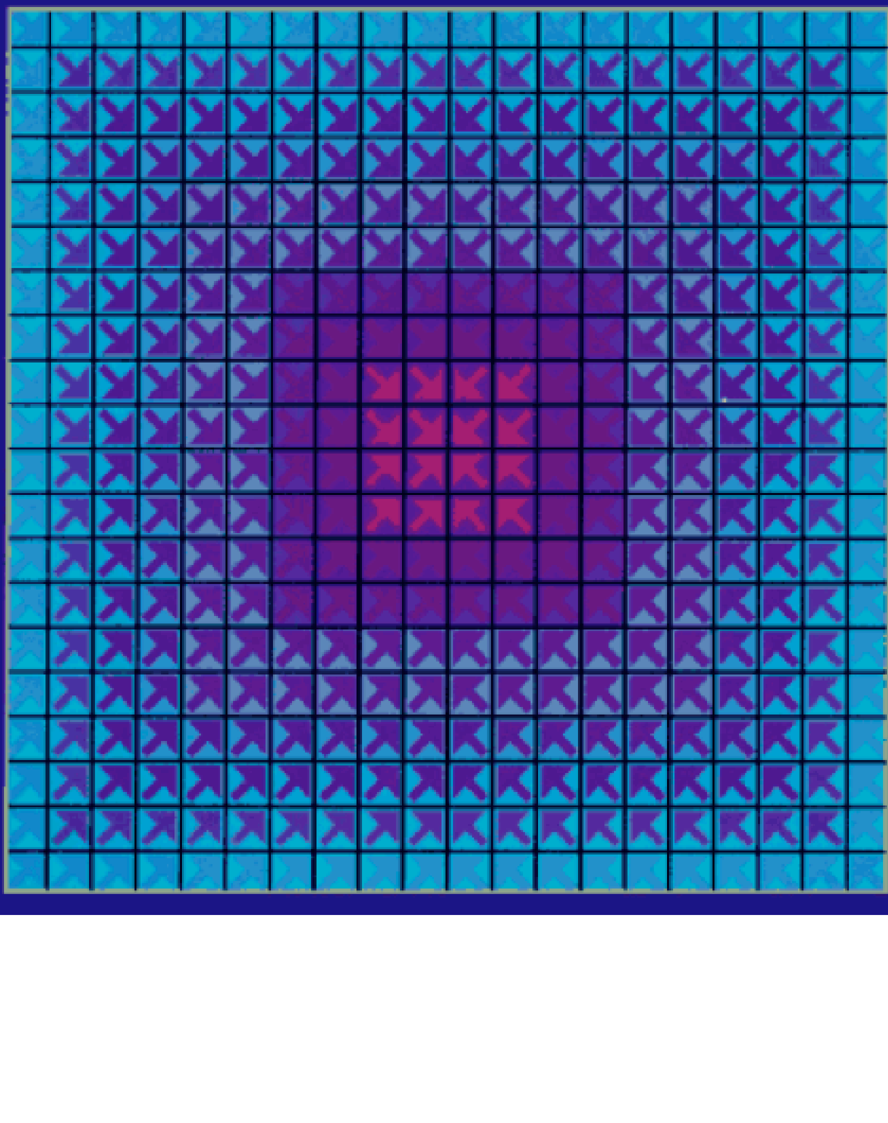
HAYDEN BOOKS UNIX® System Library

UNIX®
SHELL PROGRAMMING
REVISED EDITION

STEPHEN G. KOCHAN and PATRICK H. WOOD



CHAPTER 2

A QUICK REVIEW OF THE BASICS

This chapter provides a review of the UNIX System, including the file system, basic commands, file name substitution, I/O redirection, and pipes.

Some Basic Commands

Displaying the Date and Time: The `date` Command

The `date` command tells the system to print the date and time:

```
$ date
Sat Oct 29 15:40:52 EDT 1983
$
```

`date` prints the day of the week, month, day, time (24 hour clock, eastern daylight time), and year. Throughout this book, whenever we use **`boldface type like this`**, it's to indicate what you, the user, types in. `Normal face type like this` is used to indicate what the UNIX system prints.

Every UNIX command is ended with the pressing of the `RETURN` key. `RETURN` says that you are finished typing things in and are ready for the UNIX system to do its thing.

Finding Out Who's Logged In: The `who` Command

The `who` command can be used to get information about all users who are currently logged into the system:

```
$ who
pat       tty29    Oct 29 14:40
ruth      tty37    Oct 29 10:54
steve     tty25    Oct 29 15:52
$
```

Here there are three users logged in, `pat`, `ruth`, and `steve`. Along with each user id, is listed the *tty* number of that user and the day and time that user logged in. The tty number is a unique identification number the UNIX system gives to each terminal.

The `who` command also can be used to get information about yourself:

```
$ who am i
pat       tty29    Oct 29 14:40
$
```

`who` and `who am i` are actually the same command: `who`. In the latter case, the `am` and `i` are *arguments* to the `who` command.

Echoing Characters: The echo Command

The `echo` command prints (or *echoes*) at the terminal whatever else you happen to type on the line (there are some exceptions to this that you'll learn about later):

```
$ echo this is a test
this is a test
$ echo why not print out a longer line with echo?
why not print out a longer line with echo?
$ echo
                                   A blank line is displayed
$ echo one              two    three          four   five
one two three four five
$
```

You will notice from the last example that `echo` squeezes out extra blanks between words. That's because on a UNIX system, it's the words that are important; the blanks are merely there to separate the words. Generally, the UNIX system ignores extra blanks (you'll learn more about this in the next chapter).

• Working with Files •

The UNIX system recognizes only three basic types of files: *ordinary* files, *directory* files, and *special* files. An ordinary file is just that: any file on the system that contains data, text, program instructions, or just about anything else. Directories are described later in this chapter. As its name implies, a special file has a special meaning to the UNIX system, and is typically associated with some form of I/O.

A file name can be composed of just about any character directly available from the keyboard (and even some that aren't) provided the total number of characters contained in the name is not greater than 14. If more than 14 characters are specified, the UNIX system simply ignores the extra characters.

The UNIX system provides many tools that make working with files easy. Here we'll review many of the basic file manipulation commands.

Listing Files: The `ls` Command

To see what files you have stored in your directory, you can type the `ls` command:

```
$ ls
READ_ME
names
rje
$
```

This output indicates that three files called `READ_ME`, `names`, and `rje` are contained in the current directory.

Displaying the Contents of a File: The `cat` Command

You can examine the *contents* of a file by using the `cat` command. The argument to `cat` is the name of the file whose contents you wish to examine.

```
$ cat names
Susan
Jeff
Henry
Allan
Ken
$
```

Counting the Number of Words in a File: The `wc` Command

With the `wc` command, you can get a count of the total number of lines, words, and characters of information contained in a file. Once again, the name of the file is needed as the argument to this command:

```
$ wc names
        5       5      27 names
$
```

The `wc` command lists three numbers followed by the file name. The first number represents the number of lines contained in the file (5), the second the number of words contained in the file (in this case also 5), and the third the number of characters contained in the file (27).

Command Options

Most UNIX commands allow the specification of *options* at the time that a command is executed. These options generally follow the same format:

-letter

That is, a command option is a minus sign followed immediately by a single letter. For example, in order to count just the number of lines contained in a file, the option `-l` (that's the letter l) is given to the `wc` command:

```
$ wc -l names
        5 names
$
```

To count just the number of characters in a file, the `-c` option is specified:

```
$ wc -c names
        27 names
$
```

Finally, the `-w` option can be used to count the number of words contained in the file:

```
$ wc -w names
        5 names
$
```

Some commands require that the options be listed before the file name arguments. For example, `sort names -r` is acceptable whereas `wc names -l` is not. Let's generalize by saying that command options should *precede* file names on the command line.

Making a Copy of a File: The cp Command

In order to make a copy of a file, the `cp` command is used. The first argument to the command is the name of the file to be copied (known as the *source file*), and the second argument is the name of the file to place the copy into (known as the *destination file*). You can make a copy of the file `names` and call it `saved_names` as follows:

```
$ cp names saved_names
$
```

Execution of this command causes the file named names to be copied into a file named saved_names. As with many UNIX commands, the fact that a command prompt was displayed after the cp command was typed indicates that the command executed successfully.

Renaming a File: The mv Command

A file can be renamed with the mv command. The arguments to the mv command follow the same format as the cp command. The first argument is the name of the file to be renamed, and the second argument is the new name. So to change the name of the file saved_names to hold_it, for example, the following command would do the trick:

```
$ mv saved_names hold_it
$
```

When executing a mv or cp command, the UNIX system does not care whether the file specified as the second argument already exists. If it does, then the contents of the file will be lost.† So, for example, if a file called old_names exists, then executing the command

```
cp names old_names
```

would copy the file names to old_names, destroying the previous contents of old_names in the process. Similarly, the command

```
mv names old_names
```

would rename names to old_names, even if the file old_names existed prior to execution of the command.

Removing a File: The rm Command

To remove a file from the system, you use the rm command. The argument to rm is simply the name of the file to be removed:

```
$ rm hold_it
$
```

You can remove more than one file at a time with the rm command by simply specifying all such files on the command line. For example, the following would remove the three files wb, collect, and mon:

† Assuming you have the proper permission to write to the file.

```
$ rm wb collect mon
$
```

◦ Working with Directories ◦

Suppose you had a set of files consisting of various memos, proposals, and letters. Further suppose that you had a set of files that were computer programs. It would seem logical to group this first set of files into a directory called `documents`, for example, and the latter set of files into a directory called `programs`. Such a directory organization is illustrated in Fig. 2-1.

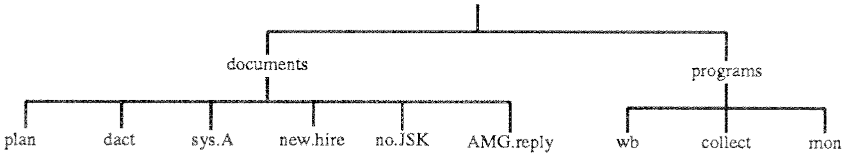


Fig. 2-1. Example directory structure

The file directory `documents` *contains* the files `plan`, `dact`, `sys.A`, `new.hire`, `no.JSK`, and `AMG.reply`. The directory `programs` contains the files `wb`, `collect`, and `mon`.

At some point you may decide to further categorize the files in a directory. This can be done by creating subdirectories and then placing each file into the appropriate subdirectory. For example, you might wish to create subdirectories called `memos`, `proposals`, and `letters` inside your `documents` directory, as shown in Fig. 2-2.

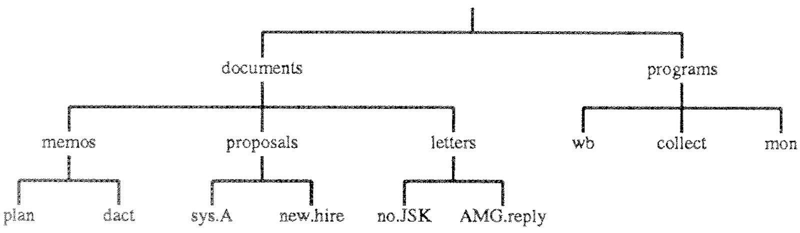


Fig. 2-2. Directories containing subdirectories

`documents` contains the subdirectories `memos`, `proposals`, and `letters`. Each of these directories in turn contains two files: `memos` contains `plan` and `dact`; `proposals` contains `sys.A` and `new.hire`; and `letters` contains `no.JSK` and `AMG.reply`.

While each file in a given directory must have a unique name, files contained in different directories do not. So, for example, you could have a file in your `programs` directory called `dact`, even though a file by that name also exists in the `memos` subdirectory.

The Home Directory and Path Names

The UNIX system always associates each user of the system with a particular directory. When you log into the system, you are placed automatically into a directory called your *home* directory.

Assume your home directory is called `steve` and that this directory is actually a subdirectory of a directory called `usr`. Therefore, if you had the directories `documents` and `programs` as illustrated in Fig. 2-2, the overall directory structure would actually look something like this:

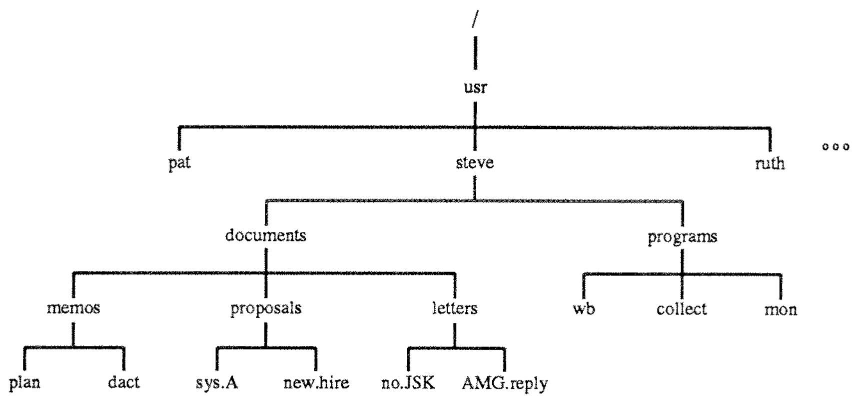


Fig. 2-3. Hierarchical directory structure

A special directory known as / (pronounced *slash*) is shown at the top of the directory tree. This directory is known as the *root*.

Whenever you are "inside" a particular directory (called your *current working* directory), the files contained within that directory are immediately accessible. If you wish to access a file from another directory, then you can either first issue a command to "change" to the appropriate directory and then access the particular file, or you can specify the particular file by its *path name*.

A path name enables you to uniquely identify a particular file to the UNIX system. In the specification of a path name, successive directories along the path are separated by the slash character /. A path name that *begins* with a slash character is known as a *full* path name, since it specifies a complete path from the root. So, for example, the path name `/usr/steve` identifies the directory `steve` contained under the directory `usr`. Similarly, the path name `/usr/steve/documents` references the directory `documents` as contained in the directory `steve` under `usr`. As a final example, the path name /usr/steve/documents/letters/AMG.reply identifies the file AMG.reply contained along the appropriate directory path.

In order to help reduce some of the typing that would otherwise be required, UNIX provides certain notational conveniences. Path names that do not begin with a slash character are known as *relative* path names. The path is relative to your current working directory. For example, if you just logged into the system and were placed into your home directory /usr/steve, then you could directly reference the directory documents simply by typing documents. Similarly, the relative path name programs/mon could be typed to access the file mon contained inside your programs directory.

By convention, the directory name .. always references the directory that is one level higher. For example, after logging in and being placed into your home directory /usr/steve, the path name .. would reference the directory usr. And if you had issued the appropriate command to change your working directory to documents/letters, then the path name .. would reference the documents directory, ../.. would reference the directory steve, and ../proposals/new.hire would reference the file new.hire contained in the proposals directory. Note that in this case, as in most cases, there is usually more than one way to specify a path to a particular file.

Another notational convention is the single period ., which always refers to the current directory.

Now it's time to examine commands designed for working with directories.

Displaying Your Working Directory: The pwd Command

The pwd command is used to help you "get your bearings" by telling you the name of your current working directory.

Recall the directory structure from Fig. 2-3. The directory that you are placed in upon logging into the system is called your home directory. You can assume from Fig. 2-3 that the home directory for the user steve is /usr/steve. Therefore, whenever steve logs into the system, he will *automatically* be placed inside this directory. To verify that this is the case, the pwd (print working directory) command can be issued:

```
$ pwd
/usr/steve
$
```

The output from the command verifies that steve's current working directory is /usr/steve.

Changing Directories: The cd Command

You can change your current working directory by using the cd command. This command takes as its argument the name of the directory you wish to change to.

Let's assume that you just logged into the system and were placed inside your home directory, `/usr/steve`. This is depicted by the ⇒ in Fig. 2-4.

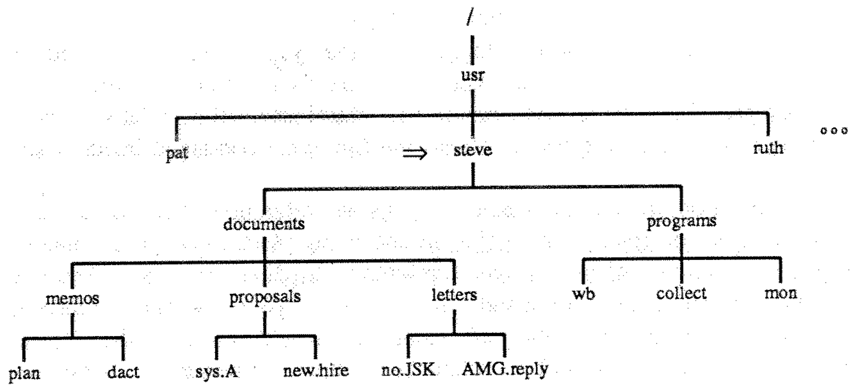


Fig. 2-4. Current working directory is `steve`

You know that there are two directories directly "below" `steve`'s home directory: `documents` and `programs`. In fact, this can be verified at the terminal by issuing the `ls` command:

```
$ ls
documents
programs
$
```

The `ls` command lists the two directories `documents` and `programs` the same way it listed other ordinary files in previous examples.

In order to change your current working directory, you issue the `cd` command, followed by the name of the directory to change to:

```
$ cd documents
$
```

After executing this command, you will be placed inside the `documents` directory, as depicted in Fig. 2-5.

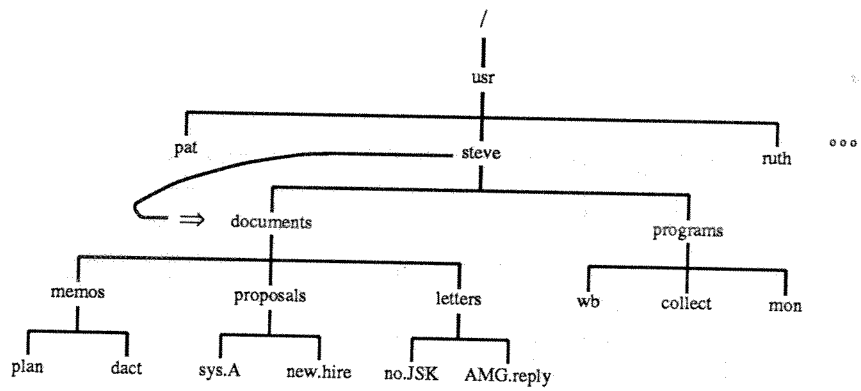


Fig. 2-5. `cd documents`

You can verify at the terminal that the working directory has been changed by issuing the `pwd` command:

```
$ pwd
/usr/steve/documents
$
```

The easiest way to get one level up in a directory is to issue the command

```
cd ..
```

since by convention `..` always refers to the directory one level up (known as the *parent* directory).

```
$ cd ..
$ pwd
/usr/steve
$
```

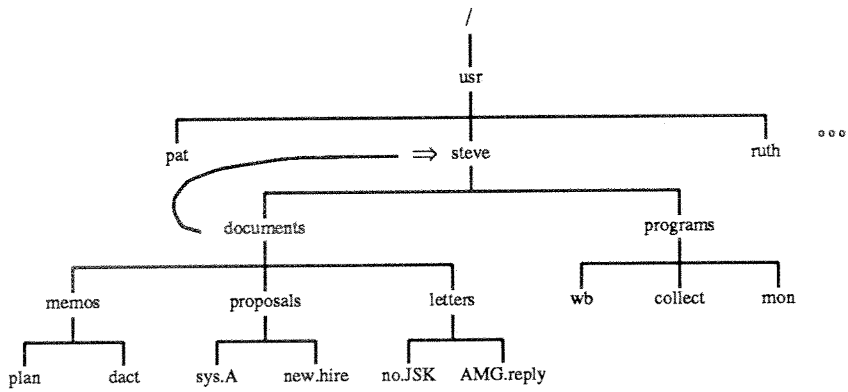


Fig. 2-6. `cd ..`

If you wanted to change to the `letters` directory, you could get there with a single `cd` command by specifying the relative path `documents/letters`:

```
$ cd documents/letters
$ pwd
/usr/steve/documents/letters
$
```

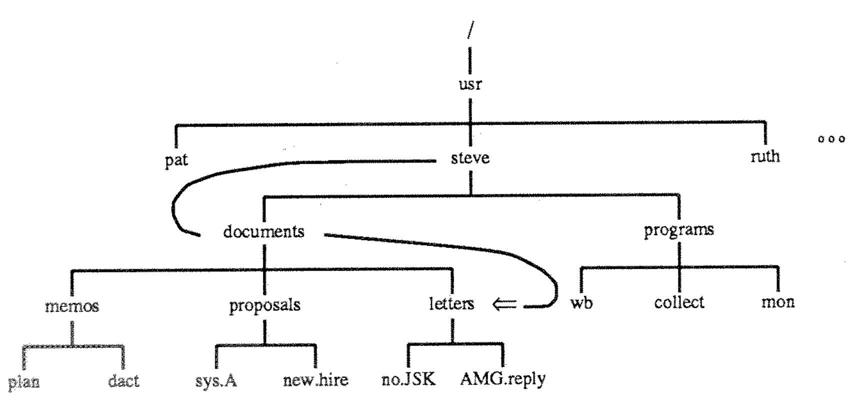


Fig. 2-7. `cd documents/letters`

You can get back up to the home directory with a single `cd` command as shown:

```
$ cd ../..
$ pwd
/usr/steve
$
```

Or you can get back to the home directory using a full path name instead of a relative one:

```
$ cd /usr/steve
$ pwd
/usr/steve
$
```

Finally, there is a third way to get back to the home directory that is also the easiest. Typing the command `cd` *without* an argument will *always* place you back into your home directory, no matter where you are in your directory path.

```
$ cd
$ pwd
/usr/steve
$
```

More on the `ls` Command

Whenever you type the command `ls`, it is the files contained in the current working directory that are listed. But you can also use `ls` to obtain a list of files in other directories by supplying an argument to the command. First let's get back to your home directory:

```
$ cd
$ pwd
/usr/steve
$
```

Now let's take a look at the files in the current working directory:

```
$ ls
documents
programs
$
```

If you supply the name of one of these directories to the `ls` command, then you can get a list of the contents of that directory. So, you can find out what's contained in the `documents` directory simply by typing the command `ls documents`:

```
$ ls documents
letters
memos
proposals
$
```

To take a look at the subdirectory memos, you follow a similar procedure:

```
$ ls documents/memos
dact
plan
$
```

If you specify a nondirectory file argument to the ls command, you simply get that file name echoed back at the terminal:

```
$ ls documents/memos/plan
documents/memos/plan
$
```

There is an option to the ls command that enables you to determine whether a particular file is a directory, among other things. The -l option (the letter l) provides a more detailed description of the files in a directory. If you were currently in steve's home directory as indicated in Fig. 2-6, then the following would illustrate the effect of supplying the -l option to the ls command:

```
$ ls -l
total 2
drwxr-xr-x   5 steve   DP3725     80 Jun 25 13:27 documents
drwxr-xr-x   2 steve   DP3725     96 Jun 25 13:31 programs
$
```

The first line of the display is a count of the total number of *blocks* (1,024 bytes as of UNIX System V) of storage that the listed files use. Each successive line displayed by the ls -l command contains detailed information about a file in the directory. The first character on each line tells whether the file is a directory. If the character is d, then it is a directory; if it is - then it is an ordinary file; finally, if it is b, c, or p, then it is a special file.

The next nine characters on the line tell how every user on the system can access the particular file. These *access modes* apply to the file's owner (the first three characters), other users in the same *group* as the file's owner (the next three characters), and finally to all other users on the system (the last three characters). They tell whether the user can read from the file, write to the file, or execute the contents of the file.

The `ls -l` command lists the *link* count (see later in this chapter), the owner of the file, the group owner of the file, how large the file is (i.e., how many characters are contained in it), and when the file was last modified. The information displayed last on the line is the file name itself.

```
$ ls -l programs
total 4
-rwxr-xr-x   1 steve   DP3725    358 Jun 25 13:31 collect
-rwxr-xr-x   1 steve   DP3725   1219 Jun 25 13:31 mon
-rwxr-xr-x   1 steve   DP3725     89 Jun 25 13:30 wb
$
```

The dash in the first column of each line indicates that the three files `collect`, `mon`, and `wb` are ordinary files and not directories.

Creating a Directory: The mkdir Command

To create a directory, the `mkdir` command must be used. The argument to this command is simply the name of the directory you want to make. As an example, assume that you are still working with the directory structure depicted in Fig. 2-7 and that you wish to create a new directory called `misc` *on the same level* as the directories `documents` and `programs`. Well, if you were currently in your home directory, then typing the command `mkdir misc` would achieve the desired effect:

```
$ mkdir misc
$
```

Now if you execute an `ls` command, you should get the new directory listed:

```
$ ls
documents
misc
programs
$
```

The directory structure will now appear as shown in Fig. 2-8.

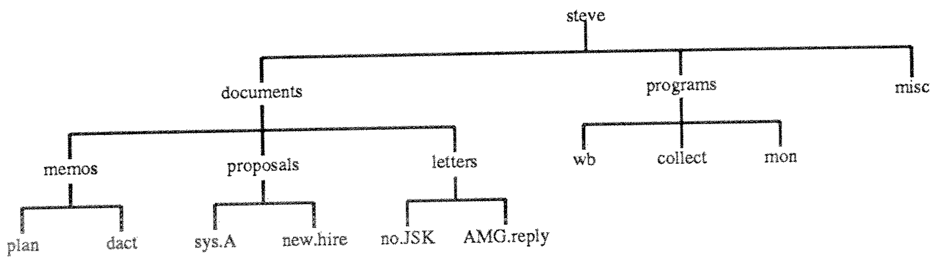


Fig. 2-8. Directory structure with newly created `misc` directory

Copying a File from One Directory to Another

The `cp` command can be used to make a copy of a file from one directory into another. For example, you can copy the file `wb` from the `programs` directory into a file called `wbx` in the `misc` directory as follows:

```
$ cp programs/wb misc/wbx
$
```

Since the two files are contained in different directories, it is not even necessary that they be given different names:

```
$ cp programs/wb misc/wb
$
```

When the destination file has the same name as the source file (in a different directory, of course), then it is necessary to specify only the destination directory as the second argument:

```
$ cp programs/wb misc
$
```

When this command gets executed, the UNIX system recognizes that the second argument is the name of a directory and copies the source file into that directory. The new file is given the same name as the source file. You can copy more than one file into a directory by listing the files to be copied before the name of the destination directory. If you were currently in the `programs` directory, then the command

```
$ cp wb collect mon ../misc
$
```

would copy the three files `wb`, `collect`, and `mon` into the `misc` directory, under the same names.

To copy a file from another directory into your current one and give it the same name, use the fact that the current directory can always be referenced as '.':

```
$ pwd
/usr/steve/misc
$ cp ../programs/collect .
$
```

The above command copies the file `collect` from the directory `../programs` into the current directory (`/usr/steve/misc`).

Moving Files between Directories

You recall that the `mv` command can be used to rename a file. However, when the two arguments to this command reference different directories, then the file is actually moved from the first directory into the second directory. For example, first change from the home directory to the `documents` directory:

```
$ cd documents
$
```

Suppose now you decide that the file `plan` contained in the `memos` directory is really a proposal and not a memo. So you would like to move it from the `memos` directory into the `proposals` directory. The following would do the trick:

```
$ mv memos/plan proposals/plan
$
```

As with the `cp` command, if the source file and destination file have the same name, then only the name of the destination directory need be supplied.

```
$ mv memos/plan proposals
$
```

Also like the `cp` command, a group of files can be simultaneously moved into a directory by simply listing all files to be moved before the name of the destination directory:

```
$ pwd
/usr/steve/programs
$ mv wb collect mon ../misc
$
```

This would move the three files `wb`, `collect`, and `mon` into the directory `misc`.

You can also use the `mv` command to change the name of a directory. For example, the following will rename the directory `programs` to `bin`.

```
$ mv programs bin
$
```

Linking Files: The `ln` Command

In simplest terms, the `ln` command provides an easy way for you to give more than one name to a file. The general form of the command is

`ln` *from to*

This links the file *from* to the file *to*.

Recall the structure of `steve's` `programs` directory from Fig. 2-8. In that directory he has stored a program called `wb`. Suppose he decides that he'd also like to call the program `writeback`. The most obvious thing to do would be to simply create a copy of `wb` called `writeback`:

```
$ cp wb writeback
$
```

The drawback with this approach is that now twice as much disk space is being consumed by the program. Furthermore, if `steve` ever changes `wb` he may forget to make a new copy of `writeback`, resulting in two different copies of what he thinks is the same program.

By linking the file `wb` to the new name, these problems are avoided:

```
$ ln wb writeback
$
```

Now instead of two copies of the file existing, only one exists with two different names: `wb` and `writeback`. The two files have been logically linked by the UNIX system. As far as you're concerned, it appears as though you have two *different* files. Executing an `ls` command shows the two files separately:

```
$ ls
collect
mon
wb
writeback
$
```

Look what happens when you execute an `ls -l`:

```
$ ls -l
total 5
-rwxr-xr-x   1 steve   DP3725    358 Jun 25 13:31 collect
```

```
-rwxr-xr-x   1 steve   DP3725   1219 Jun 25 13:31 mon
-rwxr-xr-x   2 steve   DP3725     89 Jun 25 13:30 wb
-rwxr-xr-x   2 steve   DP3725     89 Jun 25 13:30 writeback
$
```

The number right before `steve` is 1 for `collect` and `mon` and 2 for `wb` and `writeback`. This number is the number of links to a file, normally 1 for nonlinked, nondirectory files. Since `wb` and `writeback` are linked, this number is 2 for these files. This implies that you can link to a file more than once.

You can remove *either* of the two linked files at any time, and the other will *not* be removed:

```
$ rm writeback
$ ls -l
total 4
-rwxr-xr-x   1 steve   DP3725    358 Jun 25 13:31 collect
-rwxr-xr-x   1 steve   DP3725   1219 Jun 25 13:31 mon
-rwxr-xr-x   1 steve   DP3725     89 Jun 25 13:30 wb
$
```

Note that the number of links on `wb` went from 2 to 1 since one of its links was removed.

Most often, `ln` is used to link files between directories. For example, suppose `pat` wanted to have access to `steve's` `wb` program. Instead of making a copy for himself (subject to the same problems described above) or including `steve's programs` directory in his `PATH` (described in detail in a later chapter), he can simply link to the file from his own program directory; e.g.

```
$ pwd
/usr/pat/bin                              pat's program directory
$ ls -l
total 4
-rwxr-xr-x   1 pat     DP3822   1358 Jan 15 11:01 lcat
-rwxr-xr-x   2 pat     DP3822    504 Apr 21 18:30 xtr
$ ln /usr/steve/wb .                      Link wb to pat's bin
$ ls -l
total 5
-rwxr-xr-x   1 pat     DP3822   1358 Jan 15 11:01 lcat
-rwxr-xr-x   2 steve   DP3725     89 Jun 25 13:30 wb
-rwxr-xr-x   1 pat     DP3822    504 Apr 21 18:30 xtr
$
```

Note that `steve` is still listed as the owner of `wb`, even though the listing came from `pat`'s directory. This makes sense, since really only one copy of the file exists—and it's owned by `steve`.

The only stipulation on linking files is that the files to be linked together must reside on the same *file system*. If they don't, then you'll get an error from `ln` when you try to link them. (To determine the different files systems on your system, execute the `df` command. The first field on each line of output is the name of a file system.)

One last note before leaving this discussion: The `ln` command follows the same general format as `cp` and `mv`, meaning that you can link a bunch of files at once into a directory using the format

`ln` *files directory*

Removing a Directory: The `rmdir` Command

You can remove a directory with the `rmdir` command. The stipulation involved in removing a directory is that no files be contained in the directory. If there *are* files in the directory when `rmdir` is executed, then you will not be allowed to remove the directory. To remove the directory `misc` that you created earlier, the following could be used:

```
$ rmdir /usr/steve/misc
$
```

Once again, the above command will work only if no files are contained in the `misc` directory; otherwise, the following will happen:

```
$ rmdir /usr/steve/misc
rmdir: /usr/steve/misc not empty
$
```

If this happens and you still want to remove the `misc` directory, then you would first have to remove all of the files contained in that directory before reissuing the `rmdir` command.

As an alternate method for removing a directory and the files contained in it, you can use the `-r` option to the `rm` command. The format is simple:

`rm -r` *dir*

where *dir* is the name of the directory that you want to remove. `rm` will remove the indicated directory and *all* files (including directories) in it.

• File Name Substitution •

The Asterisk

One very powerful feature of the UNIX system that is actually handled by the shell is *file name substitution.* Let's say your current directory has these files in it:

```
$ ls
chapt1
chapt2
chapt3
chapt4
$
```

Suppose you want to print their contents at the terminal. Well, you could take advantage of the fact that the cat command allows you to specify more than one file name at a time. When this is done, the contents of the files are displayed one after the other.

```
$ cat chapt1 chapt2 chapt3 chapt4
      ...
$
```

But you can also type in:

```
$ cat *
      ...
$
```

and get the same results. The shell automatically *substitutes* the names of all of the files in the current directory for the *. The same substitution occurs if you use * with the echo command:

```
$ echo *
chapt1 chapt2 chapt3 chapt4
$
```

Here the * is again replaced with the names of all the files contained in the current directory, and the echo command simply displays them at the terminal.

Any place that * appears on the command line, the shell performs its substitution:

```
$ echo * : *
chapt1 chapt2 chapt3 chapt4 : chapt1 chapt2 chapt3 chapt4
$
```

The `*` can also be used in combination with other characters to limit the file names that are substituted. For example, let's say that in your current directory you have not only `chapt1` through `chapt4` but also files `a`, `b`, and `c`:

```
$ ls
a
b
c
chapt1
chapt2
chapt3
chapt4
$
```

To display the contents of just the files beginning with `chapt`, you can type in:

```
$ cat chapt*
      .
      .
      .
$
```

The `chapt*` matches any file name that *begins* with `chapt`. All such file names matched are substituted on the command line.

The `*` is not limited to the end of a file name; it can be used at the beginning or in the middle as well:

```
$ echo *t1
chapt1
$ echo *t*
chapt1 chapt2 chapt3 chapt4
$ echo *x
*x
$
```

In the first `echo`, the `*t1` specifies all file names that end in the characters `t1`. In the second `echo`, the first `*` matches everything up to a `t` and the second everything after; thus, all file names containing a `t` are printed. Since there are no files ending with `x`, no substitution occurs in the last case. Therefore, the `echo` command simply displays `*x`.

Matching Single Characters

The asterisk (`*`) matches *zero* or more characters, meaning that `x*` will match the file `x` as well as `x1`, `x2`, `xabc`, etc. The question mark (`?`) matches exactly one character. So `cat ?` will print all files with one-character names, just as `cat x?` will print all files with two-character names beginning with x.

```
$ ls
a
aa
aax
alice
b
bb
c
cc
report1
report2
report3
$ echo ?
a b c
$ echo a?
aa
$ echo ??
aa bb cc
$ echo ??*
aa aax alice bb cc report1 report2 report3
$
```

In the last example, the ?? matches two characters, and the * matches zero or more up to the end. The net effect is to match all file names of two or more characters.

Another way to match a single character is to give a list of the characters to use in the match inside square brackets [ ]. For example, [abc] matches *one* letter a, b, or c. It's similar to the ?, but it allows you to choose the characters that will be matched. The specification [0-9] matches the characters 0 *through* 9. The only restriction in specifying a *range* of characters is that the first character must be alphabetically less than the last character, so that [z-f] is not a valid range specification.

By mixing and matching ranges and characters in the list, you can perform some very complicated substitutions. For example, [a-np-z]* will match all files that start with the letters a through n *or* p through z (or more simply stated, any lowercase letter but o).

If the first character following the [is a !, then the sense of the match is inverted. That is, any character will be matched *except* those enclosed in the brackets. So

```
[!a-z]
```

matches any character except a lowercase letter, and

```
*[!o]
```

matches any file that doesn't end with the lowercase letter o.

Table 2-1 gives a few more examples of file name substitution.

TABLE 2-1. File name substitution examples

Command	*Description*
`echo a*`	Print the *names* of the files beginning with a
`cat *.c`	Print all files ending in `.c`
`rm *.*`	Remove all files containing a period
`ls x*`	List the names of all files beginning with x
`rm *`	Remove *all* files in the current directory (note: be careful when you use this)
`echo a*b`	Print the names of all files beginning with a and ending with b
`cp ../programs/*`	Copy all files from `../programs` into the current directory
`ls [a-z]*[!0-9]`	List files that begin with a lowercase letter and don't end with a digit.

◦ Standard Input, Standard Output, and I/O Redirection ◦

Standard Input and Standard Output

Most UNIX system commands take input from your terminal and send the resulting output back to your terminal. A command normally reads its input from a place called *standard input*, which happens to be your terminal by default. Similarly, a command normally writes its output to *standard output*, which is also your terminal by default. This concept is depicted in Fig. 2-9.

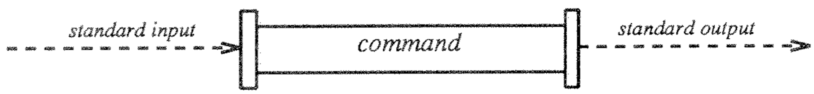


Fig. 2-9. Typical UNIX command

You will recall that executing the `who` command results in the display of the currently logged-in users. More formally, the `who` command writes a list of the logged-in users to standard output. This is depicted in Fig. 2-10.

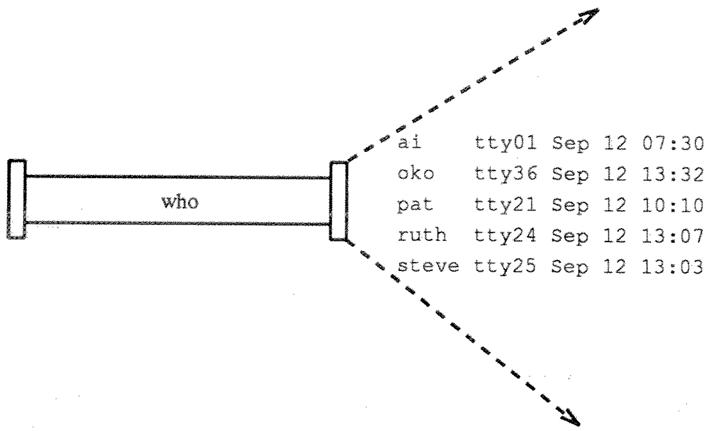


Fig. 2-10. `who` command

If a `sort` command is executed *without* a file name argument, then the command will take its input from standard input. As with standard output, this is your terminal by default.

When entering data to a command from the terminal, the `CTRL` and `D` keys (denoted *CTRL-d* in this text) must be simultaneously pressed after the last data item has been entered. This tells the command that you have finished entering data. As an example, let's use the `sort` command to sort the following four names: Tony, Barbara, Harry, Dick. Instead of first entering the names into a file, we'll enter them directly from the terminal:

```
$ sort
Tony
Barbara
Harry
Dick
CTRL-d
Barbara
Dick
Harry
Tony
$
```

Since no file name was specified to the `sort` command, the input was taken from standard input, the terminal. After the fourth name was typed in, the `CTRL` and `D` keys were pressed to signal the end of the data. At that point, the `sort` command sorted the four names and displayed the results on the standard output device, which is also the terminal. This is depicted in Fig. 2-11.

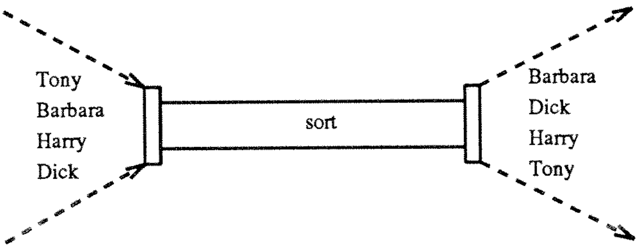


Fig. 2-11. `sort` command

The `wc` command is another example of a command that takes its input from standard input if no file name is specified on the command line. So the following shows an example of this command used to count the number of lines of text entered from the terminal:

```
$ wc -l
This is text that
is typed on the
standard input device.
CTRL-d
      3
$
```

You will note that the *CTRL-d* that is used to terminate the input is not counted as a separate line by the `wc` command. Furthermore, since no file name was specified to the `wc` command, only the count of the number of lines (3) is listed as the output of the command. (You will recall that this command normally prints the name of the file directly after the count.)

Output Redirection

The output from a command normally intended for standard output can be easily "diverted" to a file instead. This capability is known as *output redirection.*

If the notation *>file* is appended to *any* command that normally writes its output to standard output, then the output of that command will be written to *file* instead of your terminal:

```
$ who > users
$
```

This command line causes the `who` command to be executed and its output to be written into the file `users`. You will notice that no output appears at the terminal. This is because the output has been *redirected* from the default standard output device (the terminal) into the specified file:

```
$ cat users
oko   tty01  Sep 12 07:30
ai    tty15  Sep 12 13:32
ruth  tty21  Sep 12 10:10
pat   tty24  Sep 12 13:07
steve tty25  Sep 12 13:03
$
```

If a command has its output redirected to a file and the file already contains some data, then that data will be lost. Consider this example:

```
$ echo line 1 > users
$ cat users
line 1
$ echo line 2 >> users
$ cat users
line 1
line 2
$
```

The second `echo` command uses a different type of output redirection indicated by the characters >>. This character pair causes the standard output from the command to be *appended* to the specified file. Therefore, the previous contents of the file are not lost and the new output simply gets added onto the end.

By using the redirection append characters >>, you can use `cat` to append the contents of one file onto the end of another:

```
$ cat file1
This is in file1.
$ cat file2
This is in file2.
$ cat file1 >> file2          Append file1 to file2
$ cat file2
This is in file2.
This is in file1.
$
```

Recall that specifying more than one file name to `cat` results in the display of the first file followed immediately by the second file, and so on:

```
$ cat file1
This is in file1.
$ cat file2
This is in file2.
$ cat file1 file2
This is in file1.
This is in file2.
$ cat file1 file2 > file3        Redirect it instead
$ cat file3
This is in file1.
This is in file2.
$
```

Now you can see where the `cat` command gets its name: when used with more than one file its effect is to *catenate* the files together.

Incidentally, the shell recognizes a special format of output redirection. If you type

> *file*

not preceded by a command, then the shell will create an empty (i.e., zero character length) *file* for you. If *file* previously exists, then its contents will be lost.

Input Redirection

Just as the output of a command can be redirected to a file, so can the input of a command be redirected from a file. And as the greater-than character > is used for output redirection, the less-than character < is used to redirect the input of a command. Of course, only commands that normally take their input from standard input can have their input redirected from a file in this manner.

In order to redirect the input of a command, you type the < character followed by the name of the file that the input is to be read from. So, for example, to count the number of lines in the file `users`, you know that you can execute the command `wc -l users`:

```
$ wc -l users
      2 users
$
```

Or, you can count the number of lines in the file by redirecting the input of the `wc` command from the terminal to the file `users`:

```
$ wc -l < users
      2
$
```

You will note that there is a difference in the output produced by the two forms of the `wc` command. In the first case, the name of the file `users` is listed with the line count; in the second case, it is not. This points out the subtle distinction between the execution of the two commands. In the first case `wc` knows it is reading its input from the file `users`. In the second case, it only knows that it is reading its input from standard input. The shell redirects the input from the terminal to the file `users` (more about this in the next chapter). As far as `wc` is concerned, it doesn't know whether its input is coming from the terminal or from a file!

• Pipes •

As you will recall, the file `users` that was created previously contains a list of all the users currently logged into the system. Since you know that there will be one line in the file for each user logged into the system, you can easily determine the *number* of users logged in by simply counting the number of lines in the `users` file:

```
$ who > users
$ wc -l < users
      5
$
```

This output would indicate that there were currently five users logged in. Now you have a command sequence you can use whenever you want to know how many users are logged in.

There is another approach to determine the number of logged-in users that bypasses the use of a file. The UNIX system allows you to effectively "connect" two commands together. This connection is known as a *pipe*, and it enables you to take the output from one command and feed it directly into the input of another command. A pipe is effected by the character `|`, which is placed between the two commands. So to make a pipe between the `who` and `wc -l` commands, you simply type `who | wc -l`:

```
$ who | wc -l
      5
$
```

The pipe that is effected between these two commands is depicted in Fig. 2-12.

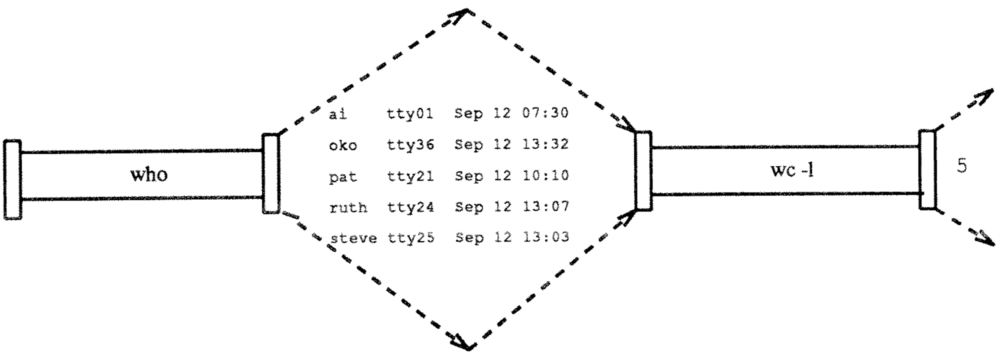


Fig. 2-12. Pipeline process: `who | wc -l`

When a pipe is set up between two commands, the standard output from the first command is connected directly to the standard input of the second command. You know that the `who` command writes its list of logged-in users to standard output. Furthermore, you know that if no file name argument is specified to the `wc` command then it takes its input from standard input. Therefore, the list of logged-in users that is output from the `who` command automatically becomes the input to the `wc` command. Note that you never see the output of the `who` command at the terminal, since it is *piped* directly into the `wc` command. This is depicted in Fig. 2-13.

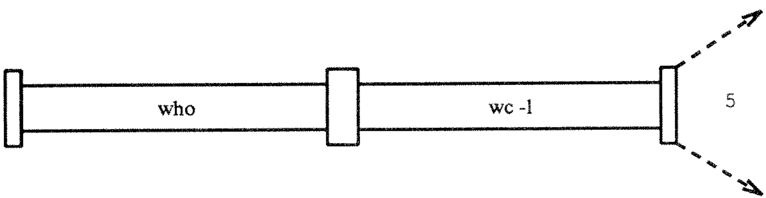


Fig. 2-13. Pipeline process

A pipe can be made between *any* two programs, provided the first program writes its output to standard output, and the second program reads its input from standard input.

As another example of a pipe, suppose you wanted to count the number of files contained in your directory. Knowledge of the fact that the `ls` command displays one line of output per file enables you to use the same type of approach as before:

```
$ ls | wc -l
      10
$
```

The output indicates that the current directory contains 10 files.

It is also possible to form a pipeline consisting of more than two programs, with the output of one program feeding into the input of the next.

Filters

The term *filter* is often used in UNIX terminology to refer to any program that can take input from standard input, perform some operation on that input, and write the results to standard output. More succinctly, a filter is any program that can be used between two other programs in a pipeline. So in the previous pipeline, `wc` is considered a filter. `ls` is not, since it does not read its input from standard input. As other examples, `cat` and `sort` are filters, while `who`, `date`, `cd`, `pwd`, `echo`, `rm`, `mv`, and `cp` are not.

• Standard Error •

In addition to standard input and standard output there is another place known as *standard error*. This is where most UNIX commands write their error messages. And as with the other two "standard" places, standard error is associated with your terminal by default. In most cases, you never know the difference between standard output and standard error:

```
$ ls n*                         List all files beginning with n
n* not found
$
```

Here the "not found" message is actually being written to standard error and not standard output by the `ls` command. You can verify that this message is not being written to standard output by redirecting the `ls` command's output:

```
$ ls n* > foo
n* not found
$
```

So you see you still get the message printed out at the terminal, even though you redirected standard output to the file `foo`.

The above example shows the raison d'être for standard error: so that error messages will still get displayed at the terminal even if standard output is redirected to a file or piped to another command.

You can also redirect standard error to a file by using the notation

command 2> *file*

No space is permitted between the 2 and the >. Any error messages normally intended for standard error will be diverted into the specified *file*, similar to the way standard output gets redirected.

```
$ ls n* 2> errors
$ cat errors
n* not found
$
```

More on Commands

Typing More Than One Command on a Line

You can type more than one command on a line provided you separate each command with a semicolon. For example, you can find out the current time and also your current working directory by typing in the `date` and `pwd` commands on the same line:

```
$ date; pwd
Wed Apr 25 20:14:32 EST 1985
/usr/pat/bin
$
```

You can string out as many commands as you like on the line, as long as each command is delimited by a semicolon.

Sending a Command to the Background

Normally, you type in a command and then wait for the results of the command to be displayed at the terminal. For all of the examples you have seen thus far, this waiting time is typically quite short—maybe a second or two. However, you may have to run commands that require many seconds or even minutes to execute. In those cases, you'll have to wait for the command to finish executing before you can proceed further *unless you execute the command in the background.*

If you type in a command followed by the ampersand character `&`, then that command will be sent to the background for execution. This means that the command will no longer tie up your terminal and you can then proceed with other work. The standard output from the command will still be directed to your terminal; however, in most cases the standard input will be dissociated from your terminal. If the command does try to read any input from standard input, it will be as if *CTRL-d* were typed.

```
$ sort data > out &          Send the sort to the background
1258                         Process id
$ date                       Your terminal is immediately available to do other work
Thu Apr 26 13:45:09 EST 1985
$
```

When a command is sent to the background, the UNIX system automatically displays a number, called the *process id* for that command. In the above example, 1258 was the process id assigned by the system. This number uniquely identifies the command that you sent to the background, and can be used to obtain status information about the command. This is done with the `ps` command.

The ps Command

The `ps` command gives you information about the processes that are running on the system. `ps` without any options prints the status of just your processes. If you type in `ps` at your terminal, you'll get a few lines back describing the processes you have running:

```
$ ps
   PID  TTY  TIME COMMAND
   195   01  0:21 sh              The shell
  1353   01  0:00 ps              This ps command
  1258   01  0:10 sort            The previous sort
$
```

The `ps` command prints out four columns of information: `PID`, the process id; `TTY`, the terminal number that the process was run from; `TIME`, the amount of computer time in minutes and seconds that process has used; and `COMMAND`, the name of the process. (The `sh` process in the above example is the shell that was started when you logged in, and it's used 21 seconds of computer time.) Until the command is finished, it shows up in the output of the `ps` command as a running process. Process number 1353 in the above example is the `ps` command that was typed in, and 1258 is the `sort` from above.

When used with the `-f` option, `ps` prints out more information about your processes, including the *parent* process id (`PPID`), the time the processes started (`STIME`), and the command arguments.

```
$ ps -f
     UID   PID  PPID  C    STIME TTY      TIME COMMAND
   steve   195     1  0 10:58:29 tty01    0:21 -sh
   steve  1360   195 43 13:54:48 tty01    0:01 ps -f
   steve  1258   195  0 13:45:04 tty01    3:17 sort data
$
```

• Command Summary •

The following table summarizes the commands reviewed in this chapter. In this table, *file* refers to a file, *file(s)* to one or more files, *dir* to a directory, and *dir(s)* to one or more directories.

TABLE 2-2. Command summary

Command	*Description*
`cat` *file(s)*	Display contents of *file(s)* or standard input if not supplied
`cd` *dir*	Change working directory to *dir*
`cp` $file_1$ $file_2$	Copy $file_1$ to $file_2$
`cp` *file(s) dir*	Copy *file(s)* into *dir*
`date`	Display the date and time
`echo` *args*	Display *args*
`ln` $file_1$ $file_2$	Link $file_1$ to $file_2$
`ln` *file(s) dir*	Link *file(s)* into *dir*
`ls` *file(s)*	List *file(s)*
`ls` *dir(s)*	List files in *dir(s)* or in current directory if *dir(s)* is not specified
`mkdir` *dir(s)*	Create directory *dir(s)*
`mv` $file_1$ $file_2$	Move $file_1$ to $file_2$ (simply rename it if both reference the same directory)
`mv` *file(s) dir*	Move *file(s)* into directory *dir*
`ps`	List information about active processes
`pwd`	Display current working directory path
`rm` *file(s)*	Remove *files(s)*
`rmdir` *dir(s)*	Remove empty directory *dir(s)*
`sort` *file(s)*	Sort lines of *file(s)* or standard input if not supplied
`wc` *file(s)*	Count the number of lines, words, and characters in *file(s)* or standard input if not supplied
`who`	Display who's logged in