/ROBB
SHELL=shell
USER=robb
PATH=/h0/cmds
```

```
TERM=kt7
_sh=1
PROMPT=@POS:
P0=data1                          First parameter
P1=data2                          Second parameter
P2=data3                          Third parameter
P*=data1 data2 data3              Value of variable P*
PN=3                              Number of parameters
                                  passed to file listfil
```

The shell uses the `PN` variable to keep track of the number of parameters passed to any given procedure file.

When the procedure file has finished executing, the shell environment returns to its previous state. The variables are not passed from the procedure file back to the shell.

Do not use `setenv` to set variables such as `P0`, and `P1` as they are not passed between the shell and the procedure file.

Using profile When Running Procedure Files

Typically, when a procedure file is executed, a new shell is forked to process the procedure file. Any changes affecting the shell (such as changing any of the current directories or changing the shell environment) made from within a procedure file do not affect the environment of the shell from which the procedure file was called.

The `profile` built-in shell command executes a procedure file without forking a child shell. This makes it possible to change current directory and environment variables from within a procedure file. For example, if you frequently work on a project located in directory `/h0/USR/PROJ/MYPROJ` and you want the environment variable `FRAME` to equal `pickone` whenever you work on your project, you could have a procedure file similar to the following:

```
$ list myproject
chd /h0/usr/proj/myproj
setenv FRAME pickone
```

When you want to work on your project, type the following command:

```
profile myproject
```

You current data directory is `/h0/USR/PROJ/MYPROJ` and `FRAME` is set to `pickone`. You may still pass parameter to procedure file by using `profile`.

The Login Shell and Special Procedure Files

The login shell is the initial shell created by the login sequence to process the user input command after logging in. To use these files, they must be located in your home directory.

`.login` is processed each time the `login` command is executed. This allows you to run a number of initializing commands without remembering each and every command. `.login` is processed as a command file by the login shell immediately after successfully logging on to a system. After all commands in the `.login` file are processed, the shell prompts you for more commands. The main difference in handling `.login` is the login shell itself actually executes the command rather than creating another shell to execute the commands.

It is possible to issue commands such as `set` and `setenv` within `.login` and have them affect the login shell. This is especially useful for setting up the environment variables `MDHOME`, `MDPATH`, `PATH`, `PROMPT`, `TERM`, and `_sh`.

Below is an example `.login` file:

```
setenv PATH ..:/h0/cmds:/d0/cmds:/dd/cmds:/h0/doc/spex
setenv PROMPT "@what next: "
setenv _sh 0
setenv TERM abm85h
setenv MDHOME
querymail
date
dir
```

`.logout` is processed when `logout` is executed to exit the login shell and leave the system. `.logout` is processed before the login shell terminates. `logout` only processes the `.logout` file when given to the login shell; subsequent shells simply terminate. You could use this to execute any clean up procedures you do on a regular schedule. This might be anything from instigating a backup procedure of some sort to printing a reminder of things to do.

Below is an example `.logout` file:

```
procs
wait
echo "all processes terminated"
* basic program to instigate backup if necessary *
disk_backup
echo "backup complete"
```

Using assign When Running Procedure Files

The OS-9 shell allows you to assign command and strings to a single word, or assignment, for command line substitution. For example, if you prefer to use the command `cd` instead of `chd`, enter the following command line:

```
assign cd chd
```

You can also `assign` strings to a single word. For example, if you frequently copy a number of large files, assign the string `copy -b=50` to `copylg`:

```
assign copylg “copy -b=50”
```

You must place strings of text containing blanks in double quotes.

To find out what assignments you have already made, enter `assign` with no parameter:

```
$ assign
cd                  chd
copylg              copy -b=50
```

To remove an assignment, enter `unassign` and the assignment(s) you wish to remove:

```
unassign cd
```

`unassign` does not report errors.

By default, your assignments are kept in your environment list. This allows them to be passed from shell to shell. If you do not want your assignments to be kept in your environment list, use the `-nq` shell option. The assignments are still passed to any procedure file forked by the shell, but they are not available to the child shells.

Assignments can be used in procedure files. For example, you can set up a procedure file to copy several large files from one directory to another. You could use `copylg`, which you previously assigned. However, if someone else uses your procedure file, they may not have a `copylg` assignment, or they may have it assigned to something else. Therefore, you can `unassign copylg` and re-assign it within your procedure file. Assignments made within a procedure file are not passed back to the parent shell.

SETTING UP A TIME-SHARING SYSTEM STARTUP PROCEDURE FILE

OS-9 systems used for timesharing usually have a procedure file that brings the system up by means of one simple command or by using the system startup file. This procedure file initiates the timesharing monitor for each terminal. It begins by starting the system clock and initiating concurrent execution of a number of processes having their I/O redirected to each timesharing terminal.

`tsmon` is a special program that monitors terminals for activity. Typically, `tsmon` is executed as part of the start-up procedure when the system is first brought up and remains active until the system shuts down.

`tsmon` is normally used to monitor I/O devices capable of bi-directional communication, such as CRT terminals. However, `tsmon` may also be used to monitor a named pipe. If this is done, `tsmon` creates the named pipe and then waits for data to be written to it by some other process.

It is possible to run several `tsmon` processes concurrently, each one watching a different group of devices. Because `tsmon` can monitor up to 28 device name pathlists, multiple `tsmon` processes must be run when more than 28 devices are to be monitored. Multiple `tsmon` processes can be useful for other reasons. For example, it may be desirable to keep modems or terminals suspected of hardware trouble isolated from other devices in the system.

Below is a sample procedure file for a timesharing system with terminals named `term`, `t1`, `t2`, `t3`, and `t71`:

```
* system startup procedure file
echo Please Enter the Date and Time
setime </term
tsmon /t1 /t2 /t3&
tsmon /t71      * This terminal has been misbehaving
```

In the previous example, `setime` has its input redirected from the system console `term`. This is necessary because it would otherwise attempt to read the time information from its current standard input path which is the procedure file and not the keyboard.

This login procedure does not work until a file called `/d0/SYS/password` with the appropriate entries has been created.

For more information on `tsmon`, see *Chapter 9, OS-9 System Management*.

The Password File

A password file is located in the `SYS` directory. Each line in the password file is a login entry for a user. The line has several fields separated by a comma. The fields are listed below:

`User name`
: The user name may contain up to 32 characters including spaces. If this field is empty, any name matches.

`Password`
: The password may contain a maximum of 32 characters including spaces. If this field is omitted, no password is required for the specified user.

`Group.user ID number`
: Both the group and the user portion of this number may be from 0 to 65535. 0.0 is the super user. This number is used by the file security system as the system-wide user ID to identify all processes initiated by the user. The system manager should assign a unique user ID to each potential user.

`Initial process priority`
: This number may be from 1 to 65535. It indicates the priority of the initial process.

`Initial execution directory`
: This field is usually set to `/d0/CMDS`. Specifying a period (.) for this field defaults to the current execution directory.

`Initial data directory`
: This is usually the specific user directory. Specifying a period (`.`) for this directory defaults to the current directory.

`Initial Program`
: This field contains the name and parameter of the program to be initially executed. This is usually `shell`.

Fields left empty are indicated by two consecutive commas.

The following is a sample password file:

```
superuser,secret,0.0,255,.,.,shell -p="@howdy"
suzy,morning,1.5,128,.,/d0/SUZY,shell
paul,dragon,3.10,100,.,/d0/PAUL,Basic
```

CREATING A TEMPORARY PROCEDURE FILE

To perform tasks requiring a sequence of commands, you can create temporary procedure files. The `cfp` utility creates a temporary procedure file in the current data directory and calls the shell to execute it. After the task has been completed, `cfp` automatically deletes the procedure file unless you use the `-nd` option to specify you do not want the procedure file deleted.

The following is the syntax for the `cfp` utility:

```
cfp [<opts>] [<path1>] {<path2>}
```

To use the `cfp` utility, type `cfp`, the name of the procedure file (`<path1>`), and the file(s) (`<path2>`) to be used by the procedure file. The name of the procedure file may be omitted if the `-s=<string>` option is used.

All occurrences of an asterisk (`*`) in the procedure file are replaced by the given pathlist(s) unless preceded by the tilde character (~). For example, `~*` translates to `*`. The command procedure is not executed until all input files have been read.

For example, if you have a procedure file in your current data directory called `copyit` consisting of a single command line: `copy *`, you could put all of your C programs from two directories, `PROGMS` and `MISC.JUNK`, into your current data directory by typing the following command:

```
$ cfp copyit ../progms/*.c ../misc.junk/*.c
```

If you do not have a procedure file, you can use the `-s` option. The `-s` option causes the `cfp` utility to read the string surrounded by quotes instead of a procedure file. For example:

```
$ cfp "-s=copy *" ../progms/*.c ../misc.junk/*.c
```

In this case, the `cfp` utility creates a temporary procedure file to copy every file ending in `.c` in both `PROGMS` and `MISC.JUNK` to the current data directory. The procedure file created by `cfp` is deleted when all the files have been copied.

Using the `-s` option is convenient because you do not have to edit the procedure file if you want to change the copy procedure. For example, if you are copying large C programs, you may want to increase the memory allocation to speed up the process. You could allocate the additional memory on the `cfp` command line:

```
$ cfp "-s=copy -b100 *" ../progms/*.c ../misc.junk/*.c
```

You can use the `-z` and `-z=<file>` options to read the file names from either standard input or a file. The `-z` option is used to read the file names from standard input. For example, if you have a procedure file called `count.em` containing the command `count -l *` and you want to count the lines in each program to see how large the programs are before you copy them, you could type the following command line:

```
$ cfp -z count.em
```

The command line prompt does not appear because the `cfp` utility is waiting for input. Type in the file names on separate command lines. For example:

```
$ cfp -z count.em
../progms/*.c
../misc.junk/*.c
```

When you have finished typing the file names, press the carriage return a second time to get the shell prompt.

For more information on `cfp`, see the *Utilities Reference* manual.

If you have a file containing a list of the files you want copied, you could type the following command:

```
$ cfp -z=files "-s=copy *"
```

MULTIPLE SHELLS

Like all OS-9 utilities, the shell can be simultaneously executed by more than one process. This means in addition to all users having their own shells, an individual user can have multiple shells.

New shells can be created with the procedure file. For example, to execute a shell whose standard input is obtained from `procfile`, type the following command:

```
$ shell <procfile
```

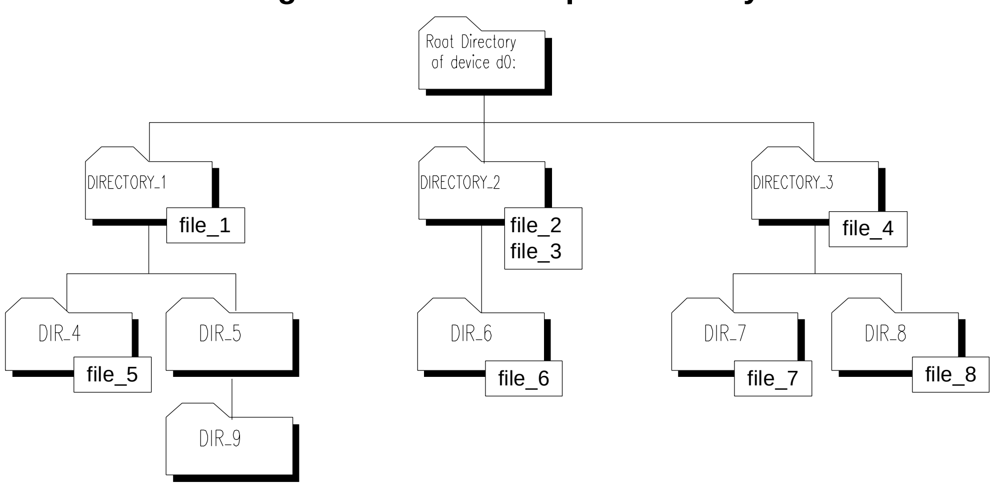
The new shell automatically accepts and executes the command lines from the procedure file instead of a terminal keyboard. This technique is sometimes called batch processing.

Shells can also fork new shells by simply processing the procedure file:

```
$ procfile
```

Basically, both of the above commands execute the commands found in the `procfile` file. By creating new shells, you can also move around the file system more efficiently. To demonstrate this application use the sample directory system in Figure 6-3.

Figure 6-3. An Example Directory



If your current data directory is `DIR_9` and you want to work on `file_8`, you could change your current data directory to `DIR_8` and access the file by typing the following command:

```
chd /d0/DIRECTORY_3/DIR_8
```

To return to `DIR_9` you execute a similar command. This is somewhat inconvenient and involves always knowing the path to each directory.

Instead, you can create a shell and change directories:

```
$ (chd /d0/DIRECTORY_3/DIR_8)
```

This makes your current directory `DIR_8`, but you can return to `DIR_9` by pressing the `<Escape> (Esc)` key. By this method, you may use any directory as a base directory and *fork* a shell out to any other directory.

You may continue to imbed as many shells as you like. Each time you press the `<Escape>` key, you are taken to the previous shell. In this fashion you could conceivably escape from `DIRECTORY_2` to `DIR_8` to `DIR_6` to `DIR_9`.

You should experiment with the multiple shell aspects to fully utilize OS-9.

Because of the nature of jumping from shell to shell, it is easy to get lost. `pd` displays a complete pathlist from the root directory to your current data directory.

Likewise, when running multiple shells, it is easy to forget how many shells are running. If the `_sh` environment variable is set to 1 and the shell prompt includes an "at" sign (`@`), the number of shells replaces the `@` in the prompt. For example, if three shells are being run under each other and the history count is on, the prompt might look like the following example:

```
3.[5]now what:
```

The procs Utility

Because OS-9 is a multi-tasking operating system, you often have more than one process executing at a time. The `procs` utility displays a list of processes running on the system you own. This allows you to keep track of your current processes.

Processes can switch states rapidly, usually many times per second. Therefore the procs display is a snapshot taken at the instant the command is executed and shows only those processes running at that exact moment.

procs displays ten items of information for each process:

Table 6-13. Information From procs

Name	Description
Id	The process ID
PId	The parent process ID
Grp.usr	The group and user number of the owner of the process
Prior	The initial priority of the process
MemSiz	The amount of memory the process is using
Sig	The number of any pending signals for the process
S	State of the process
	*CPU = Process is currently in the CPU. This will always be the procs command since it has to be running when it takes the snapshot of the process table.
	a = Active. Process wants CPU time, but is having to wait because another process is in the CPU already.
	d = Debug. Process is currently being debugged.
	e = Event. Process is blocked waiting on an event.
	p = Semaphore. Process is blocked waiting on a semaphore.
	s = Sleeping. Process is blocked waiting on a signal or time value to elapse.
	w = Waiting. Process is blocked waiting on a child process to terminate.
	z = Suspended. Process is blocked by a special kernel system call.
	- = Zombie. Process has been terminated, but the parent has not performed a wait to read the exit status.
P	Wait on semaphore
CPU Time	The amount of CPU time the process has used

Table 6-13. Information From procs (Continued)

Name	Description
`Age`	The elapsed time since the process started
`Module & I/O`	The process name and standard I/O paths: < = standard input > = standard output >> = standard error output If several of the paths point to the same pathlist, the identifiers for the paths are merged.

Below is an example of `procs`:

```
  $ procs
   Id PId Grp.Usr  Prior  MemSiz Sig S    CPU Time   Age
Module & I/O
    2   1  22.150   128    0.25k   0 w        0.01   ???
sysgo <>>>term
    3   2  22.150   128    4.75k   0 w        4.11  1:13
shell <>>>term
    4   3  22.150     5    4.00k   0 a    12:42.06  0.14
xhog  <>>>term
    5   3  22.150   128    8.50k   0 *        0.08  0:00
procs <>>>term
    6   0  22.150   128    4.00    0 s        0.02  1:12
tsmon <>>>t1
    7   0  22.150   128    4.00k   0 s        0.01  1:12
tsmon <>>>t2
```

`procs -a` displays nine pieces of information: the process ID, the parent process ID, the process name and standard I/O paths, and six new pieces of information:

Table 6-14. Information From procs -a

Information	Description
`Aging`	The age of the process based on the initial priority and how long it has waited for processing
`F$calls`	The number of service request calls made
`I$calls`	The number of I/O requests made
`Last`	The last system call made
`Read`	The number of bytes read
`Written`	The number of bytes written

The following is an example of `procs -a`:

```
$ procs -a
Id PId   Aging   F$calls   I$calls Last   Read   Written Module & I/O
2   1    129     5         1 Wait         0      0       sysgo <>>>term
3   2    132     116       127 Wait       282    129     shell <>>>term
4   3    11      1         0 TLink        0      0       xhog  <>>>term
5   3    128     7         4 GPrDsc       0      0       procs <>>>term
6   0    130     2         7 ReadLn       0      0       tsmon <>>>t1
7   0    129     2         7 ReadLn       0      0       tsmon <>>>t2
```

The `-b` option displays all information from `procs` and `procs -a`. The `-e` option displays information for all processes in the system.

WAITING FOR BACKGROUND PROCEDURES

If the multi-tasking ability of OS-9 is used, there are times when a number of procedures are running in the background. If it is important to wait for these tasks to finish before running a new procedure, use the `w` or `wait` built-in shell command.

The following are important points to remember:

- `w` waits for the last child process to be executed to finish.
- `wait` waits for all child processes running in the background to finish.
- A child process is a process being executed by the current shell or a child of the shell.
- `wait` does not wait until a process forked with the plus sign (+) concurrent execution separator finishes execution. Processes forked with the plus sign are orphan processes.

For example, if you need to create a document from three different files and each file has to be sorted by different fields, you can use the following procedure files to create the same result:

```
*start of first procedure file*
qsort -f=1 file1&
qsort -f=2 file2&
qsort -f=3 file3&
wait
merge file1 file2 file3 >report

*start of second procedure file*
qsort -f=1 file1
qsort -f=2 file2
qsort -f=3 file3
merge file1 file2 file3 >report
```

The first procedure file is much quicker because each of the files are processed concurrently.

Stopping Procedures

You can use two methods to stop a procedure. The first method involves the `<Control>C` or `<Control>E` signal. The second method uses the `kill` utility.

- `<Control>C` stops the shell from waiting for the process to terminate and returns a prompt for a command.
- `<Control>E` forwards the keyboard abort signal to the process and immediately prompts for input.

The shell handles these keyboard generated signals in the following manner. If either of these signals are received while the shell is waiting for keyboard input the following messages are issued:

```
$ Read I/O error - Error #000:177   [ ^E typed ]
$ Read I/O error - Error #000:177   [ ^C typed ]
```

These are the standard messages given whenever an I/O error occurs when reading command input data.

If the shell is waiting for keyboard input and `<Control>E` is typed, the shell forwards the keyboard abort signal to the current process and immediately prompts for command input:

```
$ sleep 500
[ ^E is typed]
abort
$
```

The `abort` message is typed by the shell to acknowledge receipt of the interrupt.

If the shell is waiting for keyboard input and you enter `<Control>C`, the shell stops waiting for the current process to terminate and prompts for command input. This action is similar to using an ampersand on the command line. For example:

```
$ sleep 500
[ ^C is typed]
+8
$
```

It is important to remember that using `<Control>C` in this fashion is possible only if the command in question has not yet performed I/O to the terminal. The signal is only received by the last process to perform I/O. If the shell has not yet finished setting up the command for execution, the signal causes the shell to abort the operation and returns the prompt.

You must own the procedure or be the super user to kill a specified process.

You can also use the `kill` utility to terminate background processes by specifying the process number of the process to be killed. Obtain the process number of the process from `procs`. Use the `kill` utility in the following manner:

```
kill <proc num>
```

For example, if you want to terminate a process called `xhog`, you would first execute a `procs`:

```
$ procs
Id PId Grp.Usr Prior MemSiz Sig S   CPU Time   Age Module & I/O
 3   2   7.03   128    4.75k   0 w       4.11 01:13 shell <>>>term
 4   3   7.03     5    4.00k   0 a   12:42.06 00:14 xhog  <>>>term
 5   3   7.03   128    8.50k   0 *       0.08 00:00 procs  <>>term
```

From `procs`, you can see the process number for `xhog` is four. You can then type the following command:

```
$ kill 4
```

When you execute `procs` again, you find `xhog` is no longer shown.

To use the `kill` utility, complete the following steps:

Step 1. Use the `procs` utility to get the process number.

Step 2. Type `kill <proc num>`.

Either of these methods terminates any process running in the background with one exception: if a process is waiting for I/O, it may not die until the current I/O operation is complete. Therefore, if you terminate a process and `procs` shows it still exists, it is probably waiting for the output buffer to be flushed before it can die.

COMMAND HISTORY

As you enter command lines, the commands are saved in a buffer. This is a history of your commands. To see the commands you have entered, type `hist` on the command line:

```
[5]$ hist
Shell History
-------------
 1) makdir /h0/usr/TMS
 2) chd /h0/usr/tms
 3) build stat
 4) procs
 5) hist
[6]$
```

These commands may be re-executed or retrieved using tildes (~). One tilde followed by a number (~`<num>`) executes the command pointed to by `<num>`. For example, entering ~`4` on the command line causes the shell to execute the fourth command in your history list.

In the example above, the `procs` command is executed:

```
[6]$ ~4
Id PId Grp.Usr Prior MemSiz  Sig S  CPU Time   Age Module & I/O
 3   2   6.10   128    5.25k    0 w      5.02 02:34 shell <>>>term
 4   3   6.10   128    8.50k    0 *      0.08 00:00 procs <>>term
[7]$ hist
Shell History
-------------
 3) build stat
 4) procs
 5) hist
 6) procs
 7) hist
[8]$
```

Entering ~`4 -e` tells the shell to execute `procs -e`.

You can also re-execute/retrieve commands using a tilde followed by text (~`<text>`). The OS-9 shell searches backwards through the history buffer for the text. For example, if you enter ~`uma` on the command line, the command `umacs stat` is executed.

You cannot include spaces in your text. Also, the text must be the first characters in the command line. In the previous example, entering ~`acs` would produce an error.

Entering a number after two tildes (`~~<num>`) places the command in the command line buffer, just as if it were the last command entered. For example, by typing `~~3`, the command is placed in a buffer as if it had just been executed. By entering `<Control>A`, you can retrieve the command line. It is placed after the shell prompt:

```
[8]$ ~~3
[8]$ <control>A
[8]$ build stat
```

You can either execute the command by pressing a carriage return or you can edit the command line and then execute it:

```
[8]$ build stat.tst
```

In the previous example, the history number (`[8]`) did not change when the `~~3` command and the `<Control>A` were entered. The history number only changes when a command line is entered. The `~~3` causes the command to be placed in the buffer. Likewise, `<Control>A` causes the command to be placed on the command line. Entering blank lines also does not increase the history count.

You can also enter text after two tildes (`~~<text>`). For example, you could type `~~uma`. Then enter `<Control>A` to retrieve the command. Once it appears on the command line, you can edit it.

ERROR REPORTING

Many programs, including the shell, use the OS-9 standard error reporting function. This displays a brief description of the error and an error number on the standard error path.

If an expanded error description is desired, set the `-e` and the `-v` shell options. This prints error messages from `/dd/SYS/errmsg` on standard output.

7 Making Files

This chapter explains the `make` utility in detail. The following sections are included:

THE MAKE UTILITY

Many types of files are dependent upon various other files in their creation. If the files comprising the final product are updated, the final product becomes out-of-date. The `make` utility is designed to automate the maintenance and
recreation of files that change over time.

`make` maintains files by using a special type of procedure file known as a “makefile”. The makefile describes the relationship between the final product and the files comprising the final product. For the purpose of this discussion, the final product is referred to as the “target file” and the files comprising the target file are referred to as “dependents”.

A makefile contains three types of entries:

- dependency entries
- command entries
- comment entries

A dependency entry specifies the relationship of a target file and the dependents used to build the target file. The entry has the following syntax:

```
<target>:[[<dependent>],<dependent>]
```

The list of files following the target file is known as the dependency list. Any number of dependents can be listed in the dependency list. Any number of dependency entries can be listed in a makefile. A dependent in one entry may also be a target file in another entry. However, there is only one main target file in each makefile. The main target file is usually specified in the first dependency entry in the makefile.

If necessary, a command entry specifies the command that was executed to update a particular target file. `make` updates a target file only if its dependents are newer than itself. If no instructions for update are provided, `make` attempts to create a command entry to perform the operation.

`make` recognizes a command entry via a line beginning with one or more spaces or tabs. Any legal OS-9 command line is acceptable. More than one command entry can be given for any dependency entry. Each command entry line is assumed to be complete unless it is continued from the previous command with a backslash (\). Comments should not be interspersed with commands. For example:

```
<target>:[[<file>],<file>]
<OS-9 command line>
<OS-9 command line>\
```

```
<continued command line>
```

A comment entry consists of any line beginning with an asterisk (*). All characters following a pound sign (#) are also ignored as comments unless a digit immediately follows the pound sign. In this case, the pound sign is considered part of the command entry. All blank lines are ignored. For example:

```
<target>:[[<file>],<file>]

* the following command will be executed if the
* dependent files are newer than the target file
<OS-9 command line> # this is also a comment
```

Spaces and tabs preceding non-command continuation lines are ignored.

You can continue any entry on the following line by placing a space followed by a backslash (\) at the end of the line to be continued. All entries longer than 256 characters must be continued on another line. All continuation lines must adhere to the rules for its type of entry. For example, if a command line is continued on a second line, the second line must begin with a space or a tab:

```
FILE: aaa.r bbb.r ccc.r ddd.r eee.r \
fff.r ggg.r

touch aaa.r bbb.r ccc.r \
ddd.r eee.r fff.r ggg.r
```

Running the Make Utility

To run the make utility, type make, followed by the name of the file(s) to create and any options desired.

make processes the makefile three times.

- During the first pass, make examines the makefile and sets up a table of dependencies. This table of dependencies stores the target file and the dependency files exactly as they are listed in the makefile. When make encounters a name on the left side of a colon, it first checks to see if it has encountered the name before. If it has, make connects the lists and continues.
- After reading the makefile, make determines the target file on the list. It then makes a second pass through the dependency table. During this pass, make tries to resolve any existing implicit dependencies. Implicit dependencies are discussed below.

- `make` does a third pass through the list to get and compare the file dates. When `make` finds a file in a dependency list that is newer than its target file, it executes the specified command(s). If no command entry is specified, `make` generates a command based on the assumptions given in the next section. Because OS-9 only stores the time down to the closest minute, `make` remakes a file if its date matches one of its dependents.

When a command is executed, it is echoed to standard output. `make` normally stops if an error code is returned when a command line is executed.

To understand the relationship of the target file, its dependents and the commands necessary to update the target file, the structure of the makefile must be carefully examined.

Implicit Definitions

Any time a command line is generated, `make` assumes the target file is a program to compile. Therefore if the target file is not a program to compile, any necessary command entries must be specified for each dependency list. `make` uses the following definitions and rules when forced to create a command line.

object files	Files with no suffixes. An object file is made from a file capable of relocation and linked when it needs to be made.
relocatable files	Files appended by the suffix: `.r`. Relocatable files are made from source files and are assembled or compiled if they need to be made.
source files	Files having one of the following suffixes: `.a`, `.c`, `.f`, or `.p`.
default compiler	`cc`

default assembler	The default options are processor specific; some examples include: • `appc` for PowerPC processors • `a386` for 80386 processors
default linker	`cc` Use the default linker only with programs using `Cstart`. default directory for all files current data directory (.)

Macro Recognition

In addition to recognizing compilation rules and definitions, `make` recognizes a macro by the dollar sign (`$`) character in front of the name. If a macro name is longer than a single character, the entire name must be surrounded by parentheses. For example, `$R` refers to the macro `R`, `$(PFLAGS)` refers to the macro `PFLAGS`, `$(B)` and `$B` refer to the macro `B`, and `$BR` is interpreted as the value for the macro `B` followed by the character `R`.

You may place macros in the makefile for convenience or on the command line for flexibility. Macros are allowed in the form of `<macro name> = <expansion>`. The expansion is substituted for the macro name whenever the macro name appears.

Defining a macro in a command line macro overrides the macro definition in a makefile. To increase `make`'s flexibility, you can define special macros in the makefile. `make` uses these macros when assumptions must be made in generating command lines or when searching for unspecified file. For example, if no source file is specified for `program.r`, `make` searches either the directory specified by `SDIR` or the current data directory for
`program.a`
(or `.c`, `.p`, `.f`).

make recognizes the following special macros:

Table 7-1. make Macros

Macro	Definition
CC=<comp>	make uses this compiler when generating command lines. The default is cc.
CFLAGS=<opts>	These compiler options are used in any necessary compiler command lines.
LC=<link>	make uses this linker when generating command lines. The default is cc.
LFLAGS=<opts>	These linker options are used in any necessary linker command lines.
ODIR=<path>	make searches the directory specified by <path> for all files with no suffix or relative pathlist. If ODIR is not defined in the makefile, make searches the current directory by default.
RC=<asm>	make uses this assembler when generating command lines. The default for users on 680x0 processors is r68. The default for users on x86 processors is cc.
RDIR=<path>	make searches the directory specified by <path> for all relocatable files not specified by a full pathlist. If RDIR is not defined, make searches the current directory by default.
RFLAGS=<opts>	These assembler options are used in any necessary assembler command lines.
SDIR=<path>	make searches the directory specified by <path> for all source files not specified by a full pathlist. If SDIR is not defined in the makefile, make searches the current directory by default.

Some reserved macros are expanded when a command line associated with a particular file dependency is forked. You may use these macros only on a command line. When you need to be explicit about a command line but have a target program with several dependencies, these macros are useful. In practice, they are wildcards with the following meanings:

Table 7-2. make Wildcards

Macro	Definition
`$@`	expands to the file name made by the command
`$*`	expands to the prefix of the file to be made
`$?`	expands to the list of files found to be newer than the target on a given dependency line

make Generated Command Lines

`make` is capable of generating three types of command lines: compiler command lines, assembler command lines, and linker command lines.

- Compiler command lines are generated if a source file with a suffix of `.c`, `.p` or, `.f` needs to be recompiled. The compiler command line generated by `make` has the following syntax:

  ```
  $(CC) $(CFLAGS) -r=$(RDIR) $(SDIR)/<file>[.c, .f, or .p]
  ```
- Assembler command lines are generated when an assembly language source file needs to be re-assembled. The assembler command line generated by `make` has the following syntax:

  ```
  $(RC) $(RFLAGS) $(SDIR)/<file>.a -o=$(RDIR)/<file>.r
  ```
- Linker command lines are generated if an object file needs to be relinked in order to re-make the program module. The linker command line generated by `make` has the following syntax:

  ```
  $(LC) $(LFLAGS) $(RELS)/<file>.r -f=$(ODIR)/<file>
  ```

When `make` is generating a command line for the linker, it looks at its list and uses the first relocatable file it finds, but only the first one. For example:

```
prog: x.r y.r z.r
```

generates:

```
cc x.r, not cc x.r y.r z.r or cc prog.r
```

make Options

Several options allow `make` even greater versatility for maintaining files/modules. You can include these options on the command line in the makefile or when you run `make`.

When a command is executed, it is echoed to standard output unless the `-s`, or silent, option is used or the command line starts with an “at” sign (`@`). When the `-n` option is used, the command is echoed to standard output but not actually executed. This is useful when building your original makefile.

`make` normally stops if an error code is returned when a command line is executed. Errors are ignored if the `-i` option is used or if a command line begins with a hyphen.

It is often helpful to see the file dependencies and the dates associated with each of the file in the list. The `-d` option turns on the `make` debugger and gives a complete listing of the macro definitions, a listing of the files as it checks the dependency list and all the file modification dates. If it cannot find a file to examine its date, it assumes a date of -1/00/00 00:00, indicating the necessity to update the file.

If you want to update the date on a file, but do not want to remake it, you can use the `-t` option. `make` merely opens the file for update and then closes it, thus making the date current.

If you are explicit about your makefile dependencies and do not want `make` to assume anything, you may use the `-b` option to turn off the built-in rules governing implicit file dependencies.

Table 7-3. make Options

Options	Description
`-?`	Display the usage of `make`.
`-b`	Do not use built in rules.
`-bo`	Do not use built in rules for object files.
`-d`	Print the dates of the files in makefile (debug mode).
`-dd`	Double debug mode. Verbose.
`-f-`	Read the makefile from standard input.
`-f=<path>`	Specify `<path>` as the makefile. If `<path>` is specified as a hyphen (`-`), `make` commands are read from standard input.
`-i`	Ignore errors.
`-n`	Do not execute commands, but does display them.
`-s`	Silent mode: execute commands without echo.
`-t`	Update the dates without executing commands.
`-u`	Do the `make` regardless of the dates on files.
`-x`	Use the cross-compiler/assembler.
`-z`	Read a list of `make` targets from standard input.
`-z=<path>`	Read a list of `make` targets from `<path>`.

EXAMPLES USING THE MAKE UTILITY

The remainder of this chapter shows details different ways to maintain programs with make.

Updating a Document

The following example shows how `make` maintains current documentation composed of different sections:

```
utils.man: chap1 chap2 apdx
     del utils.man.old;rename utils.man utils.man.old
     merge chap1 chap2 apdx >utils.man
chap1: c1a c1b c1c c1d
     del chap1.old; rename chap1 chap1.old
     list c1a c1b c1c c1d ! lxfilter >chap1
chap2: c2a c2b c2c
     del chap2.old; rename chap2 chap2.old
     list c1a c1b c1c c1d ! lxfilter >chap1
apdx: functions header footer
     del apdx.old; rename apdx apdx.old
     qsort functions >/pipe/func
     list header /pipe/func footer ! lxfilter >apdx
```

The above makefile creates the file `utils.man`. `utils.man` is created from three files: `chap1`, `chap2`, and `apdx`. Each of these files is in turn created from the files listed in their dependency lists.

If `chap1`, `chap2`, and/or `apdx` have dependencies with a more recent date, the command following their respective dependency entries are executed. If `chap1`, `chap2`, and/or `apdx` are re-created, the commands following the initial dependency entry are executed.

Compiling C Programs

In this example, make is used to compile high level language modules. Each command and dependency is specified.

```
program: xxx.r yyy.r
    cc xxx.r yyy.r -xf=program
xxx.r: xxx.c /d0/defs/oskdefs.h
    cc xxx.c -r
yyy.r: yyy.c /d0/defs/oskdefs.h
    cc yyy.c -r
```

This makefile specifies `program` is made up of two `.r` files: `xxx.r` and `yyy.r`. These files are dependent upon `xxx.c` and `yyy.c` respectively and both are dependent on the `oskdefs.h` file.

If either `xxx.c` or `/d0/defs/oskdefs.h` has a date more recent than `xxx.r`, the command `cc xxx.c -r` is executed. If `yyy.c` or `/d0/defs/oskdefs.h` is newer than `yyy.r`, then `cc yyy.c -r` is executed. If either of the former commands are executed, the command `cc xxx.r yyy.r -xf=program` is also executed.

In this example, `make` specifies each command it must execute. Often this is unnecessary, as `make` uses specific definitions, macros, and built-in assumptions to facilitate program compilation and generate its own commands.

Knowing how `make` works and understanding the implicit rules can simplify coding immensely:

```
program: xxx.r yyy.r
   cc xxx.r yyy.r -xf=program
xxx.r yyy.r: /d0/defs/oskdefs
```

This makefile exploits the `make` utility awareness of file dependencies. No mention is made of the C language files; therefore, `make` looks in the directory specified by the macro definition `SDIR = <path>` and adjusts the dependency list accordingly. In this case, `make` searches the current directory by default. `make` also generates a command line to compile `xxx.r` and `yyy.r` if either needs updating.

Further simplification is possible if `program` is made up of only one source file:

```
program:
```

`make` assumes the following from this simple command:

- `program` has no suffix. It is an object file and therefore relies on relocatable files to be made.
- No dependency list is given; therefore, `make` creates an entry in the table for `program.r`.
- After creating an entry for `program.r`, `make` creates the entry for a source file connected to the relocatable file.

Assuming it found `program.a`, `make` checks the dates on the various files and generates one or both of the following commands if required:

```
appc program.a -o=program.r
cc program.r -f=program
```

Using Macros

Using these inherent features of `make` is especially helpful if you have several object files you want `make` to check:

```
* beginning
ODIR = /d0/cmds
RDIR = rels
UTILS = attr copy load dir backup dsave
SDIR = ../utils/sources
utils.files: $(UTILS)
     touch utils.files
* end
```

`make` searches `rels` for the `.r` files (`attr.r`, `copy.r`, and so on). and looks in `../utils/sources` for the `.c` files named in the `UTILS=` line. `make` then generates the proper commands to compile and/or link any of the programs needing to be made. If one of the files in `UTILS` is made, the command `touch utils.files` is forked to maintain a current overall date.

Creating make

The following example is a makefile to create `make`:

```
* beginning
ODIR = /h0/cmds
RDIR = rels
CFILES = domake.c doname.c dodate.c domac.c
RFILES = domake.r doname.r dodate.r
PFLAGS = -p64 -nh1
R2 = ../test/domac.r
RFLAGS = -q
make: $(RFILES) $(R2) getfd.r
    linker
$(RFILES): defs.h
$(R2): defs.h
    cc $*.c -r=../test
print.file: $(CFILES)
    pr $? $(PFLAGS) >-/p1
    touch print.file
*end
```

The makefile in this example looks for the `.r` files listed in `RFILES` in the directory specified by `RDIR: rels`. The only exception is `../test/domac.r`, which has a complete pathlist specified.

Even though `getfd.r` does not have any explicit dependents, its dependency on `getfd.a` is still checked. The source files are all found in the current directory.

This makefile can also be used to make listings. By typing `make print.file` on the command line, `make` expands the macro `$?` to include all of the files updated since the last time `print.file` was updated. If you keep a dummy file called `print.file` in your directory, `make` only prints out the newly made files. If no `print.file` exists, all files are printed.

8 Performing Backups

This chapter explains the concept of incremental backups. The OS-9 utilities that create backups are detailed here. This chapter also offers two different strategies for making backups. The following sections are included:

- Incremental Backups
- Using the tape Utility

INCREMENTAL BACKUPS

Incremental backups save significant time and storage space compared to full system backups. Incremental backups save only the files that have changed since the last backup. A full system backup must still be performed, but with the use of incremental backups a full system backup does not need to be performed very often.

OS-9 provides two utilities to facilitate incremental backups. You can use each with either tape or disk media:

- `fsave`
- `frestore`

Certain terms are important to know for the discussion of incremental backups:

Level 0 backup	is a common term used to denote a full system backup. Consequent incremental backups are referenced by different level numbers. For example, a level 5 backup includes all files changed since the most recent backup with a level less than 5. While this sounds complex, it is actually quite easy to use and extremely helpful.
Source device	is the directory structure or file you are backing up.
Target device	is the tape or disk that holds your backup information.

Making an Incremental Backup: The fsave Utility

The `fsave` utility performs an incremental backup of a directory structure to tape(s) or disk(s). The syntax for the `fsave` utility is shown below:

```
fsave [<opts>] [<path>]
```

Typing `fsave` alone on the command line makes a level 0 backup of the current directory onto a target device with the name `/mt0`.

`/mt0` is the OS-9 device name for a tape device.

/h0/sys/backup_date is a backup log file maintained by fsave. Each time an fsave is executed, the backup log is updated. The backup log keeps track of the name of the backup, the date it was created and, more importantly, the level of the backup. When fsave is executed, this backup log is examined to find the specified level of the current backup and the previous backups with the same name. Once the backup is finished, a new entry is made in the file indicating the date, name, level, and other information about the current backup.

fsave Options

During the discussion of the actual fsave procedure, references to fsave options are made. The options are shown in Table 8-1.

Table 8-1. fsave Options

Option	Description
-?	Display the usage of fsave.
-b[=]<int>	Allocate <int>k buffer size to read files from the source disk.
-d[=]<dev>	Specify the target device to store the backup. The default is /mt0.
-e	Do not echo file pathlists being saved to target device.
-f[=]<path>	Save to the file specified by <path>.
-g[=]<int>	Specify a backup of files owned by group number <int> only.
-l[=]<int>	Specify the level of the backup to be performed.
-m[=]<path>	Specify the pathlist of the date backup log file to be used. The default is /h0/sys/backup_dates.
-p	Turn off the mount volume prompt for the first volume.
-s	Display the pathlists of all files needing to be saved and the size of the entire backup without actually executing the backup procedure.
-t[=]<dirpath>	Specify alternate location for the temporary index file.
-u[=]<int>	Specify backup of files owned by user number <int>.
-v	Do not verify the disk volume when mounted.
-x[=]<int>	Pre-extend temporary file. <int>; given in kilobytes.

The fsave Procedure

When starting an `fsave` procedure, `fsave` prompts you to mount the first volume to use. Volume, in this case, refers to the disk or tape used to store the backup:

```
fsave: please mount volume.
(press return when mounted).
```

If a disk is used as the backup medium, `fsave` verifies the disk and displays the following information: (The numbers below are used only as an example.)

```
verifying disk
Bytes held on this disk: 546816
Total data bytes left:   62431
Number of Disks needed: 1
```

The most common error found when executing `fsave` is a record lock error. Record lock errors are caused when another user has the file in question open. `fsave` operations should only be done when no one else is using the system to prevent record lock errors. If a tape is used as the backup medium, no preliminary information is displayed and the backup begins at this point.

As each file is saved to the backup device, the file pathlist is echoed to the terminal. If this is a long backup, you may want to use the `-e` option to turn off the echoing of pathlists.

If `fsave` receives an error when trying to backup a file, it displays the following message and continues the `fsave` operation:

```
error saving <file>, error - <error number>, its
incomplete
```

If the backup requires more than one volume, `fsave` prompts you to mount the next volume before continuing.

At the end of the backup, `fsave` prints the following information:

```
fsave: Saving the index structure
Logical backup name:
Date of backup:
Size of backup:
Size of temp/index:
Backup made by:
Data bytes written:
Number of files:
Number of volumes:
```

```
Index is on volume:
```

The index to the backup is saved on the last volume used.

`fsave` performs recursive backups for each pathlist if one or more directories are specified on the command line. A maximum of 32 directories may be specified on the command line.

The `-d` option allows you to specify an alternate target device. The default device is `/mt0`.

Use the `-m` option to specify an alternative backup log file. The default pathlist is `/h0/sys/backup_dates`.

Different levels of backups may be specified with the `-l` option. A higher level backup only saves files that have changed since the most recent backup with the next lower number. For example, a level 1 backup saves all files changed since the last level 0 backup.

When using disks for backup purposes, `fsave` does not use an RBF file structure to save the file on the target disk. It creates its own file structure. This makes the backup disk unusable for any purpose other than `fsave` and `frestore` without reformatting the disk.

Any data stored on the disk before use by `fsave` is destroyed by the backup.

Example fsave Commands

Typing `fsave` on a command line specifies a level 0 backup of the current directory. This assumes the device `/mt0` is to be used and `/h0/SYS/backup_dates` is used as the backup log file for this backup.

The following command specifies a level 2 backup of the current directory using the `/mt1` device. `/h0/misc/my_dates` is used as the backup log file:

```
$ fsave -l=2 -d=/mt1 -m=/h0/misc/my_dates
```

The following command specifies a level 0 backup of all files owned by user 0.0 in the `CMDS` directory, if `CMDS` is in your current directory:

```
$ fsave -pb=32 -g=0 -u=0 -d=/d2 CMDS
```

This backup uses `/d2` as the target device and `/h0/sys/backup_dates` as the backup log file. The mount volume prompt is not generated for the first volume. A 32k buffer is used to read the files from the `CMDS` directory.

Restoring Incremental Backups: The frestore Utility

The `frestore` utility restores a directory structure from multiple volumes of tape or disk media. The syntax for the `frestore` utility is listed below:

```
frestore [<opts>] [<path>]
```

Typing `frestore` on the command line attempts to restore a directory structure from the device `/mt0` to the current directory.

Specifying the pathlist of a directory on the command line causes the file to be restored in that directory. The directory structure and an index of the directory structure are created by `fsave`.

If more than one tape or disk is involved in the `fsave` backup, each tape or disk is considered to be a different volume. The volume count begins at one (1). When beginning a `frestore` operation, the last volume of the backup must be used first because it contains the index of the entire backup.

`frestore` first attempts to locate and read the index of the directory structure of the source device. `frestore` then begins an interactive session with the user to determine which file and directory in the backup should be restored to the current directory.

frestore Options

During the discussion of the actual `frestore` procedure, references are made to `frestore` options. The options are shown in Table 8-2.

Table 8-2. frestore Options

Option	Description
`-?`	Display the usage of `frestore`.
`-b[=]<int>`	Specify the buffer size used to restore the files.
`-c`	Checks the validity of files without using the interactive shell.
`-d[=]<path>`	Specify the source device. The default is `/mt0`.
`-e`	Display the pathlists of all files in the index, as the index is read from the source device.
`-f[=]<path>`	Restore from a file.

Table 8-2. frestore Options (Continued)

Option	Description
`-i`	Display the backup name, creation date, group.user number of the owner of the backup, volume number of the disk or tape and whether the index is on the volume. This option does not cause any files to be restored. The information is displayed, and `frestore` is terminated.
`-p`	Suppress the prompt for the first volume.
`-q`	Overwrite an already existing file when used with the `-s` option.
`-s`	Force `frestore` to restore all files from the source device without an interactive shell.
`-t[=]<dirpath>`	Specify an alternate location for the temporary index file.
`-v`	Display the same information as the `-i` option, but does not check for the index. This option does not cause any files to be restored. The information is displayed and `frestore` is terminated.
`-x[=]<int>`	Pre-extend the temporary file. `<int>` is given in kilobytes.

The Interactive Restore Process

Once `frestore` has been called, the following prompt is displayed:

```
frestore: mount the last volume
(press return when ready)
```

When you are ready, `frestore` reads the index and creates the directory structure of the backup. It then displays the prompt:

```
frestore>
```

This prompt indicates you are in the interactive shell. If the index is not on the mounted volume, `frestore` displays an error message and again prompts you to mount the last volume.

Once in the interactive shell, the `frestore` command and options are displayed when a return is typed at the prompt:

```
frestore> commands:
  add [<path>] [-g=<#> -u=<#> -r -a] -- marks file for restoration
  del [<path>] [-g=<#> -u=<#> -r -a] -- unmarks files for
  restoration
  dir [<dir names>] [-e] -- displays a directory or directory
  chd <path> -- changes directories within the restore file
  structure
  pwd -- gives the pathlist to current dir in the restore file
  structure
  cht <path> -- changes directories on target system
  rest [<path>] [-f -q] -- restores marked files in and below the
  current dir
  check [-f] -- checks validity if marked files in and below the
  current dir
  dump [<file>] -- dumps the contents of a file to stdout
  list [<file>] -- list the contents of an ASCII file to stdout
  $   -- forks a shell
  quit -- quit frestore program
options:
  -g=<group#> -- only mark files with 'group#'
  -u=<user#> -- only mark files with 'user#'
  -r -- mark directories recursively
  -e -- display directory with extended format
  -f -- force restoration of already restored files
  -q -- overwrite already existing files without question
  -a -- force marking or unmarking of an already restored file or
  dir
   * -- matches any string of characters on 'add' or 'del' only
   ? -- matches any single character on 'add' or 'del' only
frestore>
```

The index from the source device sets up a restore file structure paralleling the usual OS-9 file and directory structure.

The `dir` and `chd` shell command can display the restore file structure. For example:

```
frestore>dir
                    Directory of .
DIR1              file1             file2              file3
```

All files to be backed up onto the source device appear in the restore file structure regardless of what volume they appear in. Information concerning the file structure is available using the `-e` option with the `dir` command:

```
   frestore>dir -e
Directory of .
Owner    Last modified  Attributes Volume Block Offset   Size    Name
------   -------------- ----------- ------ ----- ------   -----   ---
1.23     89/08/22 16/14  ----r-wr       1     0      0   CF12    file1
1.23     89/08/25 11/00  ----r-wr       1     2      0   A356    file2
1.23     89/08/21 11/12  ----r-wr       1     4      0   45F0    file3
1.23     89/08/24 10/57  d-ewrewr       0     5      0    120    DIR1
```

In the interactive shell, you can mark the files you want restored with the `add` command. Groups of files can be marked using the `-g`, `-u` and `-r` options of the `add` command. The `-g` option marks files by group number. To mark files by user number, use the `-u` option. All directories within a specified directory may be marked by using the `-r` option.

- Files may be marked one at a time by specifying relative or complete pathlists within the restore file structure.
- An entire directory may be marked by specifying the pathlist of the directory.

Marking files does not restore them. It merely marks them as *to be restored*. You can see this when you use the dir command. Each file added to the *to be restored* list is marked by a plus sign (+) by its filename.

For example, the following directory has `file1` and `file2` marked for restoration, but `file3` is not marked. The directory `DIR1` and `DIR2` also have marked files:

```
   frestore>add file1 file2 dir1/file5 dir1/file6
dir2/file7
   frestore>dir
              Directory of .
   +DIR1     +DIR2      +file1     +file2
   file3
   frestore>dir dir1
              Directory of DIR1
   file4     +file5     +file6
   frestore>dir dir2
              Directory of DIR2
   +file7    file8
```

The `del` command can unmark files. Entire directories may be unmarked by specifying the directory name on the command line. If the `-r` option is also used, all files and directories included in the specified directory are unmarked. For example:

```
frestore>del -r dir2
frestore>dir
          Directory of . 10:42:32
+DIR1     DIR2     +file1+file2
file3
frestore>dir dir2
          Directory of DIR2
file7     file8
```

Once files are marked, use the `rest` command to restore the current directory of the target device.

Files existing on the target system with the same name are overwritten without prompting if `del -q` is used. Otherwise, `frestore` displays the following prompt:

```
frestore: file1 already exists
       write over it or skip it (w/s)
```

An asterisk (`*`) preceding the name of a file in a `dir` listing indicates an error occurred while backing up this file. This file is incomplete and should not be restored.

The `cht` command allows you to change directories on the target device. This allows you to selectively restore files to specific directories.

After restoring files, you may continue marking files. Files previously restored have a hyphen (`-`) displayed next to their names in the restore file structure:

```
frestore>dir
          Directory of . 10:42:32
-DIR1     DIR2     -file1     -file2
file3
frestore>dir dir1
                 Directory of DIR1
file4     -file5   -file6
```

There are two methods of restoring files more than once. The first method uses the `-a` option with the `add` command. This forces the file(s) previously marked as restored to be marked as "to be restored". The second method requires the `-f` option to be used with the `rest` command. This forces any file previously marked as restored to be restored in the current directory.

The `-s` option forces `frestore` to restore all files and directories of the backup from the source device without the interactive shell.

Using the `-d` option allows you to specify a source device other than `/mt0`. For example, to restore all files/directories found on the source device `/mt1` to the directory `BACKUP` without using the interactive shell, type:

```
$ frestore -d=/mt1 -s BACKUP
```

The `-v` option causes `frestore` to identify the name and volume number of the backup mounted on the source device. The date the backup was made and the group.user number of the person who made the backup are also displayed. This option does not restore any files. For example:

```
$ frestore -v
Backup: DOCUMENTATION
Made:   9/16/89 10:10
By:     0.0
Volume: 0
```

The `-i` option displays the above information and also indicates whether the index is on the volume. Both the `-v` and `-i` options terminate `frestore` after displaying the appropriate information. These options are useful when trying to locate the last volume of the backup if any mix-up has occurred.

The `-e` option echoes each file pathlist as the index is read off the source device.

Example Command Lines

To restore files and directories from the source device `/mt0` to the current directory by way of an interactive shell, type the following command:

```
$ frestore
```

The following example restores files/directories from the source device `/d0` to the current directory using a 32-K buffer to write the restored files. As each file is read from the index, the file's pathlist is echoed to the terminal.

```
$ frestore -eb=32 -d=/d0
```

Incremental Backup Strategies

Many different strategies are available for those concerned with regularly scheduled backups. Most strategies are well documented in computer books and magazines. The following two strategies are offered as examples.

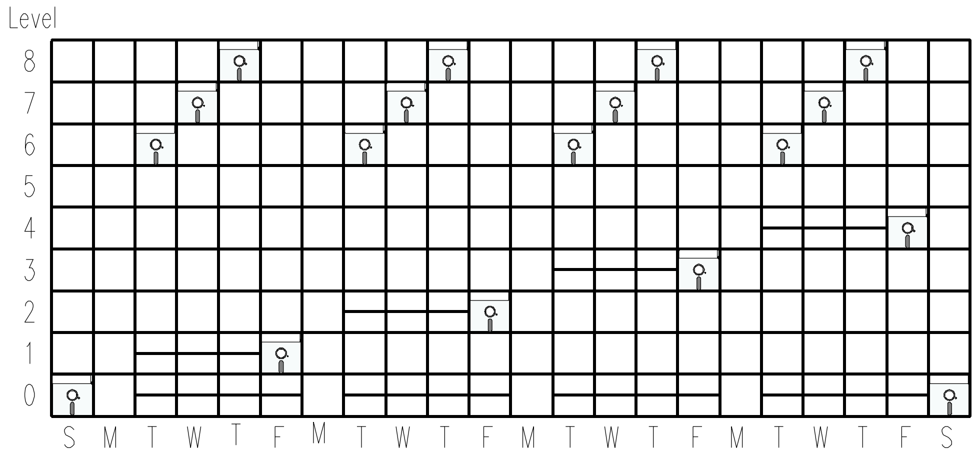
Daily Backup Strategy

This strategy requires making a level 0 backup once every four weeks. Level 1, level 2, level 3, and level 4 backups are made on the weeks following the level 0 backup. Between each major backup, four daily backups are made: level 5, 6, 7, and 8. A recommended daily schedule is graphically presented in Figure 8-1.

This strategy is ideal for small microcomputer systems backed up by floppy disks. Mounting disks is much easier and faster than tapes. Each daily backup can usually be kept on one disk to make storage simple. This strategy is perfect for small timely backups with little redundancy in the backups.

One major disadvantage of this scheme is the restore time necessary in case of a major system failure such as a hard disk being formatted, erased or corrupted. Because of the lack of redundancy, more `frestore` operations are necessary to re-create the systems file structure. On large systems with tape backups, this is a major consideration.

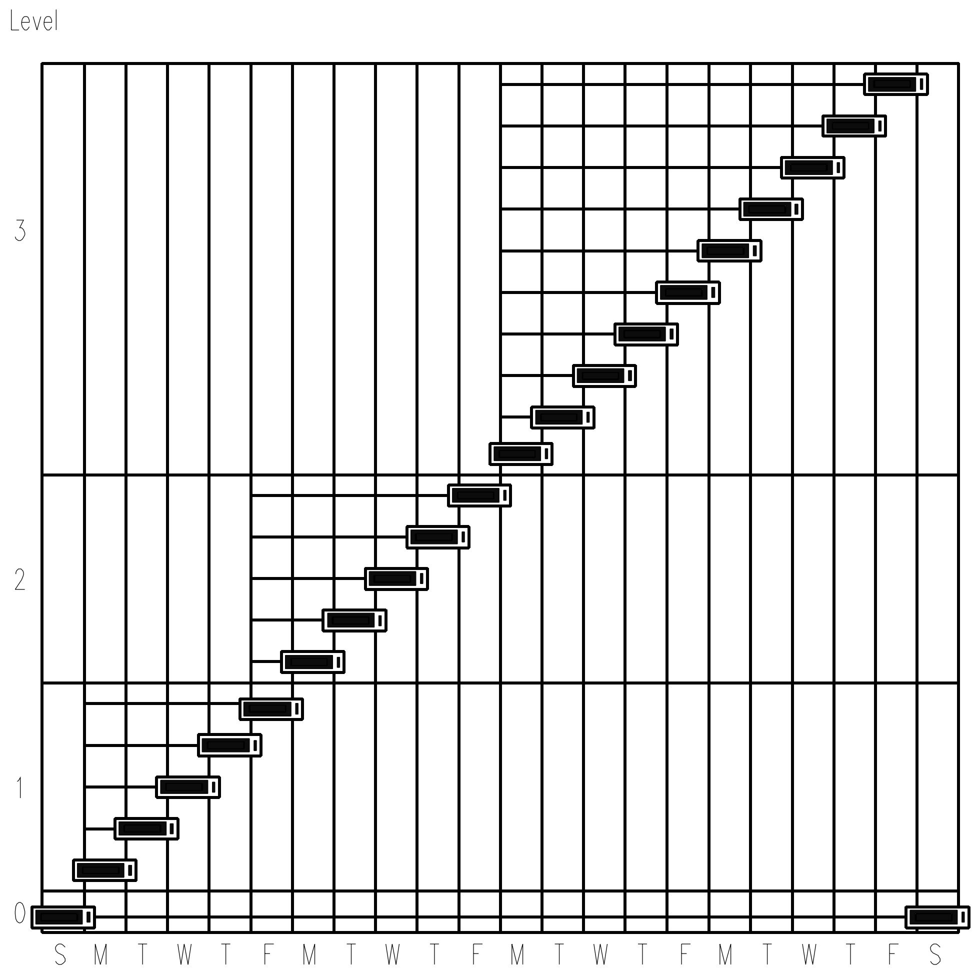
Figure 8-1. Day of Backup



Single Tape Backup Strategy

While most strategies rely on scheduled backup level changes, the single tape backup strategy depends on the size of the backup. The idea behind this strategy is to increase the level of the backup only when the backup cannot fit on a single tape. The only scheduled level backup is the level 0 backup. The level 0 backup occurs only when a higher level backup would not fit on a single tape or once a month, whichever occurs first. An example month’s schedule is graphically presented in Figure 8-2.

Figure 8-2. Single Tape Backup Strategy



This strategy is suitable for tape backups of larger systems. Tapes are used efficiently because the question of how many tapes are needed never arises. This strategy also cuts down on person hours, tape mounting, and storage space used for tapes. It allows for enough redundancy to make restoring a full system relatively simple.

Disadvantages, however, do exist. Each time a backup is done, the size of the backup must be determined by using `fsave -s`. This takes an increasing amount of time, as the tape is filled.

Use of Tapes or Disks

Whatever strategy is used, you must make a decision concerning the number of tapes or disks to use. This decision must weigh the emphasis placed on redundancy, resources, person-hours, and storage. It must be offset with the possibility of tape or disk failure and system restoration.

In the first example strategy, the daily backups must be made on different volumes to overcome the lack of redundancy. The four daily volumes can be used week after week as daily backup volumes because of the lower level backups at the beginning of each week.

In the second example, theoretically, the same tape could be used for each day until a new level backup is reached. This ensures no redundancy and minimal storage. It is also the most risky in case of tape failure. Using a number of alternating tapes for each level down on storage allows a safety net in the case of tape failure. Using alternating level 0 tapes is another possibility.

USING THE TAPE UTILITY

OS-9 provides a tape controller utility to facilitate setting up, reading and rewinding tapes from the terminal. When using tape media to backup or restore your system, the `tape` utility is very practical. The syntax of the `tape` utility is shown below:

```
tape {<opts>} [<dev>]
```

If the tape device `<dev>` is not specified on the command line and the `-z` option is not used, `tape` uses the default device `/mt0`.

`tape` has the following available options:

Table 8-3. tape Options

Options	Description
`-?`	Display the use of tape.
`-b[=<num>]`	Skip a specified number of blocks. Default is 1 block. If `<num>` is negative, the tape skips backward.
`-e=<num>`	Erase a specified number of blocks of tape.

Table 8-3. tape Options (Continued)

Options	Description
-f[=<num>]	Skip a specified number of tapemarks. Default is 1 tapemark. If <num> is negative, the tape skips backward.
-o	Put tape off-line.
-r	Rewind the tape.
-s	Determine the block size of the device.
-t	Retension the tape.
-w[=<num>]	Write a specified number of tapemarks. Default is 1 tapemark.
-z	Read a list of device names from standard input. The default is /mt0.
-z=<file>	Read a list of device names from <file>.

If more than one option is specified, `tape` executes each option function in a specific order. Therefore, it is possible to skip ahead a specified number of blocks, erase and then rewind the tape all with the same command. The order of option execution is as follows:

1. Get device name(s) from the `-z` option.
2. Skip the number of tapemarks specified by the `-f` option.
3. Skip the number of blocks specified by the `-b` option.
4. Write a specified number of tapemarks.
5. Erase a specified number of blocks of tape.

9 OS-9 System Management

System managers have a range of options to consider. OS-9 allows system managers to tailor their system to the needs of users.

This chapter discusses several topics with which system managers should become familiar. The following sections are included:

SETTING UP THE SYSTEM DEFAULTS: THE INIT MODULE

The `Init` module is sometimes referred to as the configuration module. It is a non-executable module located in memory in the `sysboot` file or in ROM. The `Init` module contains system parameters used to configure OS-9 during startup. The parameters set up the initial table sizes and system device names. For example, the amount of memory to allocate for internal tables, the name of the first program to run (usually either `sysgo` or `shell`), an initial directory, etc. are specified. You can examine the system limits defined in the `Init` module at any time.

The Init module must be present in the system in order for OS-9 to work.

The values in the `Init` module table are the system defaults. You can change these defaults by remaking the `Init` module. This is discussed later in this chapter.

The following is a list of the system defaults listed in the `Init` module. The fields in the `Init` module are defined by the structure `init_data` which is defined in `init.h.`The initialization macros are discussed later in this chapter.

Throughout this chapter, the system directory referred to are the defaults found in the `Init` module, unless otherwise specified.

The `Init` module system defaults are detailed in Table 9-1.

Table 9-1. Init Module System Defaults

Name	Initialization Macros	Description
`m_cachelist`	`CACHELIST`	This is the offset to the cache region list declared in the `default.des` file in the port directory for the system.
`m_compat`	`COMPAT`	This byte is used for revision compatibility. The following bits are currently defined: • Bit 0: set to ignore sticky bit in module headers • Bit 1:set to patternize memory when allocated and returned • Bit 2:set to inform the kernel not to automatically set the clock during coldstart
`m_consol`	`CONS_NAME`	This is the offset to the initial I/O pathlist string, usually `/term`. This pathlist is opened as the standard I/O path for the initial process. It is generally used to set up the initial I/O paths to and from a terminal. This offset should contain zero if no console device is in use.
`m_cpucompat`	`CPUCOMPAT`	This field is reserved for system-specific flags.
`m_cputyp`	`MPUCHIP`	CPU type: 403, 603, 80386, etc.
`m_dsptbl`	`DSPTBLSZ`	This field contains the number of entries in the system call dispatch table. There must be at least 256 entries in this table, and each entry requires eight bytes.

Table 9-1. Init Module System Defaults (Continued)

Name	Initialization Macros	Description
m_events	EVENTS	This is the initial number of entries allowed in the events table. If this table becomes full, it expands automatically. Refer to the *OS-9 Technical Manual* for specific information on events.
m_extens	EXTENSIONS	This is the offset to the name string of a list of customization modules, if any. A customization module is intended to complement or change existing standard system calls used by OS-9. These modules are searched for at startup and are usually found in the bootfile. If found, they are executed in system state. Module names in the name string are separated by spaces. The default name string to be searched for is OS9P2. If there are no customization modules, this value should be set zero. **NOTE:** Refer to the following section for more information on extension modules.
m_instal	INSTALNAME	This is the offset to the installation name string.
m_ioman	IOMAN_NAME	This is the offset to the name string of the module handling I/O system calls. This string is normally set to `ioman`.
m_maxage	MAXPTY	This is the initial system maximum natural age. `m_maxage` is discussed later in this chapter and in the *OS-9 Technical Manual*.

Table 9-1. Init Module System Defaults (Continued)

Name	Initialization Macros	Description
`m_memlist`	`MEMLIST`	This is the offset to the memory list declared in `default.des` and defined in `alloc.h`. For a complete discussion on colored memory, see the *OS-9 Technical Manual*.
`m_maxmem`	`MAXMEM`	This field contains the top limit of free RAM.
`m_maxsigs`	`MAXSIGS`	This field specifies the default maximum number of signals queued up for a process.
`m_minpty`	`MINPTY`	This is the initial system minimum executable priority. `m_minpty` is discussed later in this chapter and in the *OS-9 Technical Manual*.
`m_os9lvl`	`OS_LEVEL`	OS-9 Level/Version/Revision/ Edition `OS_VERSION OS_REVISION OS_EDITION`. This four byte field is divided into three parts: level: 1 byte version: 2 bytes edition: 1 byte For example, level 2, version 2.0, edition 0 is 2200.
`m_os9rev`	`OS_REVISION`	This is the offset to the OS-9 level revision string.
`m_paths`	`PATHS`	This is the initial number of open paths in the system. If this table becomes full, it is expanded automatically.

Table 9-1. Init Module System Defaults (Continued)

Name	Initialization Macros	Description
m_preio	PREIOS	This is an offset to the name string of a list of pre-I/O customization modules, if any. These extension modules are initialized and called prior to the initialization of the I/O system during bootstrap. For more information on customization modules, refer to the description of m_extens and the following section.
m_procs	PROCS	This is the number of entries in the process descriptor table. If this table becomes full, it is expanded automatically.
m_rtclock	RTC_NAME	This is the offset to the real-time clock module name string. The kernel attempts to call this module when the time is set, i.e. when _os_setime is called.
m_site	SITE	This field contains the installation site code. This user-definable field may be used to identify the site of the system.
m_slice	SLICE	This is the number of clock ticks per time-slice. The value is usually set to 1.
m_sparam	SYS_PARAMS	This is the offset to the parameter string (if any) to be passed to the first executable module.

Table 9-1. Init Module System Defaults (Continued)

Name	Initialization Macros	Description
`m_sysdrive`	`SYS_DEVICE`	This is the offset to the initial default directory name string, usually `/d0` or `/h0`. The system initially does a `chd` and `chx` to this device prior to forking the initial device. If the system does not use disk, this offset must be zero.
`m_sysgo`	`SYS_START`	This is the offset to the name string of the first executable module.
`m_syspri`	`SYS_PRIOR`	This is the system priority at which the first module (usually `Sysgo` or `Shell`) is executed. This is generally the base priority at which all processes start. This value is commonly set to 128.
`m_ticker`	`TICK_NAME`	This is the offset to the name string of the module used to generate the system clock tick. The kernel attempts to call this module when the first `_os_setime` system call is made.
`m_ticksec`	`TICK_SEC`	This is the number of ticks a second of time is divided into. This value is usually set to 100.
`m_tmzone`	`SYS_TMZONE`	This is the system time zone in minutes offset from Greenwich Mean Time (GMT). This field would be 360 for a system six time zones west of GMT and -360 for a system six time zones east of GMT.
`m_usract`	`USRACCT`	This is the offset to the name string of the user accounting module.

For more information on the Init module, see the ***OS-9 Technical Manual.***

EXTENSION MODULES

Extension modules can be attached to OS-9 during the system cold-start procedure to increase the functionality of OS-9. Extension modules can be used for a variety of functions such as user accounting, system security, and system caching.

In the `Init` module, the `m_extens` offset points to a list of module names. By default, the name of the list is `OS9P2`. If the modules are found during cold-start, they are called. If an error is returned, the system stops. Three of these modules are listed below:

`Cache`	The cache module enables the system to control any hardware caches present. This module can be customized to take advantage of any cache hardware the system may have.
`SSM`	The system security module (SSM) enables memory protection.
`FPU`	The floating point unit (FPU) module currently supplies five functions. These functions include saving, loading, and resetting the floating point processor content; setting a null context for a process; and testing for a null context.

Also, in the `Init` module, the `m_preio` offset points to a list of module names that are initialized during bootstrap prior to the initialization of the I/O system. This enables the installation of services that may be required during the initialization of the I/O system.

CHANGING SYSTEM MODULES

The provided system modules have been configured to satisfy the needs of the majority of users. However, you may wish to alter the existing modules or create new modules. New system modules and alterations to existing system modules can be made by changing the defaults in the `systype.h` file. The system modules most commonly altered are the device descriptors and the `Init` module.

The systype.h file is located in the PORTS directory. It contains macros such as TERM, DiskH0, and others for each device descriptor and the Init module. These macros contain basic memory map information, exception vector methods (for example, vectors in RAM or ROM), I/O device controller memory addresses and initialization data, and other information for each device descriptor and the Init module.

The systype.h file consists of five main sections used when installing OS-9:

- Init module CONFIG macro
- SCF Device Descriptor macros and definitions
- RBF Device Descriptor macros and definitions
- ROM configuration values
- target system specific definitions

The macros related to the Init module are surrounded in systype.h with #if defined(INITMOD). The definitions provided here override the default values when the Init module is made. This allows port-specific system tuning without modifying the generic file that all ports use to define the system configuration.

The macros device descriptors are surrounded in systype.h with #if defined (<desc>) where <desc> is the name of the descriptor being created. For example, you'll find a pre-processor directive like #if defined(TERM). The macros following this line, up to the corresponding #endif, relate to the TERM macro for your machine. The fields affected by these macros are discussed more fully in the *OS-9 Technical Manual*.

The ROM configuration values appear in systype.h surrounded by #if defined(CNFGDATA). These definitions control how your ROM modules behave for your particular port. These definitions and their effects are discussed more fully in the *BSP Reference* or *OS-9 Porting Guide* provided with your package.

System specific definitions, such as control register and vectors, should be placed in systype.h. This allows the system-specific definitions to be maintained in a single, system-specific file.

For more information on the make utility, refer to the chapter on making files and the make utility description in the *Utilities Reference* manual.

To change your system configuration, change the definitions appearing in your port `systype.h` file with any text editor. Since all relevant system components include `systype.h`, the change takes place the next time they are regenerated.

Use the `make` utility to regenerate the appropriate system components. Running the makefile in your `PORTS` directory regenerates all the port specific modules for your system. Since your changes likely only affect a small subset of these modules, you should find the makefile that is relevant to the changes you have made. For example, to change the baud rate of the `/t1` device, find the makefile for that descriptor (`SCF/SC16550/DESC`) and execute it. This regenerates the `/t1` device descriptor.

MAKING BOOTFILES

A bootfile contains a list of modules to be loaded into memory during the system's bootstrap sequence. The provided bootfiles have been configured to satisfy the majority of users, but you may want to add or remove modules from an existing bootfile.

Bootlist Files

Bootfiles are usually created using a `bootlist` file and the `-z` option of `bootgen` utility. The `bootlist` file contain a list of files, one file per line, to use in creating the bootfile. Using a `bootlist` file is a convenient way to maintain bootfile contents, as the `bootlist` file can easily be edited.

The `bootlist` files are usually located in the ports directory (for example: `/h0/MWOS/OS9000/603/PORTS/MVME1603`) along with the individual files used for constructing the bootfile.

Bootfile Requirements

The contents and module order of a bootfile are usually determined by the end-user's system configuration and requirements. However, the following points should be noted when you construct a bootfile:

- The kernel must be present in the system, either in ROM or in the bootfile. If the kernel is in the bootfile, it must be the first module.
- The `Init` module must be present in the system, either in ROM or in the bootfile.

All other modules are dependent upon the system configuration.

Making RBF Bootfile

To make a bootfile for an RBF device (hard disk or floppy disk), you need to edit the `bootlist` file to match your requirements and then run the `bootgen` utility:

```
chd /h0/MWOS/OS9000/<CPU-family>/PORTS/
<processor>/BOOTLIST
<edit bootlist file>
bootgen <device> -z=<bootlist>
```

For example:

```
chd /h0/MWOS/OS9000/80386/PORTS/PCAT/BOOTLIST
```

The `<device>` specified is the disk on which you want to install the bootfile. If this device is a hard disk, specify the format-enabled device name (for example, `h0fmt`).

For example, to make a floppy-disk bootfile, type the following command:

```
bootgen /d0 -z=d0_765.bl
```

Refer to the *BSP Reference* or *OS-9 Porting Guide* for more information.

To make a hard disk bootfile, type the following command:

```
bootgen /h0fmt -z=h0_ide.bl
```

USING THE RAM DISK

OS-9 provides support for RAM disks. These disks reside solely in Random Access Memory (RAM). The information stored on a RAM disk can be accessed significantly faster than the same information stored on a hard or floppy disk. Any file may be stored and accessed on a RAM disk. To use a RAM disk, you must have a device descriptor, a RAM disk driver and the RBF file manager.

In many system configurations, a RAM disk is used as the default system device. When the RAM disk is used as the default system device, it is known as device `dd`, instead of `r0`. The name of the device descriptor is `.r0.dd`. Using this descriptor allows compilers to use the RAM disk as a “fast access” device for temporary file. The RAM disk is usually initialized at startup with definition and library files, if it is to be used as the default system device.

RAM disks are either volatile or non-volatile. A volatile RAM disk disappears when the system is reset or the power is shut off. A non-volatile RAM disk resides in a place such as battery backed up RAM and does not disappear when the system is reset or powered down.

Volatile RAM Disks

Volatile RAM disks may be allocated memory either from free system memory or from outside free system memory. Volatile RAM disks not allocated from the free system memory must not be part of the system memory list, and they must have a port address greater than or equal to 1024. This port address indicates the actual start address of the RAM disk.

Non-Volatile RAM Disks

A non-volatile RAM disk must be located in an area of memory the system will not try to allocate. If it is located in an area known to the system, the RAM disk may be cleared because the memory is assumed to be un-allocated and may later be used by the system. In addition, the format protect bit must be set for non-volatile RAM disks and the port address must be greater than or equal to 1024.

MAKING A STARTUP FILE

Using bootfiles is not the only way of loading modules and device into memory at the time of startup. A startup procedure is executed each time OS-9 is booted and the standard `sysgo` is used. On disk-based systems, the startup procedure executes a `startup` file. The `startup` file is located in the `sys` directory in the root directory of the system disk.

The `startup` file is an OS-9 procedure file. It contains OS-9 commands to be executed immediately after booting the system.

While some modules and devices, such as the kernel, should be loaded from the `sysboot` file, having the `startup` file load most modules can be advantageous. For example, it is easier to upgrade a system by modifying the `startup` file. To change this file, you simply use a text editor and make the changes. To change the `sysboot` file, you must also use the `bootgen` utility.

A procedure file is made up of executable commands. Each command is executed exactly as if it were entered from the shell command line. Each line starting with an asterisk (*) is a comment and is not executed.

From the root directory, the `startup` file can be examined by entering the following command:

```
$ list sys/startup
```

A listing similar to the following is displayed:

```
-t -np
*
* OS-9000
* Copyright 1996 by Microware Systems Corporation
* Copyright 2001 by RadiSys Corporation
*
* The command in this file are highly system dependent
and should
* be modified by the user.
*
* setime; * start system clock
link shell csl ; * make "shell" and "csl" stay in memory
* iniz r0 h0 d0 t1 p1 ; * initialize device
* load -z=sys/loadfile ; * make some utilities stay in
memory
* load bootobjs/r0.dd ; * get default device descriptor
* tsmon /t1 & ; * start other terminals
list sys/motd
```

The first executable line, `-t -np`, turns on the talk mode option of the shell and turns off the prompt option for the duration of this procedure. The talk mode option echoes each executed command to the terminal display. This allows you to see what command are being executed.

For systems with battery-backed up clocks, run `setime` with the `-s` option to start time-slicing. The date and time are read from the clock.

The other executable lines in the distributed `startup` file are followed by a comment explaining the purpose of the command. Some standard commands are provided as comments. If you want the command executed during the startup procedure, use a text editor to remove the asterisk preceding the command.

For example, to execute the `setime` command when the `startup` file is executed, remove the asterisk preceding the command.

If you are concerned that your system may be unusable due to a corrupt or missing startup file, set the parameter string in the init module as shown below:

```
...;mshell --lp=backup- &; profile /h0/sys/startup & \n
```

This setting first brings up mshell, then profiles the startup files. (This may result in the forking off of more than one mshell.) Once you are satisfied the startup file is present and functioning, you can change your init string back to the following setting:

```
...;/h0/sys/startup & \n
```

Initializing Devices: iniz r0 h0 d0 t1 p1

The `iniz r0 h0 d0 t1 p1` commented command initializes the following specific devices:

Table 9-2. iniz Initialiized Devices

Device	Description
`r0`	RAM disk
`h0`	Hard disk
`d0`	Floppy disk
`t1`	Terminal
`p1`	Serial Printer

When OS-9 opens a path to a device, it first checks to see if the device is known to OS-9. To be known, a device must be initialized and memory must be allocated for its device driver. If the device is unknown at the time of the request, OS-9 initializes the device, allocates memory and opens the path. For example, a simple `dir /d0` command initiates this sequence of events if `d0` has not been previously initialized.

The `iniz` utility initializes devices. `iniz` performs an `I_ATTACH` system call on each device name passed to it. This initializes and links the device to the system.

To initialize a device after the system has been started, type `iniz` and the name(s) of the device(s) to attach to the system. `iniz` goes through the procedure of initializing the device(s) and allocating the memory needed for the device. If the device is already attached, it is not re-initialized, but the link count is incremented.

For example, to increment the link count of modules, `t2` and `t3`, type the following command:

```
$ iniz t2 t3
```

The device names can be read from standard input with the `-z` option or from a file with the `-z=<file>` option. To increment the link counts of devices listed in a file called `/h0/add.file`, type the following command:

```
iniz -z=/h0/add.files
```

You can use the `deiniz` utility to deinitialize a device. `deiniz` checks the link count before removing the device from storage. If the link count is greater than one, `deiniz` lowers the link count. If the link count is one, `deiniz` lowers the link count to zero, and removes the device from the system device table. The device then becomes unknown to OS-9.

Non-sharable devices must be placed in a bootfile to become known to the system. If a non-sharable device is initialized, it is unusable because the link count has been incremented, which makes it appear to be in use.

To use the `deiniz` utility, type `deiniz` followed by the name(s) of the devices(s) to remove from the system.

For example, to decrement the link count of module `p2`, type the following command:

```
$ deiniz p2
```

`deiniz` can read the device names from standard input with the `-z` option or from a file with the `-z=<file>` option. To remove the file listed in a file called `/h0/not.needed`, type the following command:

```
$ deiniz -z=/h0/not.needed
```

This initialize/de-initialize sequence can result in slower execution of programs and may cause memory fragmentation problems. To avoid these symptoms, it is recommended that all devices connected to the system at startup be initialized in the `startup` file.

For more information on the `iniz` and `deiniz` utilities, refer to the *Utilities Reference* manual.

Initializing the connected device at startup initializes the device and allocates memory for its driver for the duration of the time the system is running, unless specifically de-initialized. For example, a system with two floppy drives and one hard disk drive can initialize these devices in the `startup` file:

```
iniz h0 d0 d1 t1 p1 p
```

Loading Utilities Into Memory: load -z=sys/loadfile

The next line of the `startup` file loads a number of utilities into memory. If a utility is not already in memory, it must be loaded into memory before it is used. Pre-loading basic utilities at startup time avoids the necessity of loading the utility each time it is executed.

To load utilities into memory at startup, you must create a file containing the names of each utility to load, one utility per line. While the file may have any name, Microware recommends `loadfile`. You can locate this file in any directory as long as its location is specified on the command line. If `loadfile` is located in the `SYS` directory, the startup file command line will look like the following example:

```
load -z=sys/loadfile
```

Previous versions of the operating system had the following commented line in the `startup` file:

```
load utils
```

This method involved creating a `utils` file by merging the desired utilities into a single file in the command directory. While you may still use this method, using `loadfile` is preferable because it uses less disk space and is easier to edit.

Loading the Default Device Descriptor: Load bootobjs/r0.dd

Many OS-9 compilers and application programs look for definition files and libraries in directories located on the default system device. The default system device is known as `dd`. `dd` may be defined as any disk device, but it is usually synonymous for one of the following devices:

Table 9-3. Disk Devices

Device	Description
`r0`	RAM disk
`h0`	Hard disk
`d0`	Floppy disk

If a default device is to be used (`dd`) and the device descriptor is not in the bootfile, then the device descriptor must be loaded. The next line in the startup file loads the device descriptor. The default device used is the RAM disk named `r0`. If you want another device to be the default device descriptor, change the `.r0` extension to reflect the appropriate device. If you have a `dd` device in your bootfile or if no default device is to be used, leave this line as a comment.

Multi-user Systems: tsmon /t1 &

The `tsmon` utility is used to make your system a multi-user system. This utility supervises idle terminals and initiates the login procedure for multi-user systems. The `startup` file command line, `tsmon /t1&`, initiates the time-sharing monitor on the serial port `/t1`.

`tsmon` can monitor up to 28 device name pathlists. Therefore, if you have multiple devices for `tsmon` to monitor, you can name up to 28 devices on each `tsmon` command line. Use the `ex` built-in shell command to execute `tsmon` without creating another shell. This conserves system memory. For example:

```
ex tsmon /term /t1 /t2 /t3 /t4 /t5&
```

When a carriage return is entered on any of the specified paths, `tsmon` automatically forks `login` and standard I/O paths are opened to the device.

For more information on the `tsmon` utility, refer to the *Utilities Reference* manual.

The `login` procedure uses the `password` file located in the `SYS` directory for individual `login` validation. The provided `password` file has two example login entries. Each of the fields in an entry in the password file is explained in the chapter on the shell and in the `login` utility description in the *Utilities Reference* manual. If `login` fails because you could not supply a valid user name or password, control returns to `tsmon`.

TIME ZONES AND THE TZ ENVIRONMENT VARIABLE

The `TZ` environment variable is used to specify the time zone for the C functions to use. `TZ` should have the following format:

```
zzz[+/-n][:ddd]
```

In addition, the value of `m_tmzone` in the init module should be set to match the system time zone offset from GMT when daylight savings time is not in effect.

You must set the `TZ` environment variable correctly in order to accurately track daylight savings time. However, if it is not necessary to track daylight savings time, you do not need to set `TZ`--provided that `m_tmzone` in the init module has been set correctly.

Refer to the *Ultra C Library Reference* for more information about the `TZ` environment variable and time functions.

Time Zones

The following table gives brief descriptions of each time zone.

Table 9-4. Time Zones and Descriptions

Zone	Description
`GMT/UTC`	Greenwich Mean Time (or Coordinated Universal Time)
`PST/PDT`	USA Pacific Standard Time/Daylight Savings Time
`MST/MDT`	USA Mountain Standard Time/Daylight Savings Time
`CST/CDT`	USA Central Standard Time/Daylight Savings Time
`EST/EDT`	USA Eastern Standard Time/Daylight Savings Time
`YST`	Yukon Standard Time (Most of Alaska)
`AST`	Aleutian/Hawaiian Standard Time
`EET`	Eastern European Time

Table 9-4. Time Zones and Descriptions (Continued)

Zone	Description
CET	Central European Time
WET	Western European Time
JST	Japan Standard Time
MIT	Midway Islands Time
HST	Hawaii Standard Time
PNT	Phoenix Standard Time
IET	Indiana Eastern Standard Time
PRT	Puerto Rico Standard Time
CNT	Canada Newfoundland Time
AGT	Argentina Standard Time
BEZ	Brazillian Standard Time
CAT	Central Africa
ECT	European Central Time
ART	Arabic Standard Time
EAT	Eastern African Time
MET	Middle Eastern Time
NET	Near East Time
PLT	Pakistan Lahore Time
IST	India Standard Time
BST	Bangladesh Standard Time
VST	Vietnam Standard Time
CTT	China Taiwan Standard Time
ACT	Australia Central Time
AET	Australian Eastern Time
SST	Solomon Standard Time
NST	New Zealand Standard Time

SYSTEM SHUTDOWN PROCEDURE

There are times when you want to shut your system down. When you reset or power down your system, you may need to do more than just press the reset button. Certain programs need to be shut down gracefully. For example, most network communications, print spools, and inter-system processes need special attention. These processes may have options or other arrangements needing consideration before shutting down your system.

In addition to taking care of processes requiring special attention, you should prepare the system users for the shutdown. If at all possible, users should be allowed enough time to save their file and close their workstation. One way of alerting users that the system is going down is by echoing a message using the `echo` and `tee` utilities. However, you should realize messages sent over the system in this manner are not seen by users who do not press a carriage return after the message has been sent. For example, if a programmer is sitting at a shell prompt, the message does not appear on the terminal screen until a carriage return is entered.

In this case, verbal warnings are important. This means in addition to sending a warning message out over the system, you may want to use either an intercom system or the telephone to talk to each person connected to the system.

You can simplify the process of actually shutting down your system by creating a procedure file. Once created, you can run the procedure from the shell command line prompt or a separate password entry may be created for the sole purpose of shutting down the system.

For example, if you have a procedure file called `shutdown.sys`, you could create the following password file entry:

```
sys,shutdown,0.0,128,.,sys,shell shutdown.sys
```

Once you login as user `sys` with password `shutdown`, the shutdown procedure begins because the system immediately has the shell execute the `shutdown.sys` file.

The following code is an example of a useful procedure file for shutting down the system:

```
   -t -nx -np
   *
   * System Shutdown Procedure
   *
   echo WARNING The system will shut down in 3 minutes !
tee /t1 /t2 /t3 /t4 /t5
   sleep -s 60
   echo WARNING The system will shut down in 2 minutes !
tee /t1 /t2 /t3 /t4 /t5
   sleep -s 115
   echo WARNING 5 seconds to system shut down ! tee /t1 /t2
/t3 /t4 /t5
   sleep -s 5
   spl -$; * terminate spooler
   sleep -s 3; * wait 3 seconds
   break; * call ROM debugger
```

The first six commands after the comment identifying the procedure function broadcast three warnings to the terminals on the system. The first warning tells the users the system is going down. The other two warnings serve as reminders.

The remaining command lines shut down the system:

Table 9-5. Command Lines

Command line	Description
`spl -$`	This command terminates the spooler. All unfinished jobs are lost when the spooler is terminated.
`sleep -s 3`	This command causes the system to wait three seconds before executing the next command line. This allows the previous command time to complete execution.
`break`	This command sends a `break` call to the low-level debugger. When this debugger receives this call, it takes control of the system.

MANAGING PROCESSES IN A REAL-TIME ENVIRONMENT

The ability to manage processes in a real-time environment is one of the advantages of OS-9. OS-9 has three primary methods by which system managers can manage processes in a real-time environment:

- Manipulating process priority.
- Using `d_minpty` and `d_maxage` to alter the system process scheduling.
- Having system-state processes as well as user-state process.

Manipulating the Priority of a Process

When processes are executed on the command line, their initial priorities can be changed using the process priority modifiers discussed in the chapter on the shell. This enables users with a crucial task to set the priority on their process higher so it runs sooner and more often than less crucial processes.

The initial priority is also a parameter for the fork and chain system calls.

Changing the System's Process Scheduling

The way OS-9 schedules processes can be affected by the `d_minpty` and `d_maxage` system global variables. `d_minpty` and `d_maxage` are available to super users through the `_os_setsys` system call. These system variables can be used to effect the aging of processes.

The initial priority of a process is aged each time it is passed by for execution while it is waiting for CPU time.

`d_minpty` defines a minimum priority below which processes are neither aged nor considered candidates for execution. Processes with priorities less than `d_minpty` remain in the active queue and continue to hold any system resources they held before `d_minpty` was set.

`d_minpty` is usually set to zero. All processes are eligible for aging and execution when this value is set to zero because all processes have an initial priority greater than zero.

If you have a critical process needing to be run and several other users have processes they want to run, use the process priority modifier to increase the priority of the critical process. Then, set `d_minpty` to a value less than the priority you assigned to the critical process but greater than the priority of the other processes. The critical process now continues using the CPU until another process with a priority greater than `d_minpty` is entered into the active queue or the critical process is finished.

For example, if `d_minpty` is set to 500 and you set the priority of your process at 600, your process continues to use the CPU while processes with priorities less than 500 are not able to run until `d_minpty` is reset.

`d_minpty` is potentially dangerous. If the minimum system priority is set above the priority of all running tasks, the system completely shuts down and can only be recovered by a reset. It is crucial to restore `d_minpty` to zero when the critical task finishes or to reset `d_minpty` or a process' priority in an interrupt service routine.

`d_maxage` defines a maximum age over which processes are not allowed to mature. By default, this value is set to zero. When `d_maxage` is set to zero, it has no effect on the processes waiting to use the CPU.

When set, `d_maxage` essentially divides tasks into two classes: low priority and high priority. A low priority task is considered to be any task with a priority below `d_maxage`. Low priority tasks continue aging until they reach the `d_maxage` cutoff, but they are not executed unless there are no high priority tasks waiting to use the CPU.

A high priority task is any task with a priority above `d_maxage`. A high priority task receives the entire available CPU time, but it is not aged. When the high priority task(s) are inactive, the low priority tasks run.

For example, if `d_maxage` is set to 2000 and three processes with initial priorities of 128 are in the active queue, the processes run just as if `d_maxage` had not been set. Then, if a process with an initial priority of 2500 is entered into the active queue, it receives CPU time when the process currently in the CPU has finished. Once using the CPU, the high priority process runs uninterrupted until a process with a higher priority is entered into the active queue or the process finishes. When the process finishes executing, the low priority processes again are able to use the CPU.

Any process performing a system call is not preempted until the call is finished, unless the process voluntarily gives up its timeslice. This exception is made because these processes may be executing critical routines affecting shared system resources and could be blocking other unrelated processes.

Using System-State Processes and User-State Processes

The second method OS-9 uses to manage real-time priority processing is the existence of system-state processes. System-state processes are processes running in a supervisor or protected mode. System-state processes basically have unlimited access to system memory and other resources. When a process in system state wants to use the CPU, it waits until it has the highest age.

User-state processes do not have access to all points in memory and do not have access to all of the commands. When a process in user-state gains time in the CPU, it runs only for the time specified by the timeslice. When it has finished using its timeslice, it is entered back into the active queue according to its initial priority.

USING THE TMODE AND XMODE UTILITIES

The `tmode` and `xmode` utilities are also available to help you customize OS-9. Use the `tmode` utility to display or change the operating parameters of the user's terminal. The `xmode` utility is similar to the `tmode` utility. Use the `xmode` utility to display or change the initialization parameters of any SCF-type device such as a video display, printer, or RS-232 port. Some common uses are to change the baud rates and control key definitions.

Using the tmode Utility

To use the `tmode` utility, type `tmode` and any parameter(s) you need changed. If no parameters are given, the present values for each parameter are displayed. Otherwise, the parameter(s) given on the command line are processed. You can pass any number of parameters on a command line. Each parameter is separated by a space.

If a parameter is set to zero, OS-9 no longer uses the parameter until it is re-set to a code OS-9 recognizes. For example, the following command sets the <`tab`> and <`bell`> output characters to zero.

```
tmode tab=0x00 bell=0x00
```

Consequently, OS-9 does not output tabs or bells until the values are re-set.

The `tmode` parameters are documented in the *Utilities Reference* manual.

To re-set the values of a parameter to their default as given in this manual, specify the parameter with no value.

You can use the `-w=<path#>` option to specify the path number to be affected. If a path number is not provided, standard input is affected.

If `tmode` is used in a shell procedure file, the option `-w=<path#>` must be used to specify one of the standard paths (1 or 2) to change the terminal's operating characteristics. The change remains in effect until the path is closed.

To effect a permanent change to a device characteristic, you must first initialize the device, and then use the `xmode` utility to alter the device's initial operating parameters.

Using the xmode Utility

To use the `xmode` utility, type `xmode` and any parameter(s) to change. If no parameters are given, the present values for each parameter are displayed. Otherwise the parameter(s) given on the command line are processed. You can give any number of parameters on a command line. Each parameter is separated by spaces or commas. You must specify a device name if the given parameter(s) are to be processed.

The `xmode` parameters are documented in the *Utilities Reference* manual.

Like `tmode`, if a parameter is set to zero, the device no longer uses the parameter until it is re-set to a recognizable code. To re-set the values of parameters to their default, specify the parameter with no value. This re-sets the parameter to the default value as given in this manual.

Using `xmode`, you can also define control keys affecting the input line. For example, `<control>B` is, by default, defined as a backspace key for the command line. You can use `xmode` to redefine `<control>B` to perform another function or to redefine another key to backspace on the input line.

THE TERMCAP FILE FORMAT

The `termcap` file is a text file containing control code definitions for one or more types of terminals. Each entry is a complete description list for a particular kind of terminal.

The first section of a `termcap` entry is divided into three parts.

- a two character entry
- the most common name
- a long name

Each part is a different way of naming the terminal. A bar (`|`) character separates the parts of a `termcap` entry. The first part is a two character entry. The second part is the most common name for the terminal. This name must contain no blanks. The final part is a long name fully describing the terminal. This name may contain blanks for readability. For example:

```
kh|abm85h|kimtron abm85h:
```

You can check the values stored in `TERM` by using the `printenv` command:

```
$ printenv
TERM=abm85h
```

You must set the `TERM` environment variable to the name used in the second part of the name section. In the following example, `TERM` is set to `abm85h`:

```
$ setenv TERM abm85h
```

The rest of the entry consists of a sequence of control code specifications for each control function. Each item in the list is separated by a colon (`:`) character. An entry may be continued onto the next line by using a backslash (\) character as the last character of the line. It must appear after the last colon of the previous item. The next line must begin with a colon. For example:

```
ka|amb85|kimtron abm85:\
:ct=\E3:  ...
```

Each item begins with a terminal capability. Each capability is a two character abbreviation. Each capability is either a boolean itself or it is followed by a string or a number. If a boolean capability is present in the termcap entry, then the capability exists on that terminal.

All numeric capabilities are followed by a pound sign (#) and a number. For example, the number of columns capability for an 80 column terminal could be described as follows:

```
co#80:
```

All string capabilities are followed by an equal sign (=) and a character string. A time delay in milliseconds may be entered directly after the equal sign (=) if padding is allowed in that capability. The padding characters are supplied by `tputs()` after the remainder of the string is transmitted to provide the time delay. The time delay may be either an integer or a real. The time delay may be followed by an asterisk (`*`). The asterisk specifies the padding is proportional to the number of lines affected.

It is often useful to specify the time delay using the real format. For example, the clear screen capability is specified as `^z` with a time delay of 3.5 milliseconds by the following entry:

```
cl=3.5*^z:
```

Escape sequences are indicated by a `\E` . A control character is indicated by a circumflex (`^`) preceding the character. The following special character constants are supported:

Table 9-6. Supported Special Character Constants

Escape Sequence	Character	Hexadecimal code
`\b`	backspace	($08)
`\f`	formfeed	($0C)
`\n`	newline	($0A)
`\r`	return	($0D)
`\t`	tab	($09)
`\\`	backslash	($5C)
`\^`	circumflex	($5E)

Characters are specified as three octal digits after a backslash (\). For example, if a colon must be used in a capability definition, it must be specified by `\072`. If it is necessary to place a null character in a capability definition use `\200`. C routines using termcap strip the high bits of the output, therefore `\200` is interpreted as `\000`.

termcap Capabilities

The following table contains a list of termcap capabilities recognized by `termcap`. Not all of these capabilities need to be present for most programs to use termcap. They are provided for completeness. (`P`) indicates padding may optionally be specified. (`P*`) indicates the optional padding may be based on the number of lines affected:

Table 9-7. termcap Capabilities

Name	Type	Padding	Description
`ae`	string	(P)	End alternate character set.
`al`	string	(P*)	Add new blank line.
`am`	boolean		End alternate character set.
`as`	string	(P)	Start alternate character set.
`bc`	string		Backspace if not `^H`.
`bs`	boolean		Terminal can backspace with `^H`.
`bt`	string	(P)	Back tab.
`bw`	boolean		Backspace wraps from column 0 to last column.
`CC`	string		Command character in prototype if terminal settable.
`cd`	string	(P*)	Clear to end of display.
`ce`	string	(P)	Clear to end of line.
`ch`	string	(P)	Horizontal cursor motion only, line stays same.
`cl`	string	(P*)	Clear screen.
`cm`	string	(P)	Cursor motion.
`co`	numeric		Number of columns in line.
`cr`	string	(P*)	Carriage return (default `^M`).
`cs`	string	(P)	Change scrolling region (VT100), like `cm`.
`cv`	string	(P)	Vertical cursor motion only.
`da`	boolean		Display may be retained above.
`dB`	numeric		Number of milliseconds of backspace delay needed.
`db`	boolean		Display may be retained below.

Table 9-7. termcap Capabilities (Continued)

Name	Type	Padding	Description
`dC`	numeric		Number of milliseconds of carriage return delay needed.
`dc`	string	(P*)	Delete character.
`dF`	numeric		Number of milliseconds of formfeed delay needed.
`dl`	string	(P*)	Delete line.
`dm`	string		Delete mode (enter).
`dN`	numeric		Number of milliseconds of newline delay needed.
`do`	string		Down one line.
`dT`	numeric		Number of milliseconds of tab delay needed.
`ed`	string		End of delete mode.
`ei`	string		End insert mode. **NOTE**: If `ic` is used, enter: `ec=:`.
`eo`	string		Can erase overstrikes with a blank.
`ff`	string	(P*)	Hardcopy terminal page eject (default `^L`).
`hc`	boolean		Hardcopy terminal.
`hd`	string		Half-line down (1/2 linefeed).
`ho`	string		Home cursor (if no `cm`).
`hu`	string		Half-line up.
`hz`	string		Hazeltime: cannot print tildas (~).
`ic`	string	(P)	Insert character.
`if`	string		Name of file containing initialization string.
`im`	boolean		Insert mode (enter). **NOTE**: If `ic` is specified use `:im=:`
`in`	boolean		Insert mode distinguishes nulls on display.
`ip`	string	(P*)	Insert pad after character inserted.
`is`	string		Terminal initialization string.
`k0-k9`	string		Sent by other function keys 0-9.

Table 9-7. termcap Capabilities (Continued)

Name	Type	Padding	Description
kb	string		Sent by backspace key.
kd	string		Sent by down arrow key.
ke	string		Take terminal out of keypad transmit mode.
kh	string		Sent by home key.
kl	string		Sent by left arrow key.
kn	numeric		Number of other keys.
ko	string		termcap entries for other non-function keys.
kr	string		Sent by right arrow key.
ks	string		Put terminal in keypad transmit mode.
ku	string		Sent by up arrow key.
l0-l9	string		Labels on other function keys.
li	numeric		Number of lines on screen or page.
ll	string		Last line, first column (if no cm entry).
ma	string		Arrow key map.
mi	boolean		OK to move while in insert mode.
ml	string		Memory lock on above cursor.
ms	boolean		OK to move while in standout and underline mode.
mu	string		Turn off memory lock.
nc	boolean		Carriage return down not work.
nd	string		Non-destructive space.
nl	string	(P*)	Newline character.
ns	boolean		Terminal is a non-scrolling CRT.
os	boolean		Terminal overstrikes.
pc	string		Pad character (rather than null).
pt	boolean		Has hardware tabs.
se	string		End stand out mode.
sf	string	(P)	Scroll forwards.
sg	numeric		Number of blank characters left by se or so.

Table 9-7. termcap Capabilities (Continued)

Name	Type	Padding	Description
so	string	(P)	Begin stand out mode.
sr	string	(P)	Scroll reverse.
ta	string		Tab (other than ^I or without padding).
tc	string		Entry of terminal similar to last termcap entry.
te	string		String to end programs using cm.
ti	string		String to begin programs using cm.
uc	string		Underscore one character and move past it.
ue	string		End underscore mode.
ug	numeric		Number of blank characters left by us or ue.
ul	boolean		Terminal underlines but does not overstrike.
up	string		Upline (cursor up).
us	string		Start underscore mode.
vb	string		Visible bell.
ve	string		Sequence to end open/visual mode.
vs	string		Sequence to start open/visual mode.
xb	boolean		Beehive terminal (f1=<esc>, f2=^C).
xn	boolean		Newline is ignored after wrap.
xr	boolean		Return acts like ce \r\n.
xs	boolean		Standout not erased by writing over it.
xt	boolean		Tabs are destructive.

Of the capabilities, the most complex and important capability is `cm`: cursor addressing. The string specifying the cursor addressing is formatted similar to the C function: `printf()`. It uses `%` notation to identify addressing encodings of the current line or column position. The line and the column to be addressed could be considered the arguments to the `cm` string. All other characters are passed through unchanged. The following is the notation used for `cm` strings:

Table 9-8. cm String Notation

Notation	Description
`%d`	A decimal number (origin 0)
`%2`	Same as `%2d`
`%3`	Same as `%3d`
`%.`	ASCII equivalent of value
`%+x`	Adds *x* to value, then `%`
`%>xy`	If value > `x` adds `y`, no output
`%r`	Reverses the order of row and column, no output
`%i`	Increments line/column (for 1 origin)
`%%`	Gives a single `%`
`%n`	Exclusive or row and column with 0140
`%B`	BCD `(16*(x/10) + (x%10)`, no output
`%D`	Reverse coding `(x-2*(x%16))`, no output

Example String Notations (Continued)

The following examples illustrate the use of the preceding notations:

cm=6\E&%r%2c%2Y

This terminal needs a 6 millisecond delay, rows and columns reversed, and rows and columns to be printed as two digits

cm=5\E[%i%d;%dH

This terminal needs a 5 millisecond delay, rows and columns separated by a semicolon (;), and because of its origin of 1, rows and columns are incremented. The `<esc>[`, `;` and `H` are transmitted unchanged. (VT100)

cm=\E=%+ %+

This terminal uses rows and columns offset by a blank character. (ABM85H)

Example termcap Entries

```
ka|abm85|kimtron abm85:\
:ce=\ET:cm=\E=%+ %+ :cl=^Z:\
:se=\Ek:so\Ej:up=^K:sg#1
```

If two entries in the same termcap file are very similar, one can be defined as identical to the other with certain exceptions. To do this, `tc` is used with the name of the similar terminal. This capability must be the last in the entry. All exceptions to the other terminal must appear before the `tc` listing. If a capability must be cancelled, use `<cap>@`. For example, this might be a complete entry:

```
kh|abm85h|kimtron abm85h:\
:se=\EG0:so\EG4:tc=abm85:
```

A ASCII Conversion Chart

This appendix contains an ASCII conversion chart.

ASCII SYMBOL DEFINITIONS

ASCII is an acronym for American Standard Code for Information Interchange. It consists of 96 printable and 32 nonprintable characters.

The unprintable characters are defined in Table A-1.

Table A-1. ASCII Symbol Definitions

Symbol	Definition	Symbol	Definition
ACK	acknowledge	FS	file separator
BEL	bell	GS	group separator
BS	backspace	HT	horizontal tabulation
CAN	cancel	LF	line feed
CR	carriage return	NAK	negative acknowledgment
DC	device control	NUL	null
DEL	delete	RS	record shipment
DLE	data link escape	SI	shift in
EM	end of medium	SO	shift out
ENQ	enquiry	SOH	start of heading
EOT	end of transmission	SP	space
ESC	escape	STX	start of text
ETB	end of transmission	SUB	substitute
ETX	end of text	SYN	synchronous idle
FF	form feed	US	unit separator
		VT	vertical tabulation

Table A-2 includes binary, decimal, octal, hexadecimal, and ASCII conversions.

Table A-2. ASCII Conversions

Binary	Decimal	Octal	Hexadecimal	ASCII
0000000	0	0	0	NUL
0000001	1	1	1	SOH
0000010	2	2	2	STX
0000011	3	3	3	ETX
0000100	4	4	4	EOT
0000101	5	5	5	ENQ
0000110	6	6	6	ACK
0000111	7	7	7	BEL
0001000	8	10	8	BS
0001001	9	11	9	HT
0001010	10	12	A	LF
0001011	11	13	B	VT
0001100	12	14	C	FF
0001101	13	15	D	CR
0001110	14	16	E	SO
0001111	15	17	F	SI
0010000	16	20	10	DLE
0010001	17	21	11	DC1
0010010	18	22	12	DC2
0010011	19	23	13	DC3
0010100	20	24	14	DC4
0010101	21	25	15	NAK
0010110	22	26	16	SYN
0010111	23	27	17	ETB
0011000	24	30	18	CAN
0011001	25	31	19	EM
0011010	26	32	1A	SUB
0011011	27	33	1B	ESC
0011100	28	34	1C	FS

Table A-2. ASCII Conversions (Continued)

Binary	Decimal	Octal	Hexadecimal	ASCII
0011101	29	35	1D	GS
0011110	30	36	1E	RS
0011111	31	37	1F	US
0100000	32	40	20	SP
0100001	33	41	21	!
0100010	34	42	22	"
0100011	35	43	23	#
0100100	36	44	24	$
0100101	37	45	25	%
0100110	38	46	26	&
0100111	39	47	27	’
0101000	40	50	28	(
0101001	41	51	29	)
0101010	42	52	2A	*
0101011	43	53	2B	+
0101100	44	54	2C	,
0101101	45	55	2D	-
0101110	46	56	2E	.
0101111	47	57	2F	/
0110000	48	60	30	0
0110001	49	61	31	1
0110010	50	62	32	2
0110011	51	63	33	3
0110100	52	64	34	4
0110101	53	65	35	5
0110110	54	66	36	6
0110111	55	67	37	7
0111000	56	70	38	8
0111001	57	71	39	9
0111010	58	72	3A	:
0111011	59	73	3B	;

Table A-2. ASCII Conversions (Continued)

Binary	Decimal	Octal	Hexadecimal	ASCII
0111100	60	74	3C	<
0111101	61	75	3D	=
0111110	62	76	3E	>
0111111	63	77	3F	?
1000000	64	100	40	@
1000001	65	101	41	A
1000010	66	102	42	B
1000011	67	103	43	C
1000100	68	104	44	D
1000101	69	105	45	E
1000110	70	106	46	F
1000111	71	107	47	G
1001000	72	110	48	H
1001001	73	111	49	I
1001010	74	112	4A	J
1001011	75	113	4B	K
1001100	76	114	4C	L
1001101	77	115	4D	M
1001110	78	116	4E	N
1001111	79	117	4F	O
1010000	80	120	50	P
1010001	81	121	51	Q
1010010	82	122	52	R
1010011	83	123	53	S
1010100	84	124	54	T
1010101	85	125	55	U
1010110	86	126	56	V
1010111	87	127	57	W
1011000	88	130	58	X
1011001	89	131	59	Y
1011010	90	132	5A	Z

Table A-2. ASCII Conversions (Continued)

Binary	Decimal	Octal	Hexadecimal	ASCII
1011011	91	133	5B	[
1011100	92	134	5C	\
1011101	93	135	5D	]
1011110	94	136	5E	^
1011111	95	137	5F	_
1100000	96	140	60	‘
1100001	97	141	61	a
1100010	98	142	62	b
1100011	99	143	63	c
1100100	100	144	64	d
1100101	101	145	65	e
1100110	102	146	66	f
1100111	103	147	67	g
1101000	104	150	68	h
1101001	105	151	69	i
1101010	106	152	6A	j
1101011	107	153	6B	k
1101100	108	154	6C	l
1101101	109	155	6D	m
1101110	110	156	6E	n
1101111	111	157	6F	o
1110000	112	160	70	p
1110001	113	161	71	q
1110010	114	162	72	r
1110011	115	163	73	s
1110100	116	164	74	t
1110101	117	165	75	u
1110110	118	166	76	v
1110111	119	167	77	w
1111000	120	170	78	x
1111001	121	171	79	y

Table A-2. ASCII Conversions (Continued)

Binary	Decimal	Octal	Hexadecimal	ASCII
1111010	122	172	7A	z
1111011	123	173	7B	{
1111100	124	174	7C	|
1111101	125	175	7D	}
1111110	126	176	7E	~
1111111	127	177	7F	DEL

Index

S A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Symbols

A

B

C

D

Q

R

S

T

U