An Introduction to Shell Scripting

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What is the shell?

- A command line user interface for Unix-like operating systems.

- Interactive and scripting modes

What is the Bash Shell?

- Bourne Again SHell, replacing the older Bourne shell in 1989

- Default shell on most Linux systems and MacOS

- Now available on Windows

  https://www.howtogeek.com/249966/how-to-install-and-use-the-linux-bash-shell-on-windows-10/

When to use the shell

- As a wrapper for a workflow

- When doing lots of filesystem access

- When low level access to hardware is required

When not to use the shell

Shell scripting is of much less use when any of the following are required

- Complex calculations
- A graphical user interface
- Any kind of debugging beyond very basic

Starting up

- Often opened via the graphical desktop

- Startup files are read to provide user customisations, eg .bash_profile, .bashrc
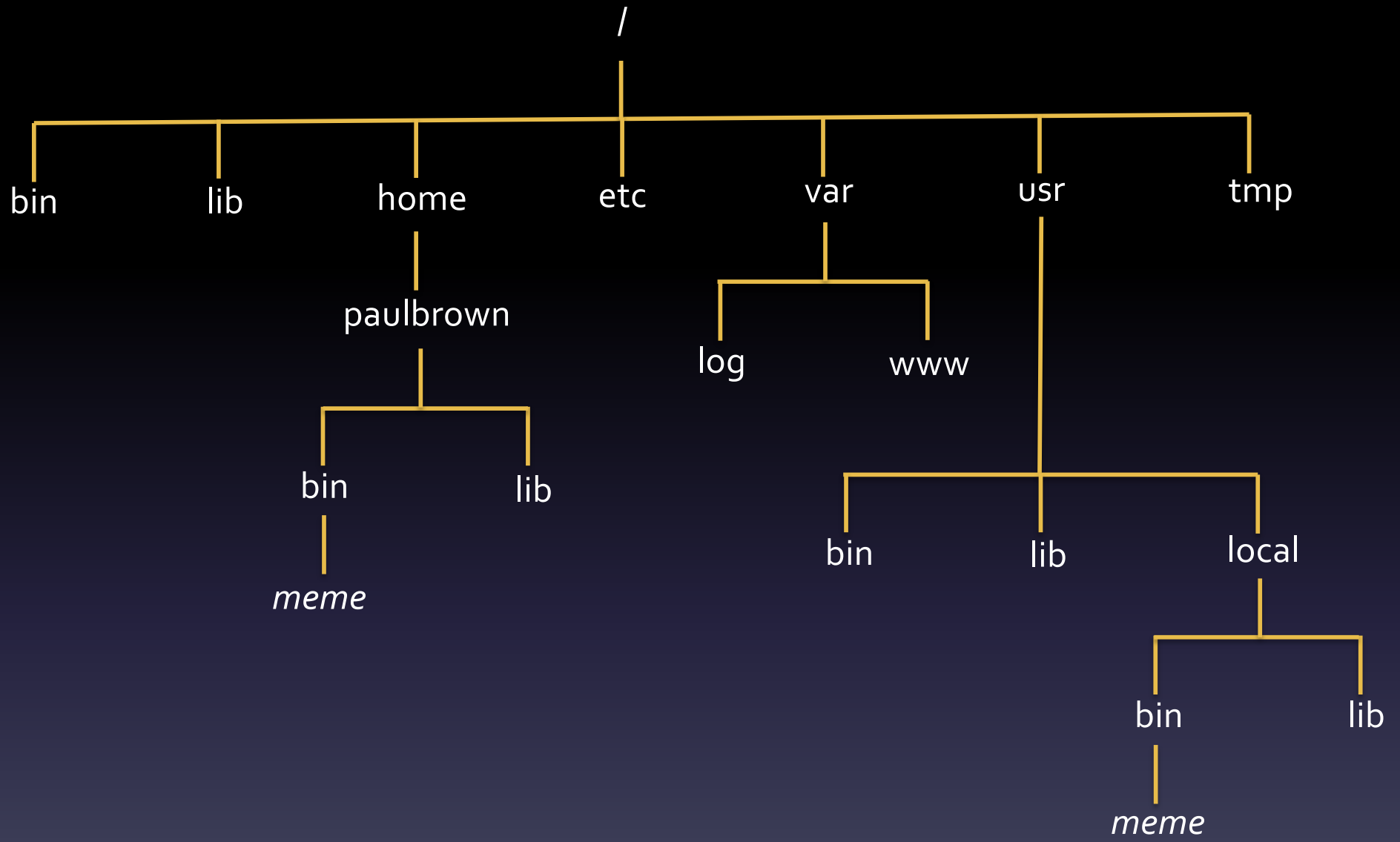
Some useful commands

```
nero:var paulbrown$ cd $HOME/bin
nero:~ paulbrown$ pwd
/home/paulbrown/bin
Nero:~ paulbrown$ cd ..
nero:~ paulbrown$ pwd
/home/paulbrown
nero:~ paulbrown$ ls -l
drwxr-xr-x   29 paulbrown   staff   928 30 Nov  2017 Android
drwx------+  93 paulbrown   staff   2976  1 Nov 12:34 Documents
-rw-r--r--    1 paulbrown   staff   0 14 Jul  2015 mcmc.csv
lrwxr-xr-x    1 paulbrown   staff   25 20 Sep  2016 meme ->
/home/paulbrown/bin/meme
nero:~ paulbrown$ mv mcmc.csv mcmc_101121.csv
nero:~ paulbrown$ cp -r Android Android.backup
nero:~ paulbrown$ rm –r Android
```
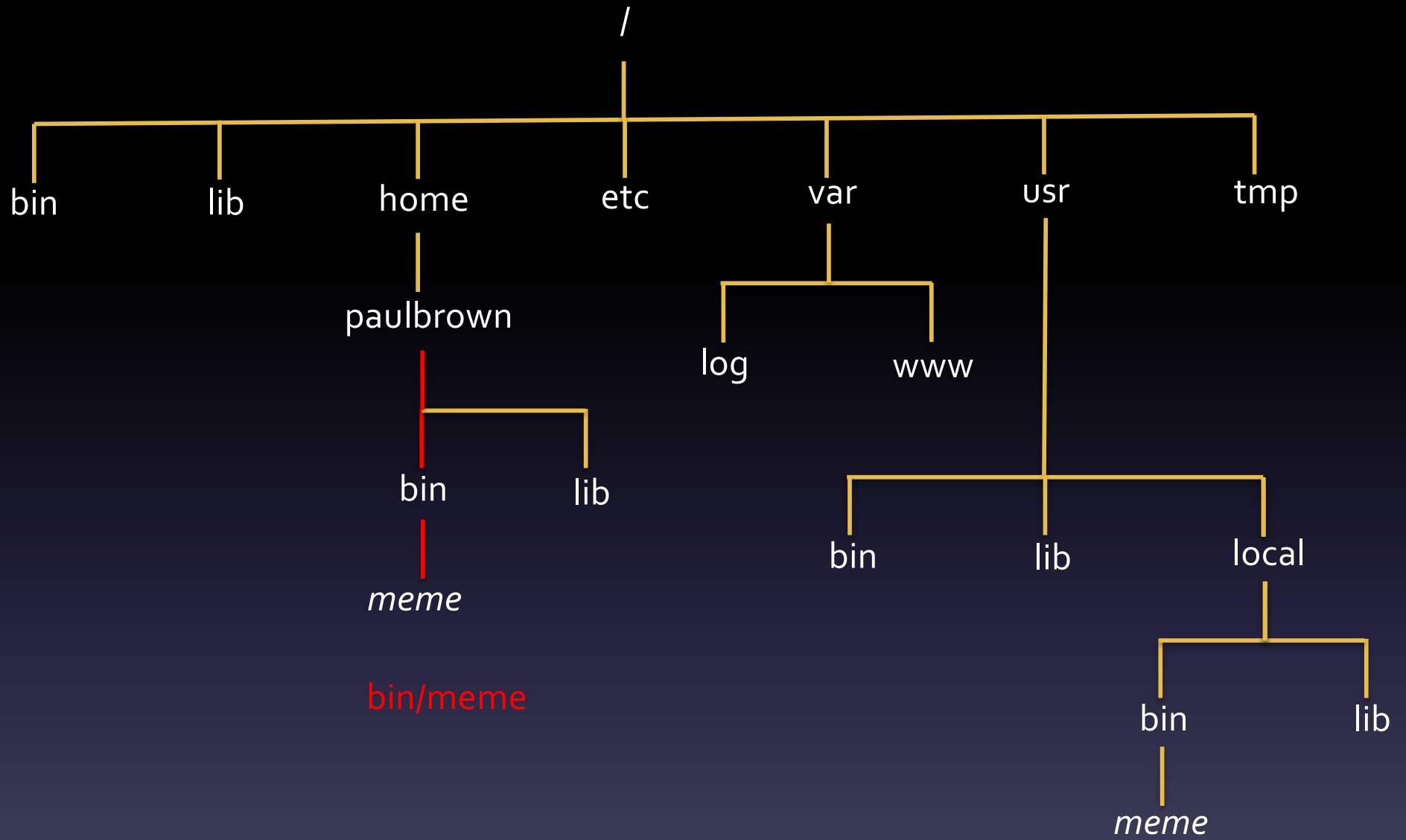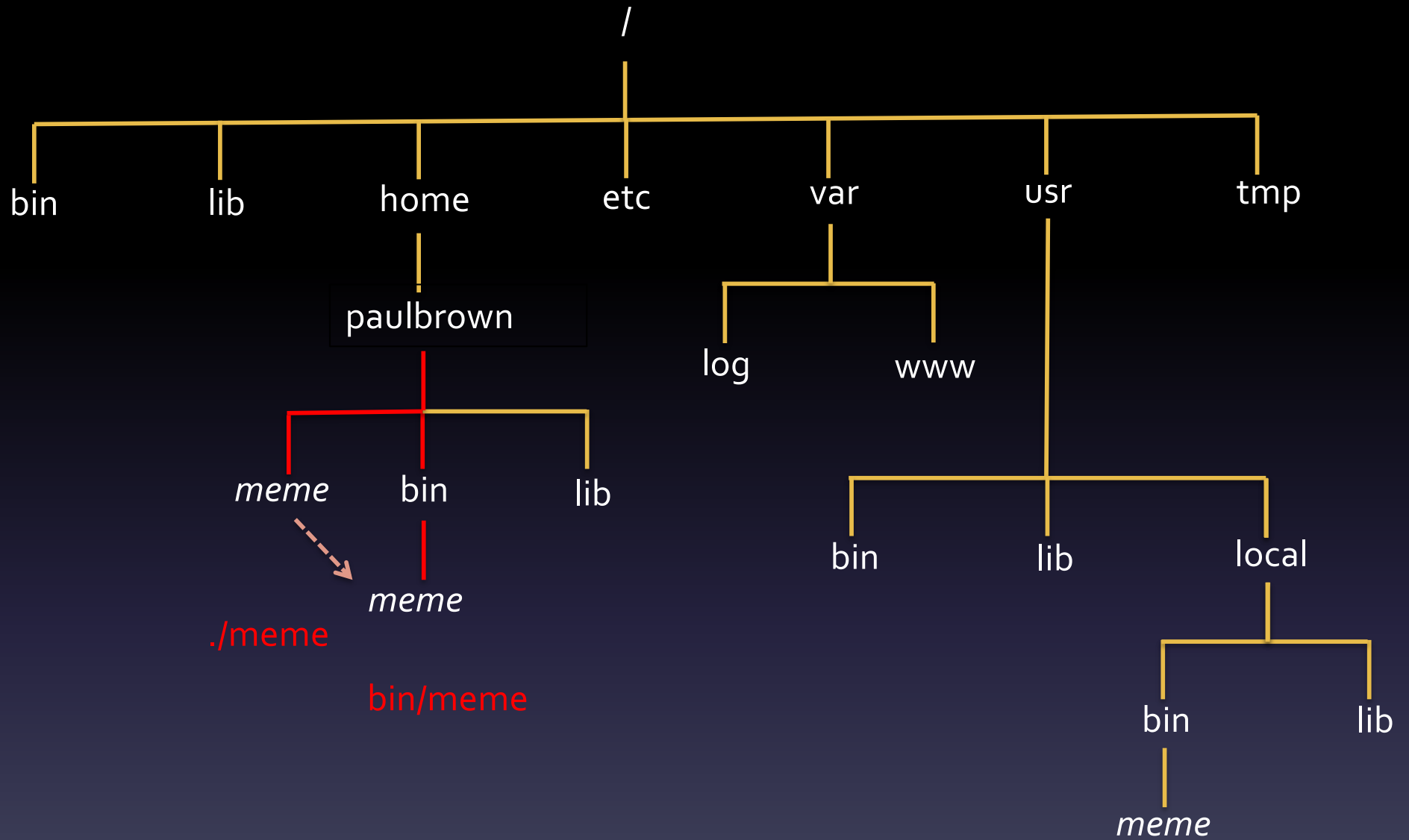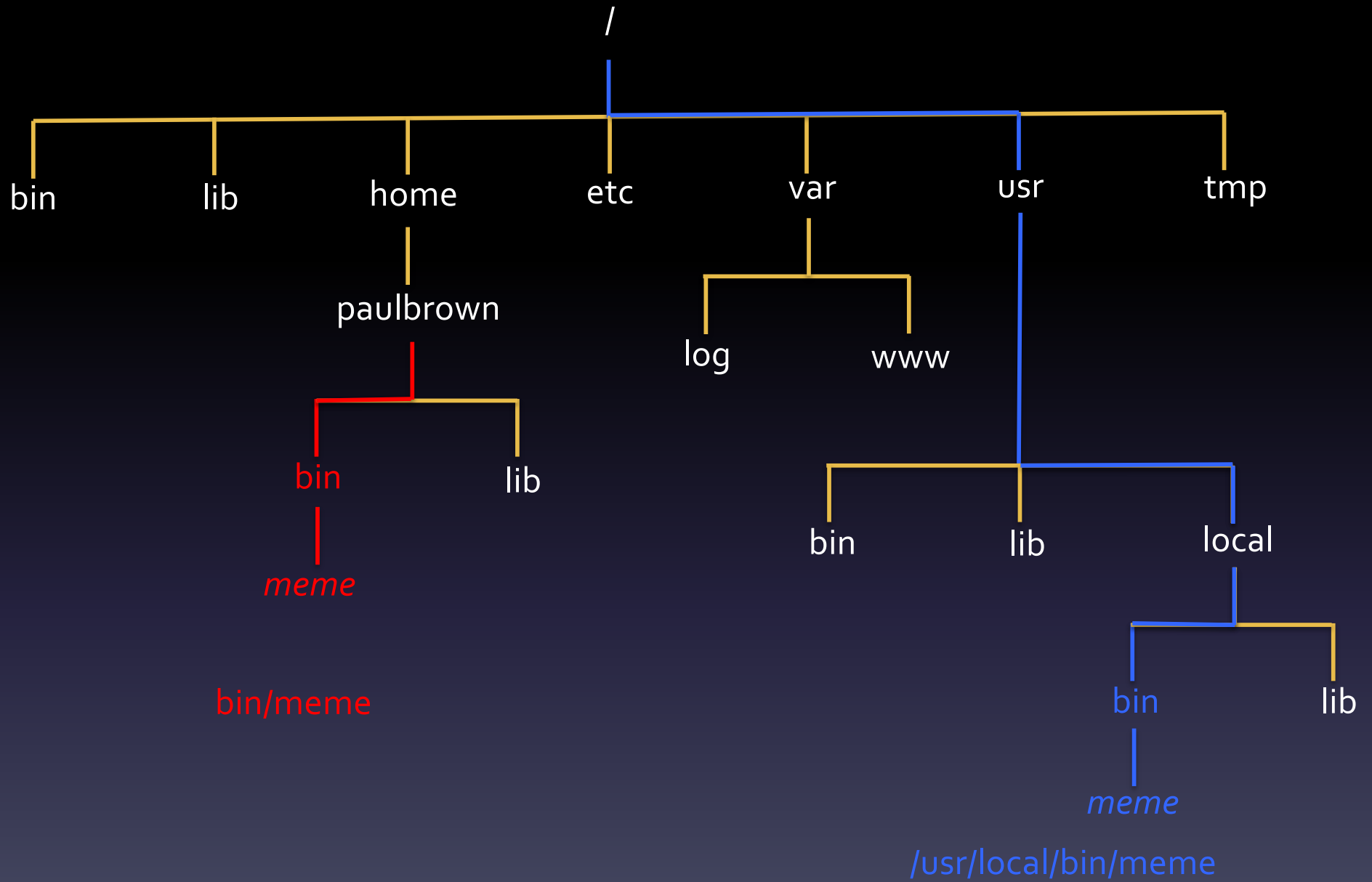
```
/
├── bin
├── lib
├── home
│   └── paulbrown
│       ├── bin
│       │   └── meme
│       └── lib
├── etc
├── var
│   ├── log
│   └── www
├── usr
│   ├── bin
│   ├── lib
│   └── local
│       ├── bin
│       │   └── meme
│       └── lib
└── tmp
```
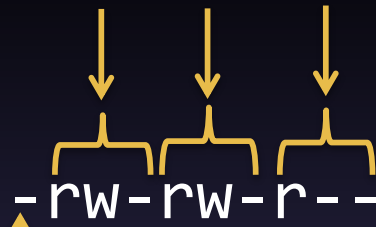
bin/meme

Changing file and directory permissions

r – read, w – write, x - execute

Owner Group Other

-rw-rw-r--. 1 admin admin 16 Jul 1 2021 TestData

File type
- regular file
d directory
l symbolic link

	file	directory	value
read	Read contents	Display content with ls	4
write	Alter contents	Add/delete file/sub-folder	2
execute	Run as a program	cd into directory/access content with ls	1

Changing file and directory permissions

- Change these with chmod

- This command takes the –R parameter when operating on directory <u>content</u>

Changing file and directory permissions

- Permissions represented by a 3 digit octal number

- Common values include

  777   rwxrwxrwx

  755   rwxr-xr-x

  700   rwx------

  644   rw-r--r--

  600   rw-------

Changing file and directory permissions

- Permissions can be set individually as well

  `chmod [ugo][+-][rwx] filename`

- Examples

  `chmod u+x script.sh`

  `chmod go+rx bindir`

  `chmod –R go+r bindir`

Startup files

- .bash_profile, .bashrc

- Need to use 'ls -a' to see these files

- Put customisations in .bashrc as this is run by .bash_profile

- Put them after the comment line to avoid being overwritten by system-wide files

Aliases

- Shortcuts to common commands

- A way of enforcing a specific way of running a command

```
alias matlab="matlab –nodesktop -nodisplay"
alias trimmomatic="java -jar /usr/local/bin/trimmomatic-0.39.jar"
```

Environment variables

- Variable can be set or appended to

- You can also create new variables

- Conventionally, always use block capitals

- Remember $ when referring to existing value

Environment variables

- Use the export command

```
export PATH=$PATH:$HOME/bin

export PATH=$HOME/bin:$PATH
```

Environment Variables

```
Nero:~paulbrown$ echo $PATH
/bin:/usr/bin:/usr/sbin:/sbin:/usr/local/bin:~/bi
n
Nero:~paulbrown$ meme
-bash: meme: command not found
Nero:~paulbrown$ export
PATH=$PATH:/usr/local/meme/bin
Nero:~paulbrown$ echo $PATH
/bin:/usr/bin:/usr/sbin:/sbin:/usr/local/bin:~/bi
n:/usr/local/meme/bin
Nero:~paulbrown$ meme
 USAGE:
     meme <dataset> [optional arguments]
```

More on variables

- There are no variable types

- VARNAME is a reference

- ${VARNAME} is the value held there

```
Nero:~paulbrown$ echo PATH
PATH
```

- Can have arrays
fruits=$('Apple', 'Banana', 'Orange')
echo ${fruits[0]}

Using quotation marks

- Important to know the difference between single and double quotes

- Expressions are evaluated inside "…", but not inside '…'

```
paul-browns-macbook:~ paulbrown$ NAME="Paul"
paul-browns-macbook:~ paulbrown$ echo "Hello $NAME"
Hello Paul
paul-browns-macbook:~ paulbrown$ echo 'Hello $NAME'
Hello $NAME
```

Working with files and directories

- Many useful commands

- Use `cat` to quickly view the contents of small files

- Use `less` to scroll though a larger file

  `-N` option to display line numbers

- Use `head`/`tail` to display the start/end of a file

  `-n` option specifies the number of lines

Searching files and directories using grep

grep stands for Global Regular Expression Print

Can be used to

- Test for the presence/absence of a word or pattern

- Names of files containing a word or pattern

Searching files and directories using grep

Useful options are

- -i ignore case

- -v invert (print non-matching lines)

- -c display only count of lines that match

- -A *number* and –B *number* Print number of lines before and after matching line

- -r recursively search all files in a directory

- -l display names of files with a match

Searching files and directories using grep

- The simplest use is to print matching lines within a file

  ```
  grep –B 2 –A 2 'paulbrown' /var/log/secure
  ```

- Or find files that contain a match

  ```
  grep –r –l "paulbrown" /var/log
  ```

Writing files

- A number of interactive text editors, eg vi, nano

- Also use re-direction >, >>

- echo "some content" >> script.sh

```
  GNU nano 2.0.6                    File: software.html

<html>
<head>
<title>Warwick Systems Biology Centre</title>
</head>
<body>

<p>Welcome to our software downloads page. The following packages are currently
available</p>

<p> </p>
<h4>Network Interference Analysis and Correction Software (Ying Wang, Miriam L. Gifford &amp; Nigel$
<p>An implementation of the method described in our paper "Regulator interference causes link under$
submitted to <i>Bioinformatics</i>. This method defines causal networks corrected for the problem o$
interference between dynamically similar regulators within the context of a sparse linear auto-regr$
model. Test data is provided within the NIACS software package.
Please see the file NIACS_Documentation.pdf contained within the package for details on how to run $
<p><i>Requirements:</i> <a href = "http://www.r-project.org" target="_blank">The R programming lang$

<p>
        <input type="button" value="Download" onclick = "window.location='http://wsbc.warwick.ac.uk$
</p>

<p> </p>
<h4>SASSy (Sensitivity Analysis Software for Systems; Mirela Domijan, Paul
Brown, Boris Shulgin &amp; David Rand)</h4>
<p>This is a GUI based Matlab toolbox for performing principal components
analysis of ODE models of gene networks. </p>
<p><i>Requirements:</i> <a href="http://www.mathworks.co.uk/">Matlab</a> R2008a or
later, plus Symbolic Math Toolbox</p>
<p>
  <input type="button" value="Download" onclick="window.location='http://wsbc.warwick.ac.uk/softwar$

<p><a href="Using_the_Theory_GUIs_Ver_6.pdf">Updated Instruction Manual</a></p>

<p> </p>
<h4>Bayesian Hierarchical Clustering for R (Richard S Savage, Katherine Heller, Yang Xu, Zoubin Gha$

^G Get Help     ^O WriteOut     ^R Read File    ^Y Prev Page    ^K Cut Text     ^C Cur Pos
^X Exit         ^J Justify      ^W Where Is     ^V Next Page    ^U UnCut Text   ^T To Spell
```

Redirection

- Input to and output from command can be re-directed away from stdin and stdout

- Re-direct output to file

```
ls –l > dircontent.txt
```

Re-direct input from file

```
sort –k5 –n < dircontent.txt
```

Redirection

Pipes are used to chain commands together so the output of one becomes the input of the next

```
ls –l | sort –k5 –n
tail –n 1000 logfile.log | sort | more
```

Command substitution

- This allows the output of a command to be captured and used piped back to be used as an argument for something else, or to be captured in a variable

- Preferred way is to use $(…)

```
rm -f $(find . -name "*.txt")
```

Arithmetic expansion

Use command substitution

```
paul-browns-macbook:~ paulbrown$ echo 2+3
2+3
paul-browns-macbook:~ paulbrown$ echo $(2+3)
-bash: 2+3: command not found
paul-browns-macbook:~ paulbrown$ echo $((2+3))
5
paul-browns-macbook:~ paulbrown$ a=$((2+3))
paul-browns-macbook:~ paulbrown$ echo $a
5
```

Arithmetic expansion

Bash handles only integer types

```
paul-browns-macbook:~ paulbrown$ echo $((4/3))

1


Use 'bc' to perform calculations with floating point types


paul-browns-macbook:~ paulbrown$ echo 'scale=3;4/3' | bc
1.333
```

Remote Shells

- rsh (remote shell). Do not use, insecure

- ssh (secure shell, port 22)

```
paul-browns-macbook:~ paulbrown$ ssh nero.wsbc.warwick.ac.uk
paulbrown@nero.wsbc.warwick.ac.uk's password:
Last login: Mon Nov  4 23:10:34 2019 from 95.149.133.253
-sh-4.1$ hostname
nero.wsbc.warwick.ac.uk
```

- Also sftp and scp

```
scp –r /local/stuff paulbrown@nero.wsbc.warwick.ac.uk:$HOME
```

Shell scripting

- Conventionally, files have .sh extension

- Remember to set execute permission

- Script begins with

`#!/bin/bash`

Input arguments

- Referred to as $1, $2 etc..

- $# is the number of inputs

- Same applies to functions

- Use read to request user input

Conditionals

- Surround an expression with [[…]]

- String operators : -z, -n, ==, !=, <, >, =~

- Numerical operators: -eq, -ne, -lt, -le, -gt, -ge

- File operators: -e, -f, -d, -r, -w, -x

Conditionals

```bash
#!/bin/bash

if [[ $# -lt 3 ]] ; then
        echo "Not enough input arguments"
        exit 0
elif [[ $# -gt 5 ]] ; then
        echo "Too many input arguments"
        exit 0
else
        echo "OK"
fi
```

Conditionals

- Can be chained together using logical operators &&, ||

```
#!/bin/bash

if [[ $# -lt 3 ]] || [[ $# -gt 5 ]]; then
        echo "Wrong number of input arguments"
        exit 0
else
        echo "OK"
fi
```

- These operators allow conditional execution

```
mkdir newdir || echo "Cannot create directory"
mkdir newdir && touch newdir/newfile
```

While Loops

```
while read  line; do
    fields=(${line}) #expand to
array
    …
done < infile
```

break and continue can be used within the
loop body

For loops

A for loop iterates a series of words in a string

```
for i in $(ls); do
        echo $i
done
```

A C-style for loop can be created using arithmetic expressions

```
for ((i = 0; i < 100; i++)); do
        echo $i
done
```

Range expression

```
for i in {1..10}; do        Note: range includes final value
        echo $i
done
```

Functions

```
myFunc() {

        local localVar="Hello "$1;

        echo localVar;

}
```

myFunc "Paul"

Return values can be captured by command substitution

Text Processing

- Bash as a comprehensive set of time-saving text processing functions.

- Be aware of these before attempting to write your own

sort

- Sorts lines of a file

- Alphabetic or numeric sort

- Can sort on columns eg csv files

- Can randomise rows as well

```
sort -n -k2 data.txt -o data.txt
```

uniq

- Remove duplicates in a list

- Use after sort as it compares only adjacent values

```
sort list.txt | uniq > unique_list.txt
```

comm

- Compare 2 files and print lines unique to each and common to both, in 3 columns

- Can suppress any of these outputs with -1, -2, -3

```
comm -12 file1 file2
```

tr

- Translates or deletes characters

```
tr a-z A-Z < lowercase.txt > upper_case.txt

tr -d _ <input.txt
```

cut

- Removes section from each line of a file with well defined columns

- Default delimiter is TAB, but can be changed

```
cat data.txt | cut  -f1,5
```

paste

- Merges lines of files into columns with the specified delimiter

```
paste -d, names.txt values.txt > scores.csv
```

Getting help

- man pages for most commands

- Huge amount on online resources, eg a good cheat sheet at https://devhints.io/bash