Effective Programming Practices for Economists

3. Introduction to the Shell

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Introducing the Shell

- What is the shell and what does it do?
- Why you want to use the shell
- When you want to use the shell

What and why

- At a high level, computers do four things
  - run programs
  - store data
  - communicate with each other
  - interact with us

What and why

- Serious Graphical User Interfaces (GUIs) weren't available until the 1990s
- Before then, interaction took place via a Command Line Interface (CLI)
- CLIs are REPLs

CLIs are REPLs

- REPL means *read-evaluate-print-loop*
- Type a command $\rightarrow$ press enter (or return) $\rightarrow$ computer reads it $\rightarrow$ executes it $\rightarrow$ prints its output
- Although it may seem as if the user talked to the computer directly, there is a program inbetween called the *command shell*

Command Shell

- It's a program like any other
- Figures out what to run given what the user inputs
- Effectively a program to run other programs
- The most popular Unix shell is bash (**B**ourne **A**gain **SH**ell)

Command Shell

- The shell allows us to combine existing tools in powerful ways with only a few keystrokes and to set up pipelines to handle large volumes of data automatically
- The command line is often the easiest way to interact with remote machines
- As clusters and cloud computing become more popular for scientific data crunching, being able to drive them is becoming a necessary skill
- Useful for teaching/learning: Much clearer what happens in which order relative to point-and-click.

Files and Directories

- We want to:
  - Explain the similarities and differences between a file and a directory
  - Translate an absolute path into a relative path and vice versa
  - Construct absolute and relative paths that identify specific files and directories
  - Explain the steps in the shell's read-run-print cycle
  - Identify the actual command, flags, and filenames in a command-line call

Files and Directories

- The part of the Operating System that handles files and directories is called the filesystem
- We differentiate between files which hold information and directories (or folders) which hold files
- The structure of the filesystems on Windows and Linux / OS X differ considerably (the latter two as well, but not for what we will need)
- We will focus on the OS X Shell for now but later mention some (of the many) differences
- Several commands are frequently used to interact with these structures

Basic Bash

The dollar sign stands for a prompt waiting for input

```
$
```

Type `whoami` and press Enter to see how the current user is named

```
$ whoami
hmg
```

Basic Bash

- When we type `whoami` the shell finds the program
- The program is run
- The output of the program is shown
- A new prompt is displayed, indicating that it's ready for new commands

Basic Bash

If we want to know where we are we can type `pwd` (print working directory) which yields

```
$ pwd

/Users/me
```

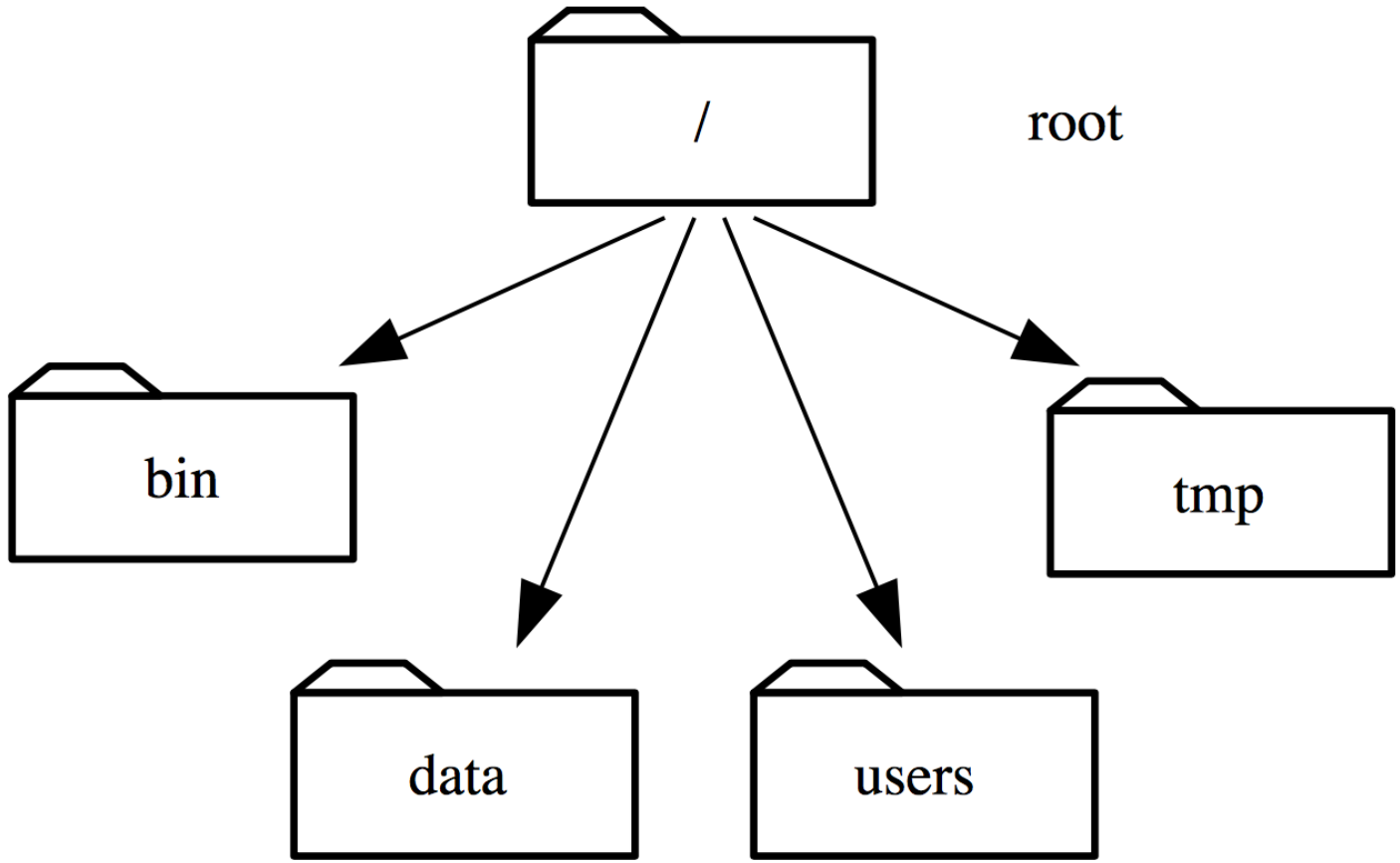
In this case, we are in our home directory.

Directory structure

- To understand what our home directory is, let's look at directory structure
- It is organized as a tree with the root directory called `/` at the very top
- Everything else is contained in it
- `/` refers to the leading slash in `/Users/me`

Directory structure

On OS X systems

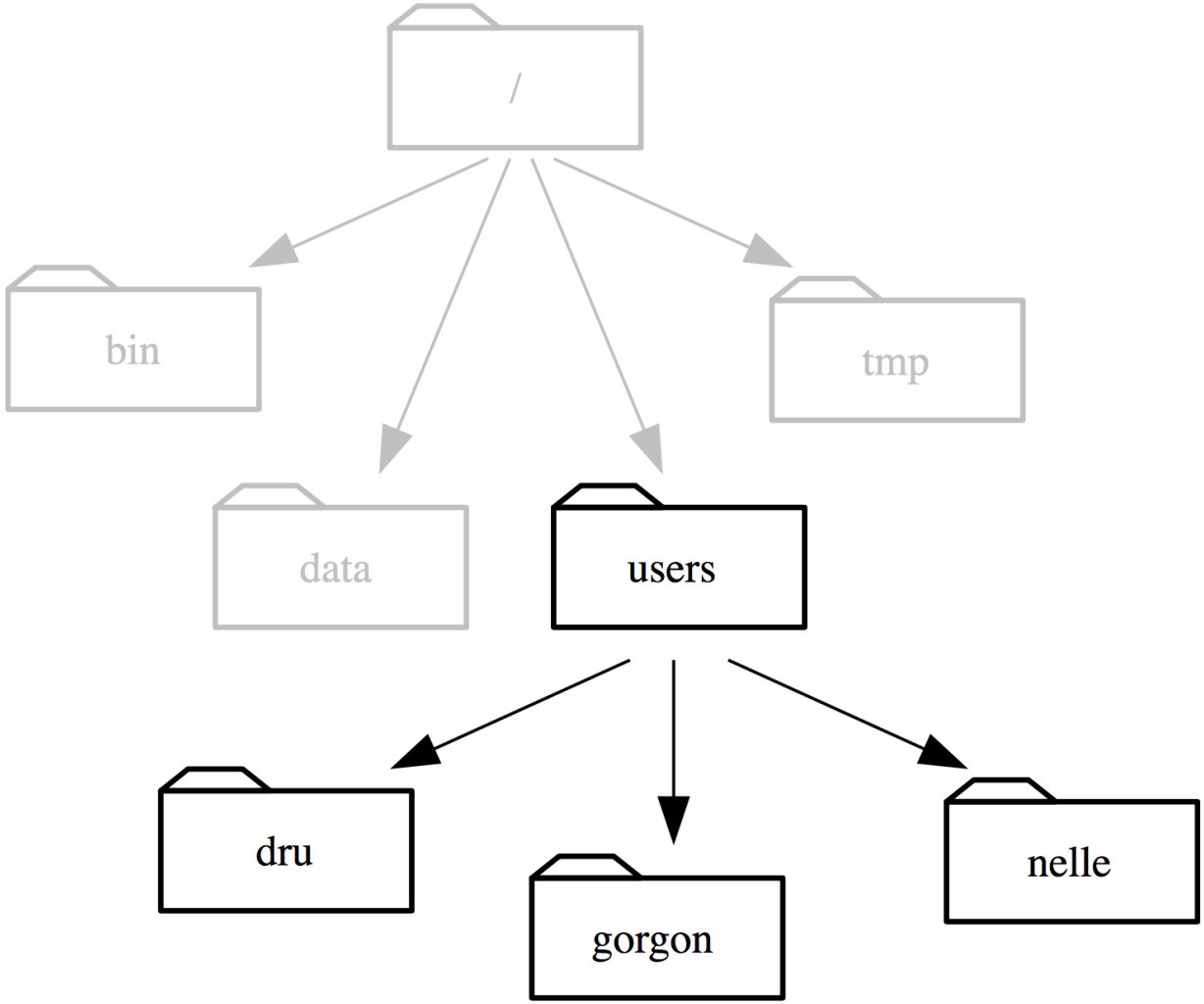


Directory structure

- Underneath `/Users` the data of the other user accounts on the machine is stored
- E.g. `/Users/another-user-on-this-machine`
- We know, that if our current folder is `/Users/me`, we are inside `/Users` because of the first part of its name. Similarly `/Users` resides in the root `/`

Directory structure

inside the `Users` folder



Directory structure

Let's see what happens when we run `ls` inside our home folder (on OS X)

```
$ ls

Applications  Desktop  bin  Documents  Library  Projects
Downloads  Music  anaconda3
```

Important commands in the shell

- There are a couple important commands that are important for manipulating items in the shell and moving around
- We will look at some of the most important ones like `cd`, `ls`, `rm`, `mv`, `cat`, `less`, `grep`, `nano`

cd

Lets first look at `cd` which allows us to change directories

```
$ pwd

/Users/me

$ ls

Desktop  Documents  Downloads ...

$ cd Documents && ls

important_doc_1  important_doc_2  important_doc_3 ...

$ pwd

/Users/me/Documents

$ cd ..

$ pwd

/Users/me
```

cd

- `.` denotes our current working directory (output of `pwd`)
- `..` the directory one above in the tree structure

ls

As we have seen before `ls` shows us what's contained inside directories. We can use parameters to specify how `ls` should work

```
$ ls -F
```

Display a slash ('/') immediately after each pathname that is a directory, an asterisk ('*') after each that is executable

ls

- Often we want to use something like `ls -laF`. This will include files starting with a `.` (so called *dotfiles*, that often hold configuration) as well as showing a so called long list (including hidden files for example) and mark directories accordingly.

- We can also write `ls some-sub-directory/` to receive the contents of the sub directory

rm

We can use `rm` to remove files. We can write

```
$ rm somefile.txt
```

or

```
$ rm some-sub-folder/somefile.txt
```

to remove a file in a subfolder. We could also use `rm -r` (for recursive) to remove directories

```
$ rm -r some-directory/
```

cat & less

We can print out files into the shell using `cat` or view them using `less`. Simply supply the file as an

```
$ cat <somefile>
```

```
$ less <somefile>
```

man

For much about every shell command distributed with Linux / OS X so called man pages exist. They represent documentation or help files. To get regarding some command just enter

```
$ man <somecommand>
```

|, grep, head, tail

We can for example use `cat`, `|` (called pipe) and `grep` to filter output for matching text

```
$ cat <somefile> | grep <somesearchterm>
```

Use `head` or `tail` to display the beginning or end of some file. This can be helpful when viewing server logs or similar. Usage is similar just (optionally) supply `n` for the number of lines and a filename

```
$ head -n <somefile>
```

```
$ tail -100 some-log-file.log
```

Summary of elementary commands

command	name
`cd`	**c**hange **d**irectory
`ls`	**ls**t directory contents
`rm`	re**m**ove directory entries
`less`	opposite of more
`cat`	con**cat**enate and print files
`grep`	file pattern search, (**g**eneral **r**egular **e**xpression **print**)
`pipe`	Postfix delivery to external command
`tail`	display the last part of a file

Looking further

- With `|` and `grep` we can do some things that would require signifant effort without the shell
- `|` can chain two functions (commands) together. The output of the first command serves as input for the second one
- `grep` can look for patterns in files and serve as a great tool to search
- We can use `ls -la | grep '\.log$'` to see all log files in the current folder
- Or `cat some_log_file.log | grep -10 'error'` to see all the errors in a log file (with 10 lines of context)

Differences between operating systems

- Shells of most Unix derivatives (Linux, OS X) are fairly similar and the basic above mentioned tools are available
- The Windows shell differs considerably from this
  - On Windows we can utilize the so called Power Shell which resembles the Linux shell to some extent
  - For all Git related matters there exists a system independent Git bash for interacting with Git and not having to worry about shell issues
  - On Windows systems path names start with \ instead of /

Why work with a shell?

- Close interaction with the operation system and compilers/interpreters
- Automation using scripts (with bash or Python or both)
- Working with (remote) servers via ssh (all you get is a bash)
- Greater control and flexibility

When to use the shell

- “When not surfing the internet or doing email” –unknown
- The learning curve can be steep in the beginning
- Trade-off because simple things may take long in the beginning
- Essential in a programming context, over time basically all administrative tasks become less time intensive than using a GUI

Some simple recipes

- The following slides have some recipes for situations you may find yourself stuck in
- No need for an in-dept understanding of those commands

How to get out of vim

- Some commands (e.g. `git commit` without a message) will trigger a default editor if user input is required. This happens to be `vim` in most cases
- It is helpful to remember two things
  - If you just want to leave: Press '`Esc`', followed by '`:q`' (a colon followed by q for quit)
  - If you want to make changes to the opened file:
    1. Press '`i`' for insert mode and make your changes
    2. Press '`Esc`' followed by '`:wq`' (for write & quit)

Using Sublime as default text editor

Enter the following commands to make Sublime Text your default editor

```
$ export EDITOR='subl -w '

$ export TEXEDIT='subl'

$ alias subl="subl --new-window"
```

Those settings will only be active for the current session. If you want to make them persistent, you can copy those terms into your `.bash_profile` / `.bashrc` in your home directory

.bashrc and Git bash

- When using Git bash on Windows you can also use a `.bashrc` file
- Create a `.bashrc` file under `~/.bashrc`, where ~ denotes your home directory
- ~ is usually your `C:\Users\<your user name>` folder. Typing `echo ~` in the git bash terminal will tell you what that folder is

Acknowledgements

- This course is designed after and borrows a lot from the `Software Carpentry` course designed by `Greg Wilson` for scientists and engineers.

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