Bash Shell Basics

This is a concise refresher on the basic commands available with the Bash shell. It is designed as a prerequisite module to the Supercomputing User Training offered by **Pawsey Supercomputing Research Centre**, Perth (Australia).
You can access this reference document both as a web page and as a PDF document.
For a more detailed tutorial on the Bash shell, see The Unix Shell by the Software Carpentries.

Outline

Concepts

- **Command Line Interface** (CLI): a type of interface to use a computer, that requires the user to type textual **commands** and read their textual outputs by means of a prompt. Some commands may require optional or mandatory **arguments**.
- **Shell**: a program with a prompt providing a command line interface, and an interpreter to execute commands. There are different implementations of a shell, using different **shell languages** for the commands.
- **Bash**: one of the most popular shell languages in the Linux world.
- **Shell script**: a text file containing a sequence of shell commands. It can be executed via the shell, and is useful to increase reproducibility of a workflow.
- Main advantages of using a shell:
  - Productivity (lots of actions with few keystrokes)
  - Task automation
  - Reproducibility (using shell scripts)
- **Text editor**: a program used to open and edit textual files; some of them are designed for use within a command line interface, such as **nano**, **vi** and **emacs**.

NOTE: in all the examples below, commands are identified by lines starting with $, which

represents the prompt (not to be typed). Other lines represent command outputs. Also note how # denotes a comment line in Bash.

Hands-on

Handling directories

First, navigate to the home directory using `cd`; here, ~ refers to the home, and can be omitted if used alone:

```
$ cd ~
$ # or also
$ cd
```

Check the path of the **current working directory** with `pwd`:

```
$ pwd
/home/username
```

Create a new directory with `mkdir`:

```
$ mkdir training
```

Enter it, and check where you are:

```
$ cd training
$ pwd
/home/username/training
```

The current directory can be referred to using a single dot, `.`:

```
$ cd .
$ pwd
/home/username/training
```

The **parent directory** can be referred to using a double dot, `..`:

```
$ cd ..
$ pwd
/home/username
$ cd training
```

Create two more directories inside `training`, create one more into the first one of these, and then access the first one:

```
$ mkdir dir1 dir2
$ mkdir dir1/one-more-dir
$ cd dir1
```

A **full path** does not depend on the current working directory, and starts with a slash, `/`, *e.g.*: `/home/username/training`.
A **relative path** depends on the current working directory, and starts with a directory name, a `.` or a `..`, *e.g.*: `one-more-dir`, `./one-more-dir`, `../dir2`.

Go back to the `training` parent directory:

```
$ cd ..
$ pwd
/home/username/training
```

Handling files

Now let us play with files. Make new empty files using `touch`:

```
$ touch file1
$ touch file2 file3
$ touch dir1/file4
```

The command is actually designed for altering timestamps of existing files; however it will create an empty file, if the provided filename does not match an existing one.

Check the content of a directory with `ls`:

```
$ ls
dir1  dir2  file1  file2  file3
$ ls dir1
file4  one-more-dir
```

Get more details about files and directories with `ls -l`:

```
$ ls -l
total 8
drwxr-x--- 3 username username 4096 Aug 26 14:10 dir1
drwxr-x--- 2 username username 4096 Aug 26 14:10 dir2
-rw-r----- 1 username username    0 Aug 26 14:10 file1
-rw-r----- 1 username username    0 Aug 26 14:10 file2
-rw-r----- 1 username username    0 Aug 26 14:10 file3
```

To make a copy of a file with another name use `cp`:

```
$ cp file1 copy1
```

To copy a directory use `cp -r`:

```
$ cp -r dir1 copydir1
```

To rename a file use `mv`:

```
$ mv copy1 another-file
```

To move a file to another directory use `mv` again, but now with the second argument as an existing directory:

```
$ mv another-file dir2/
```

Use `rm` to remove a file:

```
$ rm file3
```

Use `rm -r` to remove a directory:

```
$ rm -r copydir1
```

Multiple files and/or directories can be selected using the **wildcard** characters ? and *. The question mark, ?, means any value of a single character:

```
$ ls file?
file1  file2
```

The asterisk, *, means any value of any number of characters:

```
$ ls f*
file1  file2
```

When the * also includes directories, `ls` will output their content, too:

```
$ ls *
file1  file2

dir1:
file4  one-more-dir

dir2:
another-file
```

Using environment variables

You can assign a **value**, *i.e.* a string of characters, to a named environment **variable**. We call **shell environment** the whole set of variables defined in the current shell session. Variables are typically lost when the current shell session is closed.
Assign a variable using the assignment operator, =:

```
$ HELLO="world"
```

The value can be reused later in the same shell session by referring to the corresponding variable name, prefixed by a dollar, `$`. For instance, use `echo` to display the variable value:

```
$ echo $HELLO
world
```

To make the variable accessible inside sub-processes, you need to `export` it:

```
$ export BYE="moon"
```

A sub-process could be a program, a shell script, or just another Bash shell. Let us verify the latter case. Start a new Bash shell with `bash`, and then `exit` it when done:

```
$ bash
$ echo $HELLO

$ echo $BYE
moon
$ exit
exit
```

You can use a variable to store a directory path:

```
$ pwd
/home/username/training
$ MYDIR="/home/username/training"
```

And then use it:

```
$ echo $MYDIR
/home/username/training
$ ls $MYDIR
dir1  dir2  file1  file2
```

There is a method to store the output of a command inside the variable: encapsulating the command within the syntax `$( )`. For instance, use such syntax to capture and store the output of `pwd`:

```
$ MYDIR_AGAIN="$(pwd)"
$ echo $MYDIR_AGAIN
/home/username/training
```

Every shell session automatically defines a number of environment variables, some of which can be quite useful. Among others, `$HOME` contains the path to your home directory, `$USER` contains your username, and `$PATH` has the list of paths where the shell looks for executable programs and scripts:

```
$ echo $HOME
/home/username
$ echo $USER
username
$ echo $PATH
/usr/local/bin:/usr/bin:/bin
```

Editing and visualising text files

Let us now use the text editor `nano` to create, edit and save a text file. First, start the editor with a new empty text filw called `text`:

```
$ nano text
```

Now, type the following in the editor:

```
Line 1
Fancy line 2
Super line 3
Extra line 4
Last line 5
```

To save this text, press `Ctrl-O` (`Control` + `O`), then confirm with `Enter`. To exit the editor, press `Ctrl-X`.

Visualise the full contents of the file from the shell using `cat`:

```
$ cat text
Line 1
Fancy line 2
Super line 3
Extra line 4
Last line 5
```

For long files, the command `less` allows showing the contents one screen at a time. The next screen can be accessed using `Space` or `Ctrl-F` (forward), the previous screen using `Ctrl-B` (backwards). Quit the `less` screen with `q`. You can trial this with the file you just created, although the output will most likely fit in a single screen:

```
$ less text
Line 1
Fancy line 2
Super line 3
Extra line 4
Last line 5
text lines 1-5/5 (END)
$ # quit by typing `q`
```

Use `head`/`tail` to visualise the first/last lines of a file. By default 10 lines are displayed, but a custom number can be specified using a specific command option:

```
$ head -1 text
Line 1
$ tail -1 text
Last line 5
```

Manipulating outputs and text files

Use `wc` to get the line, word and character count of a text:

```
$ wc text
 5 14 58 text
```

You can see that the `text` file has 5 lines, 14 words and 58 characters (including newlines).

Use `grep` to filter text lines matching a specific string pattern. Search for the string `Super` in the text file created above:

```
$ grep Super text
Super line 3
```

Commands can be connected together to feed the output of a command as the input for the following command. To connect commands use the **pipe operator**, `|`:

```
$ echo "Hello world from Pawsey." | wc
      1       4      25
```

Redirection operators can be used to connect a file with the output or input of a

command.

Use > to redirect a command output into a file (file will be overwritten):

```
$ echo "Hello world from Pawsey." >hello
$ cat hello
Hello world from Pawsey.
$ echo "Hello again." >hello
$ cat hello
Hello again.
```

Use >> to append a command output into a file (file will not be overwritten):

```
$ echo "Bye bye from Pawsey." >>bye
$ echo "Bye bye again." >>bye
$ cat bye
Bye bye from Pawsey.
Bye bye again.
```

Use < to feed the contents of a file as command input:

```
$ wc < bye
 2  7 36
```

Other useful commands for file and output manipulations include `cut`, `tr`, `sort`, `sed` and `awk`.

More commands

Use `hostname` to output the name of the computer/server where the shell session is open:

```
$ hostname
setonix-01
```

Use `which` to get the full path of a program:

```
$ which grep
/usr/bin/grep
```

Some commands are not programs (see next command to know more):

```
$ which cd
which: no cd in (/usr/local/bin:/usr/bin:/bin)
```

Use `type` to get information about the typology of command:

```
$ type grep
grep is /usr/bin/grep
$ type cd
cd is a shell builtin
```

Sometimes it is useful to group together a set of files and/or directories within a single archive file, which is typically called tarball and assigned the extension `.tar`. The `tar` program is used to this end.
Create a tarball containing all files and/or directories (with their contents) whose name starts with `file` or `dir`:

```
$ tar cf archive1.tar file* dir*
```

Visualise its contents:

```
$ tar tf archive.tar
file1
file2
dir1/
dir1/one-more-dir/
dir1/file4
dir2/
dir2/another-file
```

Now create a directory `expand`, enter it, unpack the tarball there, and check the directory contents:

```
$ mkdir expand
$ cd expand
$ tar xf ../archive1.tar
$ ls
dir1  dir2  file1  file2
cd ..
```

If you also want to compress the tarball to reduce its size, add the option `z` to the commands above, and use the conventional extension `.tar.gz` (or `.tgz`):

```
$ tar czf archive2.tar.gz file* dir*
$ ls -l archive*
-rw-r----- 1 username username 20480 Aug 26 15:59 archive1.tar
-rw-r----- 1 username username   581 Aug 26 16:03 archive2.tar.gz
```

The latter tarball takes 581 bytes instead of 20480. Note that compression rates may vary significantly depending on the file contents.

Other useful Bash syntax constructs include `for`/`while` loops and `if`/`elif`/`else` conditionals.

Keyboard tricks

Use `Up-arrow` and `Down-arrow` to browse the shell history of commands:

```
$ # hit Up-arrow once
$ ls -l archive*
$ # hit Up-arrow again
$ tar czf archive2.tar.gz file* dir*
$ # hit Down-arrow once
$ ls -l archive*
```

Note you will need to hit `Enter` to actually execute the selected command, as usual.

`Tab`-completion is a handy feature that can reduce typing and make shell usage more convenient. Start typing a command, then hit `Tab` to see available commands whose name start with the typed characters:

```
$ # type without hitting Enter
$ ho
$ # hit Tab
$ host
$ # hit Tab twice
host         hostid       hostname     hostnamectl
$ # type "n"
$ hostn
$ # hit Tab again
$ hostname
```

Again, to execute the selected command hit `Enter`, after eventually having edited it or added more arguments.

You can also use `Tab`-completion with file names:

```
$ # type without hitting Enter
$ ls ar
$ # hit Tab
$ ls archive
$ # hit Tab twice
archive1.tar     archive2.tar.gz
$ # type "1"
$ ls archive1
$ # hit Tab again
$ ls archive1.tar
```

If you need to stop what you are typing, or a running program, and get back to an empty shell within the same session, use `Ctrl-C`:

```
$ # type without hitting Enter
$ hostname
$ # hit Ctrl-C
$ hostname^C
$
```

This is all for this Bash shell refresher. You can close the shell session with `exit`!

Glossary

Command	Functionality
`~`	alias for *home* directory
`cd`	**c**hange **d**irectory
`pwd`	**p**rint **w**orking (current) **d**irectory
`mkdir`	**m**a**k**e (create) **dir**ectory
`.`	alias for current directory
`..`	alias for *parent* directory
`touch`	create empty file (or update file timestamp)
`ls`	**l**i**s**t contents
`cp`	**c**o**p**y file
`cp -r`	**c**o**p**y **r**ecursively (directory)
`mv`	**m**o**v**e / rename file or directory
`rm`	**r**e**m**ove (delete) file
`rm -r`	**r**e**m**ove **r**ecursively (directory)
`?`	wildcard for any value of a single character
`*`	wildcard for any value of any number of characters
`=`	assignment operator for variables
`echo`	output text string (including variables)
`export`	**export** variable to sub- (child) processes
`$( )`	syntax to capture output of a command
`cat`	visualise whole contents of a file
`less`	visualise contents of a file, one screent at a time
`head`	visualise first lines of a file

`tail`	visualise last lines of a file
`wc`	**w**ord **c**ount (files or strings)
`grep`	**G**nu **rep**ort: filter text lines matching a string pattern
`|`	pipe operator: connect command output to input of next command
`>`	redirect operator, overwrite: send command output to file
`>>`	redirect operator, append: send command output to file
`<`	redirector operator, input: get command input from file
`hostname`	display **name** of **host** computer
`which`	display full path of program
`type`	display infor on typology of command
`tar`	manage **t**ape **ar**chives (file archives)
`Up-arrow`	navigate shell history backwards
`Down-arrow`	navigate shell history forward
`Tab`-completion	get shell to auto-complete commands and file names
`Ctrl-C`	abort typing or stop program