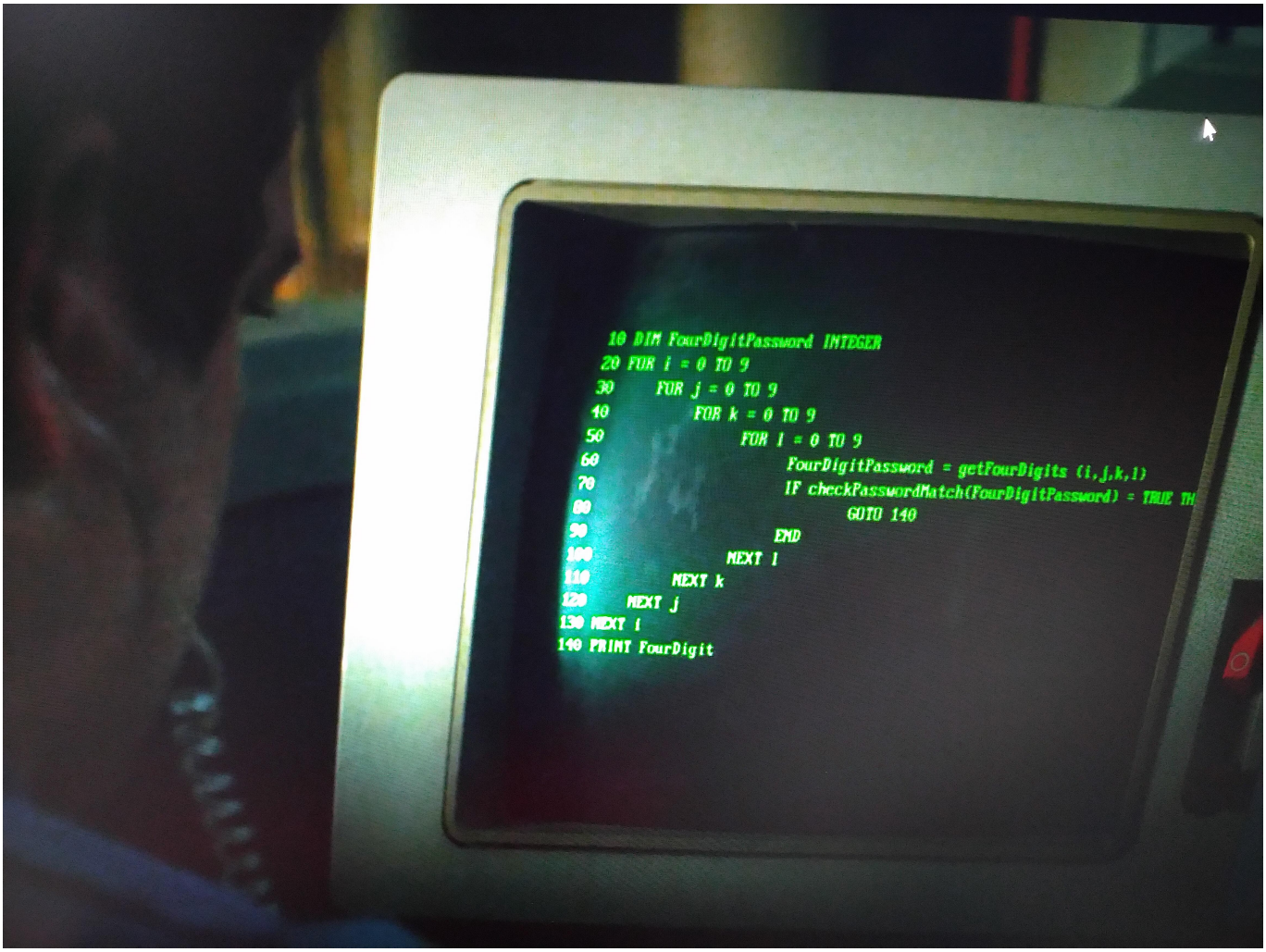
The Unix Shell




```
 _____________________________________
/ Welcome to the thrilling world of the \
\ Unix shell                            /
 -------------------------------------
        \   ^__^
         \  (@@)\_______
            (__)\       )\/\
                ||----w |
                ||     ||
```

```
$ cowsay "Welcome to the thrilling world of the Unix shell"
```

Overview

1. Shell, what/why?

2. Filesystem
3. The Unix Philosophy
4. Commands
5. Permissions
6. Streams & Pipelines
7. CLI Text Editors

Learning Objectives

- List some common UNIX CLI tools
- Solve some simple problems using CLI tools
- Describe the UNIX philosophy

Shells have been around almost since the dawn of computing.

ASCII Star Wars Episode IV:

```
telnet towel.blinkenlights.nl
```

Also, you can play Tetris online:

```
ssh netris.rocketnine.space
```

Run the demos for both of these, show them working to the group.

What is a shell?

A shell is a text-based interface with your operating system

A shell can do the same things your GUI environment does:

- Launch applications
- Open, edit and manage files and folders
- Send email
- Code
- Play Star Wars Episode IV

The Shell

- Bash is the default shell in most Unix OSs
- MacOS now uses Zsh (used to be bash)
- Windows has `cmd` and Powershell
- Windows can also run `git bash`, as well as `WSL`
- Others exist but are less common
- Shells come pre-installed with each and every OS

Next slide will show an image asking why we need a shell?

WSL: Windows Subsystem Linux

Reasons why you should use a shell

Installed everywhere: Desktops, servers, RPis... GUI environments are not

Lightweight: GUI environments have high resource demands (memory, CPU etc.)

Lower bandwidth: Uses much less than a GUI, hence are often the default when administering remote/cloud servers.

Concise and powerful: Designed for automation

Getting Around

Open your terminal and play along!

If users are on Windows, ask them to use either git bash or a dev container.

Simple commands

`pwd`: print the current directory

`ls`: list the files in the current directory

`cd`: change the current directory

`cat`: print the contents of a file

'cat' comes from the term 'concatenate'.

Quiz Time! 🤓

What is a shell?

1. A graphical-based interface within your operation system
2. A text-based interface stored on your hard drive
3. A desktop environment within your operating system
4. A text-based interface within your operating system
5. Commonly found on the beach

Answer: 4

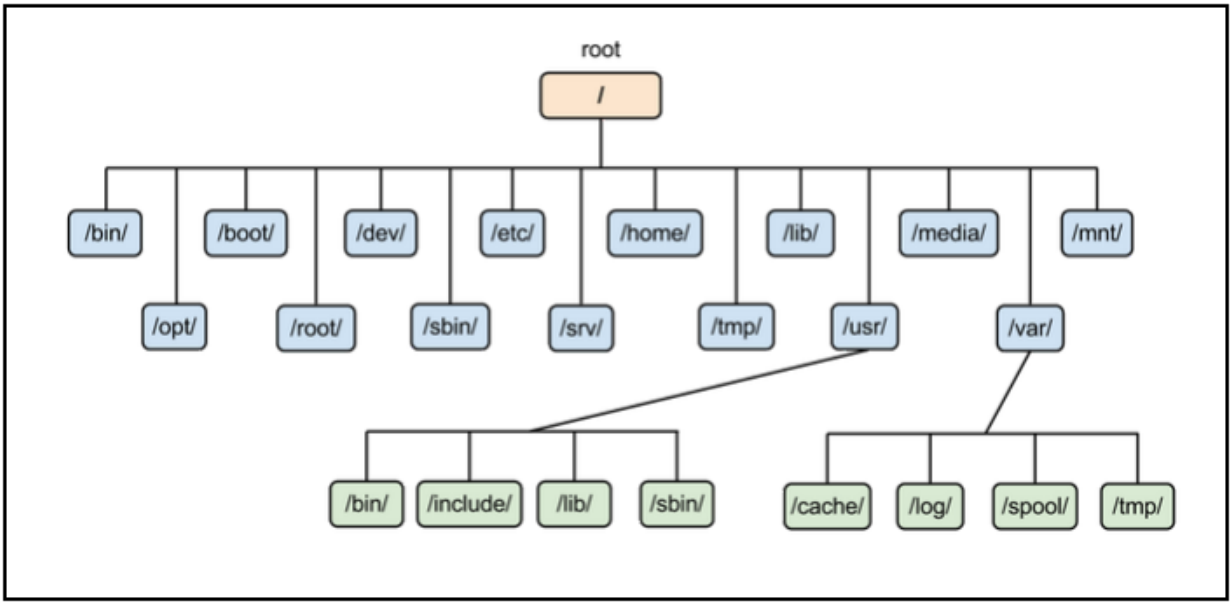
Filesystem Hierarchy

A filesystem is the system used by your OS to store and manage all of your files.

Filesystems are usually hierarchical.

In macOS and Linux, your filesystem is a tree and the top of the tree is known as the root directory, `/`.

Unix Filesystem



The filesystem has directories that often aren't needed to be accessed. Most of them have files pertaining to the system itself.

Key Directories

- `/`: your filesystem starts here
- `/home`: personal files
- `/etc`: system config files
- `/bin`: applications

Demonstrate where these are and how to access them with commands.

Paths

The location of a file in your computer is given by its path

Paths can be:

- Absolute: always start at the root directory, e.g. `/home/dennis/code/src/hello.txt`
- Relative: based on your current directory, e.g. (assuming I'm already at `/home/dennis`) `code/src/hello.txt`

Demonstrate.

Building Relative Paths

`.` current directory

`..` parent directory

You can chain them

```
$ pwd
/home/dennis/code
$ ls .
$ cd ./src
$ cat ./hello.txt.py
$ ls ../../Pictures/cats
```

Demonstrate.

Exercise

Launch a terminal, switch to the directory where your mini-project code is located and print the contents of a source code file to the screen

Answer: use cat.

The Unix philosophy

The Unix philosophy was created by the original developers of Unix and its associated tools.

It was documented and published in 1978, but is still very relevant to how we want to be developing software today!

The Unix philosophy

Make each program do one thing well. To do a new job, build afresh rather than complicate old programs by adding new "features".

The Unix philosophy

Expect the output of every program to become the input to another, as yet unknown, program.

Don't clutter output with extraneous information.

Avoid stringently columnar or binary input formats.

Don't insist on interactive input.

1. We will understand the first point more as we go through this module. 2. Keep outputted information minimal and relevant. 3. Best to allow input as text or accept a file. 4. If input isn't needed, don't ask for it.

The Unix philosophy

Design and build software, even operating systems, to be tried early, ideally within weeks.

Don't hesitate to throw away the clumsy parts and rebuild them.

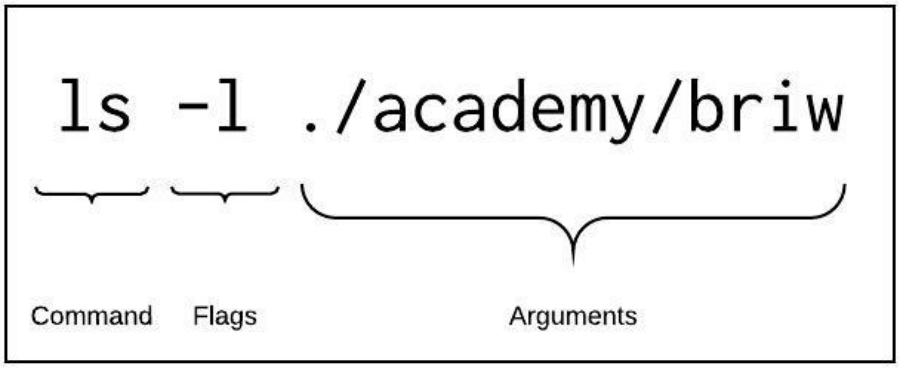
The Unix philosophy

Use tools in preference to unskilled help to lighten a programming task, even if you have to detour to build the tools and expect to throw some of them out after you've finished using them.

Basically, make use of what you've already got. Don't reinvent the wheel!

The Anatomy of a Shell Command

Shell commands can take any number of flags and arguments, or none at all



Example

```
$ ls -a -l /home/dennis/code
# Can be abbreviated as
$ ls -al /home/dennis/code
```

List the contents of the `/home/dennis/code` directory with details (-l), including hidden files (-a). Flags can be concatenated

Demonstrate.

Where are all the flags, man?

`man` will display the help page for a command

For example, to see the help page for the `ls` command we just looked at:

```
$ man ls
```

Demonstrate.

`man` Short for manual. RTM - Read the manual.

Quiz Time! 🤓

What does the `cd` command do?

1. Print out the contents of a file
2. Print the current file path
3. Change to a different directory
4. Print the contents of a folder

Answer: 3

Exercise

List your directory sorted by timestamp.

Remember to use the `man` page for the command to find out the arguments you need.

man = manual.

Filesystem Commands

`touch`: create an empty file

`mv`: move/rename a file or directory

`cp`: copy a file to a new location

`rm`: remove a file

`mkdir`: create a directory

Examples

```
$ mkdir folder-one
$ mkdir folder-two
$ mkdir backups
$ touch folder-one/hello.txt
$ mv folder-one/hello.txt folder-two
$ cp folder-two/hello.txt backups/

# Deletes a single file
$ rm folder-two/hello.txt

# Deletes an entire folder and all its sub-folders and files
$ rm -rf folder-two
```

More Useful Commands

`echo`: print some text to the screen

`history`: show list of previously run commands

`clear`: wipe the screen

`less`: show the contents of a file in a paginated way

`head`: display the first `n` lines of input

`tail`: display the last `n` lines of input

Exercise

In your shell, create a new "backups" directory and copy your entire mini-project directory (and files) into it

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Searching

Finding text

`grep`: search text in files

```
$ grep "hello" ./folder/*
```

A couple of useful flags are -i (case-insensitive) and -r (recursive)

```
$ grep -ri "hello" ./folder
```

Recursive : meaning repeating an action over and over, in this scenario, inside every directory execute the same search.

Finding files

`find`: search a file by name or other properties

```
$ find ./ -name "app.py"
# You can also use wildcards
$ find ./ -name "app*"
```

Finding programs

`whereis`: get the location of a program

```
$ whereis grep
```

Globbing

Globbing allows you to refer to many files without the hassle of typing out their paths in full

The question mark (`?`) matches any one character in a path

```
$ ls ./Pictures/longcat.jp?g
longcat.jpeg
```

The asterisk (`*`), a.k.a. wildcard, matches every letter in a path, or no letters

```
$ ls ./Pictures/longcat.jp*g
longcat.jpg longcat.jpeg
```

The above example shows matching of either a letter in `longcat.jpeg` or no letter in `longcat.jpg`.

```
$ ls ./Pictures/cats/*
longcat.jpg longcat.jpeg cat.jpg anothercat.png
```

Both wildcard characters can be put anywhere in a path

```
$ ls ./code/miniproject/*.py
app.py utils.py text.py

$ ls ./code/miniproject/app.*
app.py
```

Quiz Time! 🤓

What does `grep` do?

1. Searches for the location of a file
2. Searches text in files
3. Searches for files in a file system
4. Searches for the location of a folder

Answer: 2

Exercise

Create a sensible directory structure for your mini-project using the shell

Example:

```
miniproject
├── documentation
│   ├── overview.md
│   └── tea-types.md
├── README.md
├── source
│   ├── app.py
│   ├── beer.py
│   ├── coffee.py
│   └── tea.py
└── tests
    ├── app\_test.py
    └── tea\_test.py
```

This needs to be updated to reflect the new mini-project.

For courses using languages other than Python, mention that this is just an example.

Permissions

Unix-like systems allow you to control who has access to files in a computer and what they're allowed to do

- Users
- Groups
- Everyone

We can restrict a user's ability to read, write files or run programs

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For example if we ran the command `ls -la` we would see;

```
total 24
drwxrwxr-x.   3 jerry jerry  4096 Aug 24 17:29 .
drwxr-xr-x. 136 jerry jerry 12288 Aug 29 15:18 ..
drwxr-xr-x.   4 jerry devs   4096 Aug 19 14:43 academy-revealjs
-rw-r--r--.   1 jerry jerry    51 Aug 24 17:29 file.py
```

This is now showing us the parent folders `..` and showing us the permissions currently set on each file system object.

drwxrwxr-x - We can talk through the following

d - Indicated if the resource is a directory. rwx - In blocks of three, indicates the read/write/execute for a resource; 'file's owner', 'for the group to which the file belongs' & 'permissions for everyone else' `-` - indicated missing permission.

Setting permissions with chmod

```
$ chmod < target >< +/- >< action >
```

```
# Everyone can read
$ chmod a+r hello.txt
# Only the owner of the file can write
$ chmod u+w hello.txt
# Everyone (All) can no longer read
$ chmod a-r hello.txt
```

Targets:

- u: owner

- g: group
- a: all (everyone)

Access type:

- r: read
- w: write
- x: execute

Setting permissions the hard way

This is worth mentioning as you'll come across it many times in your career, so it's important to also understand how it works.

Permissions can be expressed numerically too, as three groups of octets (0-7), one per target.

Each octet represents the level of access given to the resource.

#	Permission	rwx	Binary
7	read, write, execute	rwx	111
6	read, write	rw-	110
5	read, execute	r-x	101
4	read only	r--	100
3	write, execute	-wx	011
2	write only	-w-	010
1	execute only	--x	001
0	none	---	000

Examples

All permissions for everyone

```
$ chmod 777 file.py
```

Owner can do anything, no-one else has access to file

```
$ chmod 700 file.py
```

Owner can read and write, group can read and no one else can access the file

```
$ chmod 640 file.py
```

Quiz Time! 🤓

I want to set the following permissions for `file.py` - owner/user can do everything, group can read and execute, everyone else can read only - which is the correct command?

1. `$ chmod 732 file.py`
2. `$ chmod 754 file.py`
3. `$ chmod 650 file.py`
4. `$ chmod 444 file.py`

Answer: 2

Quiz Time! 🤓

I want to set the following permissions for `file.py` - owner/user and group should be able to read and execute, everyone else has no permissions - which is the correct command?

1. `$ chmod 661 file.py`
2. `$ chmod 777 file.py`
3. `$ chmod 650 file.py`
4. `$ chmod 550 file.py`

Answer: 4

Regular users cannot modify protected system resources such as external devices (/dev), system commands or system directories (any immediate children of the root directory, except /home and maybe /var, /tmp)

The Root User

There are two types of users in a Unix-like environment:

- **Regular users**: can only create and modify files and programs they own or they've been given permission to
- **The superuser**: a.k.a. root, administrator, etc., has full control over the entire OS

With great power comes great responsibility

You can log in as the root user by typing `su` in a terminal.

```
```

```
$ su
Password:
# echo "Congratulations, you're now root!"
```

You should avoid logging into your system as root. However, sometimes we need to make changes for which we require elevated privilege

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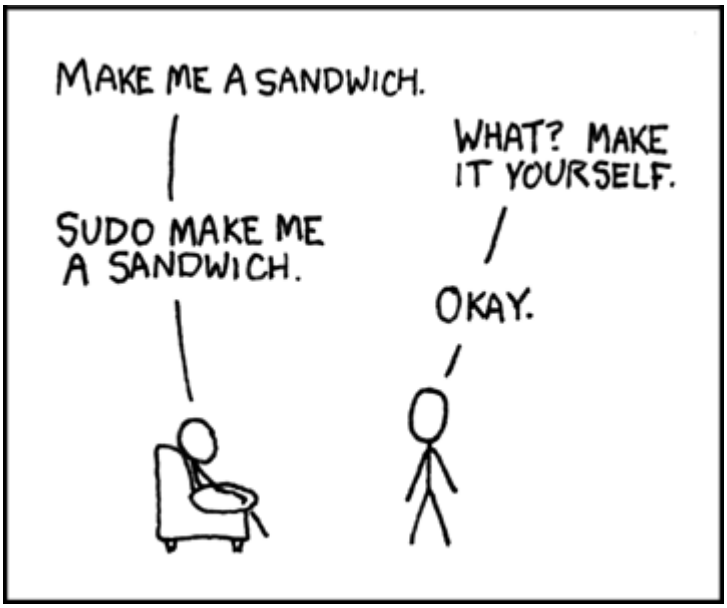
The sudo command



The sudo command

`sudo` allows regular users to become root temporarily so they can run privileged commands

```
$ cp /bin/python3 /bin/python-three
cp: cannot create regular file 'python-three': \
  Permission denied
$ sudo cp /bin/python3 /bin/python-three
```

---

sudo's and sudont's

The risk with running the root account, security aside, is that you may accidentally run a harmful command and end up destroying something important

- Use root account as least as possible.
- Protect root account with a strong password
- Use sudo with caution