An Introduction to the C shell

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ABSTRACT

Csh is a new command language interpreter for UNIX† systems. It incorporates good features of other shells and a *history* mechanism similar to the *redo* of INTERLISP. While incorporating many features of other shells which make writing shell programs (shell scripts) easier, most of the features unique to *csh* are designed more for the interactive UNIX user.

UNIX users who have read a general introduction to the system will find a valuable basic explanation of the shell here. Simple terminal interaction with *csh* is possible after reading just the first section of this document. The second section describes the shell's capabilities which you can explore after you have begun to become acquainted with the shell. Later sections introduce features which are useful, but not necessary for all users of the shell.

Additional information includes an appendix listing special characters of the shell and a glossary of terms and commands introduced in this manual.

Introduction

A *shell* is a command language interpreter. *Csh* is the name of one particular command interpreter on UNIX. The primary purpose of *csh* is to translate command lines typed at a terminal into system actions, such as invocation of other programs. *Csh* is a user program just like any you might write. Hopefully, *csh* will be a very useful program for you in interacting with the UNIX system.

In addition to this document, you will want to refer to a copy of the UNIX User Reference Manual. The *csh* documentation in section 1 of the manual provides a full description of all features of the shell and is the definitive reference for questions about the shell.

Many words in this document are shown in *italics.* These are important words; names of commands, and words which have special meaning in discussing the shell and UNIX. Many of the words are defined in a glossary at the end of this document. If you don't know what is meant by a word, you should look for it in the glossary.

Acknowledgements

Numerous people have provided good input about previous versions of *csh* and aided in its debugging and in the debugging of its documentation. I would especially like to thank Michael Ubell who made the crucial observation that history commands could be done well over the word structure of input text, and implemented a prototype history mechanism in an older version of the shell. Eric Allman has also provided a large number of useful comments on the shell, helping to unify those concepts which are present

† UNIX is a trademark of Bell Laboratories.

and to identify and eliminate useless and marginally useful features. Mike O'Brien suggested the path-name hashing mechanism which speeds command execution. Jim Kulp added the job control and directory stack primitives and added their documentation to this introduction.

1. Terminal usage of the shell

1.1. The basic notion of commands

A *shell* in UNIX acts mostly as a medium through which other *programs* are invoked. While it has a set of *builtin* functions which it performs directly, most commands cause execution of programs that are, in fact, external to the shell. The shell is thus distinguished from the command interpreters of other systems both by the fact that it is just a user program, and by the fact that it is used almost exclusively as a mechanism for invoking other programs.

Commands in the UNIX system consist of a list of strings or *words* interpreted as a *command name* followed by *arguments.* Thus the command

```
mail bill
```

consists of two words. The first word *mail* names the command to be executed, in this case the mail program which sends messages to other users. The shell uses the name of the command in attempting to execute it for you. It will look in a number of *directories* for a file with the name *mail* which is expected to contain the mail program.

The rest of the words of the command are given as *arguments* to the command itself when it is executed. In this case we specified also the argument *bill* which is interpreted by the *mail* program to be the name of a user to whom mail is to be sent. In normal terminal usage we might use the *mail* command as follows.

```
% mail bill
I have a question about the csh documentation.
My document seems to be missing page 5.
Does a page five exist?
        Bill
EOT
%
```

Here we typed a message to send to *bill* and ended this message with a ˆD which sent an end-of-file to the mail program. (Here and throughout this document, the notation ‘‘ˆ*x*’’ is to be read ‘‘control-*x*’’ and represents the striking of the *x* key while the control key is held down.) The mail program then echoed the characters ‘EOT’ and transmitted our message. The characters ‘% ’ were printed before and after the mail command by the shell to indicate that input was needed.

After typing the ‘% ’ prompt the shell was reading command input from our terminal. We typed a complete command ‘mail bill’. The shell then executed the *mail* program with argument *bill* and went dormant waiting for it to complete. The mail program then read input from our terminal until we signalled an end-of-file via typing a ˆD after which the shell noticed that mail had completed and signaled us that it was ready to read from the terminal again by printing another ‘% ’ prompt.

This is the essential pattern of all interaction with UNIX through the shell. A complete command is typed at the terminal, the shell executes the command and when this execution completes, it prompts for a new command. If you run the editor for an hour, the shell will patiently wait for you to finish editing and obediently prompt you again whenever you finish editing.

An example of a useful command you can execute now is the *tset* command, which sets the default *erase* and *kill* characters on your terminal – the erase character erases the last character you typed and the kill character erases the entire line you have entered so far. By default, the erase character is the delete key (equivalent to ‘ˆ?’) and the kill character is ‘ˆU’. Some people prefer to make the erase character the backspace key (equivalent to ‘ˆH’). You can make this be true by typing

```
tset –e
```

which tells the program *tset* to set the erase character to tset’s default setting for this character (a backspace).

1.2. Flag arguments

A useful notion in UNIX is that of a *flag* argument. While many arguments to commands specify file names or user names, some arguments rather specify an optional capability of the command which you wish to invoke. By convention, such arguments begin with the character '–' (hyphen). Thus the command

```
ls
```

will produce a list of the files in the current *working directory*. The option *–s* is the size option, and

```
ls –s
```

causes *ls* to also give, for each file the size of the file in blocks of 512 characters. The manual section for each command in the UNIX reference manual gives the available options for each command. The *ls* command has a large number of useful and interesting options. Most other commands have either no options or only one or two options. It is hard to remember options of commands which are not used very frequently, so most UNIX utilities perform only one or two functions rather than having a large number of hard to remember options.

1.3. Output to files

Commands that normally read input or write output on the terminal can also be executed with this input and/or output done to a file.

Thus suppose we wish to save the current date in a file called 'now'. The command

```
date
```

will print the current date on our terminal. This is because our terminal is the default *standard output* for the date command and the date command prints the date on its standard output. The shell lets us *redirect* the *standard output* of a command through a notation using the *metacharacter* '>' and the name of the file where output is to be placed. Thus the command

```
date > now
```

runs the *date* command such that its standard output is the file 'now' rather than the terminal. Thus this command places the current date and time into the file 'now'. It is important to know that the *date* command was unaware that its output was going to a file rather than to the terminal. The shell performed this *redirection* before the command began executing.

One other thing to note here is that the file 'now' need not have existed before the *date* command was executed; the shell would have created the file if it did not exist. And if the file did exist? If it had existed previously these previous contents would have been discarded! A shell option *noclobber* exists to prevent this from happening accidentally; it is discussed in section 2.2.

The system normally keeps files which you create with '>' and all other files. Thus the default is for files to be permanent. If you wish to create a file which will be removed automatically, you can begin its name with a '#' character, this 'scratch' character denotes the fact that the file will be a scratch file.* The system will remove such files after a couple of days, or sooner if file space becomes very tight. Thus, in running the *date* command above, we don't really want to save the output forever, so we would more likely do

```
date > #now
```

*Note that if your erase character is a '#', you will have to precede the '#' with a '\'. The fact that the '#' character is the old (pre-CRT) standard erase character means that it seldom appears in a file name, and allows this convention to be used for scratch files. If you are using a CRT, your erase character should be a ˆH, as we demonstrated in section 1.1 how this could be set up.

1.4. Metacharacters in the shell

The shell has a large number of special characters (like '>') which indicate special functions. We say that these notations have *syntactic* and *semantic* meaning to the shell. In general, most characters which are neither letters nor digits have special meaning to the shell. We shall shortly learn a means of *quotation* which allows us to use *metacharacters* without the shell treating them in any special way.

Metacharacters normally have effect only when the shell is reading our input. We need not worry about placing shell metacharacters in a letter we are sending via *mail,* or when we are typing in text or data to some other program. Note that the shell is only reading input when it has prompted with '% ' (although we can type our input even before it prompts).

1.5. Input from files; pipelines

We learned above how to *redirect* the *standard output* of a command to a file. It is also possible to redirect the *standard input* of a command from a file. This is not often necessary since most commands will read from a file whose name is given as an argument. We can give the command

```
sort < data
```

to run the *sort* command with standard input, where the command normally reads its input, from the file 'data'. We would more likely say

```
sort data
```

letting the *sort* command open the file 'data' for input itself since this is less to type.

We should note that if we just typed

```
sort
```

then the sort program would sort lines from its *standard input.* Since we did not *redirect* the standard input, it would sort lines as we typed them on the terminal until we typed a ^D to indicate an end-of-file.

A most useful capability is the ability to combine the standard output of one command with the standard input of another, i.e. to run the commands in a sequence known as a *pipeline.* For instance the command

```
ls –s
```

normally produces a list of the files in our directory with the size of each in blocks of 512 characters. If we are interested in learning which of our files is largest we may wish to have this sorted by size rather than by name, which is the default way in which *ls* sorts. We could look at the many options of *ls* to see if there was an option to do this but would eventually discover that there is not. Instead we can use a couple of simple options of the *sort* command, combining it with *ls* to get what we want.

The *–n* option of sort specifies a numeric sort rather than an alphabetic sort. Thus

```
ls –s | sort –n
```

specifies that the output of the *ls* command run with the option *–s* is to be *piped* to the command *sort* run with the numeric sort option. This would give us a sorted list of our files by size, but with the smallest first. We could then use the *–r* reverse sort option and the *head* command in combination with the previous command doing

```
ls –s | sort –n –r | head –5
```

Here we have taken a list of our files sorted alphabetically, each with the size in blocks. We have run this to the standard input of the *sort* command asking it to sort numerically in reverse order (largest first). This output has then been run into the command *head* which gives us the first few lines. In this case we have asked *head* for the first 5 lines. Thus this command gives us the names and sizes of our 5 largest files.

The notation introduced above is called the *pipe* mechanism. Commands separated by '|' characters are connected together by the shell and the standard output of each is run into the standard input of the next. The leftmost command in a pipeline will normally take its standard input from the terminal and the rightmost will place its standard output on the terminal. Other examples of pipelines will be given later when we discuss the history mechanism; one important use of pipes which is illustrated there is in the routing of information to the line printer.

1.6. Filenames

Many commands to be executed will need the names of files as arguments. UNIX *pathnames* consist of a number of *components* separated by '/'. Each component except the last names a directory in which the next component resides, in effect specifying the *path* of directories to follow to reach the file. Thus the pathname

/etc/motd

specifies a file in the directory 'etc' which is a subdirectory of the *root* directory '/'. Within this directory the file named is 'motd' which stands for 'message of the day'. A *pathname* that begins with a slash is said to be an *absolute* pathname since it is specified from the absolute top of the entire directory hierarchy of the system (the *root*). *Pathnames* which do not begin with '/' are interpreted as starting in the current *working directory*, which is, by default, your *home* directory and can be changed dynamically by the *cd* change directory command. Such pathnames are said to be *relative* to the working directory since they are found by starting in the working directory and descending to lower levels of directories for each *component* of the pathname. If the pathname contains no slashes at all then the file is contained in the working directory itself and the pathname is merely the name of the file in this directory. Absolute pathnames have no relation to the working directory.

Most filenames consist of a number of alphanumeric characters and '.'s (periods). In fact, all printing characters except '/' (slash) may appear in filenames. It is inconvenient to have most non-alphabetic characters in filenames because many of these have special meaning to the shell. The character '.' (period) is not a shell-metacharacter and is often used to separate the *extension* of a file name from the base of the name. Thus

prog.c prog.o prog.errs prog.output

are four related files. They share a *base* portion of a name (a base portion being that part of the name that is left when a trailing '.' and following characters which are not '.' are stripped off). The file 'prog.c' might be the source for a C program, the file 'prog.o' the corresponding object file, the file 'prog.errs' the errors resulting from a compilation of the program and the file 'prog.output' the output of a run of the program.

If we wished to refer to all four of these files in a command, we could use the notation

prog.*

This expression is expanded by the shell, before the command to which it is an argument is executed, into a list of names which begin with 'prog.'. The character '*' here matches any sequence (including the empty sequence) of characters in a file name. The names which match are alphabetically sorted and placed in the *argument list* of the command. Thus the command

echo prog.*

will echo the names

prog.c prog.errs prog.o prog.output

Note that the names are in sorted order here, and a different order than we listed them above. The *echo* command receives four words as arguments, even though we only typed one word as as argument directly. The four words were generated by *filename expansion* of the one input word.

Other notations for *filename expansion* are also available. The character '?' matches any single character in a filename. Thus

echo ? ?? ???

will echo a line of filenames; first those with one character names, then those with two character names, and finally those with three character names. The names of each length will be independently sorted.

Another mechanism consists of a sequence of characters between '[' and ']'. This metasequence matches any single character from the enclosed set. Thus

    prog.[co]

will match

    prog.c prog.o

in the example above. We can also place two characters around a '–' in this notation to denote a range. Thus

    chap.[1–5]

might match files

    chap.1 chap.2 chap.3 chap.4 chap.5

if they existed. This is shorthand for

    chap.[12345]

and otherwise equivalent.

An important point to note is that if a list of argument words to a command (an *argument list)* contains filename expansion syntax, and if this filename expansion syntax fails to match any existing file names, then the shell considers this to be an error and prints a diagnostic

    No match.

and does not execute the command.

Another very important point is that files with the character '.' at the beginning are treated specially. Neither '*' or '?' or the '[' ']' mechanism will match it. This prevents accidental matching of the filenames '.' and '..' in the working directory which have special meaning to the system, as well as other files such as *.cshrc* which are not normally visible. We will discuss the special role of the file *.cshrc* later.

Another filename expansion mechanism gives access to the pathname of the *home* directory of other users. This notation consists of the character '˜' (tilde) followed by another user's login name. For instance the word '˜bill' would map to the pathname '/usr/bill' if the home directory for 'bill' was '/usr/bill'. Since, on large systems, users may have login directories scattered over many different disk volumes with different prefix directory names, this notation provides a convenient way of accessing the files of other users.

A special case of this notation consists of a '˜' alone, e.g. '˜/mbox'. This notation is expanded by the shell into the file 'mbox' in your *home* directory, i.e. into '/usr/bill/mbox' for me on Ernie Co-vax, the UCB Computer Science Department VAX machine, where this document was prepared. This can be very useful if you have used *cd* to change to another directory and have found a file you wish to copy using *cp.* If I give the command

    cp thatfile ˜

the shell will expand this command to

    cp thatfile /usr/bill

since my home directory is /usr/bill.

There also exists a mechanism using the characters '{' and '}' for abbreviating a set of words which have common parts but cannot be abbreviated by the above mechanisms because they are not files, are the names of files which do not yet exist, are not thus conveniently described. This mechanism will be described much later, in section 4.2, as it is used less frequently.

1.7. Quotation

We have already seen a number of metacharacters used by the shell. These metacharacters pose a problem in that we cannot use them directly as parts of words. Thus the command

echo *

will not echo the character '*'. It will either echo an sorted list of filenames in the current *working directory,* or print the message 'No match' if there are no files in the working directory.

The recommended mechanism for placing characters which are neither numbers, digits, '/', '.' or '–' in an argument word to a command is to enclose it with single quotation characters '´', i.e.

echo ´*´

There is one special character '!' which is used by the *history* mechanism of the shell and which cannot be *escaped* by placing it within '´' characters. It and the character '´' itself can be preceded by a single '\' to prevent their special meaning. Thus

echo \´\!

prints

´!

These two mechanisms suffice to place any printing character into a word which is an argument to a shell command. They can be combined, as in

echo \´´*´

which prints

´*

since the first '\' escaped the first '´' and the '*' was enclosed between '´' characters.

1.8. Terminating commands

When you are executing a command and the shell is waiting for it to complete there are several ways to force it to stop. For instance if you type the command

cat /etc/passwd

the system will print a copy of a list of all users of the system on your terminal. This is likely to continue for several minutes unless you stop it. You can send an INTERRUPT *signal* to the *cat* command by typing ˆC on your terminal.* Since *cat* does not take any precautions to avoid or otherwise handle this signal the INTERRUPT will cause it to terminate. The shell notices that *cat* has terminated and prompts you again with '% '. If you hit INTERRUPT again, the shell will just repeat its prompt since it handles INTERRUPT signals and chooses to continue to execute commands rather than terminating like *cat* did, which would have the effect of logging you out.

Another way in which many programs terminate is when they get an end-of-file from their standard input. Thus the *mail* program in the first example above was terminated when we typed a ˆD which generates an end-of-file from the standard input. The shell also terminates when it gets an end-of-file printing 'logout'; UNIX then logs you off the system. Since this means that typing too many ˆD's can accidentally log us off, the shell has a mechanism for preventing this. This *ignoreeof* option will be discussed in section 2.2.

If a command has its standard input redirected from a file, then it will normally terminate when it reaches the end of this file. Thus if we execute

mail bill < prepared.text

*On some older Unix systems the DEL or RUBOUT key has the same effect. "stty all" will tell you the INTR key value.

the mail command will terminate without our typing a ˆD. This is because it read to the end-of-file of our file ‘prepared.text’ in which we placed a message for ‘bill’ with an editor program. We could also have done

```
cat prepared.text | mail bill
```

since the *cat* command would then have written the text through the pipe to the standard input of the mail command. When the *cat* command completed it would have terminated, closing down the pipeline and the *mail* command would have received an end-of-file from it and terminated. Using a pipe here is more complicated than redirecting input so we would more likely use the first form. These commands could also have been stopped by sending an INTERRUPT.

Another possibility for stopping a command is to suspend its execution temporarily, with the possibility of continuing execution later. This is done by sending a STOP signal via typing a ˆZ. This signal causes all commands running on the terminal (usually one but more if a pipeline is executing) to become suspended. The shell notices that the command(s) have been suspended, types ‘Stopped’ and then prompts for a new command. The previously executing command has been suspended, but otherwise unaffected by the STOP signal. Any other commands can be executed while the original command remains suspended. The suspended command can be continued using the *fg* command with no arguments. The shell will then retype the command to remind you which command is being continued, and cause the command to resume execution. Unless any input files in use by the suspended command have been changed in the meantime, the suspension has no effect whatsoever on the execution of the command. This feature can be very useful during editing, when you need to look at another file before continuing. An example of command suspension follows.

```
% mail harold
Someone just copied a big file into my directory and its name is
ˆZ
Stopped
% ls
funnyfile
prog.c
prog.o
% jobs
[1]  + Stopped                mail harold
% fg
mail harold
funnyfile. Do you know who did it?
EOT
%
```

In this example someone was sending a message to Harold and forgot the name of the file he wanted to mention. The mail command was suspended by typing ˆZ. When the shell noticed that the mail program was suspended, it typed ‘Stopped’ and prompted for a new command. Then the *ls* command was typed to find out the name of the file. The *jobs* command was run to find out which command was suspended. At this time the *fg* command was typed to continue execution of the mail program. Input to the mail program was then continued and ended with a ˆD which indicated the end of the message at which time the mail program typed EOT. The *jobs* command will show which commands are suspended. The ˆZ should only be typed at the beginning of a line since everything typed on the current line is discarded when a signal is sent from the keyboard. This also happens on INTERRUPT, and QUIT signals. More information on suspending jobs and controlling them is given in section 2.6.

If you write or run programs which are not fully debugged then it may be necessary to stop them somewhat ungracefully. This can be done by sending them a QUIT signal, sent by typing a ˆ\. This will usually provoke the shell to produce a message like:

```
Quit (Core dumped)
```

indicating that a file ‘core’ has been created containing information about the running program’s state when it terminated due to the QUIT signal. You can examine this file yourself, or forward information to the maintainer of the program telling him/her where the *core file* is.

If you run background commands (as explained in section 2.6) then these commands will ignore INTERRUPT and QUIT signals at the terminal. To stop them you must use the *kill* command. See section 2.6 for an example.

If you want to examine the output of a command without having it move off the screen as the output of the

```
cat /etc/passwd
```

command will, you can use the command

```
more /etc/passwd
```

The *more* program pauses after each complete screenful and types '−−More−−' at which point you can hit a space to get another screenful, a return to get another line, a '?' to get some help on other commands, or a 'q' to end the *more* program. You can also use more as a filter, i.e.

```
cat /etc/passwd | more
```

works just like the more simple more command above.

For stopping output of commands not involving *more* you can use the ˆS key to stop the typeout. The typeout will resume when you hit ˆQ or any other key, but ˆQ is normally used because it only restarts the output and does not become input to the program which is running. This works well on low-speed terminals, but at 9600 baud it is hard to type ˆS and ˆQ fast enough to paginate the output nicely, and a program like *more* is usually used.

An additional possibility is to use the ˆO flush output character; when this character is typed, all output from the current command is thrown away (quickly) until the next input read occurs or until the next shell prompt. This can be used to allow a command to complete without having to suffer through the output on a slow terminal; ˆO is a toggle, so flushing can be turned off by typing ˆO again while output is being flushed.

1.9. What now?

We have so far seen a number of mechanisms of the shell and learned a lot about the way in which it operates. The remaining sections will go yet further into the internals of the shell, but you will surely want to try using the shell before you go any further. To try it you can log in to UNIX and type the following command to the system:

```
chsh myname /bin/csh
```

Here 'myname' should be replaced by the name you typed to the system prompt of 'login:' to get onto the system. Thus I would use 'chsh bill /bin/csh'. **You only have to do this once; it takes effect at next login.** You are now ready to try using *csh.*

Before you do the 'chsh' command, the shell you are using when you log into the system is '/bin/sh'. In fact, much of the above discussion is applicable to '/bin/sh'. The next section will introduce many features particular to *csh* so you should change your shell to *csh* before you begin reading it.

2. Details on the shell for terminal users

2.1. Shell startup and termination

When you login, the shell is started by the system in your *home* directory and begins by reading commands from a file *.cshrc* in this directory. All shells which you may start during your terminal session will read from this file. We will later see what kinds of commands are usefully placed there. For now we need not have this file and the shell does not complain about its absence.

A *login shell*, executed after you login to the system, will, after it reads commands from *.cshrc,* read commands from a file *.login* also in your home directory. This file contains commands which you wish to do each time you login to the UNIX system. My *.login* file looks something like:

```
set ignoreeof
set mail=(/usr/spool/mail/bill)
echo "${prompt}users" ; users
alias ts \
        ´set noglob ; eval `tset –s –m dialup:c100rv4pna –m plugboard:?hp2621nl *`´;
ts; stty intr ˆC kill ˆU crt
set time=15 history=10
msgs –f
if (–e $mail) then
        echo "${prompt}mail"
        mail
endif
```

This file contains several commands to be executed by UNIX each time I login. The first is a *set* command which is interpreted directly by the shell. It sets the shell variable *ignoreeof* which causes the shell to not log me off if I hit ˆD. Rather, I use the *logout* command to log off of the system. By setting the *mail* variable, I ask the shell to watch for incoming mail to me. Every 5 minutes the shell looks for this file and tells me if more mail has arrived there. An alternative to this is to put the command

```
biff y
```

in place of this *set;* this will cause me to be notified immediately when mail arrives, and to be shown the first few lines of the new message.

Next I set the shell variable ‘time’ to ‘15’ causing the shell to automatically print out statistics lines for commands which execute for at least 15 seconds of CPU time. The variable ‘history’ is set to 10 indicating that I want the shell to remember the last 10 commands I type in its *history list*, (described later).

I create an *alias* ‘‘ts’’ which executes a *tset*(1) command setting up the modes of the terminal. The parameters to *tset* indicate the kinds of terminal which I usually use when not on a hardwired port. I then execute ‘‘ts’’ and also use the *stty* command to change the interrupt character to ˆC and the line kill character to ˆU.

I then run the ‘msgs’ program, which provides me with any system messages which I have not seen before; the ‘–f’ option here prevents it from telling me anything if there are no new messages. Finally, if my mailbox file exists, then I run the ‘mail’ program to process my mail.

When the ‘mail’ and ‘msgs’ programs finish, the shell will finish processing my *.login* file and begin reading commands from the terminal, prompting for each with ‘% ’. When I log off (by giving the *logout* command) the shell will print ‘logout’ and execute commands from the file ‘.logout’ if it exists in my home directory. After that the shell will terminate and UNIX will log me off the system. If the system is not going down, I will receive a new login message. In any case, after the ‘logout’ message the shell is committed to terminating and will take no further input from my terminal.

2.2. Shell variables

The shell maintains a set of *variables.* We saw above the variables *history* and *time* which had values '10' and '15'. In fact, each shell variable has as value an array of zero or more *strings.* Shell variables may be assigned values by the set command. It has several forms, the most useful of which was given above and is

```
set name=value
```

Shell variables may be used to store values which are to be used in commands later through a substitution mechanism. The shell variables most commonly referenced are, however, those which the shell itself refers to. By changing the values of these variables one can directly affect the behavior of the shell.

One of the most important variables is the variable *path.* This variable contains a sequence of directory names where the shell searches for commands. The *set* command with no arguments shows the value of all variables currently defined (we usually say *set)* in the shell. The default value for path will be shown by *set* to be

```
% set
argv      ()
cwd       /usr/bill
home      /usr/bill
path      (. /usr/ucb /bin /usr/bin)
prompt    %
shell     /bin/csh
status    0
term      c100rv4pna
user      bill
%
```

This output indicates that the variable path points to the current directory '.' and then '/usr/ucb', '/bin' and '/usr/bin'. Commands which you may write might be in '.' (usually one of your directories). Commands developed at Berkeley, live in '/usr/ucb' while commands developed at Bell Laboratories live in '/bin' and '/usr/bin'.

A number of locally developed programs on the system live in the directory '/usr/local'. If we wish that all shells which we invoke to have access to these new programs we can place the command

```
set path=(. /usr/ucb /bin /usr/bin /usr/local)
```

in our file *.cshrc* in our home directory. Try doing this and then logging out and back in and do

```
set
```

again to see that the value assigned to *path* has changed.

One thing you should be aware of is that the shell examines each directory which you insert into your path and determines which commands are contained there. Except for the current directory '.', which the shell treats specially, this means that if commands are added to a directory in your search path after you have started the shell, they will not necessarily be found by the shell. If you wish to use a command which has been added in this way, you should give the command

```
rehash
```

to the shell, which will cause it to recompute its internal table of command locations, so that it will find the newly added command. Since the shell has to look in the current directory '.' on each command, placing it at the end of the path specification usually works equivalently and reduces overhead.

† Another directory that might interest you is /usr/new, which contains many useful user-contributed programs provided with Berkeley Unix.

Other useful built in variables are the variable *home* which shows your home directory, *cwd* which contains your current working directory, the variable *ignoreeof* which can be set in your *.login* file to tell the shell not to exit when it receives an end-of-file from a terminal (as described above). The variable 'ignoreeof' is one of several variables which the shell does not care about the value of, only whether they are *set* or *unset.* Thus to set this variable you simply do

```
set ignoreeof
```

and to unset it do

```
unset ignoreeof
```

These give the variable 'ignoreeof' no value, but none is desired or required.

Finally, some other built-in shell variables of use are the variables *noclobber* and *mail.* The metasyntax

```
> filename
```

which redirects the standard output of a command will overwrite and destroy the previous contents of the named file. In this way you may accidentally overwrite a file which is valuable. If you would prefer that the shell not overwrite files in this way you can

```
set noclobber
```

in your *.login* file. Then trying to do

```
date > now
```

would cause a diagnostic if 'now' existed already. You could type

```
date >!  now
```

if you really wanted to overwrite the contents of 'now'. The '>!' is a special metasyntax indicating that clobbering the file is ok.†

2.3. The shell's history list

The shell can maintain a *history list* into which it places the words of previous commands. It is possible to use a notation to reuse commands or words from commands in forming new commands. This mechanism can be used to repeat previous commands or to correct minor typing mistakes in commands.

The following figure gives a sample session involving typical usage of the history mechanism of the shell. In this example we have a very simple C program which has a bug (or two) in it in the file 'bug.c', which we 'cat' out on our terminal. We then try to run the C compiler on it, referring to the file again as '!$', meaning the last argument to the previous command. Here the '!' is the history mechanism invocation metacharacter, and the '$' stands for the last argument, by analogy to '$' in the editor which stands for the end of the line. The shell echoed the command, as it would have been typed without use of the history mechanism, and then executed it. The compilation yielded error diagnostics so we now run the editor on the file we were trying to compile, fix the bug, and run the C compiler again, this time referring to this command simply as '!c', which repeats the last command which started with the letter 'c'. If there were other commands starting with 'c' done recently we could have said '!cc' or even '!cc:p' which would have printed the last command starting with 'cc' without executing it.

After this recompilation, we ran the resulting 'a.out' file, and then noting that there still was a bug, ran the editor again. After fixing the program we ran the C compiler again, but tacked onto the command an extra '−o bug' telling the compiler to place the resultant binary in the file 'bug' rather than 'a.out'. In general, the history mechanisms may be used anywhere in the formation of new commands and other characters may be placed before and after the substituted commands.

---

†The space between the '!' and the word 'now' is critical here, as '!now' would be an invocation of the *history* mechanism, and have a totally different effect.

```
% cat bug.c
main()

{
        printf("hello);
}
% cc !$
cc bug.c
"bug.c", line 4: newline in string or char constant
"bug.c", line 5: syntax error
% ed !$
ed bug.c
29
4s/);/"&/p
        printf("hello");
w
30
q
% !c
cc bug.c
% a.out
hello% !e
ed bug.c
30
4s/lo/lo\\n/p
        printf("hello\n");
w
32
q
% !c −o bug
cc bug.c −o bug
% size a.out bug
a.out: 2784+364+1028 = 4176b = 0x1050b
bug: 2784+364+1028 = 4176b = 0x1050b
% ls −l !*
ls −l a.out bug
−rwxr−xr−x 1 bill       3932 Dec 19 09:41 a.out
−rwxr−xr−x 1 bill       3932 Dec 19 09:42 bug
% bug
hello
% num bug.c | spp
spp: Command not found.
% ˆsppˆssp
num bug.c | ssp
    1   main()
    3   {
    4           printf("hello\n");
    5   }
% !! | lpr
num bug.c | ssp | lpr
%
```

We then ran the 'size' command to see how large the binary program images we have created were, and then an 'ls –l' command with the same argument list, denoting the argument list '*'. Finally we ran the program 'bug' to see that its output is indeed correct.

To make a numbered listing of the program we ran the 'num' command on the file 'bug.c'. In order to compress out blank lines in the output of 'num' we ran the output through the filter 'ssp', but misspelled it as spp. To correct this we used a shell substitute, placing the old text and new text between '^' characters. This is similar to the substitute command in the editor. Finally, we repeated the same command with '!!', but sent its output to the line printer.

There are other mechanisms available for repeating commands. The *history* command prints out a number of previous commands with numbers by which they can be referenced. There is a way to refer to a previous command by searching for a string which appeared in it, and there are other, less useful, ways to select arguments to include in a new command. A complete description of all these mechanisms is given in the C shell manual pages in the UNIX Programmer's Manual.

2.4. Aliases

The shell has an *alias* mechanism which can be used to make transformations on input commands. This mechanism can be used to simplify the commands you type, to supply default arguments to commands, or to perform transformations on commands and their arguments. The alias facility is similar to a macro facility. Some of the features obtained by aliasing can be obtained also using shell command files, but these take place in another instance of the shell and cannot directly affect the current shells environment or involve commands such as *cd* which must be done in the current shell.

As an example, suppose that there is a new version of the mail program on the system called 'newmail' you wish to use, rather than the standard mail program which is called 'mail'. If you place the shell command

```
alias mail newmail
```

in your *.cshrc* file, the shell will transform an input line of the form

```
mail bill
```

into a call on 'newmail'. More generally, suppose we wish the command 'ls' to always show sizes of files, that is to always do '–s'. We can do

```
alias ls ls –s
```

or even

```
alias dir ls –s
```

creating a new command syntax 'dir' which does an 'ls –s'. If we say

```
dir ˜bill
```

then the shell will translate this to

```
ls –s /mnt/bill
```

Thus the *alias* mechanism can be used to provide short names for commands, to provide default arguments, and to define new short commands in terms of other commands. It is also possible to define aliases which contain multiple commands or pipelines, showing where the arguments to the original command are to be substituted using the facilities of the history mechanism. Thus the definition

```
alias cd ´cd \!* ; ls ´
```

would do an *ls* command after each change directory *cd* command. We enclosed the entire alias definition in '´' characters to prevent most substitutions from occurring and the character ';' from being recognized as a metacharacter. The '!' here is escaped with a '\' to prevent it from being interpreted when the alias command is typed in. The '\!*' here substitutes the entire argument list to the pre-aliasing *cd* command, without giving an error if there were no arguments. The ';' separating commands is used here to indicate that one command is to be done and then the next. Similarly the definition

```
alias whois ´grep \!ˆ /etc/passwd´
```

defines a command which looks up its first argument in the password file.

Warning: The shell currently reads the *.cshrc* file each time it starts up. If you place a large number of commands there, shells will tend to start slowly. A mechanism for saving the shell environment after reading the *.cshrc* file and quickly restoring it is under development, but for now you should try to limit the number of aliases you have to a reasonable number... 10 or 15 is reasonable, 50 or 60 will cause a noticeable delay in starting up shells, and make the system seem sluggish when you execute commands from within the editor and other programs.

2.5. More redirection; >> and >&

There are a few more notations useful to the terminal user which have not been introduced yet.

In addition to the standard output, commands also have a *diagnostic output* which is normally directed to the terminal even when the standard output is redirected to a file or a pipe. It is occasionally desirable to direct the diagnostic output along with the standard output. For instance if you want to redirect the output of a long running command into a file and wish to have a record of any error diagnostic it produces you can do

```
command >& file
```

The '>&' here tells the shell to route both the diagnostic output and the standard output into 'file'. Similarly you can give the command

```
command |& lpr
```

to route both standard and diagnostic output through the pipe to the line printer daemon *lpr*.‡

Finally, it is possible to use the form

```
command >> file
```

to place output at the end of an existing file.†

2.6. Jobs; Background, Foreground, or Suspended

When one or more commands are typed together as a pipeline or as a sequence of commands separated by semicolons, a single *job* is created by the shell consisting of these commands together as a unit. Single commands without pipes or semicolons create the simplest jobs. Usually, every line typed to the shell creates a job. Some lines that create jobs (one per line) are

```
sort < data
ls –s | sort –n | head –5
mail harold
```

If the metacharacter '&' is typed at the end of the commands, then the job is started as a *background* job. This means that the shell does not wait for it to complete but immediately prompts and is ready for another command. The job runs *in the background* at the same time that normal jobs, called *foreground* jobs, continue to be read and executed by the shell one at a time. Thus

```
du > usage &
```

‡ A command of the form

```
command >&! file
```

exists, and is used when *noclobber* is set and *file* already exists.

† If *noclobber* is set, then an error will result if *file* does not exist, otherwise the shell will create *file* if it doesn't exist. A form

```
command >>! file
```

makes it not be an error for file to not exist when *noclobber* is set.

would run the *du* program, which reports on the disk usage of your working directory (as well as any directories below it), put the output into the file 'usage' and return immediately with a prompt for the next command without out waiting for *du* to finish. The *du* program would continue executing in the background until it finished, even though you can type and execute more commands in the mean time. When a background job terminates, a message is typed by the shell just before the next prompt telling you that the job has completed. In the following example the *du* job finishes sometime during the execution of the *mail* command and its completion is reported just before the prompt after the *mail* job is finished.

```
% du > usage &
[1] 503
% mail bill
How do you know when a background job is finished?
EOT
[1] − Done                du > usage
%
```

If the job did not terminate normally the 'Done' message might say something else like 'Killed'. If you want the terminations of background jobs to be reported at the time they occur (possibly interrupting the output of other foreground jobs), you can set the *notify* variable. In the previous example this would mean that the 'Done' message might have come right in the middle of the message to Bill. Background jobs are unaffected by any signals from the keyboard like the STOP, INTERRUPT, or QUIT signals mentioned earlier.

Jobs are recorded in a table inside the shell until they terminate. In this table, the shell remembers the command names, arguments and the *process numbers* of all commands in the job as well as the working directory where the job was started. Each job in the table is either running *in the foreground* with the shell waiting for it to terminate, running *in the background,* or *suspended.* Only one job can be running in the foreground at one time, but several jobs can be suspended or running in the background at once. As each job is started, it is assigned a small identifying number called the *job number* which can be used later to refer to the job in the commands described below. Job numbers remain the same until the job terminates and then are re-used.

When a job is started in the backgound using '&', its number, as well as the process numbers of all its (top level) commands, is typed by the shell before prompting you for another command. For example,

```
% ls −s | sort −n > usage &
[2] 2034 2035
%
```

runs the 'ls' program with the '−s' options, pipes this output into the 'sort' program with the '−n' option which puts its output into the file 'usage'. Since the '&' was at the end of the line, these two programs were started together as a background job. After starting the job, the shell prints the job number in brackets (2 in this case) followed by the process number of each program started in the job. Then the shell immediates prompts for a new command, leaving the job running simultaneously.

As mentioned in section 1.8, foreground jobs become *suspended* by typing ^Z which sends a STOP signal to the currently running foreground job. A background job can become suspended by using the *stop* command described below. When jobs are suspended they merely stop any further progress until started again, either in the foreground or the backgound. The shell notices when a job becomes stopped and reports this fact, much like it reports the termination of background jobs. For foreground jobs this looks like

```
% du > usage
^Z
Stopped
%
```

'Stopped' message is typed by the shell when it notices that the *du* program stopped. For background jobs, using the *stop* command, it is

```
% sort usage &
[1] 2345
% stop %1
[1] + Stopped (signal)          sort usage
%
```

Suspending foreground jobs can be very useful when you need to temporarily change what you are doing (execute other commands) and then return to the suspended job. Also, foreground jobs can be suspended and then continued as background jobs using the *bg* command, allowing you to continue other work and stop waiting for the foreground job to finish. Thus

```
% du > usage
^Z
Stopped
% bg
[1] du > usage &
%
```

starts 'du' in the foreground, stops it before it finishes, then continues it in the background allowing more foreground commands to be executed. This is especially helpful when a foreground job ends up taking longer than you expected and you wish you had started it in the backgound in the beginning.

All *job control* commands can take an argument that identifies a particular job. All job name arguments begin with the character '%', since some of the job control commands also accept process numbers (printed by the *ps* command.) The default job (when no argument is given) is called the *current* job and is identified by a '+' in the output of the *jobs* command, which shows you which jobs you have. When only one job is stopped or running in the background (the usual case) it is always the current job thus no argument is needed. If a job is stopped while running in the foreground it becomes the *current* job and the existing current job becomes the *previous* job – identified by a '–' in the output of *jobs.* When the current job terminates, the previous job becomes the current job. When given, the argument is either '%–' (indicating the previous job); '%#', where # is the job number; '%pref' where pref is some unique prefix of the command name and arguments of one of the jobs; or '%?' followed by some string found in only one of the jobs.

The *jobs* command types the table of jobs, giving the job number, commands and status ('Stopped' or 'Running') of each backgound or suspended job. With the '–l' option the process numbers are also typed.

```
% du > usage &
[1] 3398
% ls –s | sort –n > myfile &
[2] 3405
% mail bill
^Z
Stopped
% jobs
[1] – Running                   du > usage
[2]   Running                   ls –s | sort –n > myfile
[3] + Stopped                   mail bill
% fg %ls
ls –s | sort –n > myfile
% more myfile
```

The *fg* command runs a suspended or background job in the foreground. It is used to restart a previously suspended job or change a background job to run in the foreground (allowing signals or input from the terminal). In the above example we used *fg* to change the 'ls' job from the background to the foreground since we wanted to wait for it to finish before looking at its output file. The *bg* command runs a suspended job in the background. It is usually used after stopping the currently running foreground job with the STOP signal. The combination of the STOP signal and the *bg* command changes a foreground job into a background job. The *stop* command suspends a background job.

The *kill* command terminates a background or suspended job immediately. In addition to jobs, it may be given process numbers as arguments, as printed by *ps.* Thus, in the example above, the running *du* command could have been terminated by the command

```
% kill %1
[1]  Terminated                du > usage
%
```

The *notify* command (not the variable mentioned earlier) indicates that the termination of a specific job should be reported at the time it finishes instead of waiting for the next prompt.

If a job running in the background tries to read input from the terminal it is automatically stopped. When such a job is then run in the foreground, input can be given to the job. If desired, the job can be run in the background again until it requests input again. This is illustrated in the following sequence where the ‘s’ command in the text editor might take a long time.

```
% ed bigfile
120000
1,$s/thisword/thatword/
^Z
Stopped
% bg
[1] ed bigfile &
%
 . . .  some foreground commands
[1] Stopped (tty input)        ed bigfile
% fg
ed bigfile
w
120000
q
%
```

So after the ‘s’ command was issued, the ‘ed’ job was stopped with ˆZ and then put in the background using *bg.* Some time later when the ‘s’ command was finished, *ed* tried to read another command and was stopped because jobs in the backgound cannot read from the terminal. The *fg* command returned the ‘ed’ job to the foreground where it could once again accept commands from the terminal.

The command

```
stty tostop
```

causes all background jobs run on your terminal to stop when they are about to write output to the terminal. This prevents messages from background jobs from interrupting foreground job output and allows you to run a job in the background without losing terminal output. It also can be used for interactive programs that sometimes have long periods without interaction. Thus each time it outputs a prompt for more input it will stop before the prompt. It can then be run in the foreground using *fg,* more input can be given and, if necessary stopped and returned to the background. This *stty* command might be a good thing to put in your *.login* file if you do not like output from background jobs interrupting your work. It also can reduce the need for redirecting the output of background jobs if the output is not very big:

```
% stty tostop
% wc hugefile &
[1] 10387
% ed text
. . . some time later
q
[1] Stopped (tty output)       wc hugefile
% fg wc
wc hugefile
  13371   30123   302577
% stty −tostop
```

Thus after some time the 'wc' command, which counts the lines, words and characters in a file, had one line of output. When it tried to write this to the terminal it stopped. By restarting it in the foreground we allowed it to write on the terminal exactly when we were ready to look at its output. Programs which attempt to change the mode of the terminal will also block, whether or not *tostop* is set, when they are not in the foreground, as it would be very unpleasant to have a background job change the state of the terminal.

Since the *jobs* command only prints jobs started in the currently executing shell, it knows nothing about background jobs started in other login sessions or within shell files. The *ps* can be used in this case to find out about background jobs not started in the current shell.

2.7. Working Directories

As mentioned in section 1.6, the shell is always in a particular *working directory.* The 'change directory' command *chdir* (its short form *cd* may also be used) changes the working directory of the shell, that is, changes the directory you are located in.

It is useful to make a directory for each project you wish to work on and to place all files related to that project in that directory. The 'make directory' command, *mkdir,* creates a new directory. The *pwd* ('print working directory') command reports the absolute pathname of the working directory of the shell, that is, the directory you are located in. Thus in the example below:

```
% pwd
/usr/bill
% mkdir newpaper
% chdir newpaper
% pwd
/usr/bill/newpaper
%
```

the user has created and moved to the directory *newpaper.* where, for example, he might place a group of related files.

No matter where you have moved to in a directory hierarchy, you can return to your 'home' login directory by doing just

```
cd
```

with no arguments. The name '..' always means the directory above the current one in the hierarchy, thus

```
cd ..
```

changes the shell's working directory to the one directly above the current one. The name '..' can be used in any pathname, thus,

```
cd ../programs
```

means change to the directory 'programs' contained in the directory above the current one. If you have several directories for different projects under, say, your home directory, this shorthand notation permits you to switch easily between them.

The shell always remembers the pathname of its current working directory in the variable *cwd.* The shell can also be requested to remember the previous directory when you change to a new working directory. If the 'push directory' command *pushd* is used in place of the *cd* command, the shell saves the name of the current working directory on a *directory stack* before changing to the new one. You can see this list at any time by typing the 'directories' command *dirs.*

```
% pushd newpaper/references
˜/newpaper/references ˜
% pushd /usr/lib/tmac
/usr/lib/tmac ˜/newpaper/references ˜
% dirs
/usr/lib/tmac ˜/newpaper/references ˜
% popd
˜/newpaper/references ˜
% popd
˜
%
```

The list is printed in a horizontal line, reading left to right, with a tilde (˜) as shorthand for your home directory—in this case '/usr/bill'. The directory stack is printed whenever there is more than one entry on it and it changes. It is also printed by a *dirs* command. *Dirs* is usually faster and more informative than *pwd* since it shows the current working directory as well as any other directories remembered in the stack.

The *pushd* command with no argument alternates the current directory with the first directory in the list. The 'pop directory' *popd* command without an argument returns you to the directory you were in prior to the current one, discarding the previous current directory from the stack (forgetting it). Typing *popd* several times in a series takes you backward through the directories you had been in (changed to) by *pushd* command. There are other options to *pushd* and *popd* to manipulate the contents of the directory stack and to change to directories not at the top of the stack; see the *csh* manual page for details.

Since the shell remembers the working directory in which each job was started, it warns you when you might be confused by restarting a job in the foreground which has a different working directory than the current working directory of the shell. Thus if you start a background job, then change the shell's working directory and then cause the background job to run in the foreground, the shell warns you that the working directory of the currently running foreground job is different from that of the shell.

```
% dirs –l
/mnt/bill
% cd myproject
% dirs
˜/myproject
% ed prog.c
1143
ˆZ
Stopped
% cd ..
% ls
myproject
textfile
% fg
ed prog.c (wd: ˜/myproject)
```

This way the shell warns you when there is an implied change of working directory, even though no cd command was issued. In the above example the 'ed' job was still in '/mnt/bill/project' even though the shell had changed to '/mnt/bill'. A similar warning is given when such a foreground job terminates or is suspended (using the STOP signal) since the return to the shell again implies a change of working directory.

```
% fg
ed prog.c (wd: ˜/myproject)
 . . . after some editing
q
(wd now: ˜)
%
```

These messages are sometimes confusing if you use programs that change their own working directories, since the shell only remembers which directory a job is started in, and assumes it stays there. The '–l' option of *jobs* will type the working directory of suspended or background jobs when it is different from the current working directory of the shell.

2.8. Useful built-in commands

We now give a few of the useful built-in commands of the shell describing how they are used.

The *alias* command described above is used to assign new aliases and to show the existing aliases. With no arguments it prints the current aliases. It may also be given only one argument such as

```
alias ls
```

to show the current alias for, e.g., 'ls'.

The *echo* command prints its arguments. It is often used in *shell scripts* or as an interactive command to see what filename expansions will produce.

The *history* command will show the contents of the history list. The numbers given with the history events can be used to reference previous events which are difficult to reference using the contextual mechanisms introduced above. There is also a shell variable called *prompt.* By placing a '!' character in its value the shell will there substitute the number of the current command in the history list. You can use this number to refer to this command in a history substitution. Thus you could

```
set prompt=´\! % ´
```

Note that the '!' character had to be *escaped* here even within '´' characters.

The *limit* command is used to restrict use of resources. With no arguments it prints the current limitations:

```
cputime        unlimited
filesize       unlimited
datasize       5616 kbytes
stacksize      512 kbytes
coredumpsize   unlimited
```

Limits can be set, e.g.:

```
limit coredumpsize 128k
```

Most reasonable units abbreviations will work; see the *csh* manual page for more details.

The *logout* command can be used to terminate a login shell which has *ignoreeof* set.

The *rehash* command causes the shell to recompute a table of where commands are located. This is necessary if you add a command to a directory in the current shell's search path and wish the shell to find it, since otherwise the hashing algorithm may tell the shell that the command wasn't in that directory when the hash table was computed.

The *repeat* command can be used to repeat a command several times. Thus to make 5 copies of the file *one* in the file *five* you could do

```
repeat 5 cat one >> five
```

The *setenv* command can be used to set variables in the environment. Thus

```
setenv TERM adm3a
```

will set the value of the environment variable TERM to ‘adm3a’. A user program *printenv* exists which will print out the environment. It might then show:

```
% printenv
HOME=/usr/bill
SHELL=/bin/csh
PATH=:/usr/ucb:/bin:/usr/bin:/usr/local
TERM=adm3a
USER=bill
%
```

The *source* command can be used to force the current shell to read commands from a file. Thus

```
source .cshrc
```

can be used after editing in a change to the *.cshrc* file which you wish to take effect right away.

The *time* command can be used to cause a command to be timed no matter how much CPU time it takes. Thus

```
% time cp /etc/rc /usr/bill/rc
0.0u 0.1s 0:01 8% 2+1k 3+2io 1pf+0w
% time wc /etc/rc /usr/bill/rc
     52    178   1347 /etc/rc
     52    178   1347 /usr/bill/rc
    104    356   2694 total
0.1u 0.1s 0:00 13% 3+3k 5+3io 7pf+0w
%
```

indicates that the *cp* command used a negligible amount of user time (u) and about 1/10th of a system time (s); the elapsed time was 1 second (0:01), there was an average memory usage of 2k bytes of program space and 1k bytes of data space over the cpu time involved (2+1k); the program did three disk reads and two disk writes (3+2io), and took one page fault and was not swapped (1pf+0w). The word count command *wc* on the other hand used 0.1 seconds of user time and 0.1 seconds of system time in less than a second of elapsed time. The percentage ‘13%’ indicates that over the period when it was active the command ‘wc’ used an average of 13 percent of the available CPU cycles of the machine.

The *unalias* and *unset* commands can be used to remove aliases and variable definitions from the shell, and *unsetenv* removes variables from the environment.

2.9. What else?

This concludes the basic discussion of the shell for terminal users. There are more features of the shell to be discussed here, and all features of the shell are discussed in its manual pages. One useful feature which is discussed later is the *foreach* built-in command which can be used to run the same command sequence with a number of different arguments.

If you intend to use UNIX a lot you you should look through the rest of this document and the csh manual pages (section1) to become familiar with the other facilities which are available to you.

3. Shell control structures and command scripts

3.1. Introduction

It is possible to place commands in files and to cause shells to be invoked to read and execute commands from these files, which are called *shell scripts.* We here detail those features of the shell useful to the writers of such scripts.

3.2. Make

It is important to first note what shell scripts are *not* useful for. There is a program called *make* which is very useful for maintaining a group of related files or performing sets of operations on related files. For instance a large program consisting of one or more files can have its dependencies described in a *makefile* which contains definitions of the commands used to create these different files when changes occur. Definitions of the means for printing listings, cleaning up the directory in which the files reside, and installing the resultant programs are easily, and most appropriately placed in this *makefile.* This format is superior and preferable to maintaining a group of shell procedures to maintain these files.

Similarly when working on a document a *makefile* may be created which defines how different versions of the document are to be created and which options of *nroff* or *troff* are appropriate.

3.3. Invocation and the argv variable

A *csh* command script may be interpreted by saying

```
% csh script ...
```

where *script* is the name of the file containing a group of *csh* commands and '...' is replaced by a sequence of arguments. The shell places these arguments in the variable *argv* and then begins to read commands from the script. These parameters are then available through the same mechanisms which are used to reference any other shell variables.

If you make the file 'script' executable by doing

```
chmod 755 script
```

and place a shell comment at the beginning of the shell script (i.e. begin the file with a '#' character) then a '/bin/csh' will automatically be invoked to execute 'script' when you type

```
script
```

If the file does not begin with a '#' then the standard shell '/bin/sh' will be used to execute it. This allows you to convert your older shell scripts to use *csh* at your convenience.

3.4. Variable substitution

After each input line is broken into words and history substitutions are done on it, the input line is parsed into distinct commands. Before each command is executed a mechanism know as *variable substitution* is done on these words. Keyed by the character '$' this substitution replaces the names of variables by their values. Thus

```
echo $argv
```

when placed in a command script would cause the current value of the variable *argv* to be echoed to the output of the shell script. It is an error for *argv* to be unset at this point.

A number of notations are provided for accessing components and attributes of variables. The notation

```
$?name
```

expands to '1' if name is *set* or to '0' if name is not *set.* It is the fundamental mechanism used for checking whether particular variables have been assigned values. All other forms of reference to undefined variables cause errors.

The notation

```
$#name
```

expands to the number of elements in the variable *name.* Thus

```
% set argv=(a b c)
% echo $?argv
1
% echo $#argv
3
% unset argv
% echo $?argv
0
% echo $argv
Undefined variable: argv.
%
```

It is also possible to access the components of a variable which has several values. Thus

```
$argv[1]
```

gives the first component of *argv* or in the example above ‘a’. Similarly

```
$argv[$#argv]
```

would give ‘c’, and

```
$argv[1−2]
```

would give ‘a b’. Other notations useful in shell scripts are

```
$n
```

where *n* is an integer as a shorthand for

```
$argv[n]
```

the *n th* parameter and

```
$*
```

which is a shorthand for

```
$argv
```

The form

```
$$
```

expands to the process number of the current shell. Since this process number is unique in the system it can be used in generation of unique temporary file names. The form

```
$<
```

is quite special and is replaced by the next line of input read from the shell’s standard input (not the script it is reading). This is useful for writing shell scripts that are interactive, reading commands from the terminal, or even writing a shell script that acts as a filter, reading lines from its input file. Thus the sequence

```
echo ’yes or no?\c’
set a=($<)
```

would write out the prompt ‘yes or no?’ without a newline and then read the answer into the variable ‘a’. In this case ‘$#a’ would be ‘0’ if either a blank line or end-of-file (ˆD) was typed.

One minor difference between ‘$*n*’ and ‘$argv[*n*]’ should be noted here. The form ‘$argv[*n*]’ will yield an error if *n* is not in the range ‘1−$#argv’ while ‘$n’ will never yield an out of range subscript error.

This is for compatibility with the way older shells handled parameters.

Another important point is that it is never an error to give a subrange of the form ‘n–’; if there are less than *n* components of the given variable then no words are substituted. A range of the form ‘m–n’ likewise returns an empty vector without giving an error when *m* exceeds the number of elements of the given variable, provided the subscript *n* is in range.

3.5. Expressions

In order for interesting shell scripts to be constructed it must be possible to evaluate expressions in the shell based on the values of variables. In fact, all the arithmetic operations of the language C are available in the shell with the same precedence that they have in C. In particular, the operations ‘==’ and ‘!=’ compare strings and the operators ‘&&’ and ‘| |’ implement the boolean and/or operations. The special operators ‘=~’ and ‘!~’ are similar to ‘==’ and ‘!=’ except that the string on the right side can have pattern matching characters (like *, ? or []) and the test is whether the string on the left matches the pattern on the right.

The shell also allows file enquiries of the form

  –? filename

where ‘?’ is replace by a number of single characters. For instance the expression primitive

  –e filename

tell whether the file ‘filename’ exists. Other primitives test for read, write and execute access to the file, whether it is a directory, or has non-zero length.

It is possible to test whether a command terminates normally, by a primitive of the form ‘{ command }’ which returns true, i.e. ‘1’ if the command succeeds exiting normally with exit status 0, or ‘0’ if the command terminates abnormally or with exit status non-zero. If more detailed information about the execution status of a command is required, it can be executed and the variable ‘$status’ examined in the next command. Since ‘$status’ is set by every command, it is very transient. It can be saved if it is inconvenient to use it only in the single immediately following command.

For a full list of expression components available see the manual section for the shell.

3.6. Sample shell script

A sample shell script which makes use of the expression mechanism of the shell and some of its control structure follows:

```
% cat copyc
#
# Copyc copies those C programs in the specified list
# to the directory ~/backup if they differ from the files
# already in ~/backup
#
set noglob
foreach i ($argv)

        if ($i !~ *.c) continue  # not a .c file so do nothing

        if (! −r ~/backup/$i:t) then
                echo $i:t not in backup... not cp\´ed
                continue
        endif

        cmp −s $i ~/backup/$i:t # to set $status

        if ($status != 0) then
                echo new backup of $i
                cp $i ~/backup/$i:t
        endif
end
```

This script makes use of the *foreach* command, which causes the shell to execute the commands between the *foreach* and the matching *end* for each of the values given between '(' and ')' with the named variable, in this case 'i' set to successive values in the list. Within this loop we may use the command *break* to stop executing the loop and *continue* to prematurely terminate one iteration and begin the next. After the *foreach* loop the iteration variable (*i* in this case) has the value at the last iteration.

We set the variable *noglob* here to prevent filename expansion of the members of *argv*. This is a good idea, in general, if the arguments to a shell script are filenames which have already been expanded or if the arguments may contain filename expansion metacharacters. It is also possible to quote each use of a '$' variable expansion, but this is harder and less reliable.

The other control construct used here is a statement of the form

```
if ( expression ) then
        command
        ...
endif
```

The placement of the keywords here is **not** flexible due to the current implementation of the shell.†

The shell does have another form of the if statement of the form

†The following two formats are not currently acceptable to the shell:

```
if ( expression )                # Won't work!
then
        command
        ...
endif
```

and

```
if ( expression ) then command endif                # Won't work
```

if (expression) **command**

which can be written

if (expression) \
    command

Here we have escaped the newline for the sake of appearance. The command must not involve '|', '&' or ';' and must not be another control command. The second form requires the final '\' to **immediately** precede the end-of-line.

The more general *if* statements above also admit a sequence of *else−if* pairs followed by a single *else* and an *endif,* e.g.:

if (expression) **then**
    commands
else if (expression) **then**
    commands
...

else
    commands
endif

Another important mechanism used in shell scripts is the ':' modifier. We can use the modifier ':r' here to extract a root of a filename or ':e' to extract the *extension.* Thus if the variable *i* has the value '/mnt/foo.bar' then

```
% echo $i $i:r $i:e
/mnt/foo.bar /mnt/foo bar
%
```

shows how the ':r' modifier strips off the trailing '.bar' and the the ':e' modifier leaves only the 'bar'. Other modifiers will take off the last component of a pathname leaving the head ':h' or all but the last component of a pathname leaving the tail ':t'. These modifiers are fully described in the *csh* manual pages in the User's Reference Manual. It is also possible to use the *command substitution* mechanism described in the next major section to perform modifications on strings to then reenter the shell's environment. Since each usage of this mechanism involves the creation of a new process, it is much more expensive to use than the ':' modification mechanism.‡ Finally, we note that the character '#' lexically introduces a shell comment in shell scripts (but not from the terminal). All subsequent characters on the input line after a '#' are discarded by the shell. This character can be quoted using '´' or '\' to place it in an argument word.

3.7. Other control structures

The shell also has control structures *while* and *switch* similar to those of C. These take the forms

while (expression)
    commands
end

‡ It is also important to note that the current implementation of the shell limits the number of ':' modifiers on a '$' substitution to 1. Thus

```
% echo $i $i:h:t
/a/b/c /a/b:t
%
```

does not do what one would expect.

and

```
switch ( word )

case str1:
        commands
        breaksw

 ...

case strn:
        commands
        breaksw

default:
        commands
        breaksw

endsw
```

For details see the manual section for *csh.* C programmers should note that we use *breaksw* to exit from a *switch* while *break* exits a *while* or *foreach* loop. A common mistake to make in *csh* scripts is to use *break* rather than *breaksw* in switches.

Finally, *csh* allows a *goto* statement, with labels looking like they do in C, i.e.:

```
loop:
        commands
        goto loop
```

3.8. Supplying input to commands

Commands run from shell scripts receive by default the standard input of the shell which is running the script. This is different from previous shells running under UNIX. It allows shell scripts to fully participate in pipelines, but mandates extra notation for commands which are to take inline data.

Thus we need a metanotation for supplying inline data to commands in shell scripts. As an example, consider this script which runs the editor to delete leading blanks from the lines in each argument file:

```
% cat deblank
# deblank –– remove leading blanks
foreach i ($argv)
ed – $i << ´EOF´
1,$s/^[ ]*//
w
q
´EOF´
end
%
```

The notation '<< ´EOF´' means that the standard input for the *ed* command is to come from the text in the shell script file up to the next line consisting of exactly '´EOF´'. The fact that the 'EOF' is enclosed in '´' characters, i.e. quoted, causes the shell to not perform variable substitution on the intervening lines. In general, if any part of the word following the '<<' which the shell uses to terminate the text to be given to the command is quoted then these substitutions will not be performed. In this case since we used the form '1,$' in our editor script we needed to insure that this '$' was not variable substituted. We could also have insured this by preceding the '$' here with a '\', i.e.:

```
1,\$s/^[ ]*//
```

but quoting the ‘EOF’ terminator is a more reliable way of achieving the same thing.

3.9. Catching interrupts

If our shell script creates temporary files, we may wish to catch interruptions of the shell script so that we can clean up these files. We can then do

```
onintr label
```

where *label* is a label in our program. If an interrupt is received the shell will do a ‘goto label’ and we can remove the temporary files and then do an *exit* command (which is built in to the shell) to exit from the shell script. If we wish to exit with a non-zero status we can do

```
exit(1)
```

e.g. to exit with status ‘1’.

3.10. What else?

There are other features of the shell useful to writers of shell procedures. The *verbose* and *echo* options and the related *−v* and *−x* command line options can be used to help trace the actions of the shell. The *−n* option causes the shell only to read commands and not to execute them and may sometimes be of use.

One other thing to note is that *csh* will not execute shell scripts which do not begin with the character ‘#’, that is shell scripts that do not begin with a comment. Similarly, the ‘/bin/sh’ on your system may well defer to ‘csh’ to interpret shell scripts which begin with ‘#’. This allows shell scripts for both shells to live in harmony.

There is also another quotation mechanism using ‘"’ which allows only some of the expansion mechanisms we have so far discussed to occur on the quoted string and serves to make this string into a single word as ‘´’ does.

4. Other, less commonly used, shell features

4.1. Loops at the terminal; variables as vectors

It is occasionally useful to use the *foreach* control structure at the terminal to aid in performing a number of similar commands. For instance, there were at one point three shells in use on the Cory UNIX system at Cory Hall, '/bin/sh', '/bin/nsh', and '/bin/csh'. To count the number of persons using each shell one could have issued the commands

```
% grep –c csh$ /etc/passwd
27
% grep –c nsh$ /etc/passwd
128
% grep –c –v sh$ /etc/passwd
430
%
```

Since these commands are very similar we can use *foreach* to do this more easily.

```
% foreach i (´sh$´ ´csh$´ ´–v sh$´)
? grep –c $i /etc/passwd
? end
27
128
430
%
```

Note here that the shell prompts for input with '? ' when reading the body of the loop.

Very useful with loops are variables which contain lists of filenames or other words. You can, for example, do

```
% set a=(`ls`)
% echo $a
csh.n csh.rm
% ls
csh.n
csh.rm
% echo $#a
2
%
```

The *set* command here gave the variable *a* a list of all the filenames in the current directory as value. We can then iterate over these names to perform any chosen function.

The output of a command within '`' characters is converted by the shell to a list of words. You can also place the '`' quoted string within '"' characters to take each (non-empty) line as a component of the variable; preventing the lines from being split into words at blanks and tabs. A modifier ':x' exists which can be used later to expand each component of the variable into another variable splitting it into separate words at embedded blanks and tabs.

4.2. Braces { ... } in argument expansion

Another form of filename expansion, alluded to before involves the characters '{' and '}'. These characters specify that the contained strings, separated by ',' are to be consecutively substituted into the containing characters and the results expanded left to right. Thus

```
A{str1,str2,...strn}B
```

expands to

Astr1B Astr2B ... AstrnB

This expansion occurs before the other filename expansions, and may be applied recursively (i.e. nested). The results of each expanded string are sorted separately, left to right order being preserved. The resulting filenames are not required to exist if no other expansion mechanisms are used. This means that this mechanism can be used to generate arguments which are not filenames, but which have common parts.

A typical use of this would be

```
mkdir ~/{hdrs,retrofit,csh}
```

to make subdirectories 'hdrs', 'retrofit' and 'csh' in your home directory. This mechanism is most useful when the common prefix is longer than in this example, i.e.

```
chown root /usr/{ucb/{ex,edit},lib/{ex?.?*,how_ex}}
```

4.3. Command substitution

A command enclosed in '`' characters is replaced, just before filenames are expanded, by the output from that command. Thus it is possible to do

```
set pwd=`pwd`
```

to save the current directory in the variable *pwd* or to do

```
ex `grep –l TRACE *.c`
```

to run the editor *ex* supplying as arguments those files whose names end in '.c' which have the string 'TRACE' in them.*

4.4. Other details not covered here

In particular circumstances it may be necessary to know the exact nature and order of different substitutions performed by the shell. The exact meaning of certain combinations of quotations is also occasionally important. These are detailed fully in its manual section.

The shell has a number of command line option flags mostly of use in writing UNIX programs, and debugging shell scripts. See the csh(1) manual section for a list of these options.

*Command expansion also occurs in input redirected with '<<' and within '"' quotations. Refer to the shell manual section for full details.

Appendix − Special characters

The following table lists the special characters of *csh* and the UNIX system, giving for each the section(s) in which it is discussed. A number of these characters also have special meaning in expressions. See the *csh* manual section for a complete list.

Syntactic metacharacters

;	2.4	separates commands to be executed sequentially
|	1.5	separates commands in a pipeline
( )	2.2,3.6	brackets expressions and variable values
&	2.5	follows commands to be executed without waiting for completion

Filename metacharacters

/	1.6	separates components of a file's pathname
?	1.6	expansion character matching any single character
*	1.6	expansion character matching any sequence of characters
[ ]	1.6	expansion sequence matching any single character from a set
˜	1.6	used at the beginning of a filename to indicate home directories
{ }	4.2	used to specify groups of arguments with common parts

Quotation metacharacters

\	1.7	prevents meta-meaning of following single character
´	1.7	prevents meta-meaning of a group of characters
"	4.3	like ´, but allows variable and command expansion

Input/output metacharacters

<	1.5	indicates redirected input
>	1.3	indicates redirected output

Expansion/substitution metacharacters

$	3.4	indicates variable substitution
!	2.3	indicates history substitution
:	3.6	precedes substitution modifiers
ˆ	2.3	used in special forms of history substitution
`	4.3	indicates command substitution

Other metacharacters

#	1.3,3.6	begins scratch file names; indicates shell comments
−	1.2	prefixes option (flag) arguments to commands
%	2.6	prefixes job name specifications

Glossary

This glossary lists the most important terms introduced in the introduction to the shell and gives references to sections of the shell document for further information about them. References of the form 'pr (1)' indicate that the command *pr* is in the UNIX User Reference manual in section 1. You can look at an online copy of its manual page by doing

```
man 1 pr
```

References of the form (2.5) indicate that more information can be found in section 2.5 of this manual.

. Your current directory has the name '.' as well as the name printed by the command *pwd;* see also *dirs.* The current directory '.' is usually the first *component* of the search path contained in the variable *path*, thus commands which are in '.' are found first (2.2). The character '.' is also used in separating *components* of filenames (1.6). The character '.' at the beginning of a *component* of a *pathname* is treated specially and not matched by the *filename expansion* metacharacters '?', '*', and '[' ']' pairs (1.6).

.. Each directory has a file '..' in it which is a reference to its parent directory. After changing into the directory with *chdir*, i.e.

```
chdir paper
```

you can return to the parent directory by doing

```
chdir ..
```

The current directory is printed by *pwd* (2.7).

a.out Compilers which create executable images create them, by default, in the file *a.out.* for historical reasons (2.3).

absolute pathname

A *pathname* which begins with a '/' is *absolute* since it specifies the *path* of directories from the beginning of the entire directory system – called the *root* directory. *Pathname*s which are not *absolute* are called *relative* (see definition of *relative pathname*) (1.6).

alias An *alias* specifies a shorter or different name for a UNIX command, or a transformation on a command to be performed in the shell. The shell has a command *alias* which establishes *aliases* and can print their current values. The command *unalias* is used to remove *aliases* (2.4).

argument Commands in UNIX receive a list of *argument* words. Thus the command

```
echo a b c
```

consists of the *command name* 'echo' and three *argument* words 'a', 'b' and 'c'. The set of *arguments* after the *command name* is said to be the *argument list* of the command (1.1).

argv The list of arguments to a command written in the shell language (a shell script or shell procedure) is stored in a variable called *argv* within the shell. This name is taken from the conventional name in the C programming language (3.4).

background Commands started without waiting for them to complete are called *background* commands (2.6).

base A filename is sometimes thought of as consisting of a *base* part, before any '.' character, and an *extension* – the part after the '.'. See *filename* and *extension* (1.6) and basename (1).

bg The *bg* command causes a *suspended* job to continue execution in the *background* (2.6).

bin A directory containing binaries of programs and shell scripts to be executed is typically called a *bin* directory. The standard system *bin* directories are '/bin' containing the most heavily used commands and '/usr/bin' which contains most other user programs.

Programs developed at UC Berkeley live in '/usr/ucb', while locally written programs live in '/usr/local'. Games are kept in the directory '/usr/games'. You can place binaries in any directory. If you wish to execute them often, the name of the directories should be a *component* of the variable *path*.

break — *Break* is a builtin command used to exit from loops within the control structure of the shell (3.7).

breaksw — The *breaksw* builtin command is used to exit from a *switch* control structure, like a *break* exits from loops (3.7).

builtin — A command executed directly by the shell is called a *builtin* command. Most commands in UNIX are not built into the shell, but rather exist as files in *bin* directories. These commands are accessible because the directories in which they reside are named in the *path* variable.

case — A *case* command is used as a label in a *switch* statement in the shell's control structure, similar to that of the language C. Details are given in the shell documentation 'csh (1)' (3.7).

cat — The *cat* program catenates a list of specified files on the *standard output*. It is usually used to look at the contents of a single file on the terminal, to 'cat a file' (1.8, 2.3).

cd — The *cd* command is used to change the *working directory*. With no arguments, *cd* changes your *working directory* to be your *home* directory (2.4, 2.7).

chdir — The *chdir* command is a synonym for *cd*. *Cd* is usually used because it is easier to type.

chsh — The *chsh* command is used to change the shell which you use on UNIX. By default, you use an different version of the shell which resides in '/bin/sh'. You can change your shell to '/bin/csh' by doing

```
chsh your-login-name /bin/csh
```

Thus I would do

```
chsh bill /bin/csh
```

It is only necessary to do this once. The next time you log in to UNIX after doing this command, you will be using *csh* rather than the shell in '/bin/sh' (1.9).

cmp — *Cmp* is a program which compares files. It is usually used on binary files, or to see if two files are identical (3.6). For comparing text files the program *diff*, described in 'diff (1)' is used.

command — A function performed by the system, either by the shell (a builtin *command*) or by a program residing in a file in a directory within the UNIX system, is called a *command* (1.1).

command name — When a command is issued, it consists of a *command name*, which is the first word of the command, followed by arguments. The convention on UNIX is that the first word of a command names the function to be performed (1.1).

command substitution — The replacement of a command enclosed in '`' characters by the text output by that command is called *command substitution* (4.3).

component — A part of a *pathname* between '/' characters is called a *component* of that *pathname*. A variable which has multiple strings as value is said to have several *component*s; each string is a *component* of the variable.

continue — A builtin command which causes execution of the enclosing *foreach* or *while* loop to cycle prematurely. Similar to the *continue* command in the programming language C (3.6).

control- Certain special characters, called *control* characters, are produced by holding down the CONTROL key on your terminal and simultaneously pressing another character, much like the SHIFT key is used to produce upper case characters. Thus *control-* c is produced by holding down the CONTROL key while pressing the ‘c’ key. Usually UNIX prints an caret (ˆ) followed by the corresponding letter when you type a *control* character (e.g. ‘ˆC’ for *control-* c (1.8).

core dump When a program terminates abnormally, the system places an image of its current state in a file named ‘core’. This *core dump* can be examined with the system debugger ‘adb (1)’ or ‘sdb (1)’ in order to determine what went wrong with the program (1.8). If the shell produces a message of the form

Illegal instruction (core dumped)

(where ‘Illegal instruction’ is only one of several possible messages), you should report this to the author of the program or a system administrator, saving the ‘core’ file.

cp The *cp* (copy) program is used to copy the contents of one file into another file. It is one of the most commonly used UNIX commands (1.6).

csh The name of the shell program that this document describes.

.cshrc The file *.cshrc* in your *home* directory is read by each shell as it begins execution. It is usually used to change the setting of the variable *path* and to set *alias* parameters which are to take effect globally (2.1).

cwd The *cwd* variable in the shell holds the *absolute pathname* of the current *working directory*. It is changed by the shell whenever your current *working directory* changes and should not be changed otherwise (2.2).

date The *date* command prints the current date and time (1.3).

debugging *Debugging* is the process of correcting mistakes in programs and shell scripts. The shell has several options and variables which may be used to aid in shell *debugging* (4.4).

default: The label *default:* is used within shell *switch* statements, as it is in the C language to label the code to be executed if none of the *case* labels matches the value switched on (3.7).

DELETE The DELETE or RUBOUT key on the terminal normally causes an interrupt to be sent to the current job. Many users change the interrupt character to be ˆC.

detached A command that continues running in the *background* after you logout is said to be *detached*.

diagnostic An error message produced by a program is often referred to as a *diagnostic*. Most error messages are not written to the *standard output*, since that is often directed away from the terminal (1.3, 1.5). Error messsages are instead written to the *diagnostic output* which may be directed away from the terminal, but usually is not. Thus *diagnostics* will usually appear on the terminal (2.5).

directory A structure which contains files. At any time you are in one particular *directory* whose names can be printed by the command *pwd*. The *chdir* command will change you to another *directory*, and make the files in that *directory* visible. The *directory* in which you are when you first login is your *home* directory (1.1, 2.7).

directory stack The shell saves the names of previous *working directories* in the *directory stack* when you change your current *working directory* via the *pushd* command. The *directory stack* can be printed by using the *dirs* command, which includes your current *working directory* as the first directory name on the left (2.7).

dirs The *dirs* command prints the shell’s *directory stack* (2.7).

du The *du* command is a program (described in ‘du (1)’) which prints the number of disk blocks is all directories below and including your current *working directory* (2.6).

echo — The *echo* command prints its arguments (1.6, 3.6).

else — The *else* command is part of the 'if-then-else-endif' control command construct (3.6).

endif — If an *if* statement is ended with the word *then*, all lines following the *if* up to a line starting with the word *endif* or *else* are executed if the condition between parentheses after the *if* is true (3.6).

EOF — An *end-of-file* is generated by the terminal by a control-d, and whenever a command reads to the end of a file which it has been given as input. Commands receiving input from a *pipe* receive an *end-of-file* when the command sending them input completes. Most commands terminate when they receive an *end-of-file*. The shell has an option to ignore *end-of-file* from a terminal input which may help you keep from logging out accidentally by typing too many control-d's (1.1, 1.8, 3.8).

escape — A character '\' used to prevent the special meaning of a metacharacter is said to *escape* the character from its special meaning. Thus

```
echo \*
```

will echo the character '*' while just

```
echo *
```

will echo the names of the file in the current directory. In this example, \ *escape*s '*' (1.7). There is also a non-printing character called *escape*, usually labelled ESC or ALTMODE on terminal keyboards. Some older UNIX systems use this character to indicate that output is to be *suspended*. Most systems use control-s to stop the output and control-q to start it.

/etc/passwd — This file contains information about the accounts currently on the system. It consists of a line for each account with fields separated by ':' characters (1.8). You can look at this file by saying

```
cat /etc/passwd
```

The commands *finger* and *grep* are often used to search for information in this file. See 'finger (1)', 'passwd(5)', and 'grep (1)' for more details.

exit — The *exit* command is used to force termination of a shell script, and is built into the shell (3.9).

exit status — A command which discovers a problem may reflect this back to the command (such as a shell) which invoked (executed) it. It does this by returning a non-zero number as its *exit status*, a status of zero being considered 'normal termination'. The *exit* command can be used to force a shell command script to give a non-zero *exit status* (3.6).

expansion — The replacement of strings in the shell input which contain metacharacters by other strings is referred to as the process of *expansion*. Thus the replacement of the word '*' by a sorted list of files in the current directory is a 'filename expansion'. Similarly the replacement of the characters '!!' by the text of the last command is a 'history expansion'. *Expansions* are also referred to as *substitutions* (1.6, 3.4, 4.2).

expressions — *Expressions* are used in the shell to control the conditional structures used in the writing of shell scripts and in calculating values for these scripts. The operators available in shell *expressions* are those of the language C (3.5).

extension — Filenames often consist of a *base* name and an *extension* separated by the character '.'. By convention, groups of related files often share the same *root* name. Thus if 'prog.c' were a C program, then the object file for this program would be stored in 'prog.o'. Similarly a paper written with the '–me' nroff macro package might be stored in 'paper.me' while a formatted version of this paper might be kept in 'paper.out' and a list of spelling errors in 'paper.errs' (1.6).

fg — The *job control* command *fg* is used to run a *background* or *suspended* job in the *foreground* (1.8, 2.6).

filename — Each file in UNIX has a name consisting of up to 14 characters and not including the character '/' which is used in *pathname* building. Most *filenames* do not begin with the character '.', and contain only letters and digits with perhaps a '.' separating the *base* portion of the *filename* from an *extension* (1.6).

filename expansion — *Filename expansion* uses the metacharacters '*', '?' and '[' and ']' to provide a convenient mechanism for naming files. Using *filename expansion* it is easy to name all the files in the current directory, or all files which have a common *root* name. Other *filename expansion* mechanisms use the metacharacter '~' and allow files in other users' directories to be named easily (1.6, 4.2).

flag — Many UNIX commands accept arguments which are not the names of files or other users but are used to modify the action of the commands. These are referred to as *flag* options, and by convention consist of one or more letters preceded by the character '−' (1.2). Thus the *ls* (list files) command has an option '−s' to list the sizes of files. This is specified

```
ls −s
```

foreach — The *foreach* command is used in shell scripts and at the terminal to specify repetition of a sequence of commands while the value of a certain shell variable ranges through a specified list (3.6, 4.1).

foreground — When commands are executing in the normal way such that the shell is waiting for them to finish before prompting for another command they are said to be *foreground jobs* or *running in the foreground*. This is as opposed to *background*. *Foreground* jobs can be stopped by signals from the terminal caused by typing different control characters at the keyboard (1.8, 2.6).

goto — The shell has a command *goto* used in shell scripts to transfer control to a given label (3.7).

grep — The *grep* command searches through a list of argument files for a specified string. Thus

```
grep bill /etc/passwd
```

will print each line in the file */etc/passwd* which contains the string 'bill'. Actually, *grep* scans for *regular expressions* in the sense of the editors 'ed (1)' and 'ex (1)'. *Grep* stands for 'globally find *regular expression* and print' (2.4).

head — The *head* command prints the first few lines of one or more files. If you have a bunch of files containing text which you are wondering about it is sometimes useful to run *head* with these files as arguments. This will usually show enough of what is in these files to let you decide which you are interested in (1.5).
Head is also used to describe the part of a *pathname* before and including the last '/' character. The *tail* of a *pathname* is the part after the last '/'. The ':h' and ':t' modifiers allow the *head* or *tail* of a *pathname* stored in a shell variable to be used (3.6).

history — The *history* mechanism of the shell allows previous commands to be repeated, possibly after modification to correct typing mistakes or to change the meaning of the command. The shell has a *history list* where these commands are kept, and a *history* variable which controls how large this list is (2.3).

home directory — Each user has a *home directory*, which is given in your entry in the password file, */etc/passwd*. This is the directory which you are placed in when you first login. The *cd* or *chdir* command with no arguments takes you back to this directory, whose name is recorded in the shell variable *home*. You can also access the *home directories* of other users in forming filenames using a *filename expansion* notation and the character ‘˜’ (1.6).

if — A conditional command within the shell, the *if* command is used in shell command scripts to make decisions about what course of action to take next (3.6).

ignoreeof — Normally, your shell will exit, printing ‘logout’ if you type a control-d at a prompt of ‘% ’. This is the way you usually log off the system. You can *set* the *ignoreeof* variable if you wish in your *.login* file and then use the command *logout* to logout. This is useful if you sometimes accidentally type too many control-d characters, logging yourself off (2.2).

input — Many commands on UNIX take information from the terminal or from files which they then act on. This information is called *input*. Commands normally read for *input* from their *standard input* which is, by default, the terminal. This *standard input* can be redirected from a file using a shell metanotation with the character ‘<’. Many commands will also read from a file specified as argument. Commands placed in *pipelines* will read from the output of the previous command in the *pipeline*. The leftmost command in a *pipeline* reads from the terminal if you neither redirect its *input* nor give it a filename to use as *standard input*. Special mechanisms exist for supplying input to commands in shell scripts (1.5, 3.8).

interrupt — An *interrupt* is a signal to a program that is generated by typing ˆC. (On older versions of UNIX the RUBOUT or DELETE key were used for this purpose.) It causes most programs to stop execution. Certain programs, such as the shell and the editors, handle an *interrupt* in special ways, usually by stopping what they are doing and prompting for another command. While the shell is executing another command and waiting for it to finish, the shell does not listen to *interrupts.* The shell often wakes up when you hit *interrupt* because many commands die when they receive an *interrupt* (1.8, 3.9).

job — One or more commands typed on the same input line separated by ‘|’ or ‘;’ characters are run together and are called a *job*. Simple commands run by themselves without any ‘|’ or ‘;’ characters are the simplest *jobs. Jobs* are classified as *foreground*, *background*, or *suspended* (2.6).

job control — The builtin functions that control the execution of jobs are called *job control* commands. These are *bg, fg, stop, kill* (2.6).

job number — When each job is started it is assigned a small number called a *job number* which is printed next to the job in the output of the *jobs* command. This number, preceded by a ‘%’ character, can be used as an argument to *job control* commands to indicate a specific job (2.6).

jobs — The *jobs* command prints a table showing jobs that are either running in the *background* or are *suspended* (2.6).

kill — A command which sends a signal to a job causing it to terminate (2.6).

.login — The file *.login* in your *home* directory is read by the shell each time you login to UNIX and the commands there are executed. There are a number of commands which are usefully placed here, especially *set* commands to the shell itself (2.1).

login shell — The shell that is started on your terminal when you login is called your *login shell*. It is different from other shells which you may run (e.g. on shell scripts) in that it reads the *.login* file before reading commands from the terminal and it reads the *.logout* file after you logout (2.1).

logout — The *logout* command causes a login shell to exit. Normally, a login shell will exit when you hit control-d generating an *end-of-file,* but if you have set *ignoreeof* in you *.login* file then this will not work and you must use *logout* to log off the UNIX system (2.8).

.logout — When you log off of UNIX the shell will execute commands from the file *.logout* in your *home* directory after it prints ‘logout’.

lpr — The command *lpr* is the line printer daemon. The standard input of *lpr* spooled and printed on the UNIX line printer. You can also give *lpr* a list of filenames as arguments to be printed. It is most common to use *lpr* as the last component of a *pipeline* (2.3).

ls — The *ls* (list files) command is one of the most commonly used UNIX commands. With no argument filenames it prints the names of the files in the current directory. It has a number of useful *flag* arguments, and can also be given the names of directories as arguments, in which case it lists the names of the files in these directories (1.2).

mail — The *mail* program is used to send and receive messages from other UNIX users (1.1, 2.1), whether they are logged on or not.

make — The *make* command is used to maintain one or more related files and to organize functions to be performed on these files. In many ways *make* is easier to use, and more helpful than shell command scripts (3.2).

makefile — The file containing commands for *make* is called *makefile* or *Makefile* (3.2).

manual — The *manual* often referred to is the ‘UNIX manual’. It contains 8 numbered sections with a description of each UNIX program (section 1), system call (section 2), subroutine (section 3), device (section 4), special data structure (section 5), game (section 6), miscellaneous item (section 7) and system administration program (section 8). There are also supplementary documents (tutorials and reference guides) for individual programs which require explanation in more detail. An online version of the *manual* is accessible through the *man* command. Its documentation can be obtained online via

```
man man
```

If you can’t decide what manual page to look in, try the *apropos*(1) command. The supplementary documents are in subdirectories of /usr/doc.

metacharacter — Many characters which are neither letters nor digits have special meaning either to the shell or to UNIX. These characters are called *metacharacters*. If it is necessary to place these characters in arguments to commands without them having their special meaning then they must be *quoted*. An example of a *metacharacter* is the character ‘>’ which is used to indicate placement of output into a file. For the purposes of the *history* mechanism, most unquoted *metacharacters* form separate words (1.4). The appendix to this user’s manual lists the *metacharacters* in groups by their function.

mkdir — The *mkdir* command is used to create a new directory.

modifier — Substitutions with the *history* mechanism, keyed by the character ‘!’ or of variables using the metacharacter ‘$’, are often subjected to modifications, indicated by placing the character ‘:’ after the substitution and following this with the *modifier* itself. The *command substitution* mechanism can also be used to perform modification in a similar way, but this notation is less clear (3.6).

more — The program *more* writes a file on your terminal allowing you to control how much text is displayed at a time. *More* can move through the file screenful by screenful, line by line, search forward for a string, or start again at the beginning of the file. It is generally the easiest way of viewing a file (1.8).

noclobber — The shell has a variable *noclobber* which may be set in the file *.login* to prevent accidental destruction of files by the ‘>’ output redirection metasyntax of the shell (2.2, 2.5).

noglob — The shell variable *noglob* is set to suppress the *filename expansion* of arguments containing the metacharacters ‘~’, ‘*’, ‘?’, ‘[’ and ‘]’ (3.6).

notify — The *notify* command tells the shell to report on the termination of a specific *background job* at the exact time it occurs as opposed to waiting until just before the next prompt to report the termination. The *notify* variable, if set, causes the shell to always report the termination of *background* jobs exactly when they occur (2.6).

onintr — The *onintr* command is built into the shell and is used to control the action of a shell command script when an *interrupt* signal is received (3.9).

output — Many commands in UNIX result in some lines of text which are called their *output.* This *output* is usually placed on what is known as the *standard output* which is normally connected to the user's terminal. The shell has a syntax using the metacharacter '>' for redirecting the *standard output* of a command to a file (1.3). Using the *pipe* mechanism and the metacharacter '|' it is also possible for the *standard output* of one command to become the *standard input* of another command (1.5). Certain commands such as the line printer daemon *p* do not place their results on the *standard output* but rather in more useful places such as on the line printer (2.3). Similarly the *write* command places its output on another user's terminal rather than its *standard output* (2.3). Commands also have a *diagnostic output* where they write their error messages. Normally these go to the terminal even if the *standard output* has been sent to a file or another command, but it is possible to direct error diagnostics along with *standard output* using a special metanotation (2.5).

path — The shell has a variable *path* which gives the names of the directories in which it searches for the commands which it is given. It always checks first to see if the command it is given is built into the shell. If it is, then it need not search for the command as it can do it internally. If the command is not builtin, then the shell searches for a file with the name given in each of the directories in the *path* variable, left to right. Since the normal definition of the *path* variable is

```
path   (. /usr/ucb /bin /usr/bin)
```

the shell normally looks in the current directory, and then in the standard system directories '/usr/ucb', '/bin' and '/usr/bin' for the named command (2.2). If the command cannot be found the shell will print an error diagnostic. Scripts of shell commands will be executed using another shell to interpret them if they have 'execute' permission set. This is normally true because a command of the form

```
chmod 755 script
```

was executed to turn this execute permission on (3.3). If you add new commands to a directory in the *path*, you should issue the command *rehash* (2.2).

pathname — A list of names, separated by '/' characters, forms a *pathname.* Each *component,* between successive '/' characters, names a directory in which the next *component* file resides. *Pathnames* which begin with the character '/' are interpreted relative to the *root* directory in the filesystem. Other *pathnames* are interpreted relative to the current directory as reported by *pwd.* The last component of a *pathname* may name a directory, but usually names a file.

pipeline — A group of commands which are connected together, the *standard output* of each connected to the *standard input* of the next, is called a *pipeline.* The *pipe* mechanism used to connect these commands is indicated by the shell metacharacter '|' (1.5, 2.3).

popd — The *popd* command changes the shell's *working directory* to the directory you most recently left using the *pushd* command. It returns to the directory without having to type its name, forgetting the name of the current *working directory* before doing so (2.7).

port — The part of a computer system to which each terminal is connected is called a *port*. Usually the system has a fixed number of *ports*, some of which are connected to telephone lines for dial-up access, and some of which are permanently wired directly to specific terminals.

pr — The *pr* command is used to prepare listings of the contents of files with headers giving the name of the file and the date and time at which the file was last modified (2.3).

printenv — The *printenv* command is used to print the current setting of variables in the environment (2.8).

process — An instance of a running program is called a *process* (2.6). UNIX assigns each *process* a unique number when it is started – called the *process number*. *Process numbers* can be used to stop individual *processes* using the *kill* or *stop* commands when the *processes* are part of a detached *background* job.

program — Usually synonymous with *command*; a binary file or shell command script which performs a useful function is often called a *program*.

prompt — Many programs will print a *prompt* on the terminal when they expect input. Thus the editor 'ex (1)' will print a ':' when it expects input. The shell *prompts* for input with '% ' and occasionally with '? ' when reading commands from the terminal (1.1). The shell has a variable *prompt* which may be set to a different value to change the shell's main *prompt*. This is mostly used when debugging the shell (2.8).

pushd — The *pushd* command, which means 'push directory', changes the shell's *working directory* and also remembers the current *working directory* before the change is made, allowing you to return to the same directory via the *popd* command later without retyping its name (2.7).

ps — The *ps* command is used to show the processes you are currently running. Each process is shown with its unique process number, an indication of the terminal name it is attached to, an indication of the state of the process (whether it is running, stopped, awaiting some event (sleeping), and whether it is swapped out), and the amount of CPU time it has used so far. The command is identified by printing some of the words used when it was invoked (2.6). Shells, such as the *csh* you use to run the *ps* command, are not normally shown in the output.

pwd — The *pwd* command prints the full *pathname* of the current *working directory*. The *dirs* builtin command is usually a better and faster choice.

quit — The *quit* signal, generated by a control-\, is used to terminate programs which are behaving unreasonably. It normally produces a core image file (1.8).

quotation — The process by which metacharacters are prevented their special meaning, usually by using the character '´ in pairs, or by using the character '\', is referred to as *quotation* (1.7).

redirection — The routing of input or output from or to a file is known as *redirection* of input or output (1.3).

rehash — The *rehash* command tells the shell to rebuild its internal table of which commands are found in which directories in your *path*. This is necessary when a new program is installed in one of these directories (2.8).

relative pathname — A *pathname* which does not begin with a '/' is called a *relative pathname* since it is interpreted *relative* to the current *working directory*. The first *component* of such a *pathname* refers to some file or directory in the *working directory*, and subsequent *components* between '/' characters refer to directories below the *working directory*. *Pathnames* that are not *relative* are called *absolute pathnames* (1.6).

repeat — The *repeat* command iterates another command a specified number of times.

root — The directory that is at the top of the entire directory structure is called the *root* directory since it is the 'root' of the entire tree structure of directories. The name used in *pathnames* to indicate the *root* is '/'. *Pathnames* starting with '/' are said to be *absolute* since they start at the *root* directory. *Root* is also used as the part of a *pathname* that is left after removing the *extension*. See *filename* for a further explanation (1.6).

RUBOUT — The RUBOUT or DELETE key is often used to erase the previously typed character; some users prefer the BACKSPACE for this purpose. On older versions of UNIX this key served as the INTR character.

scratch file — Files whose names begin with a ‘#’ are referred to as *scratch files*, since they are automatically removed by the system after a couple of days of non-use, or more frequently if disk space becomes tight (1.3).

script — Sequences of shell commands placed in a file are called shell command *scripts*. It is often possible to perform simple tasks using these *scripts* without writing a program in a language such as C, by using the shell to selectively run other programs (3.3, 3.10).

set — The builtin *set* command is used to assign new values to shell variables and to show the values of the current variables. Many shell variables have special meaning to the shell itself. Thus by using the *set* command the behavior of the shell can be affected (2.1).

setenv — Variables in the environment ‘environ (5)’ can be changed by using the *setenv* builtin command (2.8). The *printenv* command can be used to print the value of the variables in the environment.

shell — A *shell* is a command language interpreter. It is possible to write and run your own *shell*, as *shells* are no different than any other programs as far as the system is concerned. This manual deals with the details of one particular *shell*, called *csh.*

shell script — See *script* (3.3, 3.10).

signal — A *signal* in UNIX is a short message that is sent to a running program which causes something to happen to that process. *Signals* are sent either by typing special *control* characters on the keyboard or by using the *kill* or *stop* commands (1.8, 2.6).

sort — The *sort* program sorts a sequence of lines in ways that can be controlled by argument *flags* (1.5).

source — The *source* command causes the shell to read commands from a specified file. It is most useful for reading files such as *.cshrc* after changing them (2.8).

special character — See *metacharacters* and the appendix to this manual.

standard — We refer often to the *standard input* and *standard output* of commands. See *input* and *output* (1.3, 3.8).

status — A command normally returns a *status* when it finishes. By convention a *status* of zero indicates that the command succeeded. Commands may return non-zero *status* to indicate that some abnormal event has occurred. The shell variable *status* is set to the *status* returned by the last command. It is most useful in shell commmand scripts (3.6).

stop — The *stop* command causes a *background* job to become *suspended* (2.6).

string — A sequential group of characters taken together is called a *string*. *Strings* can contain any printable characters (2.2).

stty — The *stty* program changes certain parameters inside UNIX which determine how your terminal is handled. See ‘stty (1)’ for a complete description (2.6).

substitution — The shell implements a number of *substitutions* where sequences indicated by metacharacters are replaced by other sequences. Notable examples of this are history *substitution* keyed by the metacharacter ‘!’ and variable *substitution* indicated by ‘$’. We also refer to *substitutions* as *expansions* (3.4).

suspended — A job becomes *suspended* after a STOP signal is sent to it, either by typing a *control*-z at the terminal (for *foreground* jobs) or by using the *stop* command (for *background* jobs). When *suspended*, a job temporarily stops running until it is restarted by either the *fg* or *bg* command (2.6).

switch — The *switch* command of the shell allows the shell to select one of a number of sequences of commands based on an argument string. It is similar to the *switch* statement in the language C (3.7).

termination — When a command which is being executed finishes we say it undergoes *termination* or *terminates.* Commands normally terminate when they read an *end-of-file* from their *standard input*. It is also possible to terminate commands by sending them an *interrupt* or *quit* signal (1.8). The *kill* program terminates specified jobs (2.6).

then — The *then* command is part of the shell's 'if-then-else-endif' control construct used in command scripts (3.6).

time — The *time* command can be used to measure the amount of CPU and real time consumed by a specified command as well as the amount of disk i/o, memory utilized, and number of page faults and swaps taken by the command (2.1, 2.8).

tset — The *tset* program is used to set standard erase and kill characters and to tell the system what kind of terminal you are using. It is often invoked in a *.login* file (2.1).

tty — The word *tty* is a historical abbreviation for 'teletype' which is frequently used in UNIX to indicate the *port* to which a given terminal is connected. The *tty* command will print the name of the *tty* or *port* to which your terminal is presently connected.

unalias — The *unalias* command removes aliases (2.8).

UNIX — UNIX is an operating system on which *csh* runs. UNIX provides facilities which allow *csh* to invoke other programs such as editors and text formatters which you may wish to use.

unset — The *unset* command removes the definitions of shell variables (2.2, 2.8).

variable expansion — See *variables* and *expansion* (2.2, 3.4).

variables — *Variables* in *csh* hold one or more strings as value. The most common use of *variables* is in controlling the behavior of the shell. See *path*, *noclobber*, and *ignoreeof* for examples. *Variables* such as *argv* are also used in writing shell programs (shell command scripts) (2.2).

verbose — The *verbose* shell variable can be set to cause commands to be echoed after they are history expanded. This is often useful in debugging shell scripts. The *verbose* variable is set by the shell's *–v* command line option (3.10).

wc — The *wc* program calculates the number of characters, words, and lines in the files whose names are given as arguments (2.6).

while — The *while* builtin control construct is used in shell command scripts (3.7).

word — A sequence of characters which forms an argument to a command is called a *word*. Many characters which are neither letters, digits, '–', '.' nor '/' form *words* all by themselves even if they are not surrounded by blanks. Any sequence of characters may be made into a *word* by surrounding it with '´' characters except for the characters '´' and '!' which require special treatment (1.1). This process of placing special characters in *words* without their special meaning is called *quoting*.

working directory — At any given time you are in one particular directory, called your *working directory*. This directory's name is printed by the *pwd* command and the files listed by *ls* are the ones in this directory. You can change *working directories* using *chdir*.

write — The *write* command is an obsolete way of communicating with other users who are logged in to UNIX (you have to take turns typing). If you are both using display terminals, use *talk*(1), which is much more pleasant.