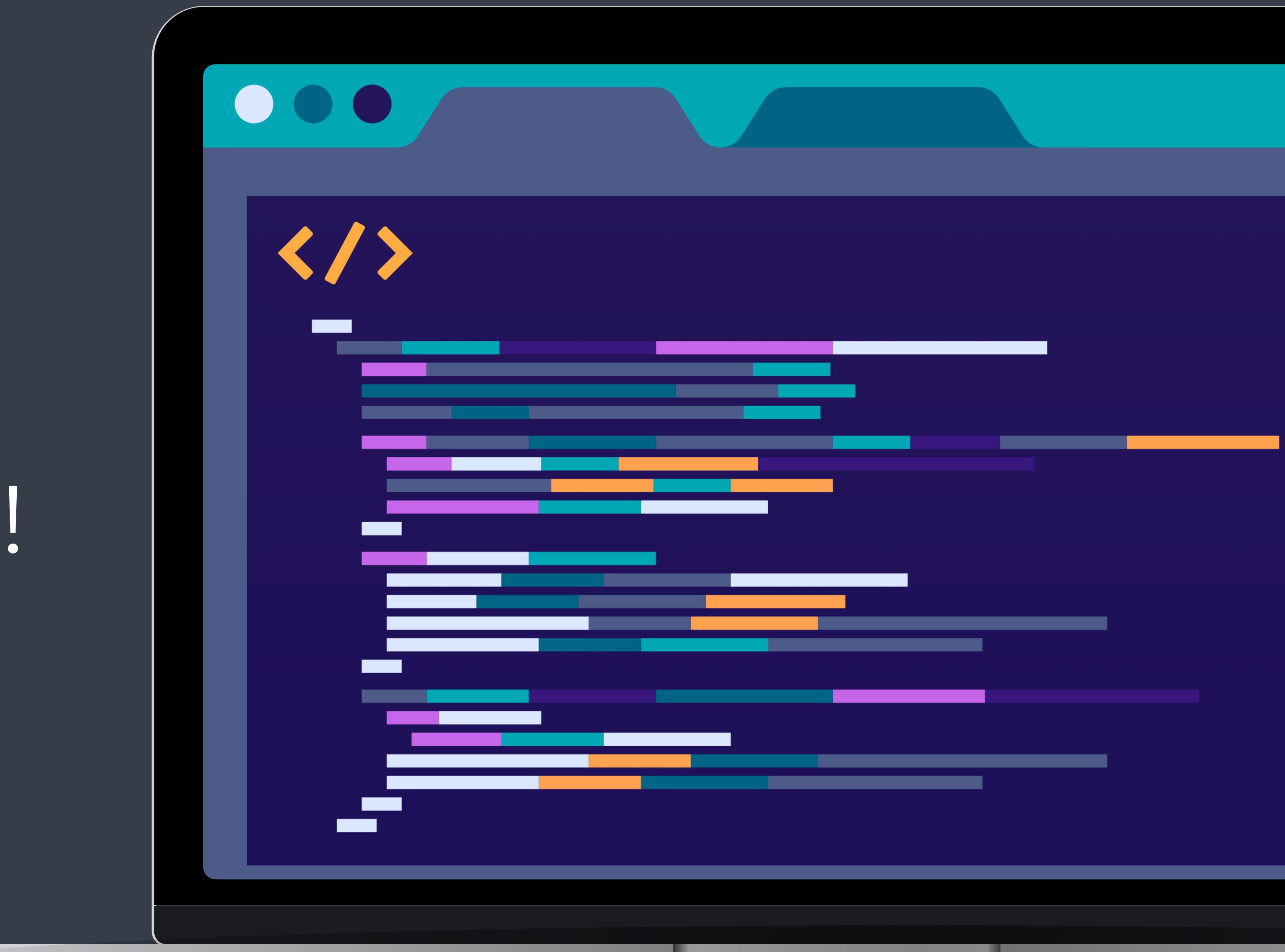
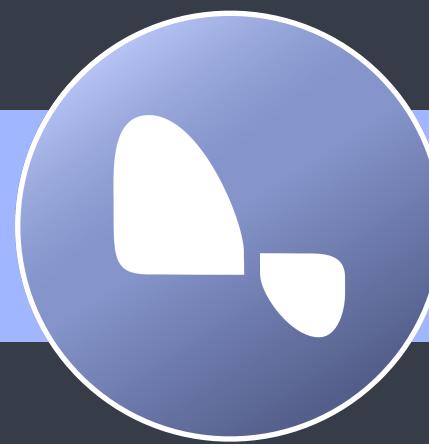


# JUST BASH IT!





## CENTER FOR HEALTH DATA SCIENCE (HEADS)

- Data Lab Supports Researchers at the Faculty
- Consultation, Commission & Collaboration:
  - Data science and bioinformatics analyses
- Teaching: Courses & Workshops, Seminars.



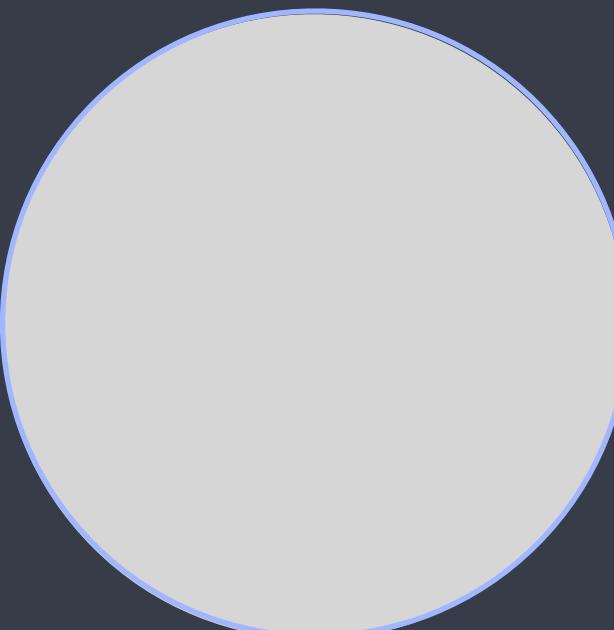
Henrike Zschach



Thilde Terkelsen

## COPENHAGEN UNIVERSITY LIBRARY (KUB)

- XXXXXX XXXXXX
- XXXXXX XXXXXX
- XXXXXX XXXXXX



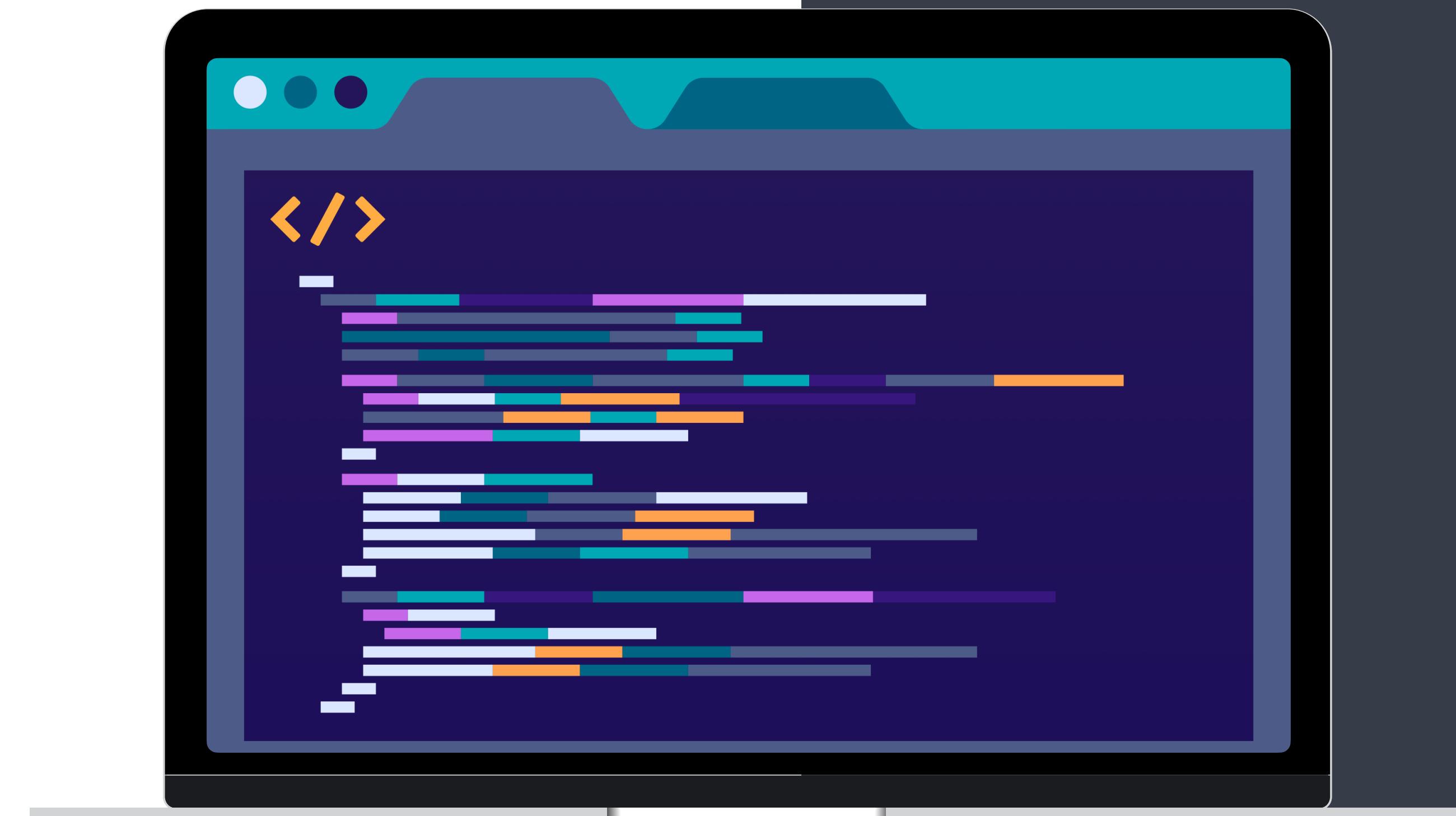
Ene Rammer Nielsen



Daniel Pryn

# PROGRAM

- 09:00 - INTRODUCTION TO COMMANDLINE
- 09:15 - NAVIGATING FILES & DIRECTORIES
- 09:40 - EXERCISE 1
- 10:00 - PROJECT ORGANIZATION & BACKUP
- 10:20 - COFFEE BREAK
- 10:30 - EXERCISE 2
- 10:50 - WORKING WITH FILES & DIRECTORIES
- 11:10 - EXERCISE 3
- 11:30 - MORE BASH COMMANDS
- 12:00 - LUNCH
- 13:00 - EXERCISE 4 (part 1 + 2)
- 14:00 - REDIRECTION & PIPES
- 14:20 - EXERCISE 5
- 14:50 - COFFEE BREAK
- 15:05 - SHELL SCRIPTS & LOOPS
- 15:20 - EXERCISE (part 1 + 2)
- 15:50 - SOFTWARE INSTALLATION UPKEEP & MORE
- 16:10 - EXERCISE 7



## COURSE MATERIALS:

<https://github.com/Center-for-Health-Data-Science/Just-Bash-It>



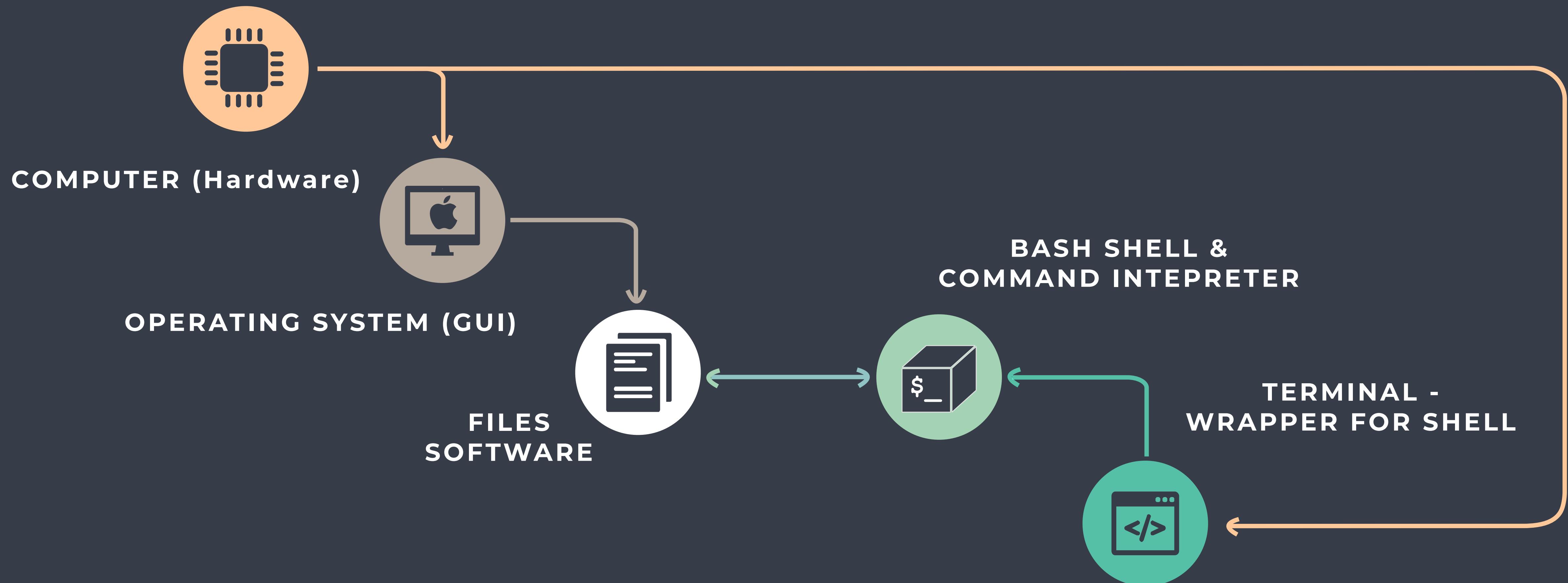
```
Last login: Fri Jun 24 15:05:34 on ttys000  
[kgx936@SUN1007442 ~ % echo "Just Bash It"  
Just Bash It  
kgx936@SUN1007442 ~ % █
```

“

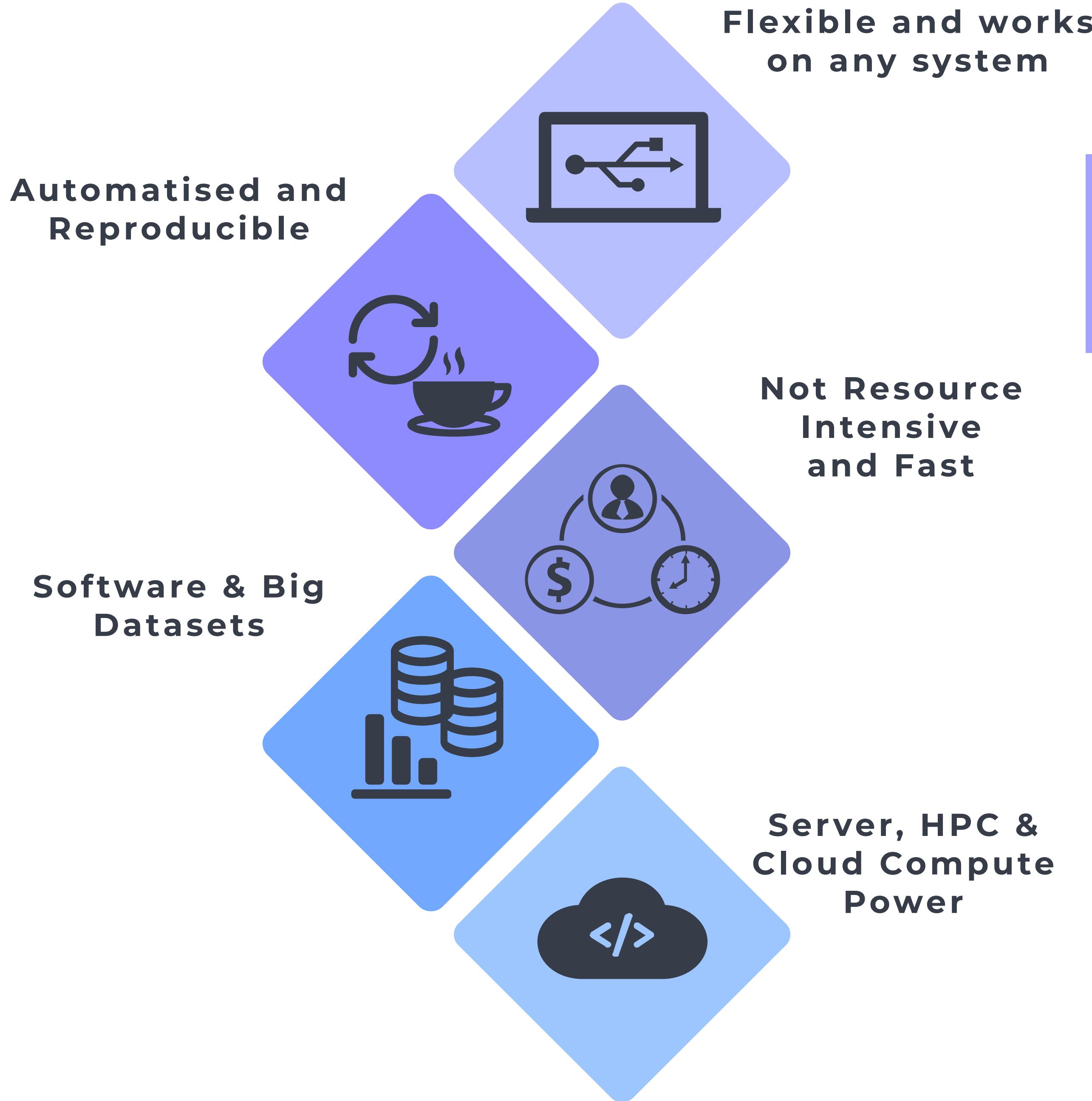
“What is a shell, a terminal, a command-line, and what is bash?”

“How do these concepts connected to my computer?”

# TERMINOLOGY



- You open the terminal on your computer
- You type bash commands
- Commands are interpreted and fed to the OS



## SELL IT TO ME!

Benefits of bash & command line:

- Your analysis will be reproducible, automated and parallelised.
- Fast processes, less computationally intensive.
- Command line softwares.
- Power to handle big data and heavy computations.

# A COUPLE OF EXAMPLES

---



## REGISTRY DATA

Drug adverse effects and mortality:

Person sensitive  
Huge files, many columns  
Different formats



## SEQUENCING DATA

Single Cell RNA from Cystic Fibrosis:

Paired-end sequencing  
300 patients  
Two fastq files per patient



## DATABASES

Drug Databases - molecular structure & interaction:

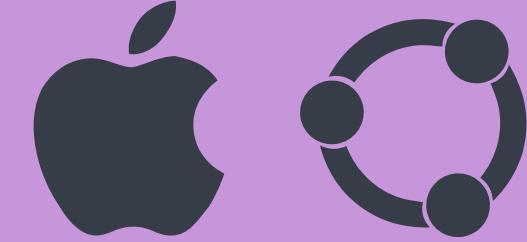
Multiple large databases  
Different formats  
Maybe not downloadable

# HOW DO I GET A BASH SHELL?

---

**YEAH!**  
**YOU HAVE A BASH SHELL &**  
**TERMINAL ALREADY.**

**Search for terminal on your laptop and open it.**



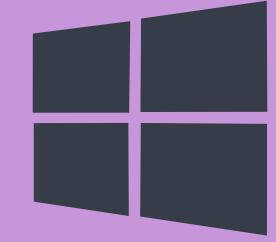
**OS X or UBUNTU**

**>= WINDOWS 10 - Windows Subsystem for Linux:**

(<https://adamtheautomator.com/windows-subsystem-for-linux/> ).

**OR INSTALL A BASH SHELL/TERMINAL:**

- **MobaXterm:** <https://mobaxterm.mobatek.net/download.html>
- **Cygwin:** <https://www.cygwin.com/index.html>
- **Cmder:** <https://cmder.net/>
- **PuTTY:** <https://www.putty.org/>



**WINDOWS**

In this course Windows users will be working on **MobaXterm**.

You should have **installed this shell** via. instructions in the introduction email.

# WHAT WILL I LEARN TODAY?



## The BASICS OF BASH

- The terminology
- Navigation w. bash
- Read, Edit, Copy

1

## ORGANIZATION & STRUCTURE

- Directory Structure
- Paths & Permission
- Reproducibility

2

## MORE BASH COMMANDS

- Manipulate files
- Subset, Count
- Print, Sort, Match
- Cut, Paste, Split

3

## SCRIPTS & AUTOMATIZATION

- Stdin & Stdout
- Piping
- Loops & Scripts
- Pipelines

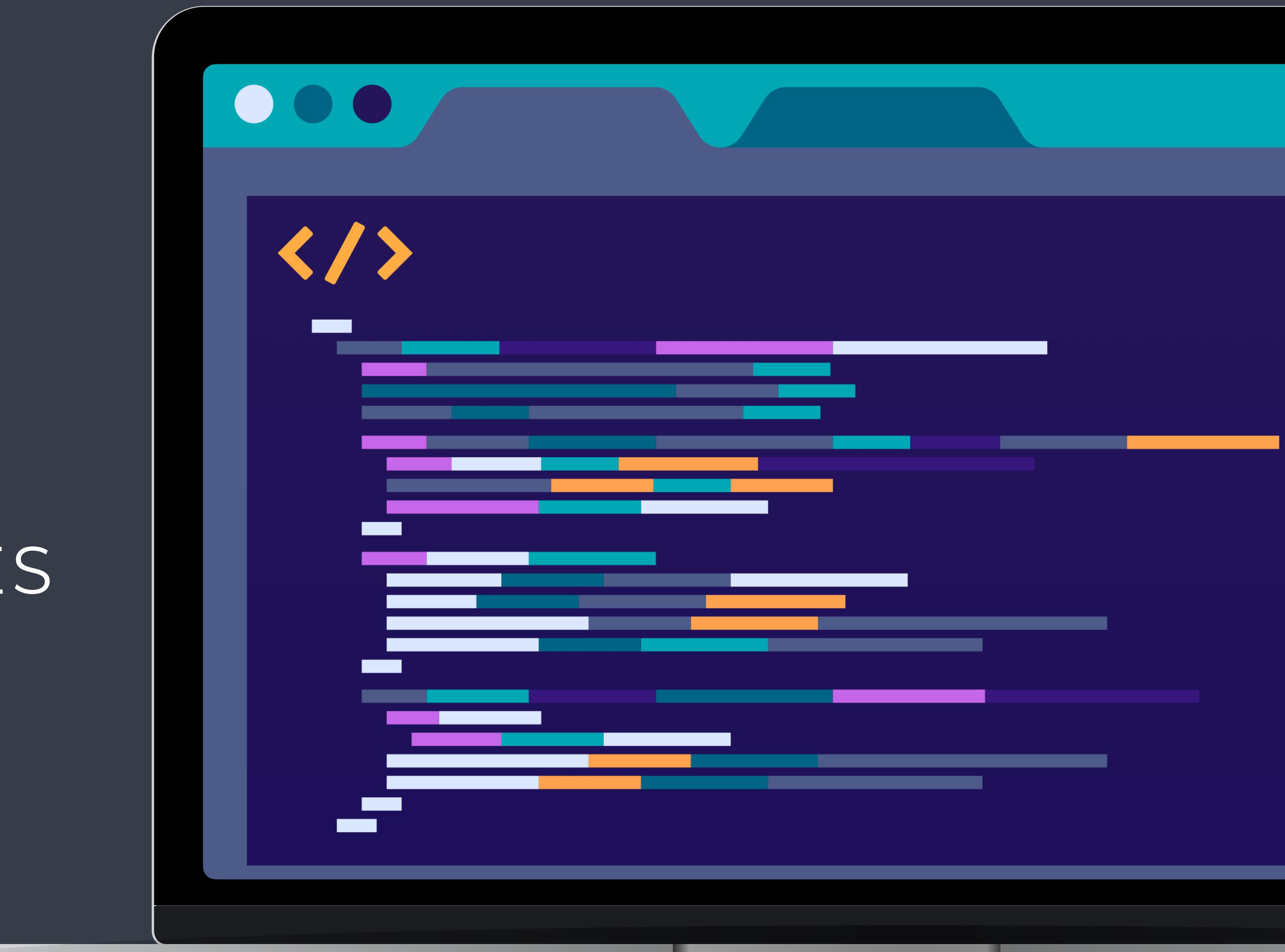
4

## STORAGE, BACKUP & MORE...

- Manage Software
- Workflows
- Backups
- Computing Power

5

# 1. NAVIGATING FILES & DIRECTORIES

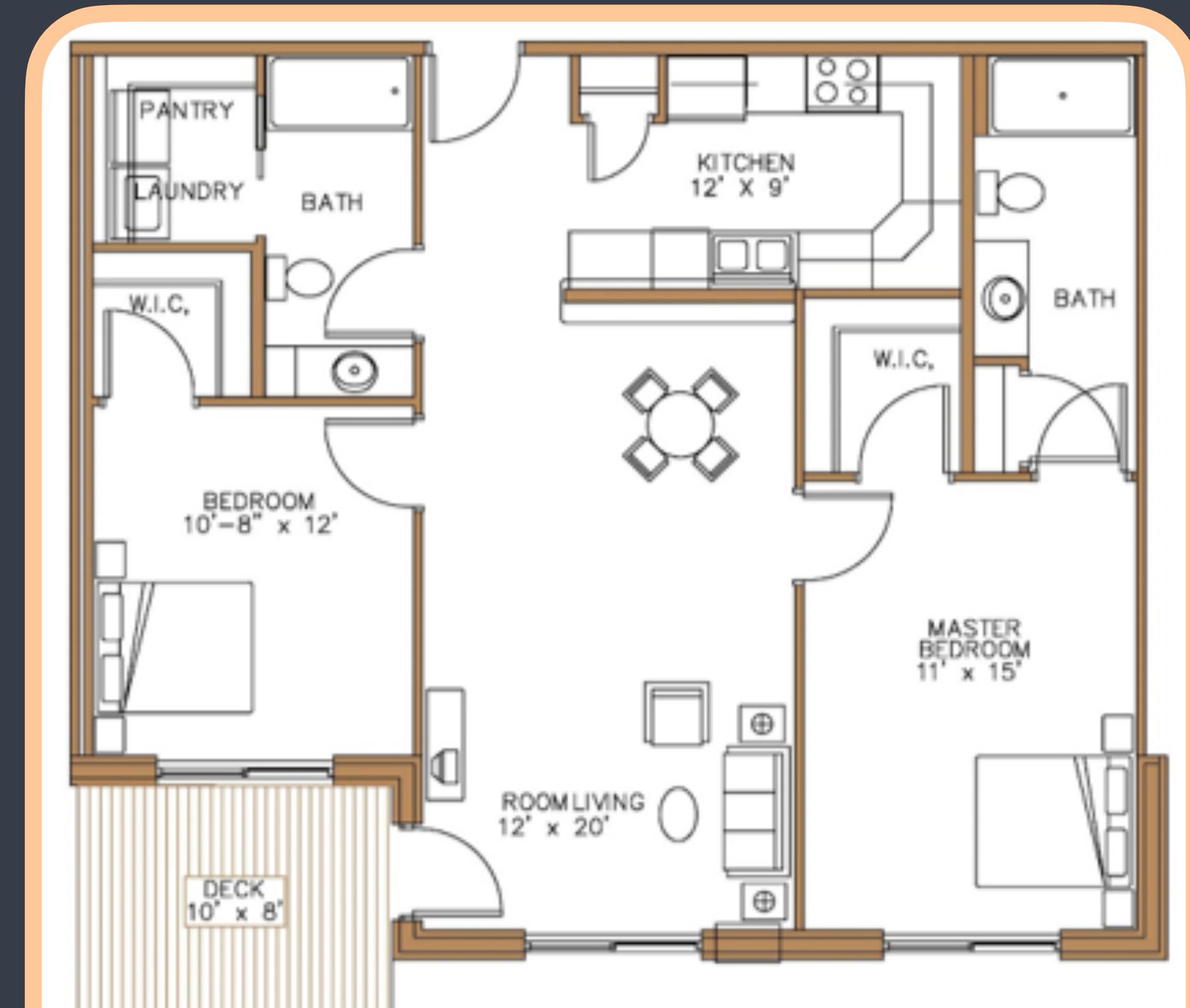


# THE DIRECTORY TREE

---

Your computer is **like a house**:

- It has different rooms, i.e. **directories** which contain items, i.e. **files**.
- You cannot be in two different rooms at the same time.
- Your files are items in the house and they are in specific places. Your bed is in your bedroom.
- In order to interact with your item **you need to know where it is**.
- You can move items from one room to another.

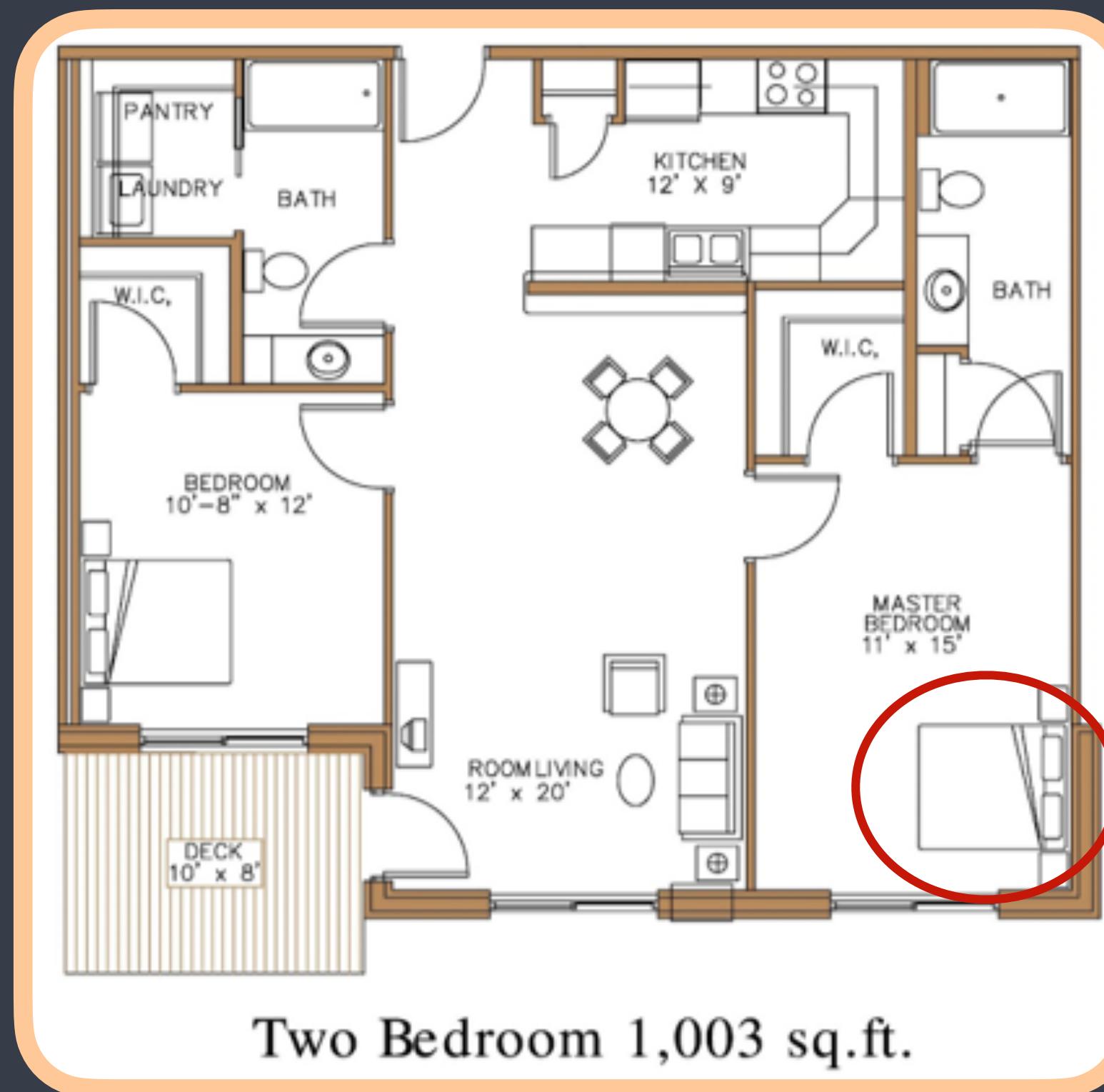


Two Bedroom 1,003 sq.ft.

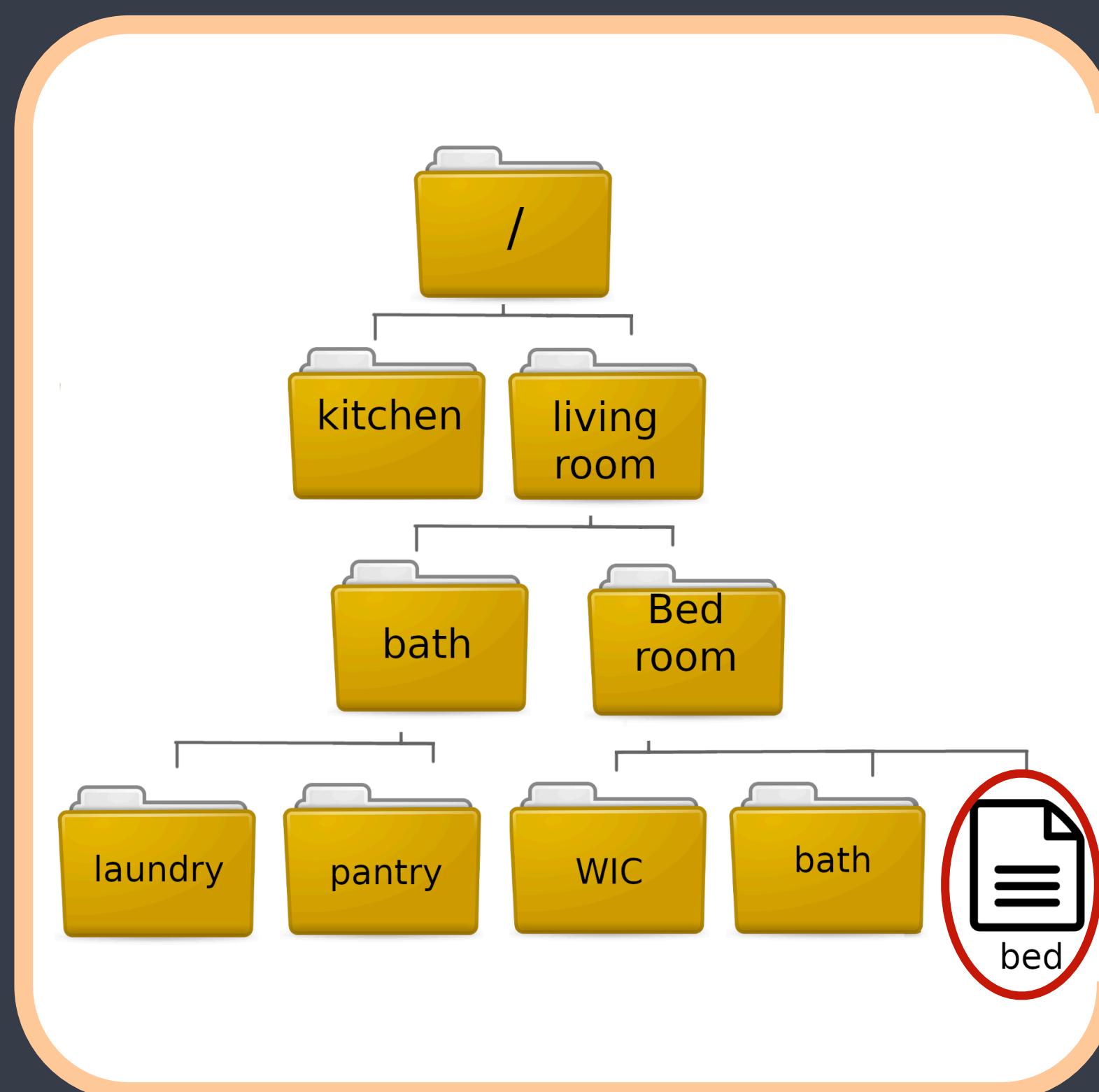
# THE DIRECTORY TREE

---

A loose translation of the floor plan into a directory tree:



The **directory tree** is hierarchical and starts at the 'root' = '/'

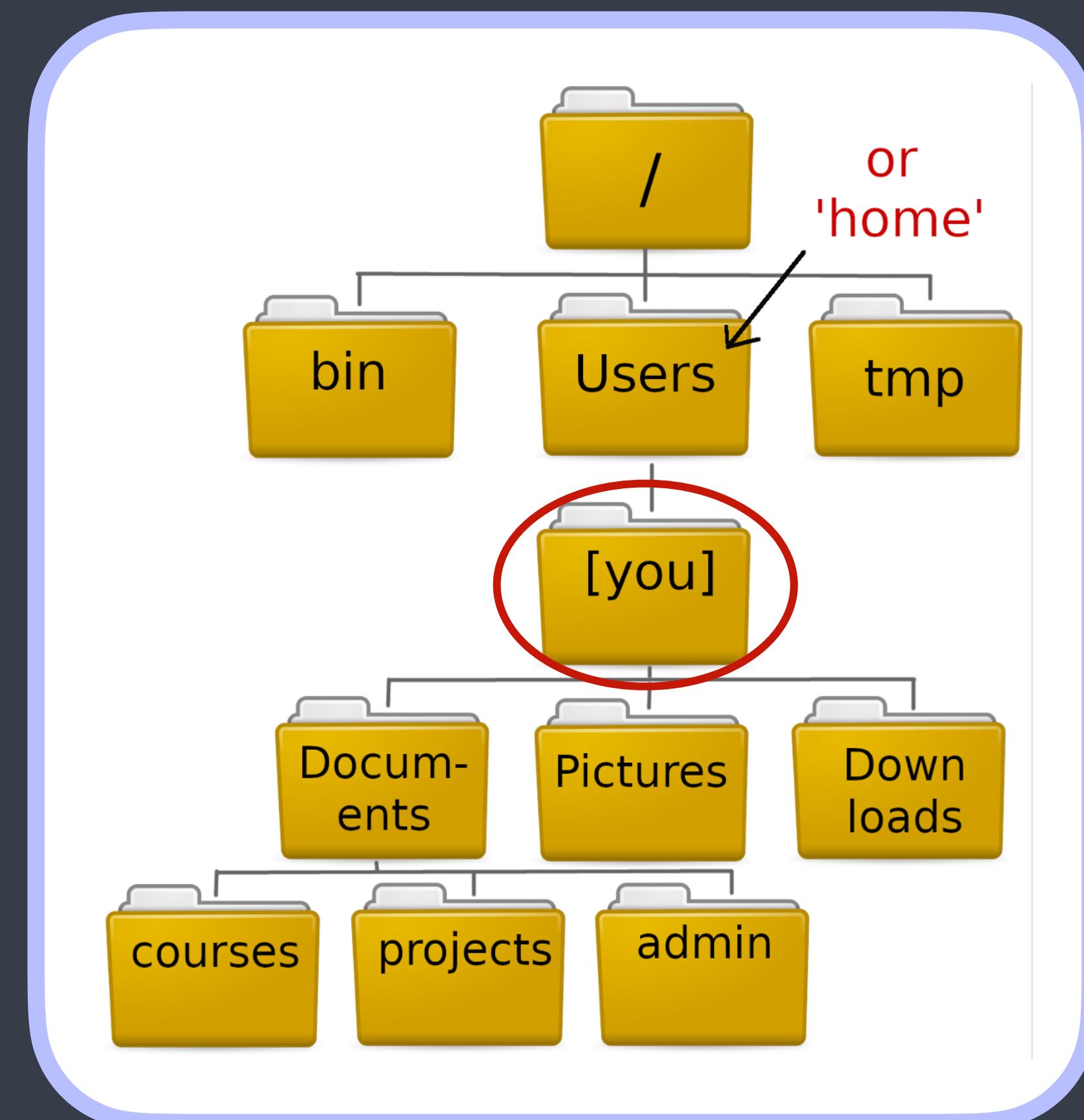


# THE HOME DIRECTORY

- When you open your terminal you are in your home directory.
- The directory you are currently in is called your **working directory (wd)** - you can **check it**:

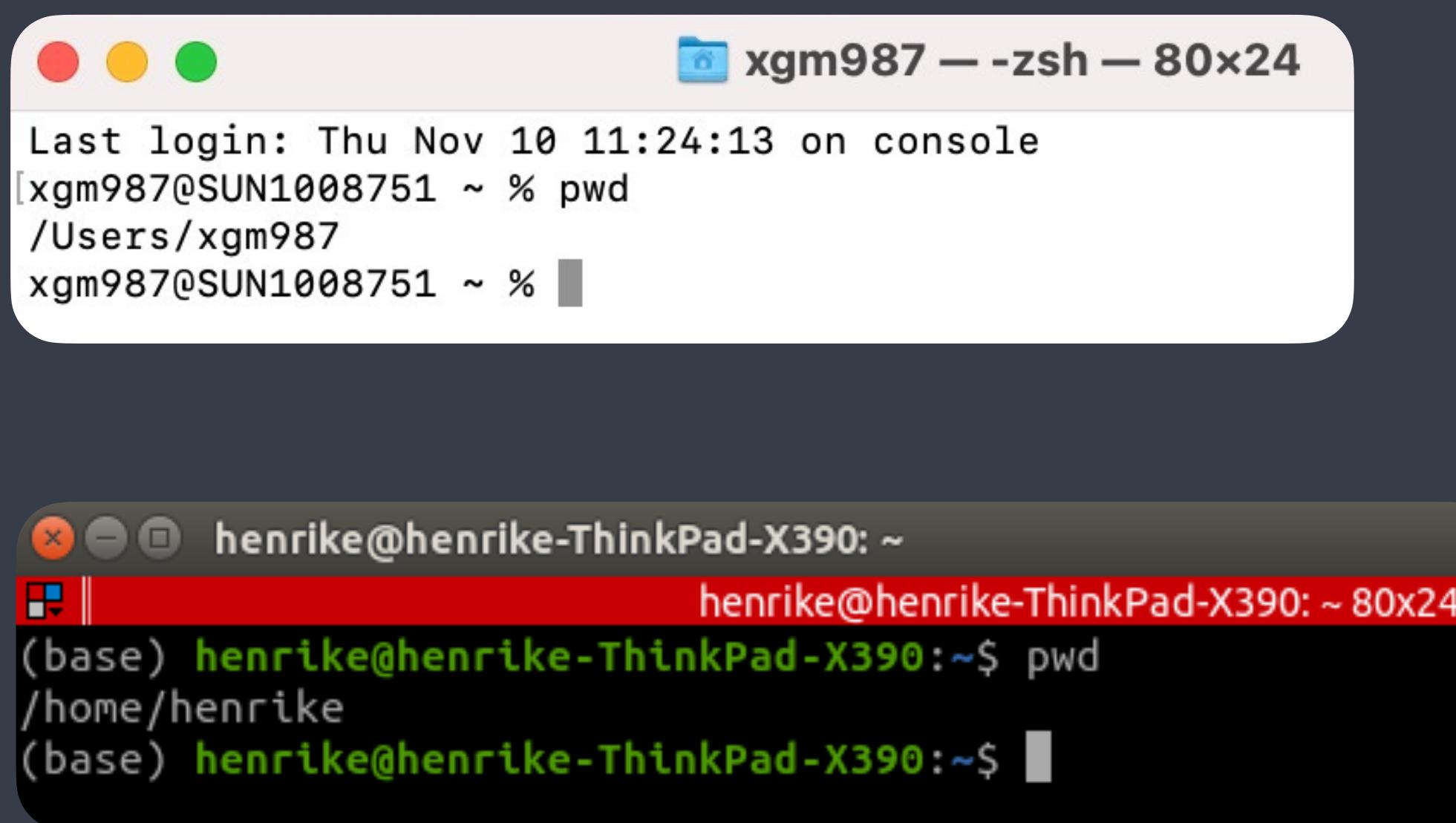
```
$ pwd
```

- **Open your terminal and check where you are!**



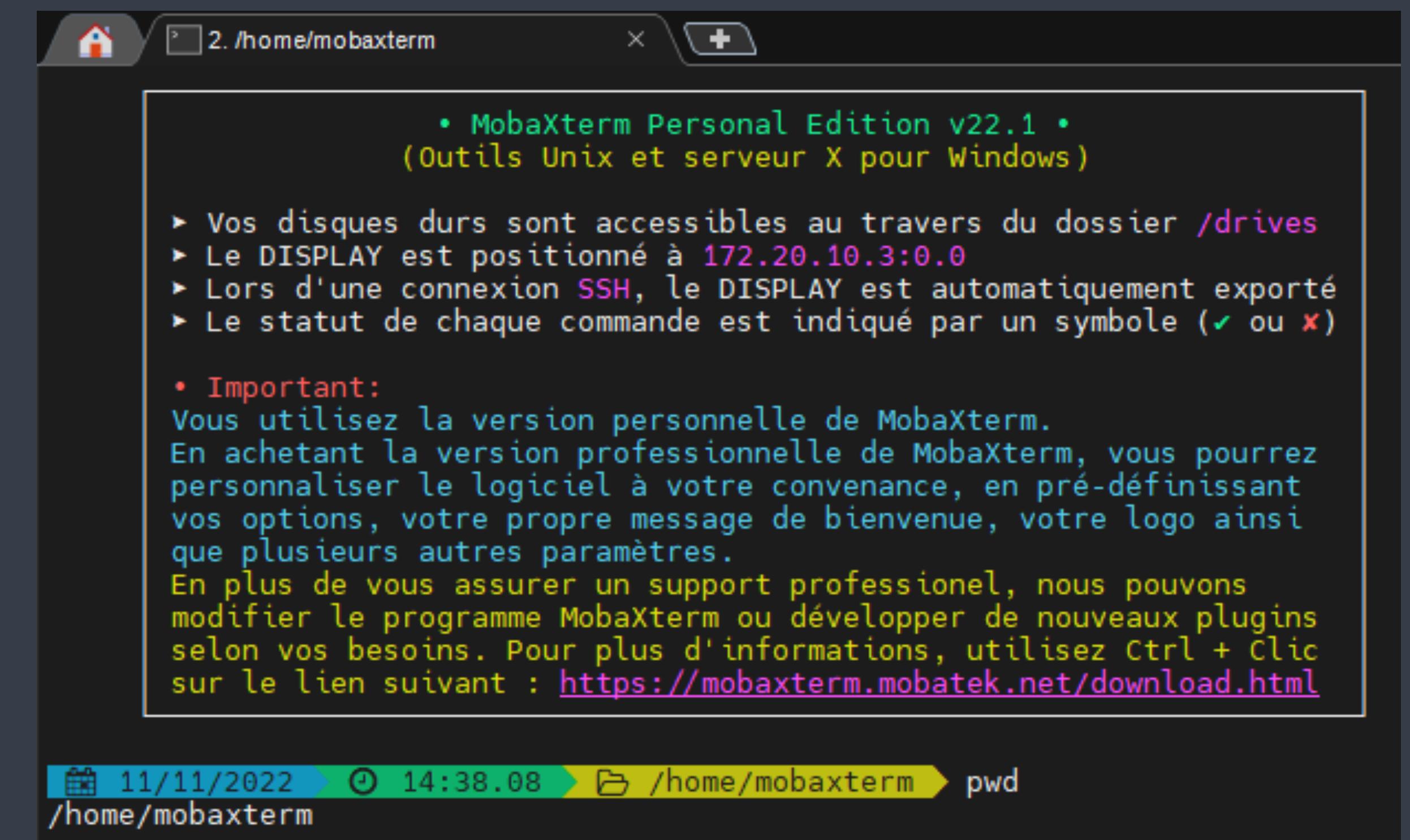
# THE HOME DIRECTORY

What the home directory is called can differ between computers! Do not be too bothered by that. All home directories are beautiful <3!



The image shows two separate terminal windows. The top window is titled 'xgm987 -- zsh -- 80x24' and displays the command 'pwd' which returns '/Users/xgm987'. The bottom window is titled 'henrike@henrike-ThinkPad-X390: ~' and displays the command 'pwd' which returns '/home/henrike'. Both windows show the user's last login information at the top.

```
Last login: Thu Nov 10 11:24:13 on console  
[xgm987@SUN1008751 ~ % pwd  
/Users/xgm987  
xgm987@SUN1008751 ~ %  
  
henrike@henrike-ThinkPad-X390: ~  
henrike@henrike-ThinkPad-X390: ~ 80x24  
(base) henrike@henrike-ThinkPad-X390:~$ pwd  
/home/henrike  
(base) henrike@henrike-ThinkPad-X390:~$
```



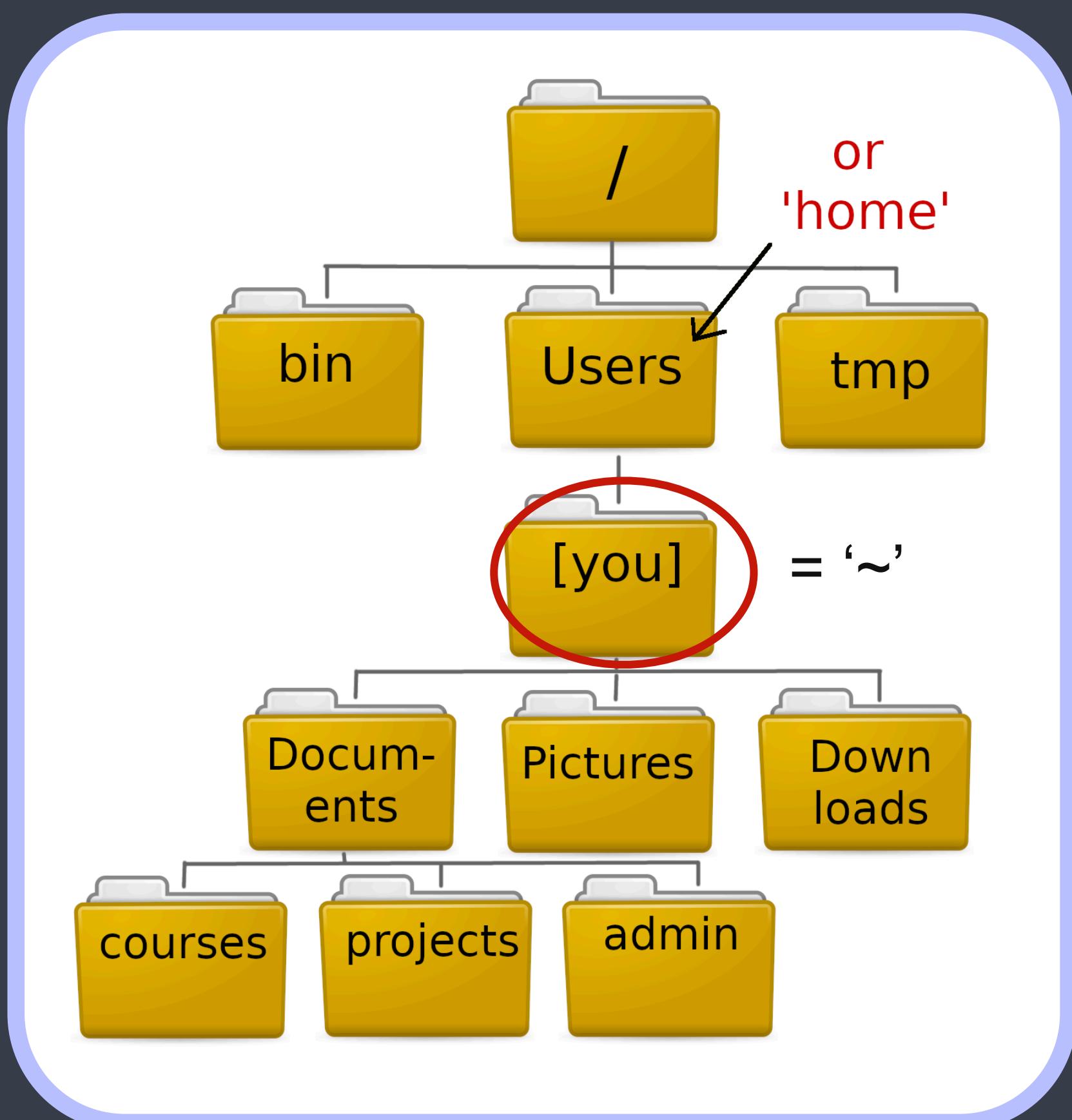
The image shows a MobaXterm window titled '2. /home/mobaxterm'. It contains a welcome message for version 22.1, mentioning accessible drives, the DISPLAY environment variable, and command status symbols. It also includes an 'Important' section about the personal edition and professional options. At the bottom, there is a file history bar.

```
• MobaXterm Personal Edition v22.1 •  
(Outils Unix et serveur X pour Windows)  
  
► Vos disques durs sont accessibles au travers du dossier /drives  
► Le DISPLAY est positionné à 172.20.10.3:0.0  
► Lors d'une connexion SSH, le DISPLAY est automatiquement exporté  
► Le statut de chaque commande est indiqué par un symbole (✓ ou ✘)  
  
• Important:  
Vous utilisez la version personnelle de MobaXterm.  
En achetant la version professionnelle de MobaXterm, vous pourrez  
personnaliser le logiciel à votre convenance, en pré-définissant  
vos options, votre propre message de bienvenue, votre logo ainsi  
que plusieurs autres paramètres.  
En plus de vous assurer un support professionnel, nous pouvons  
modifier le programme MobaXterm ou développer de nouveaux plugins  
selon vos besoins. Pour plus d'informations, utilisez Ctrl + Clic  
sur le lien suivant : https://mobaxterm.mobatek.net/download.html  
  
11/11/2022 14:38.08 /home/mobaxterm pwd  
/home/mobaxterm
```

As a rule the home directory is generally two steps from the root '/' and it is personal. When there are several users on the same machine each has their own home directory.

# THE HOME DIRECTORY

- Your home directory is also represented by the symbol ‘~’ (**tilde**).
- You may notice this symbol later when looking at your current directory or changing to another directory.



# LISTING CONTENT

- To **list all contents of a directory**, including other directories, use the command:

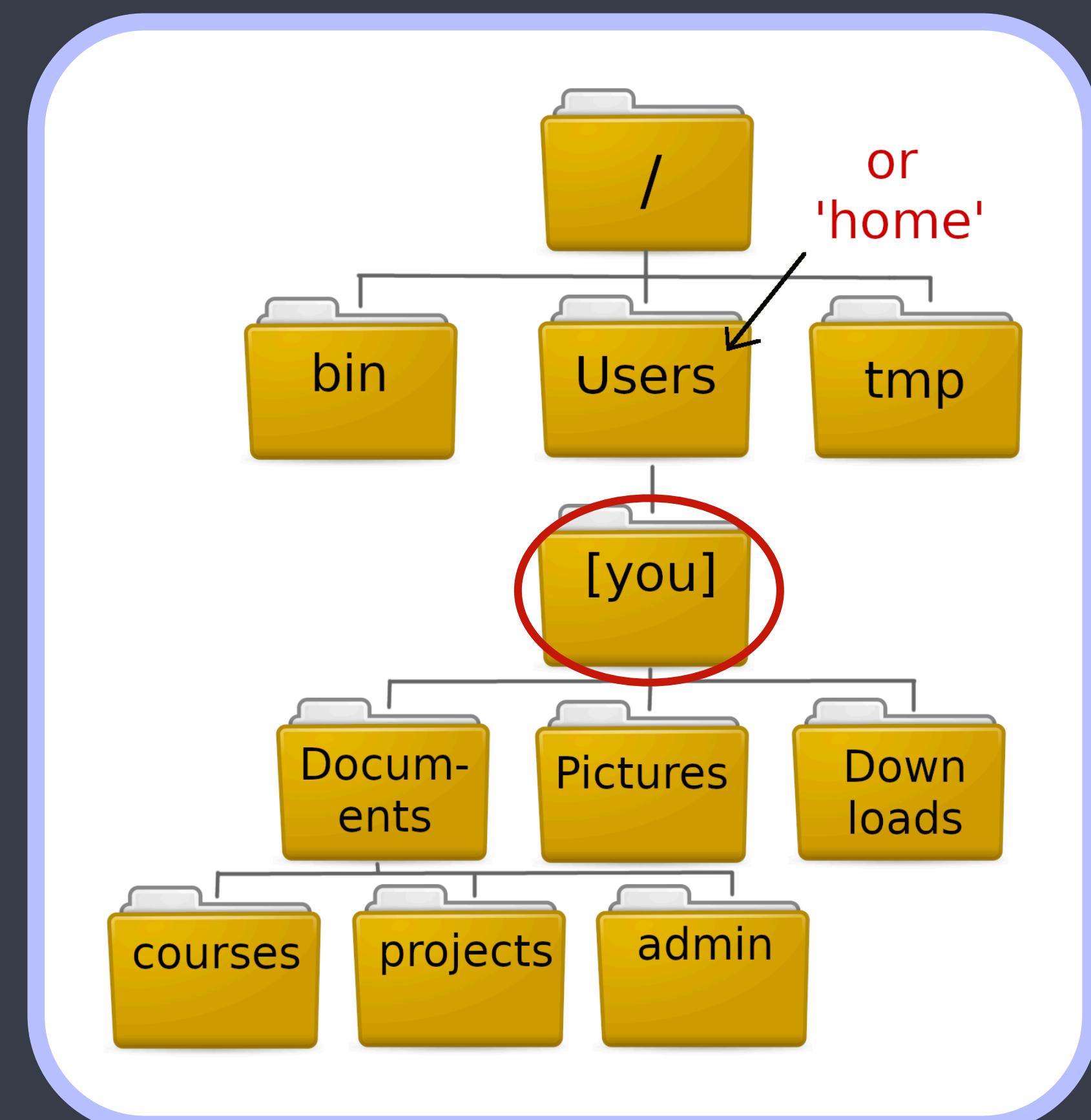
```
$ ls
```

- ls will list what is in your current **wd**.
- You can list other directories by specifying the **path** to them:

```
$ ls /home
```

```
$ ls /Users
```

- ls has many useful options such as **-l**, **-t** and **-h**, **-F**. Try it out!



# CHANGING DIRECTORIES

- From your **wd**, you can easily move into any subdirectory:

```
$ cd Documents
```

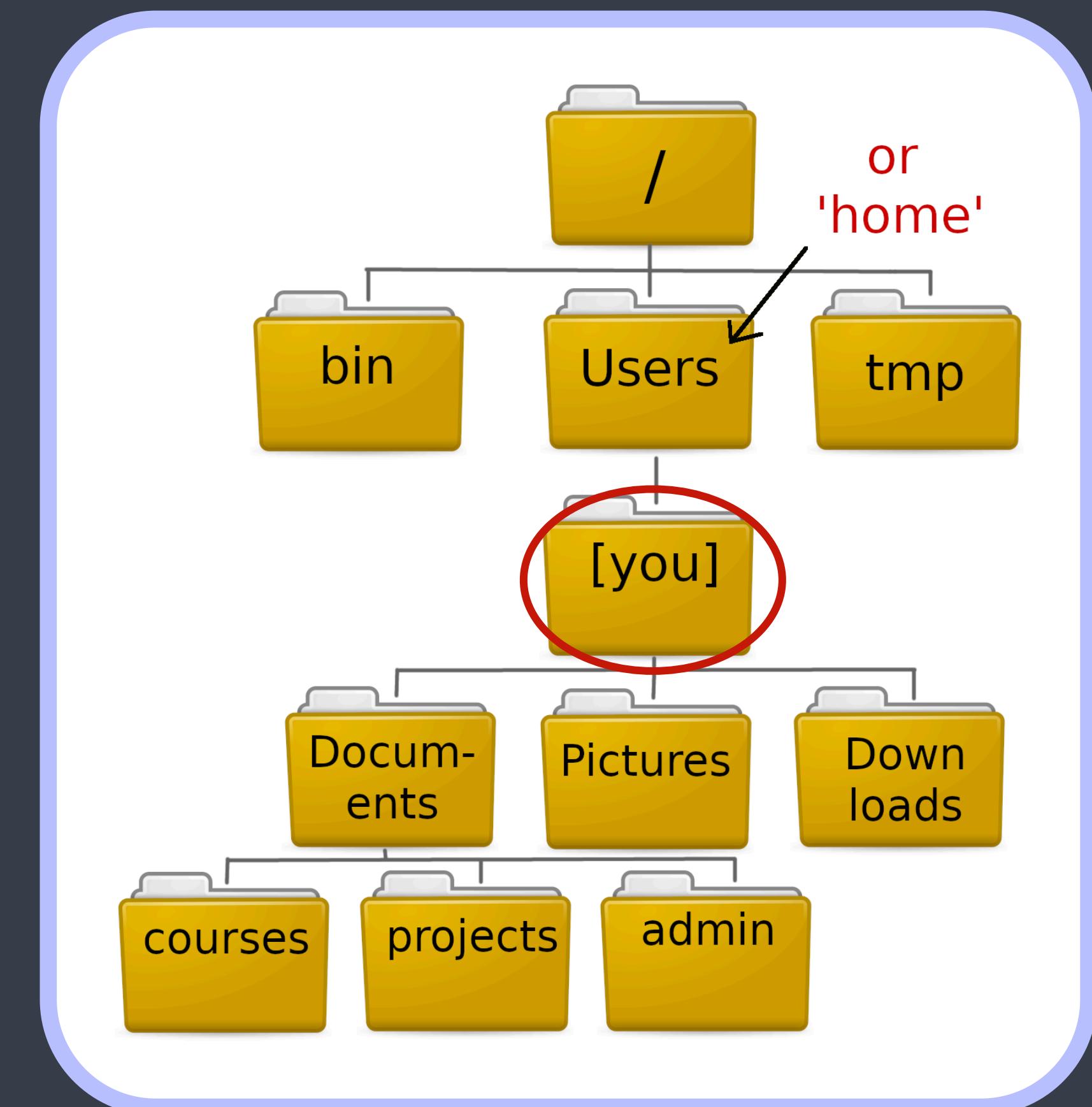
- You can also move several directories down:

```
$ cd Documents/courses
```

- To move 'up' in the directory tree you need to use '..'. Each time you write this, you go one level up.

```
$ cd ../../tmp
```

- 'cd' without any arguments brings you back to your home directory. Try it out!



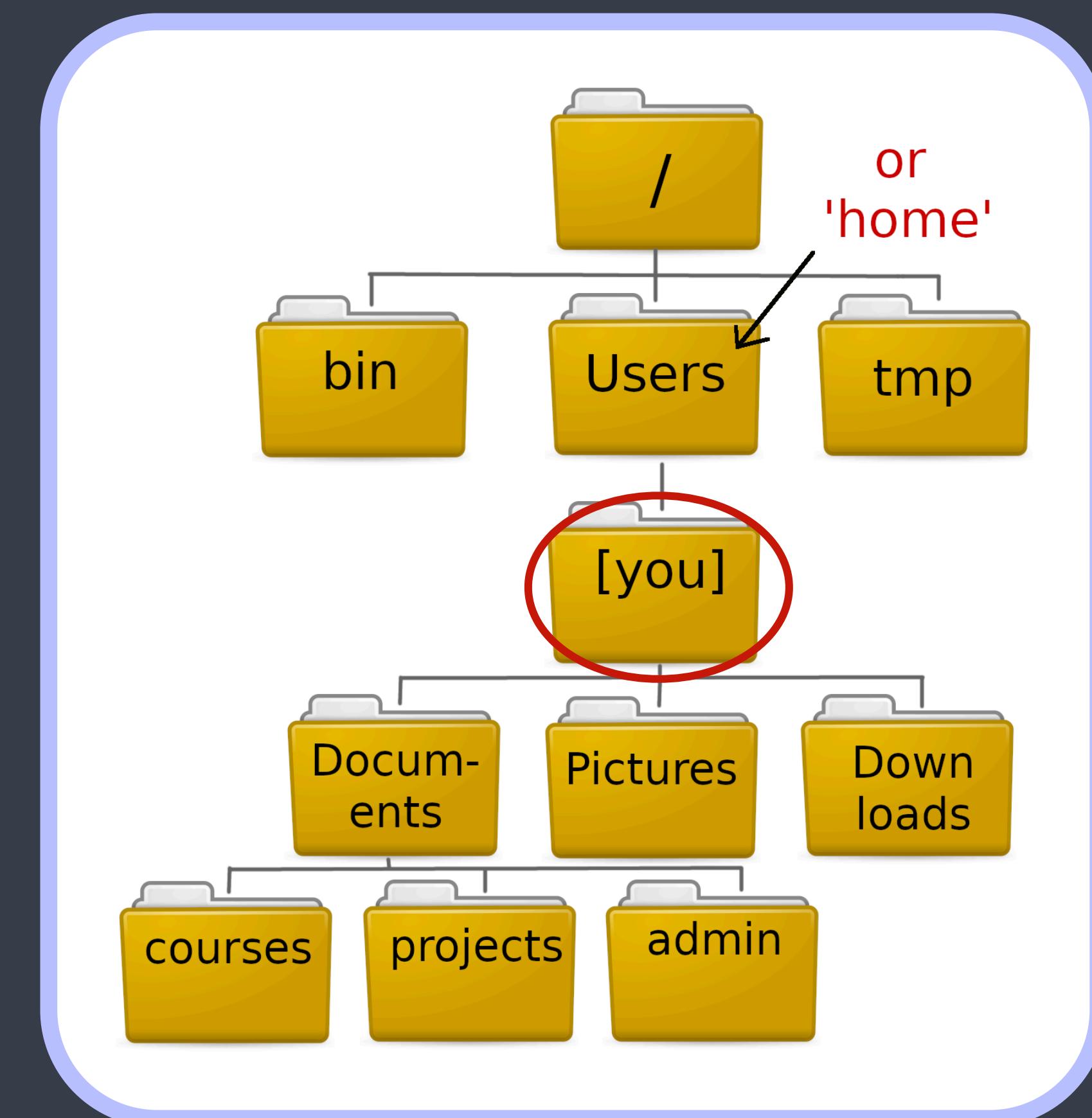
# CHANGING DIRECTORIES

- cd without any arguments will always bring you to your home directory, no matter what your current directory is:

```
$ cd
```

- cd with a minus will bring you back to the last directory you came from:

```
$ cd -
```

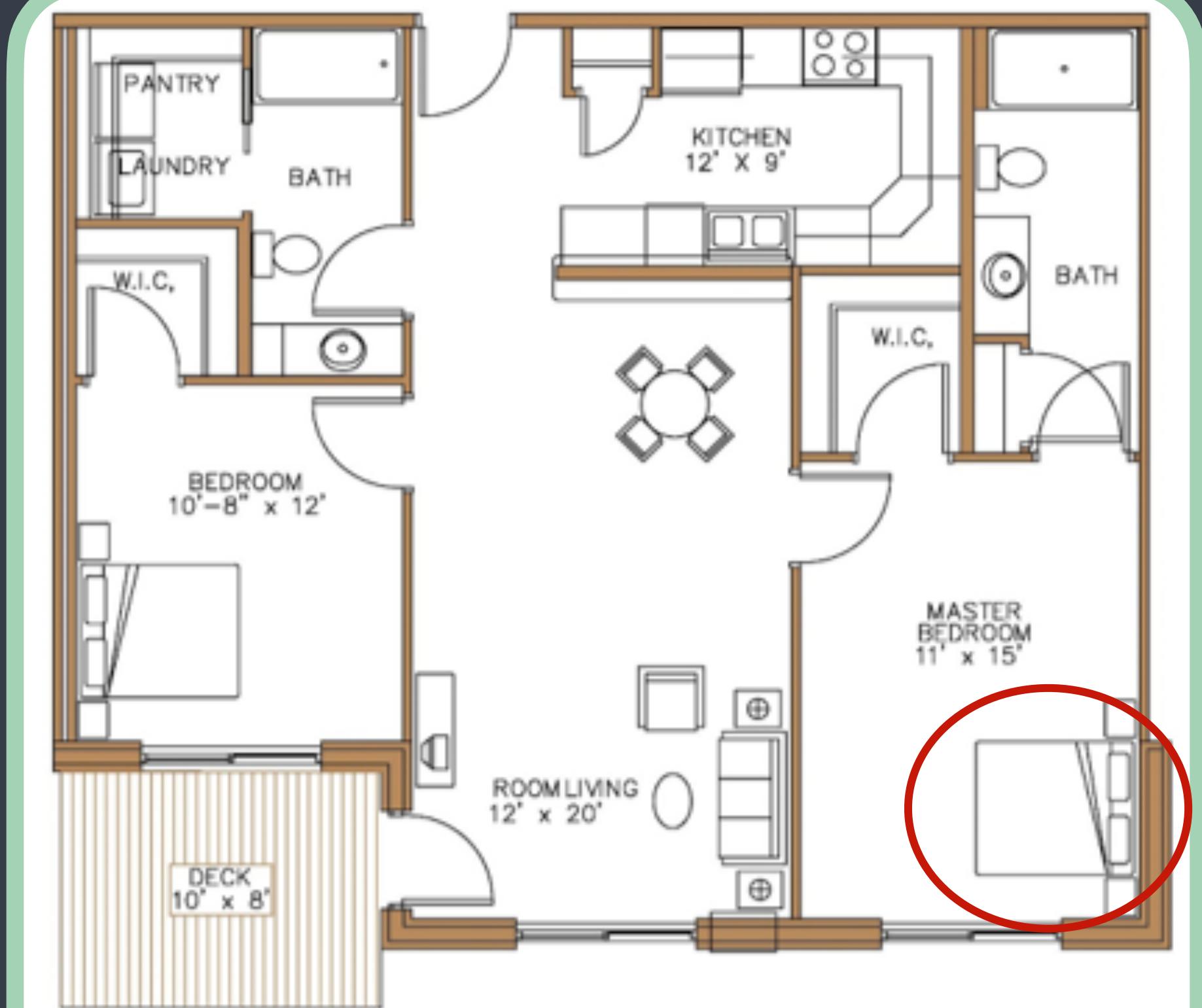


# PATHS

---

- Each file and directory exist in one specific place on your computer. One could say they have an address.
- This ‘address’ is called their path. It is an instructions how to find the file or directory.
- Following the example from earlier, the path to your bed would be:

```
/entrance/living_room/Bedroom/bed.txt
```



Two Bedroom 1,003 sq.ft.

# PATHS

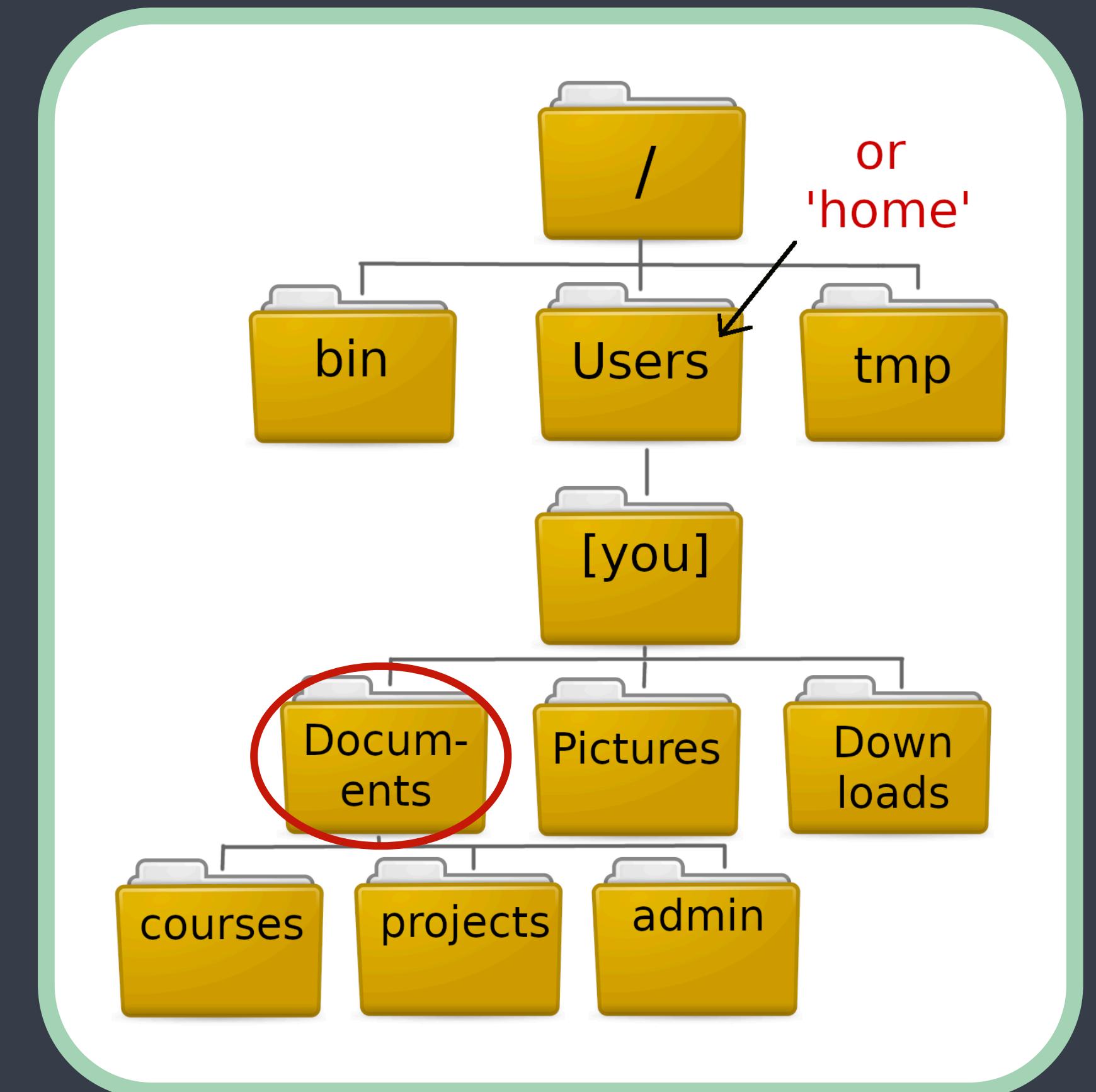
- Paths can be full/absolute or relative.
- Full paths always start at the root. Since ~ represent the path to your home directory it naturally includes the root. So

/home/[you]/Documents

and

~/Documents

- Are the same place and the same path.
- Full paths are always unambiguous since they describe the entire 'journey' starting from the root.



# PATHS

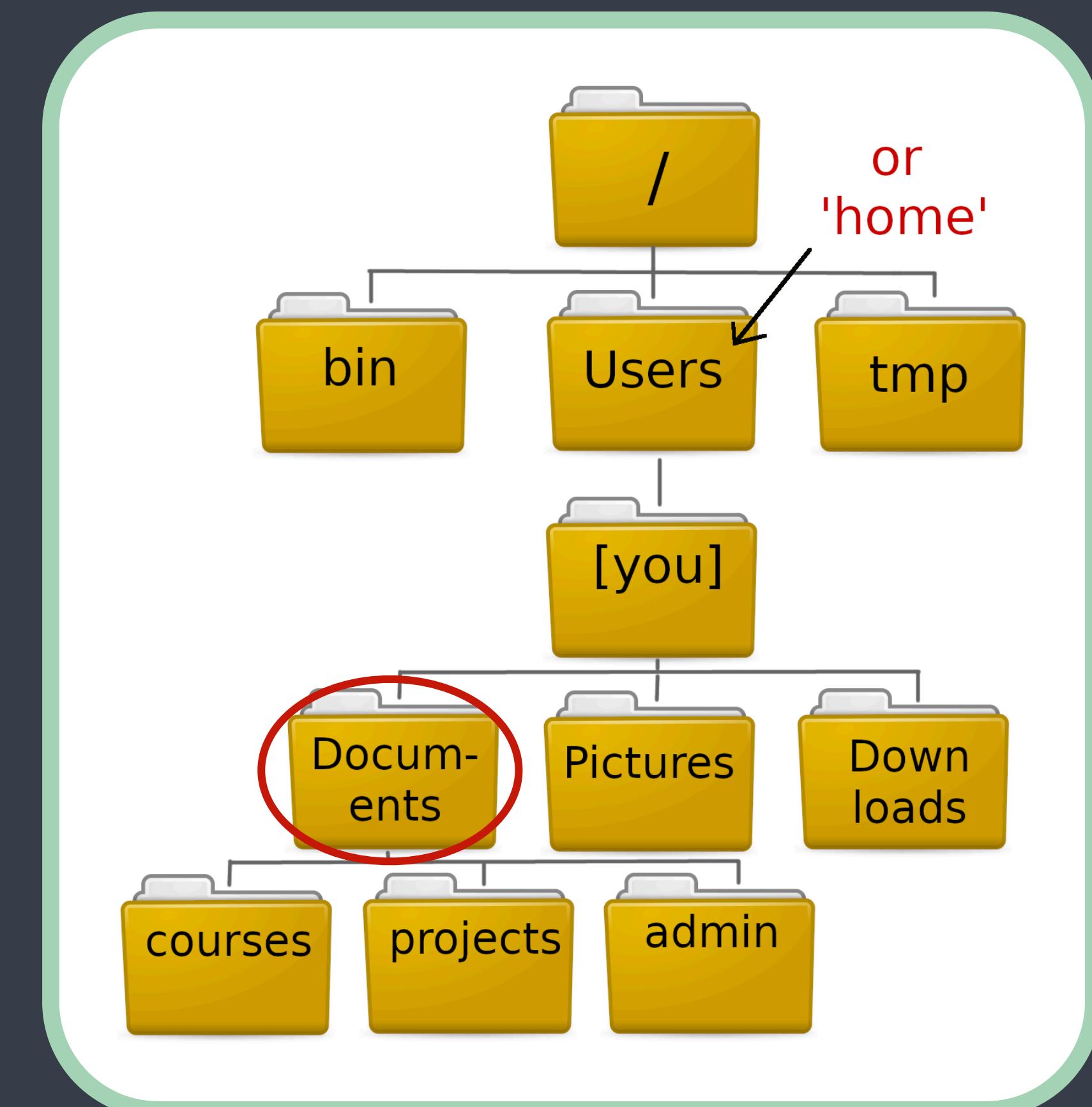
- A relative paths is an address relative to the current working directory.
- If my working directory is 'Documents', I can address this presentation as:

```
courses/Just-Bash-It-main/Commandline_
Workshop.pptx
```

- Relative paths can include going up the directory tree:

```
.../Pictures/summer2022/Bornholm
```

- This notation does not make sense for full paths as they start from the root and go strictly downwards.



# MOVING FILES AND DIRS

---

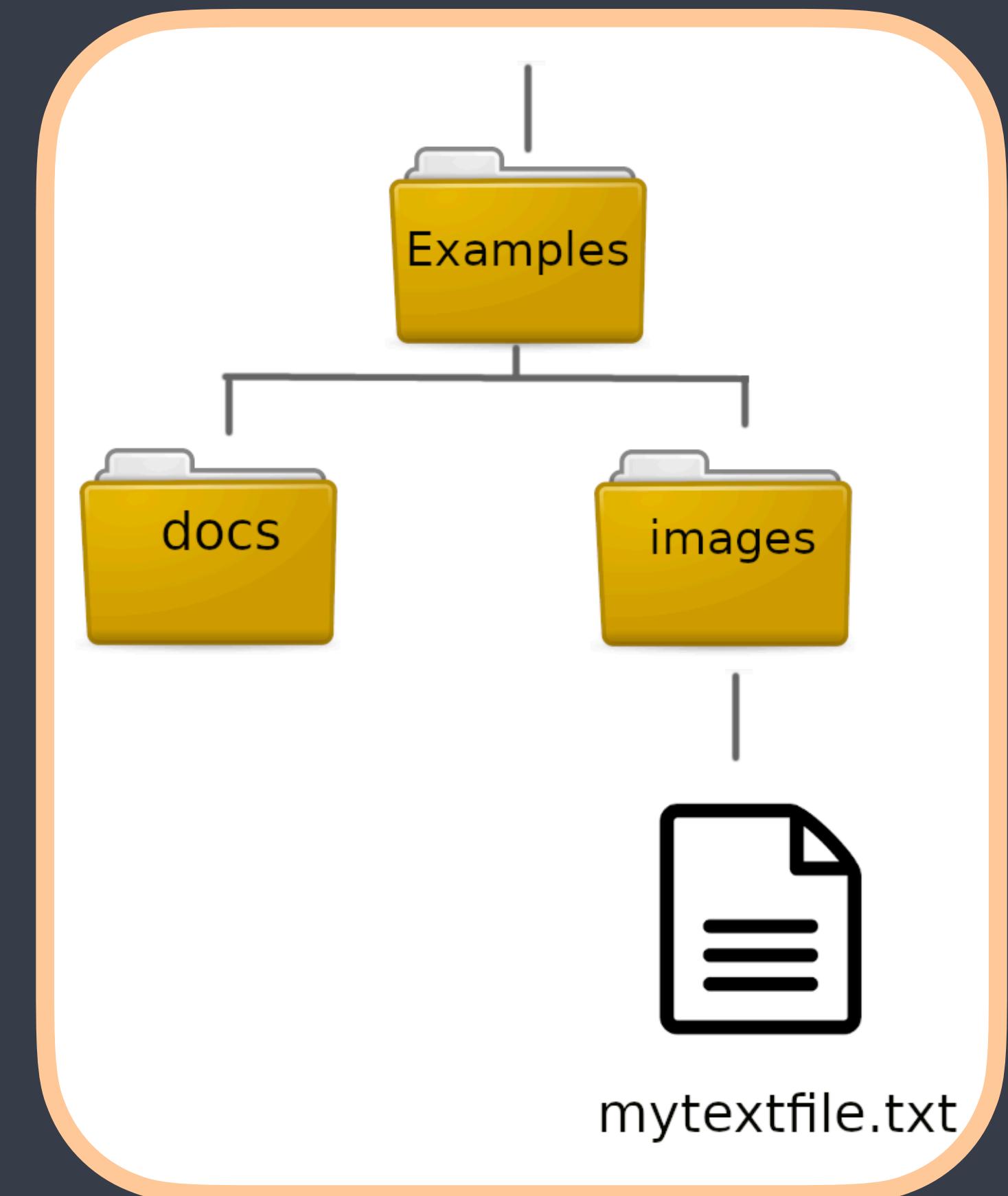
- For this part, lets go into the '*Examples*' folder of the github repo.
- You can move files (and directories) from one place into another with **mv**:

```
$ mv mytextfile.txt ../docs
```

- **mv** can also be used for renaming:

```
$ mv mytextfile.txt my_text_file.txt
```

- Do not try to move or remove your home directory or other system critical dirs. This may have unintended consequences.



# COPY AND REMOVE

---

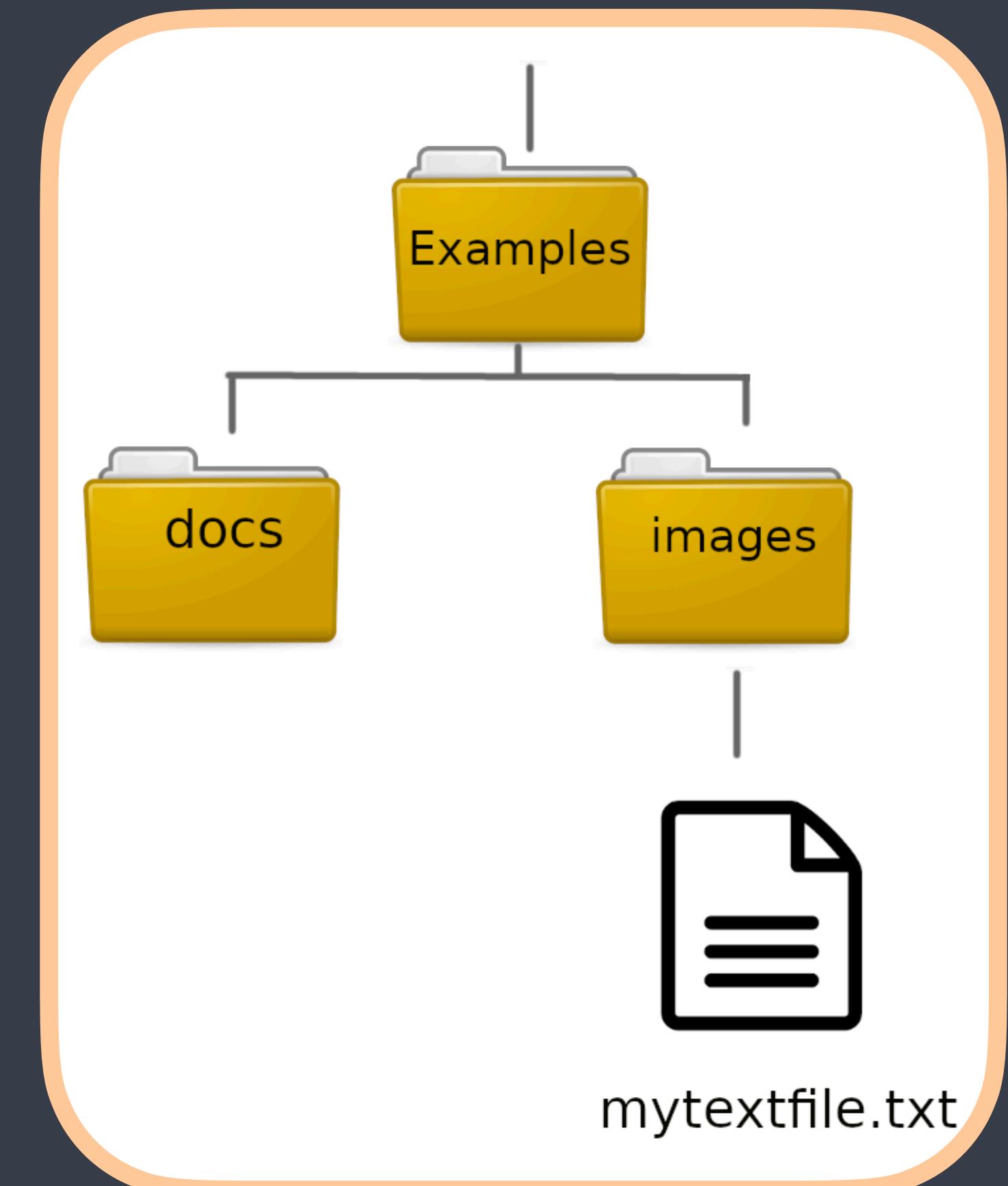
- Files can also be duplicated with the **cp** command:

```
$ cp my_text_file.txt text_copy.txt
```

- To copy a directory (and all its contents!) you need the **-r** flag
- To remove files and dirs, use **rm**

```
$ rm text_copy.txt
```

- Unlike in many graphical file managers, **rm** **is permanent!** You cannot recover a removed file and you will not be asked whether you are sure you want it gone.

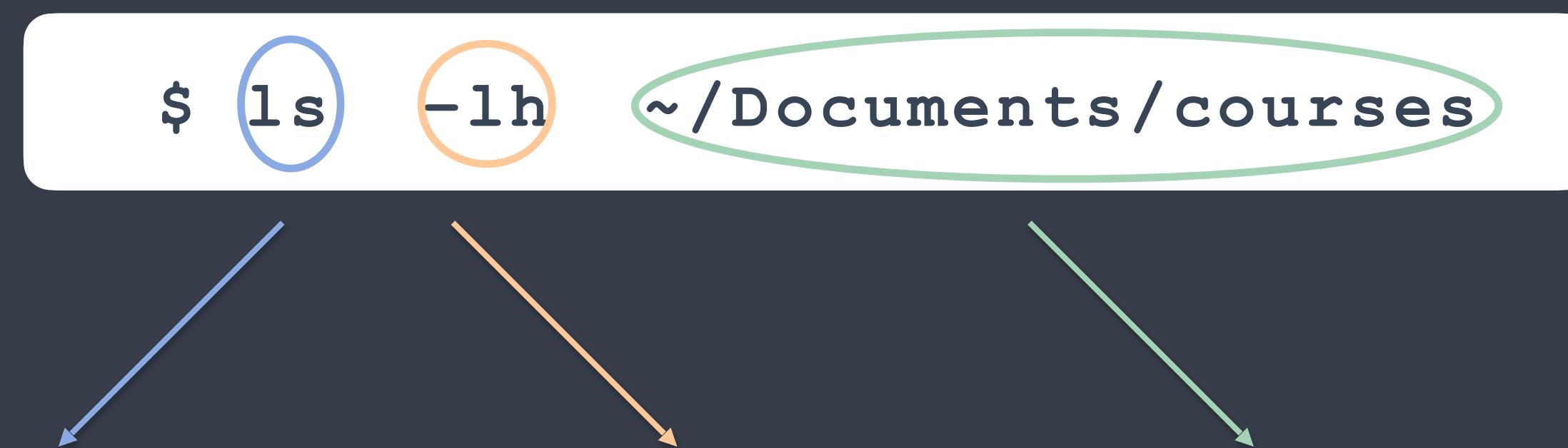


# COMMANDS

---

We interact with the computer by issuing **commands** to it. You have already tried some like **cd**, **ls**, **pwd**.

Some commands can stand by themselves like **pwd**, but often they have arguments and options/flags:



**The command:**  
List contents

**The options/ flags:**  
Long format &  
Human-readable size

**The argument:**  
Path to the directory  
to work on

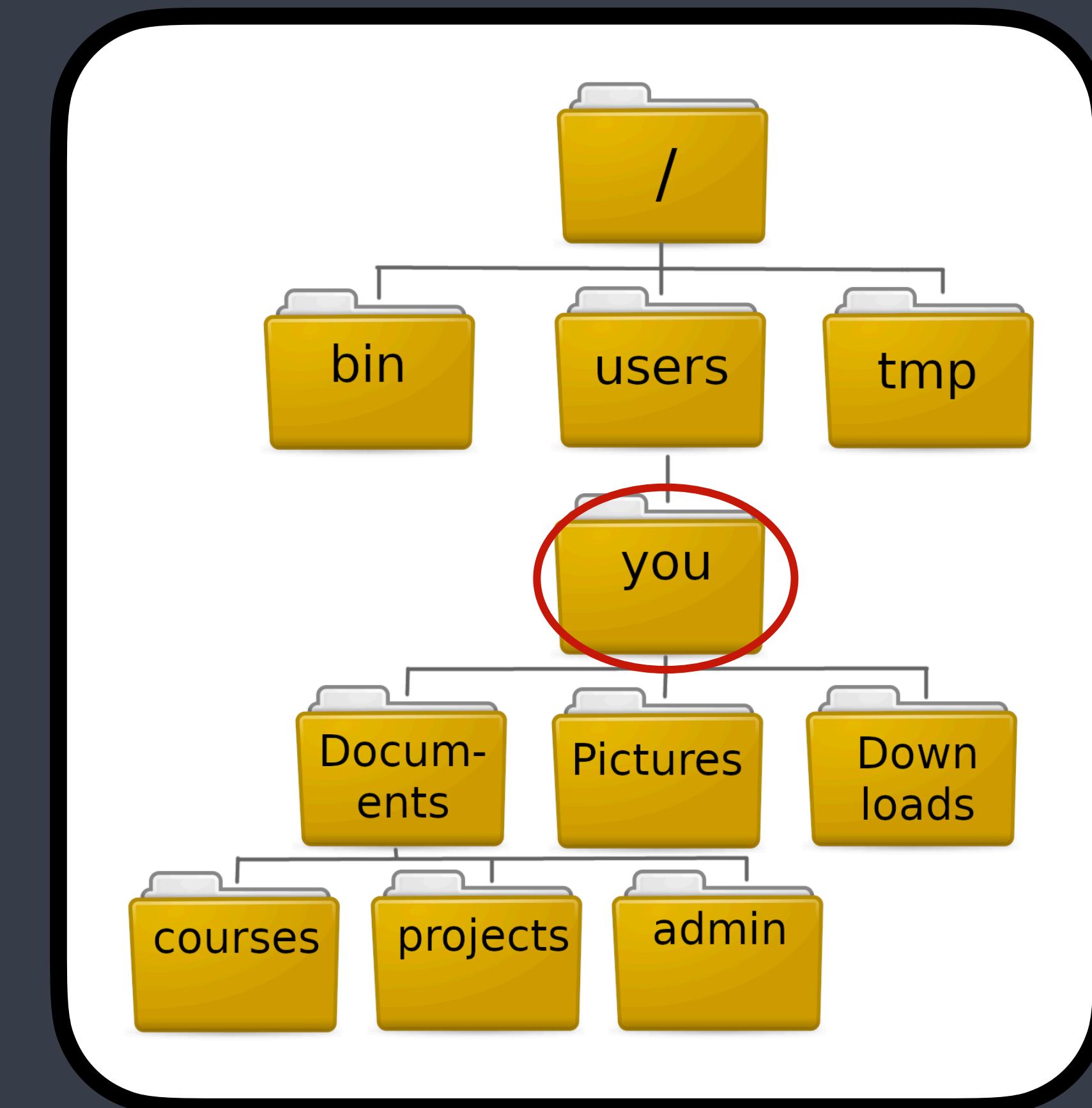
# WHEN THINGS GO WRONG

Assuming I am in my home directory and I write:

```
$ cd courses
```

What will happen?

```
henrike@henrike-Swift-SF314-42: ~
henrike@henrike-Swift-SF314-42: ~ 56x24
henrike@henrike-Swift-SF314-42:~$ pwd
/home/henrike
henrike@henrike-Swift-SF314-42:~$ ls
Desktop  Downloads  Pictures  snap      Videos
Documents  Music    Public     Templates
henrike@henrike-Swift-SF314-42:~$ ls Documents/
courses  planets1.xcf  tap-fix.sh
henrike@henrike-Swift-SF314-42:~$ cd courses
bash: cd: courses: No such file or directory
henrike@henrike-Swift-SF314-42:~$
```



# WHEN THINGS GO WRONG

---

1

Don't panic!

2

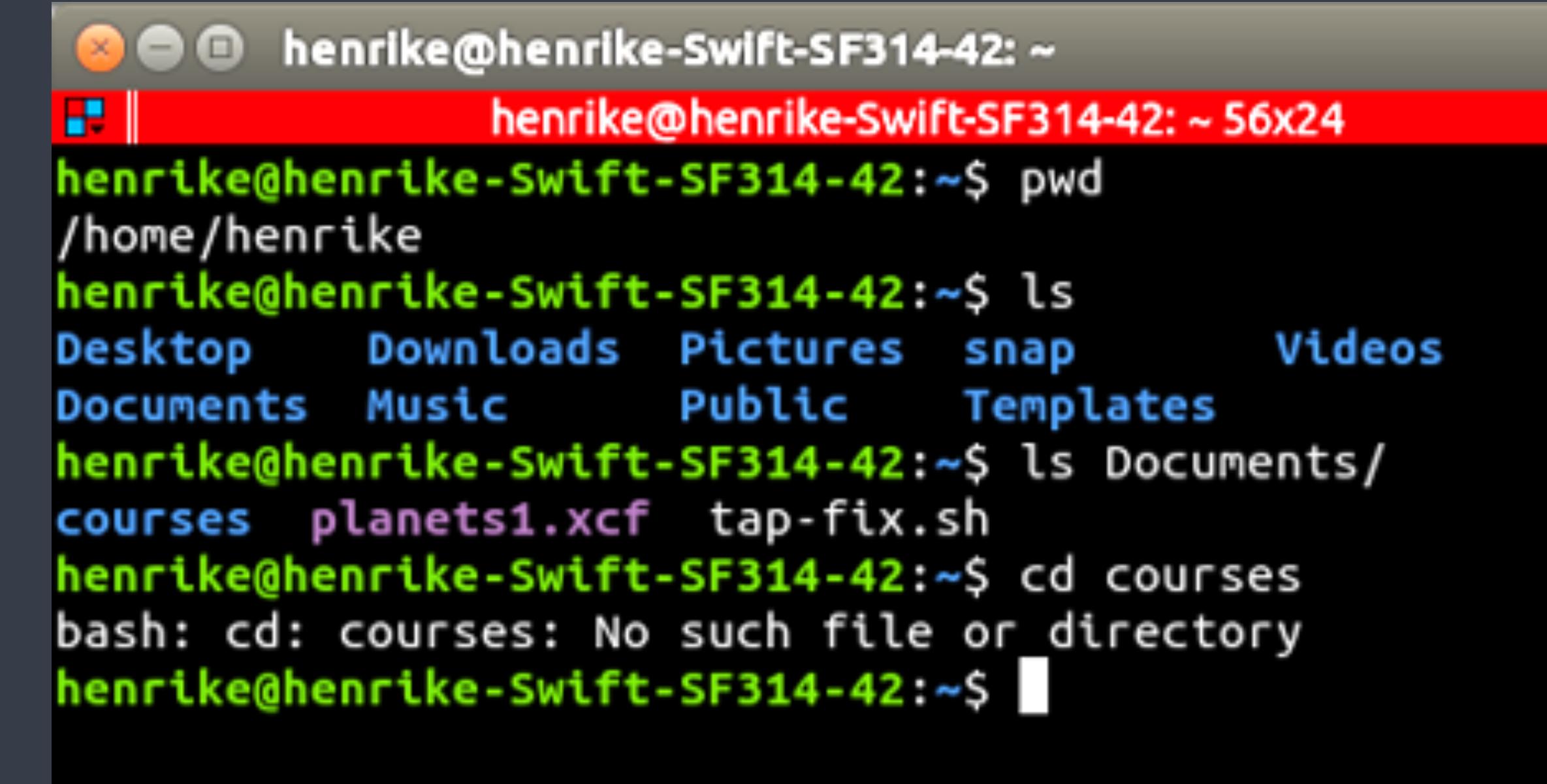
Read the error message

3

Try to correct your error

4

If lost, google or read the help page



```
henrike@henrike-Swift-SF314-42: ~
henrike@henrike-Swift-SF314-42: ~ 56x24
henrike@henrike-Swift-SF314-42:~$ pwd
/home/henrike
henrike@henrike-Swift-SF314-42:~$ ls
Desktop    Downloads  Pictures  snap      Videos
Documents  Music     Public    Templates
henrike@henrike-Swift-SF314-42:~$ ls Documents/
courses   planets1.xcf  tap-fix.sh
henrike@henrike-Swift-SF314-42:~$ cd courses
bash: cd: courses: No such file or directory
henrike@henrike-Swift-SF314-42:~$
```

# GETTING HELP

---

- Many commands have a help page, i.e. a **manual**. You can call it with **man**:

```
$ man ls
```

- The **man** page includes:

- A description of what the command does
- Explanation for arguments
- Usage examples (the syntax of the command, what goes where)

- Commands that do not have a man page often have a help instead, option **(-)help** or **(-)h**

```
henrike@henrike-Swift-SF314-42: ~
henrike@henrike-Swift-SF314-42: ~ 56x24
LS(1) User Commands LS(1)

NAME
    ls - list directory contents

SYNOPSIS
    ls [OPTION]... [FILE]...

DESCRIPTION
    List information about the FILEs (the current
    directory by default). Sort entries alphabeti-
    cally if none of -cftuvSUX nor --sort is speci-
    fied.

    Mandatory arguments to long options are manda-
    tory for short options too.

    -a, --all
            do not ignore entries starting with .

    -A, --almost-all
            do not list implied . and ..
```

ge ls(1) line 1/297 7% (press h for help or q to quit)

# CHEAT SHEET 1

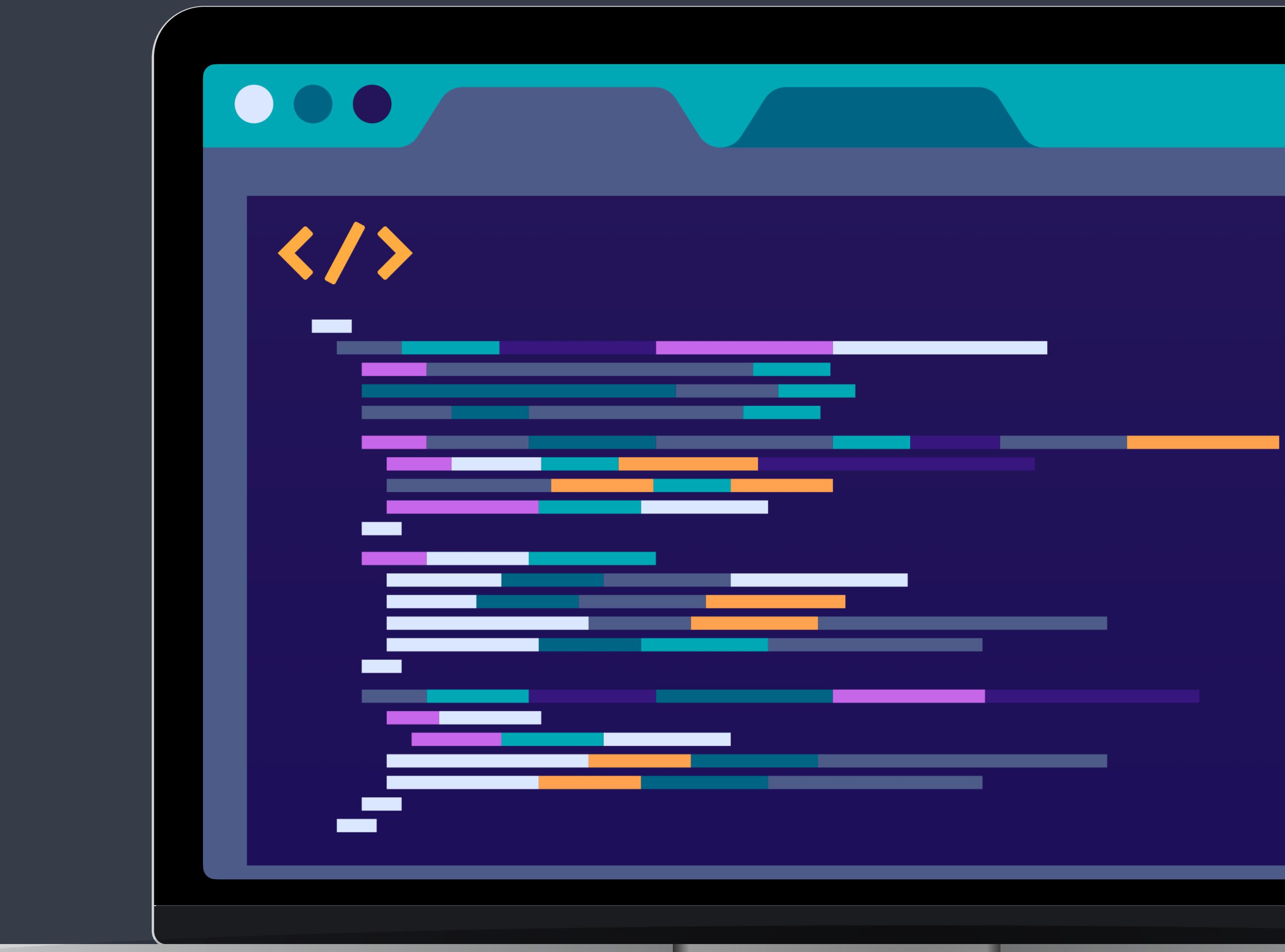
```
pwd # print working dir  
cd # go to home dir  
cd [path] # change dir (remember path)  
ls # list dir content  
man [cmd] # get info about command  
[cmd] --help # view the help for command
```

## WHERE & WHAT

```
rm [name] # remove file or dir  
cp [name] # copy a file/dir  
mv [name] [path] # move file/dir
```

## FILE/DIR BASICS

## 2. PROJECT ORGANIZATION & BACKUP



# IS YOUR COMPUTER A LAUNDRY BASKET?

**Why should I care about directory structure and file naming?**

- Not nice to not “work” in a mess.
- If your computer crashes it is MUCH easier to recover work if files/directories are structured.
- If you apply a command (bash, R, Python) to a group of files/directories, naming is important!
- Large files should be stored smartly to save space (storage & memory).



# DO'S and DON'TS



**Consistent and Logical Directory Structure**



**Consistant & Non-redundant File Naming**



**Version Control System  
git/GitHub & Back-up**



**Clean and Update Your Computer Regularly**



**Don't Use Symbols or Spaces in File/Directory Names**



**Don't store multiple copies of file, instead point to it (path).**



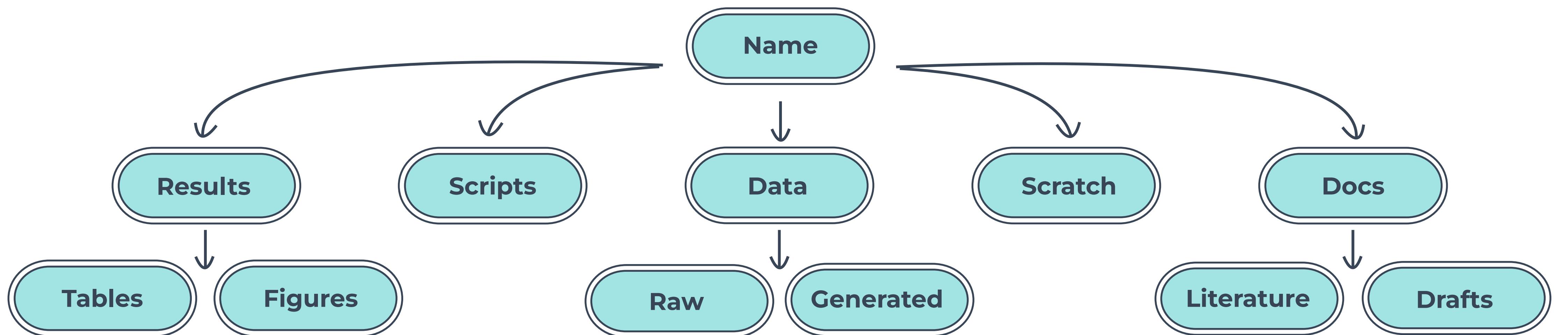
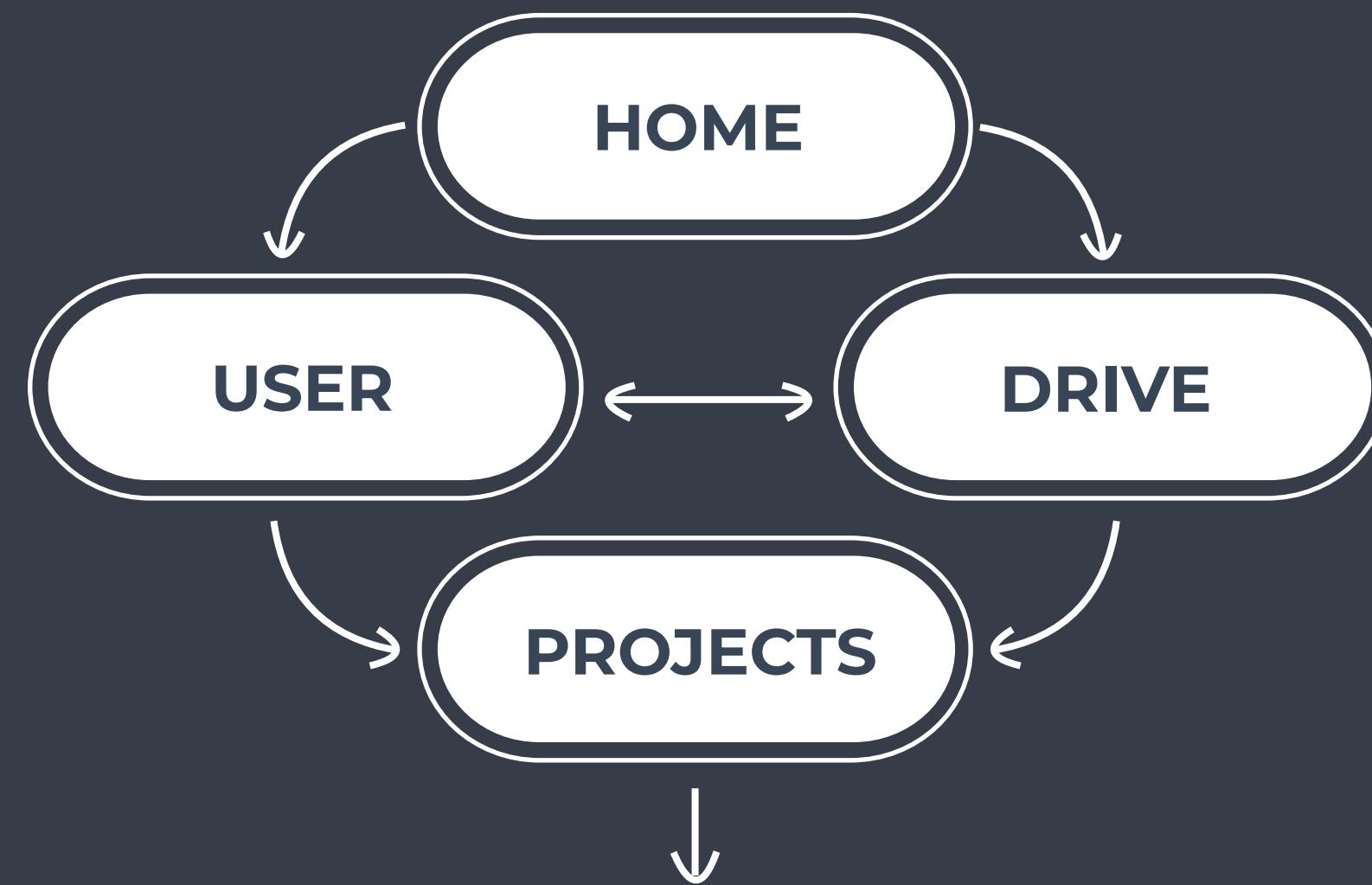
**Don't Store Large Data/Files on Your Local Computer**



**Don't Store Sensitive Datasets on Your Computer**

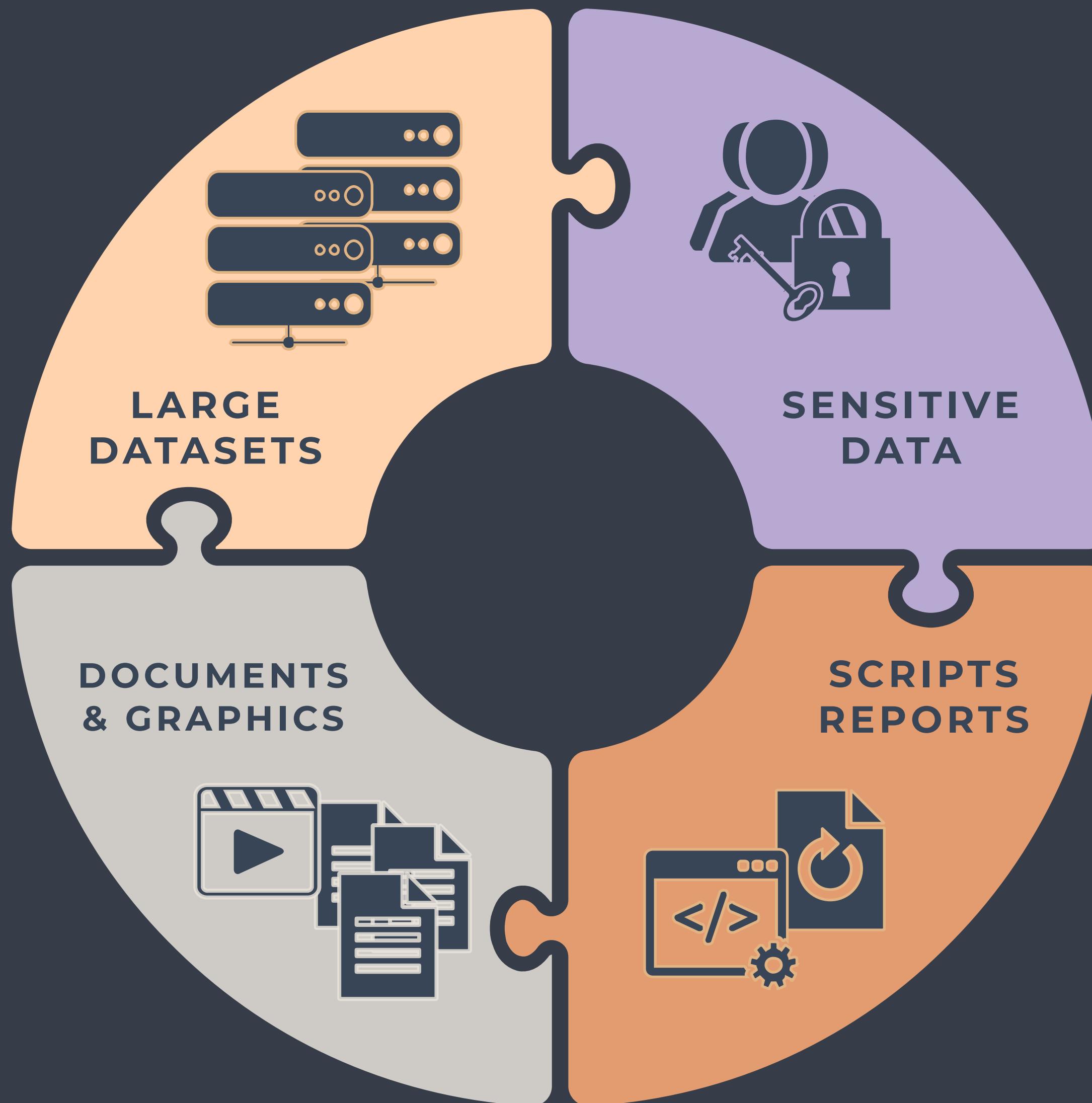
# A SUGGESTION FOR STRUCTURE

LOCAL COMPUTER



# STORAGE & BACKUP

---



- BIG DATA & SENSITIVE DATA:
  - Your own KU drives (S-drive)
  - ERDA & SIF (KU data storage)
  - Lab or department server
  - Lab or department cloud solution
- DOCX, EXCEL, POWERPOINT:
  - Google Drive
  - Dropbox
  - KU drives
- SCRIPTS:
  - git/GitHub**
  - (KU drives)

# GIT & GITHUB

**Git** is a version control software, created by Linus Torvalds for the management of the Linux kernel.

Other clients exist.

<https://git-scm.com>



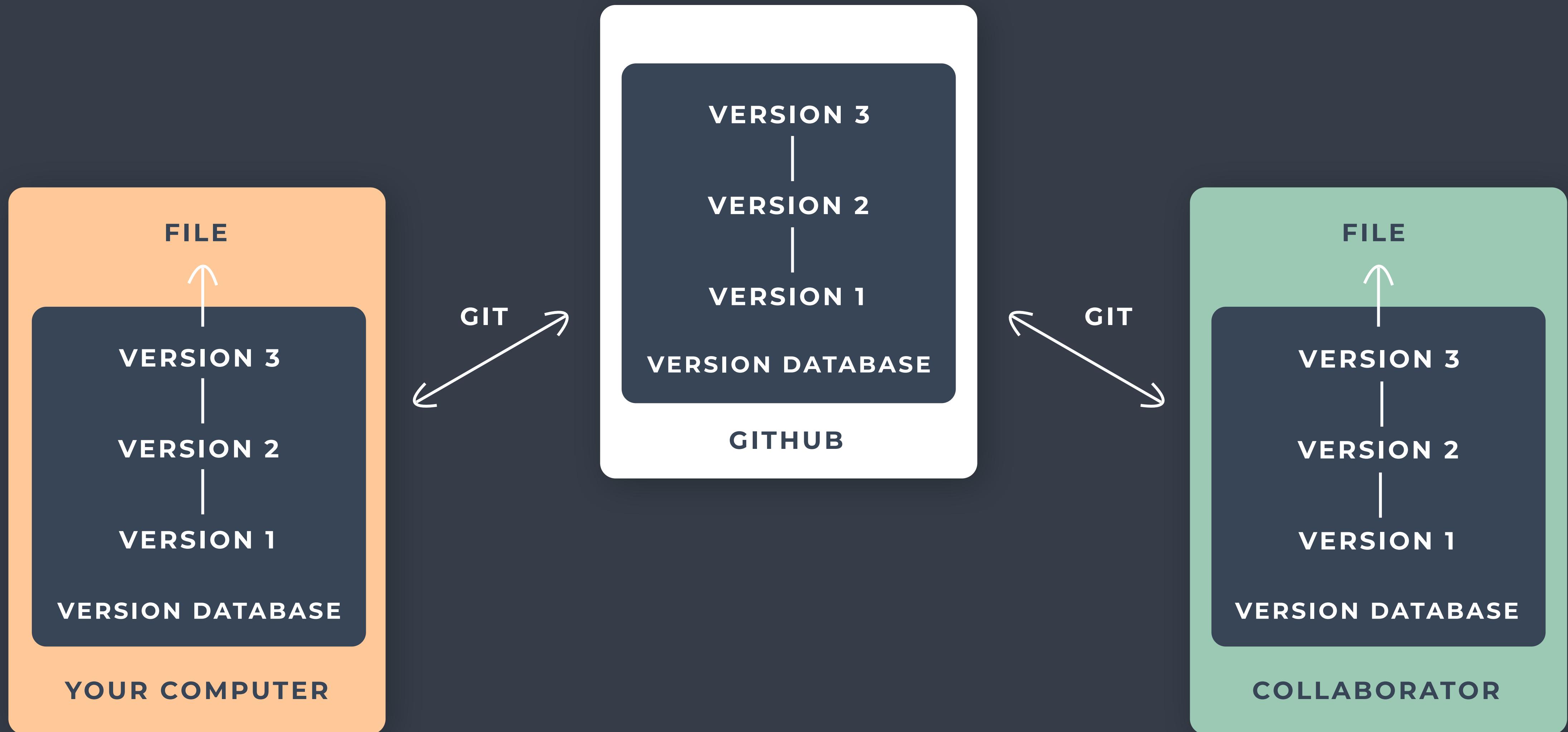
**GitHub** is a web-based hosting service for version control that uses git

Other services exist.

<https://github.com>

# WHAT IS A VERSION CONTROL SYSTEM?

---

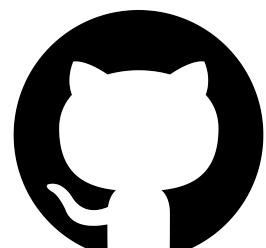


# GIT WORKS FROM THE COMMAND LINE

**Git is used from the command line to edit directories & files in a version controlled way**

**A git command always begins with git**

**Git enables a local computer to interact with a cloud service (GitHub) to back up your work**



**Sounds cool, yes!**  
**Take our 'Introduction to git & GitHub' Workshop and learn how to git**

**git clone [your repository]**

*Username: [your user]*

*Password: [your password]*

**git status (status of the repo)**

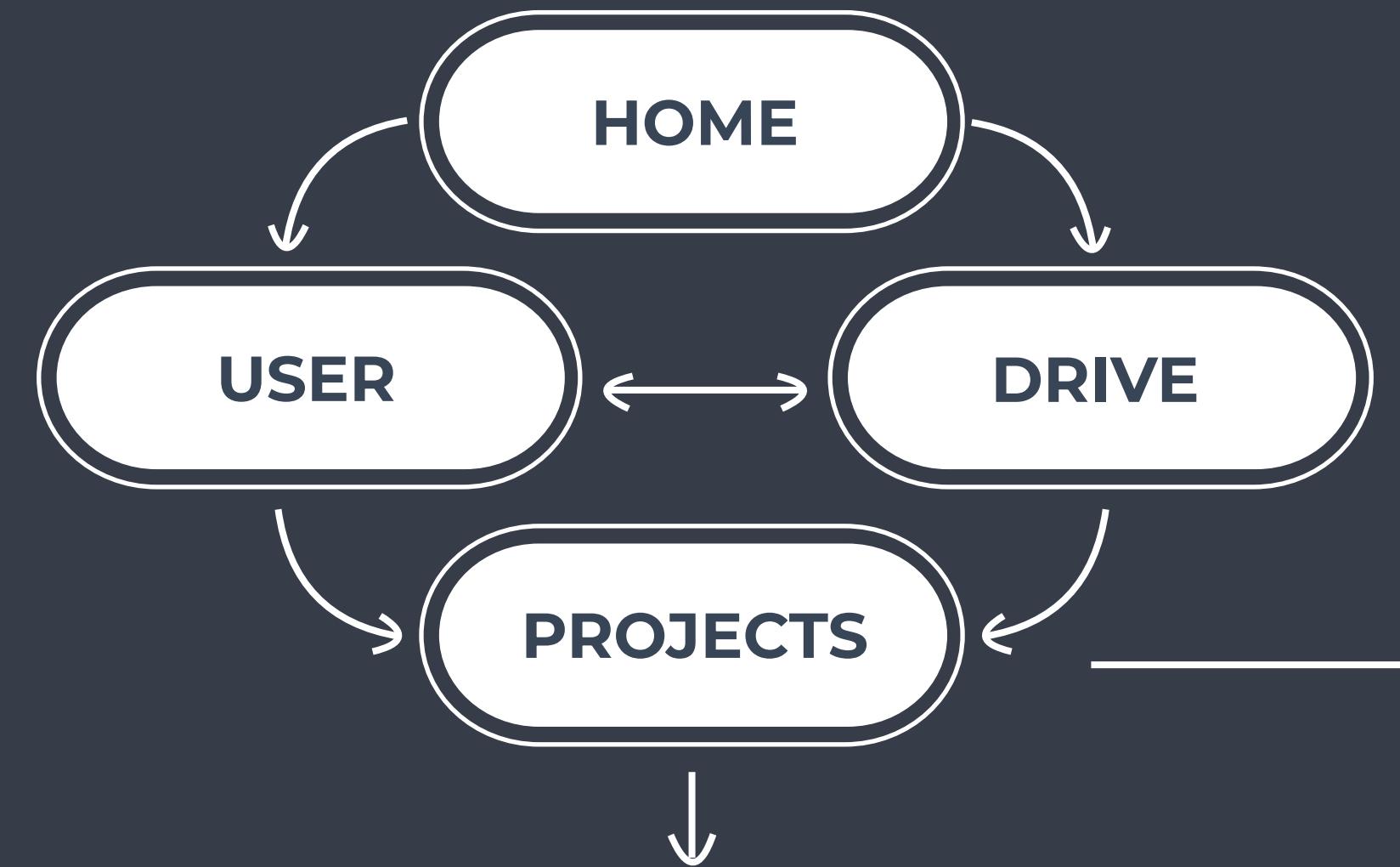
**git add (add new files or changes)**

**git commit -m (commit the changes)**

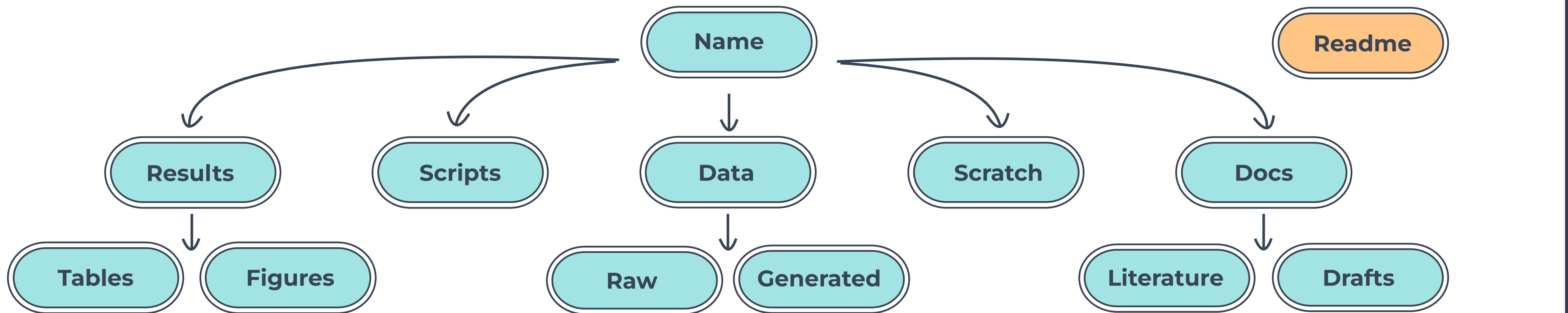
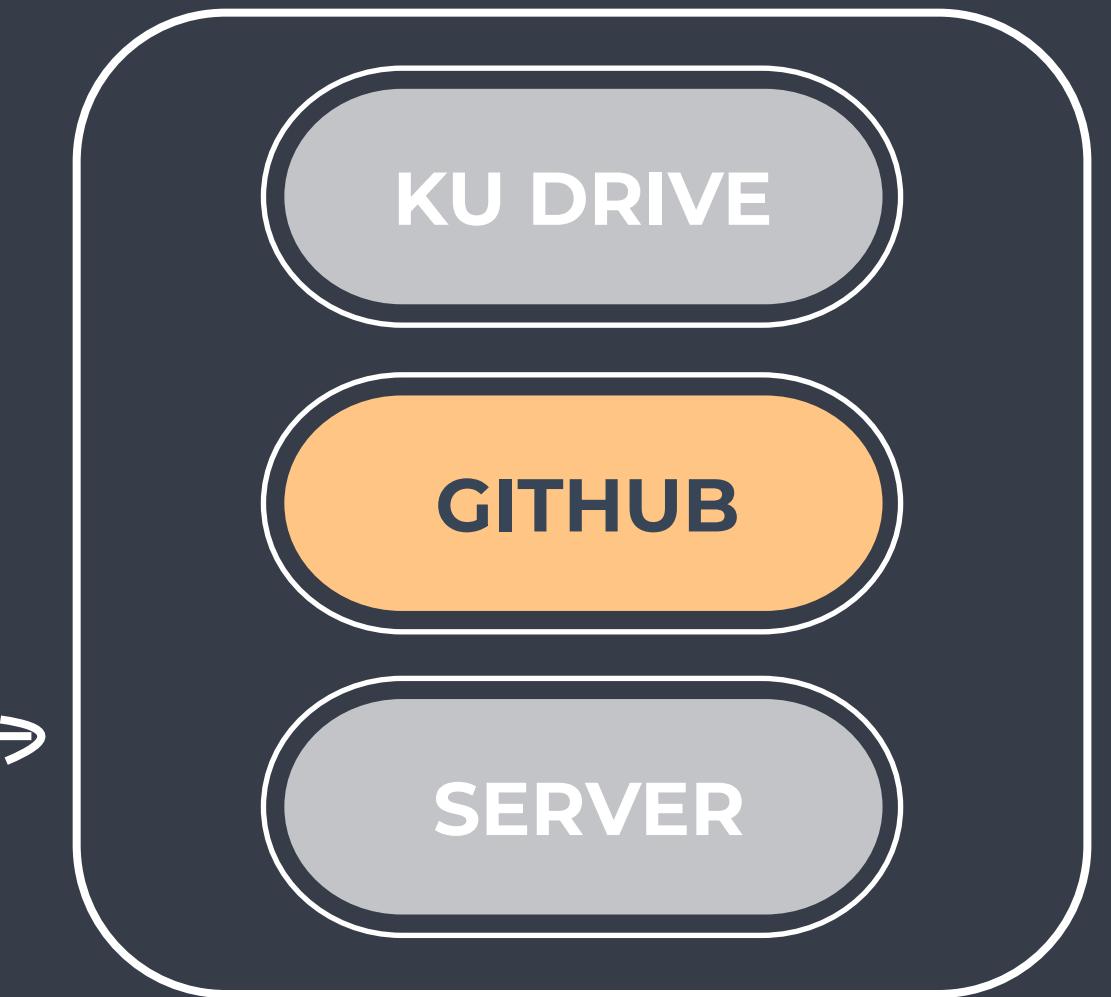
**git push (push the changes to GitHub)**

# A SUGGESTION FOR STRUCTURE

LOCAL COMPUTER

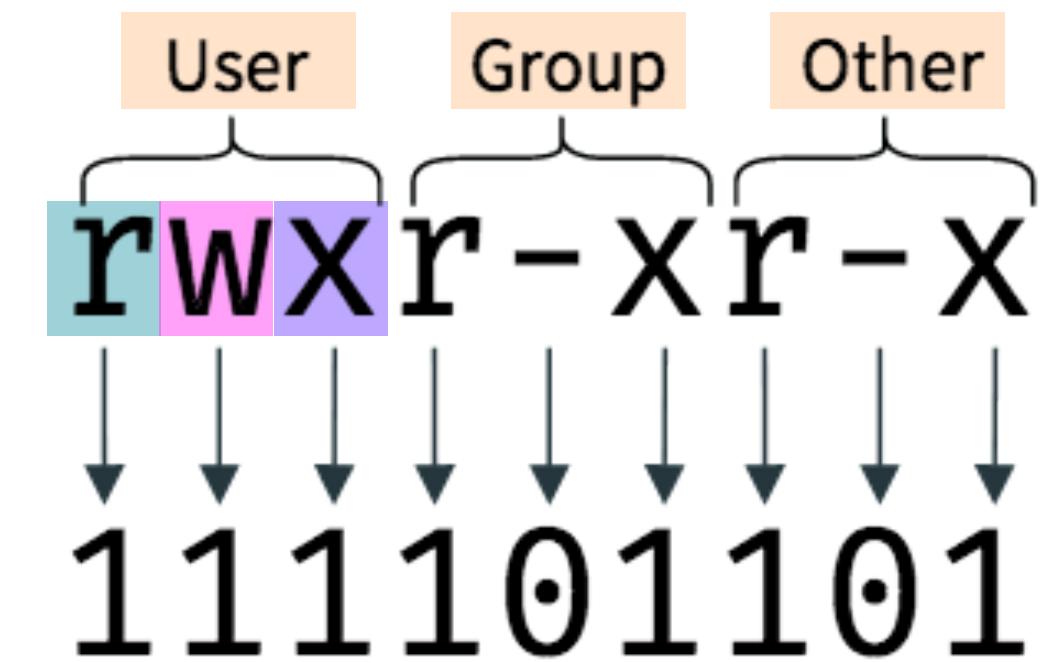


EXTERNAL BACKUP



# USERS, GROUPS & PERMISSIONS

- Files & directories have **permission settings**
- Permissions denote who can **read**, **write** (edit) and **execute** a file/dir
- Permissions can be changed **IF** you are a system administrator (sys admin).
  - **Private computer** : You are sys admin
  - **KU computer** : You may be the system admin
  - **Shared KU drives** : You are not sys admin
  - **HPCs, Servers & Clouds** : You are not sys admin



```
chmod +rwx [filename]  
chmod -wx [directoryname]  
  
chmod u+rwx [filename]  
chmod g-w [filename]  
chmod o-rwx [filename]
```

# CHEAT SHEET 1

```
pwd # print working dir  
cd # go to home dir  
cd [path] # change dir (remember path)  
ls # list dir content  
man [cmd] # get info about command  
[cmd] --help # view the help for command
```

## WHERE & WHAT

```
* # select everything  
/ # forward slash paths  
\ # escape character (don't use for now)  
.. # one dir up/back  
. # current dir  
- # denotes a flag/argument
```

## SPECIAL CHARACTERS

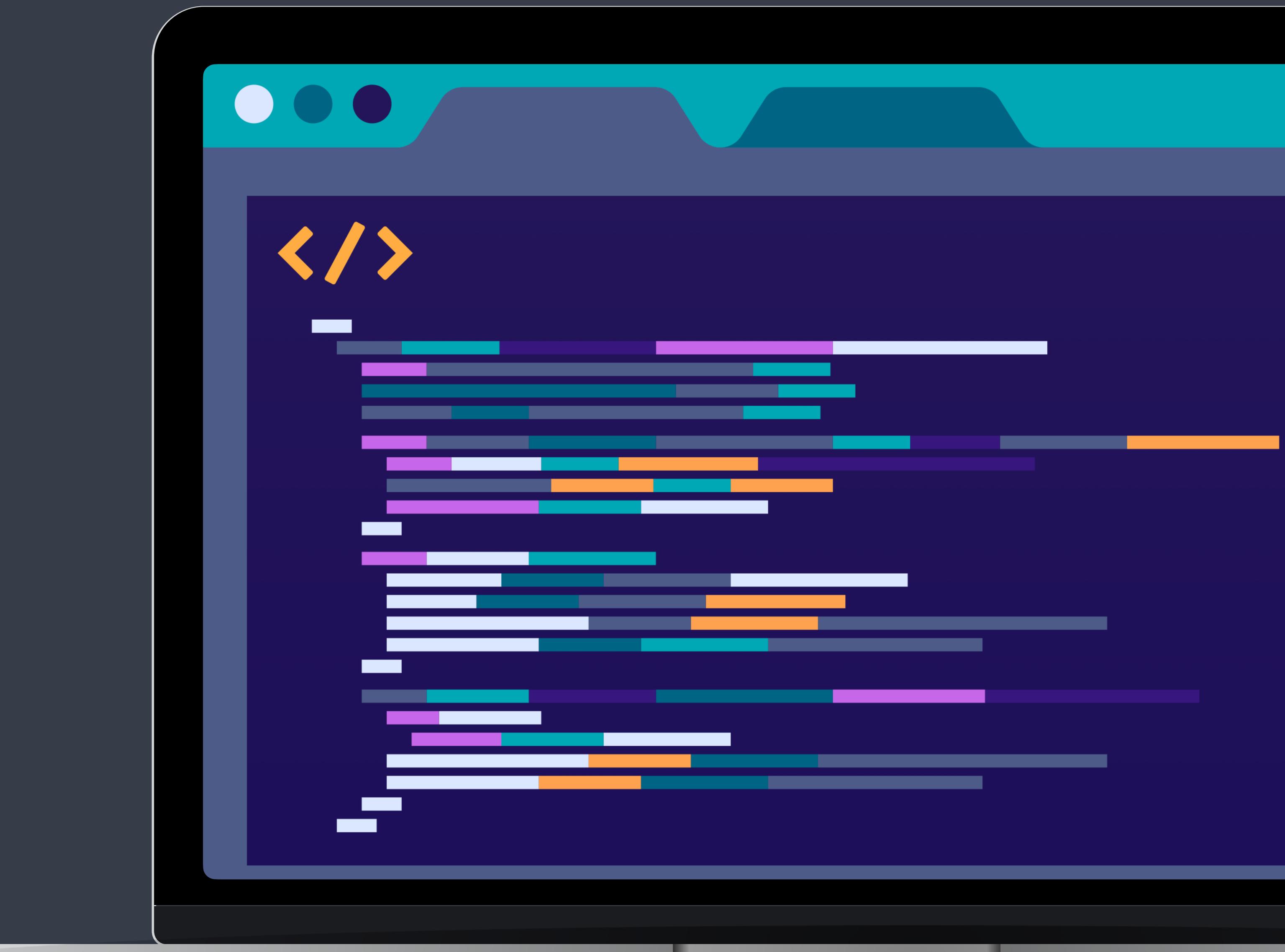
```
rm [name] # remove file or dir  
cp [name] # copy a file/dir  
mv [name] [path] # move file/dir  
  
touch [name] # make a file  
mkdir [name] # make a dir
```

## FILE/DIR BASICS

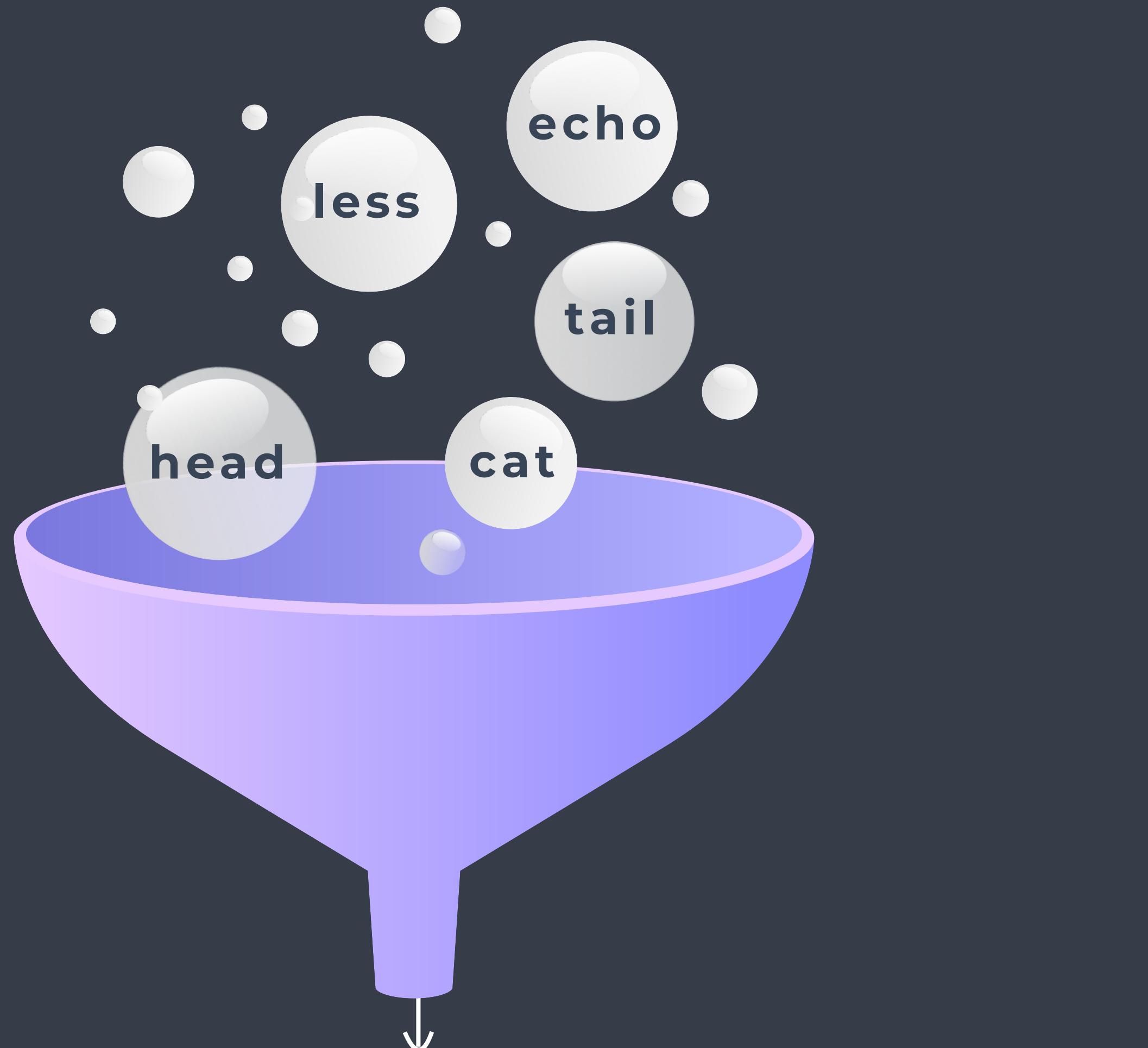
```
ls -lh * # all sizes  
ls -lh [name] # file/dir size  
du -sh # disk space  
chmod +rwx [name] # add permission  
chmod -rwx [name] # remove permission  
chmod ugo+rw [name] # specify who, add permission
```

## SIZE & PERMISSION

### 3. WORKING WITH FILES



# VIEWING FILES



- Many roads lead to Rome... For viewing files we can use:
- **less [file]**:
  - Prints N first lines of file. You can change the default N. Interactive viewing.
  - Exit with **q**
- **cat [file]**:
  - (concatenation), prints all lines of file.
  - Exit with **ctrl + c**
- **head/tail [file]**:
  - Prints **n first / last** lines of file. You can change the default **n**. Static viewing.

# VIEW - SUBSET & RENAME

**echo**

```
echo 'Hello, World!'
```

**less  
&  
cat**

```
less myfile.txt
```

Patient	Age	Sex	Smoker	Grade
ID1	61	Female	No	G2
ID2	58	Female	Yes	G3
.	.	.	.	.

```
cat myfile.txt
```

**head  
&  
tail**

```
head -n 20 myfile.txt
```

```
head -n 20 myfile.txt > myfile_small.txt
```

**>** = Redirect - Save output to new file.

More on this later.

# EDITING FILES

- **Nano** [file] :

- Simple and easy to use
- Limited functionality
- Exit with **Ctrl + x (Y + enter)**

- **VIM or VI** [file] :

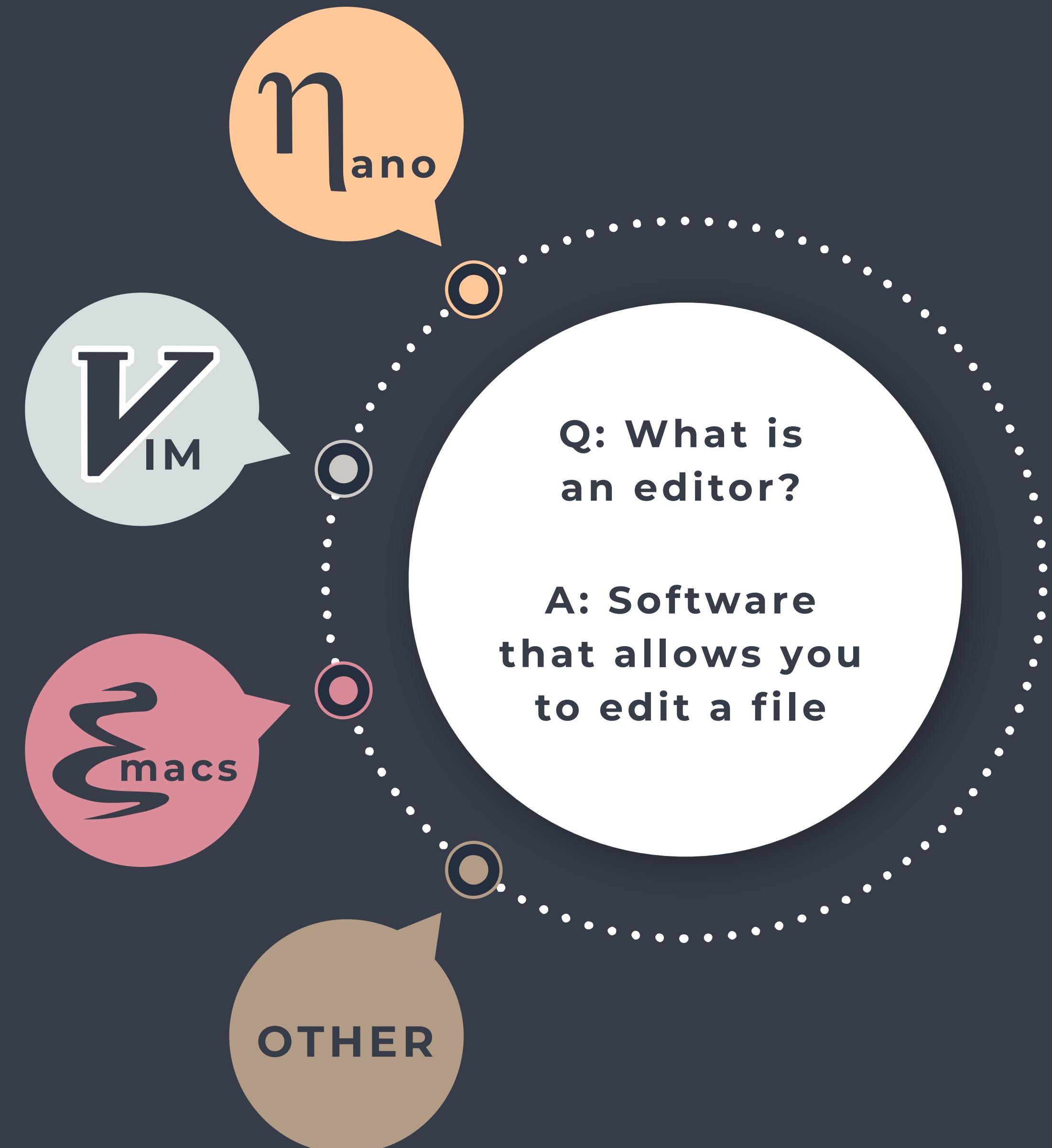
- Many functionalities, i.e. complex
- Keyboard shortcuts
- Exit with **:q (:w or :q!)**

- **EMACS** [file] :

- Oldest editor
- Keyboard shortcuts, **Ctrl, Alt/Esc + [L]**
- Exit with **Ctrl + x (Ctrl + s)**

- **OTHER** [file] :

- There are many other editors ...



# COMPRESSED FILES

.GZ

Compresses a file with standard gzip (GNU zip) compression.

.TAR

Combines all files within a directory in one, single archive file.

.TAR.GZ

gzip and tar together. Gives a compressed archive of multiple files put together inside a single file.

`gzip [file.gz]`

`gunzip -k [file.gz]`

`unzip [file.zip]`

`tar -cvf [file.tar.gz] [dir]`

`tar -xvf [file.tar.gz]`

`tar -tf [file.tar]`



# CHEAT SHEET 2

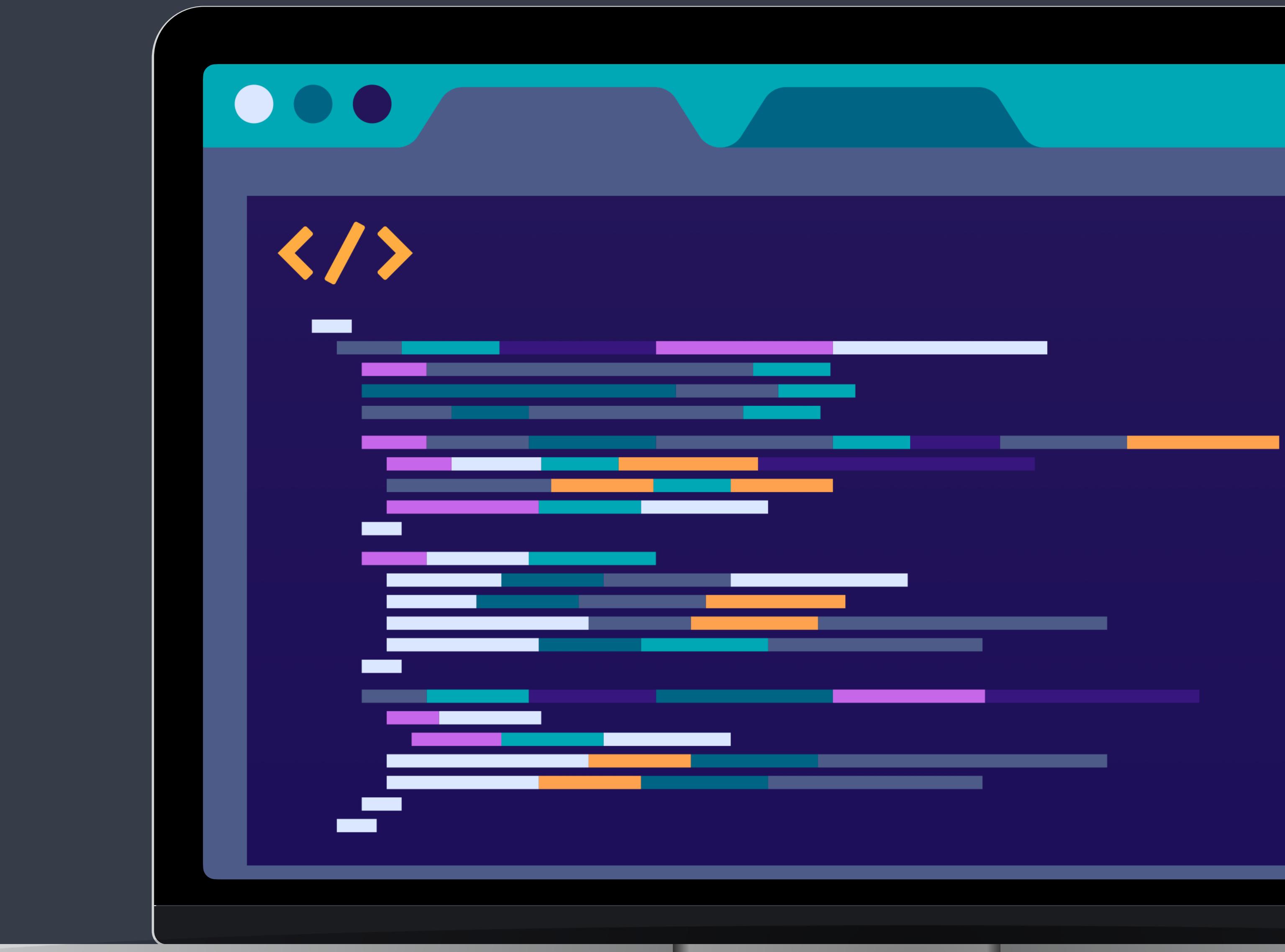
## View Files

```
less [file] # view file content  
cat [file] # view file content (full)  
head / tail -n 10 [file] # view n first/last lines  
nano [file] # https://www.nano-editor.org/dist/latest/cheatsheet.html  
vim | vi [file] # https://vim.rtorr.com/
```

## Compressed Files

```
tar -[f] [file] # .tar files  
gzip -[f] [file] # decompress (.tar).gz files  
unzip -[f] [file] # decompress .zip files  
zless -[f][file] # view .gz file w/o decompression  
  
others: zcat, zmore, gzcat
```

## 4. MORE BASH COMMANDS



# FROM FILE NAVIGATION TO MANIPULATION

- FILES & DIRECTORIES:

- Move & Copy
- Make & Remove
- Open & Read
- Edit & Save
- Subset & Rename
- View & Change Permissions



NAVIGATE THE TERMINAL  
&  
FILE MANAGEMENT

- FILES:

- Sort
- Count Lines & Entries
- Merge & Concatenate
- Find & Replace Patterns
- Cut & Paste
- Insert & Delete



FILE MANIPULATION,  
WRANGLING, SUMMATION

# BASH COMMANDS

Sort  
Sort a file/column  
Number, character, mixed



Search & Extract  
pattern in file



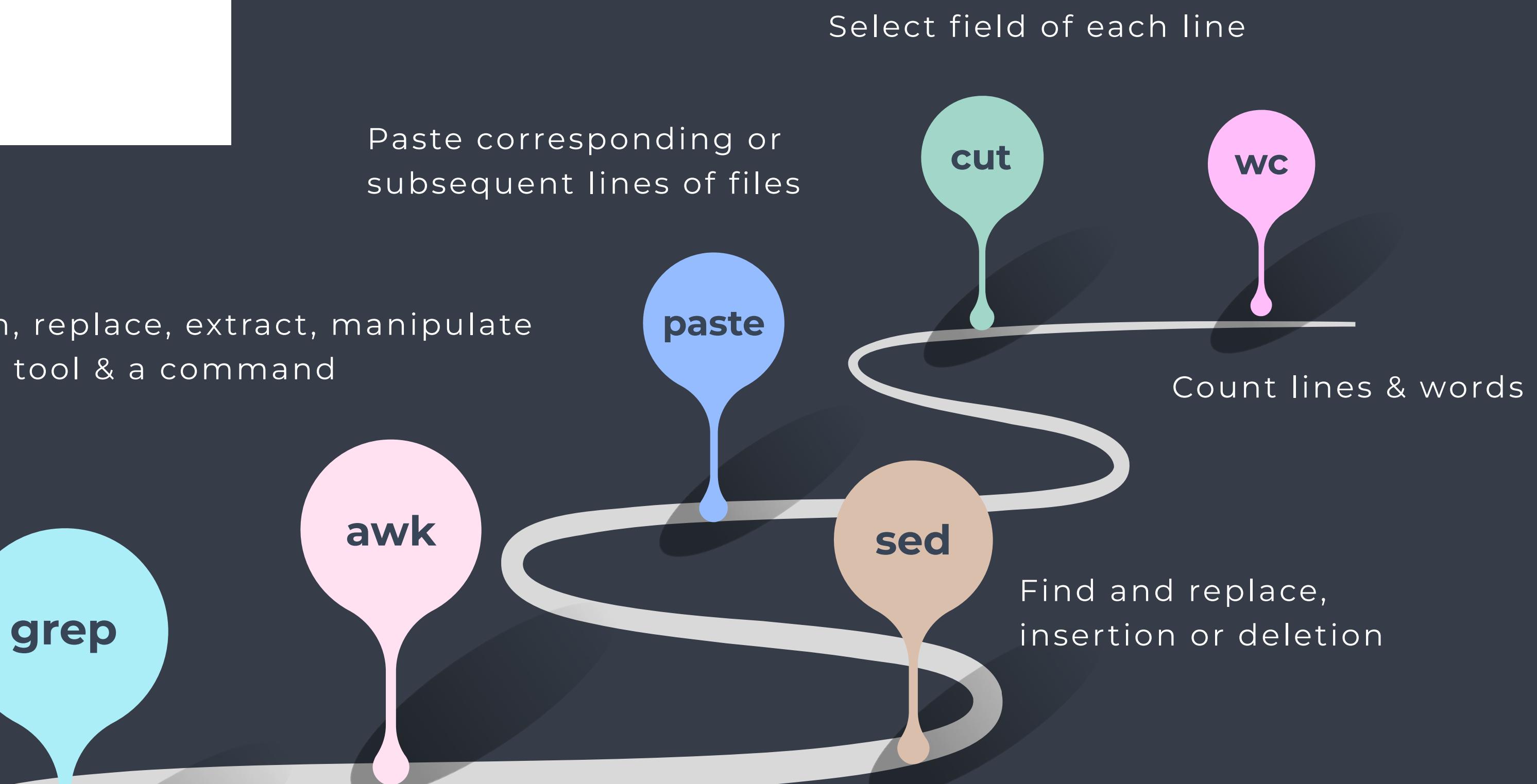
Search, replace, extract, manipulate  
awk is tool & a command



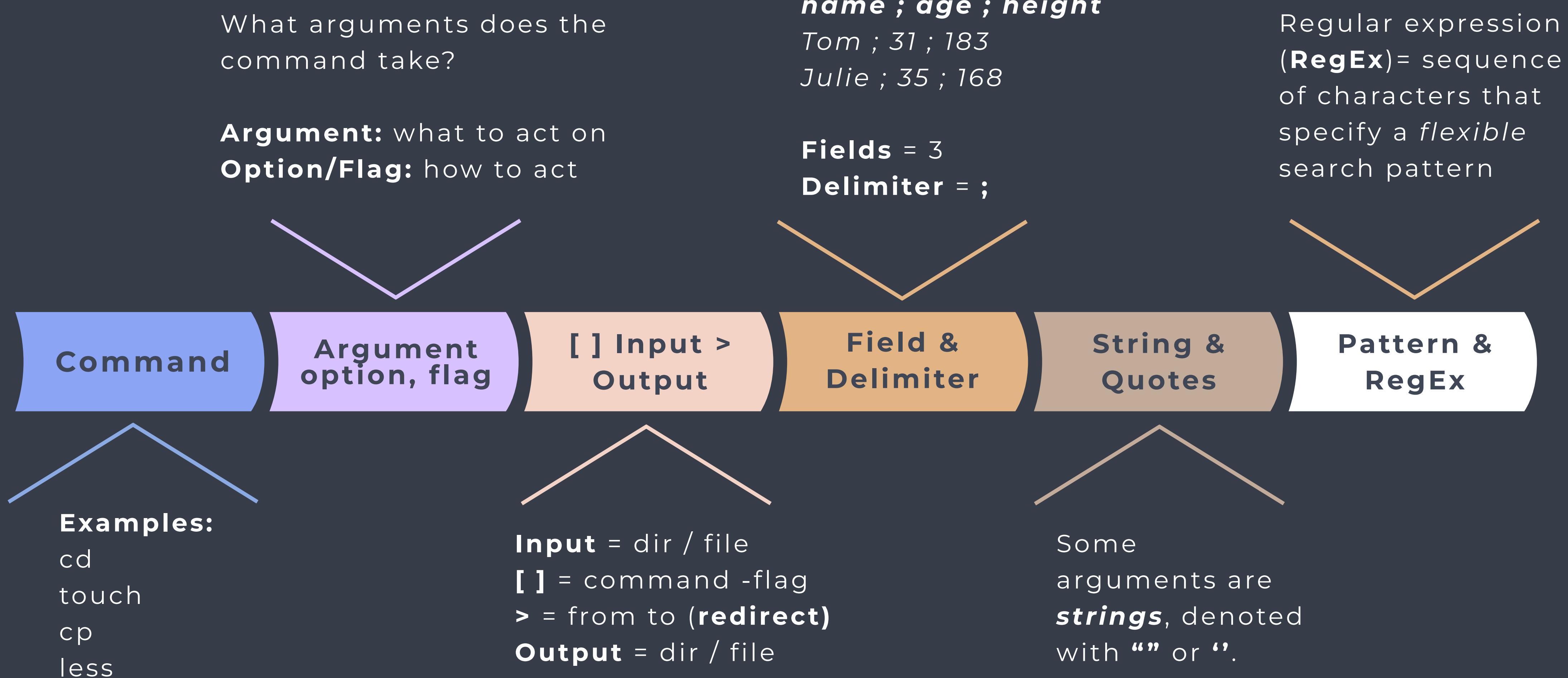
Report unique entries only



Search for pattern in file &  
directory name(s).



# A LITTLE TERMINOLOGY



# REGULAR EXPRESSIONS

**Regular expression (RegEx)** = sequence of characters that specify a *flexible* search pattern

Anchors				Quantifiers				Groups and Ranges	
^	Start of string, or start of line in multi-line pattern	*	0 or more	{3}	Exactly 3	.	Any character except new line (\n)		
\A	Start of string	+	1 or more	{3,}	3 or more	(a b)	a or b		
\$	End of string, or end of line in multi-line pattern	?	0 or 1	{3,5}	3, 4 or 5	(...)	Group		
\Z	End of string	Add a ? to a quantifier to make it ungreedy.				(?:...)	Passive (non-capturing) group		
\b	Word boundary					[abc]	Range (a or b or c)		
\B	Not word boundary					[^abc]	Not (a or b or c)		
\<	Start of word					[a-q]	Lower case letter from a to q		
\>	End of word					[A-Q]	Upper case letter from A to Q		
Character Classes								[0-7]	Digit from 0 to 7
\c	Control character					\x	Group/subpattern number "x"		
"Escaping" is a way of treating characters which have a special meaning in regular expressions literally, rather than as special characters.					Ranges are inclusive.				
<a href="https://cheatography.com/davechild/cheat-sheets/regular-expressions/">https://cheatography.com/davechild/cheat-sheets/regular-expressions/</a>					Regex Testers : <a href="https://regexr.com/">https://regexr.com/</a> <a href="https://regex101.com/">https://regex101.com/</a>				

# CHEAT SHEET 2

## View Files

```
less [file] # view file content  
cat [file] # view file content (full)  
head / tail -n 10 [file] # view n first/last lines  
nano [file] # https://www.nano-editor.org/dist/latest/cheatsheet.html  
vim [file] # https://vim.rtorr.com/
```

## Compressed Files

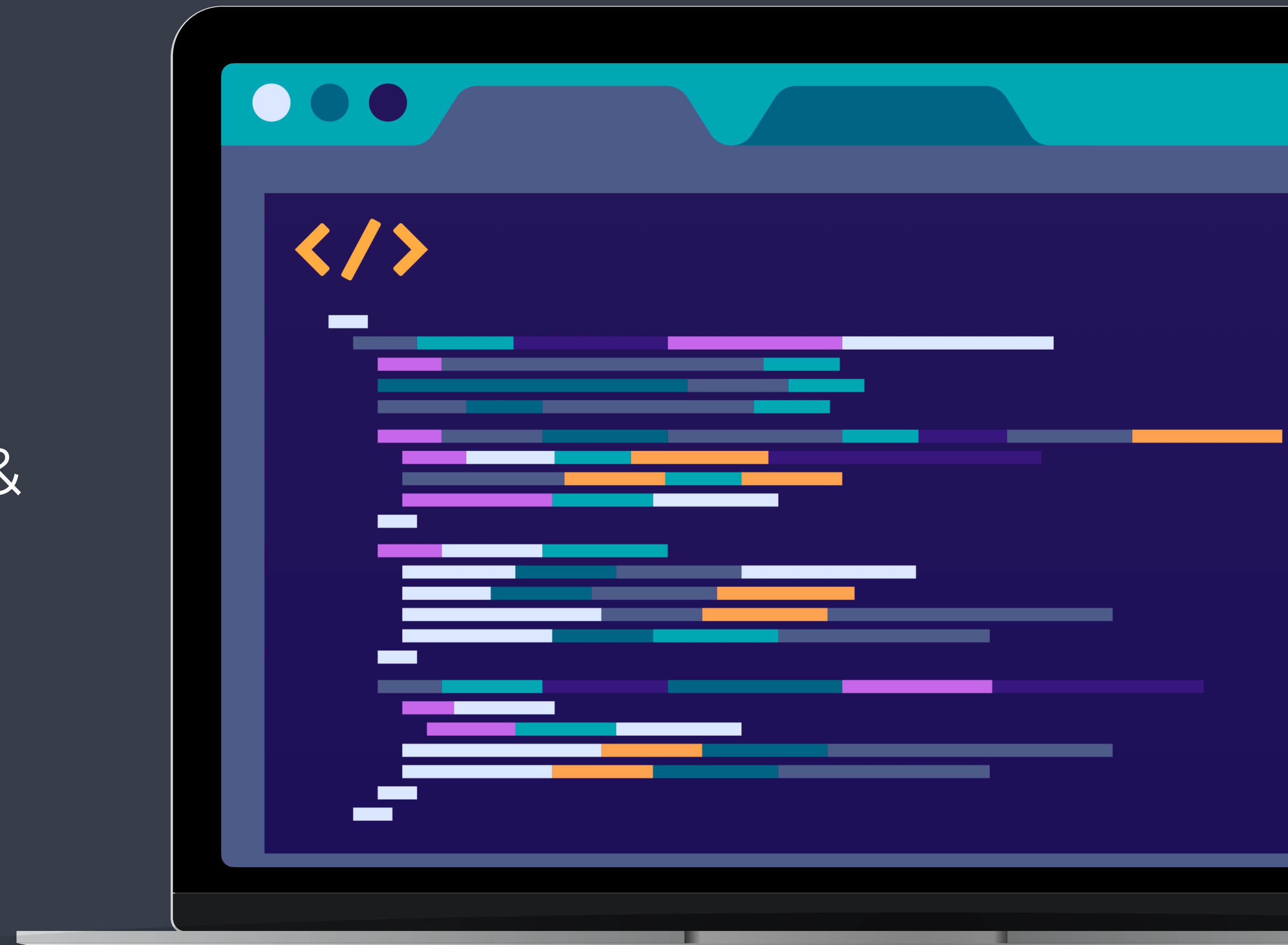
```
tar -[f] [file] # .tar files  
gzip -[f] [file] # decompress (.tar).gz files  
unzip -[f] [file] # decompress .zip files  
zless -[f] [file] # view .gz file w/o decompression  
  
others: zcat, zmore, gzcat
```

## Manipulating Files

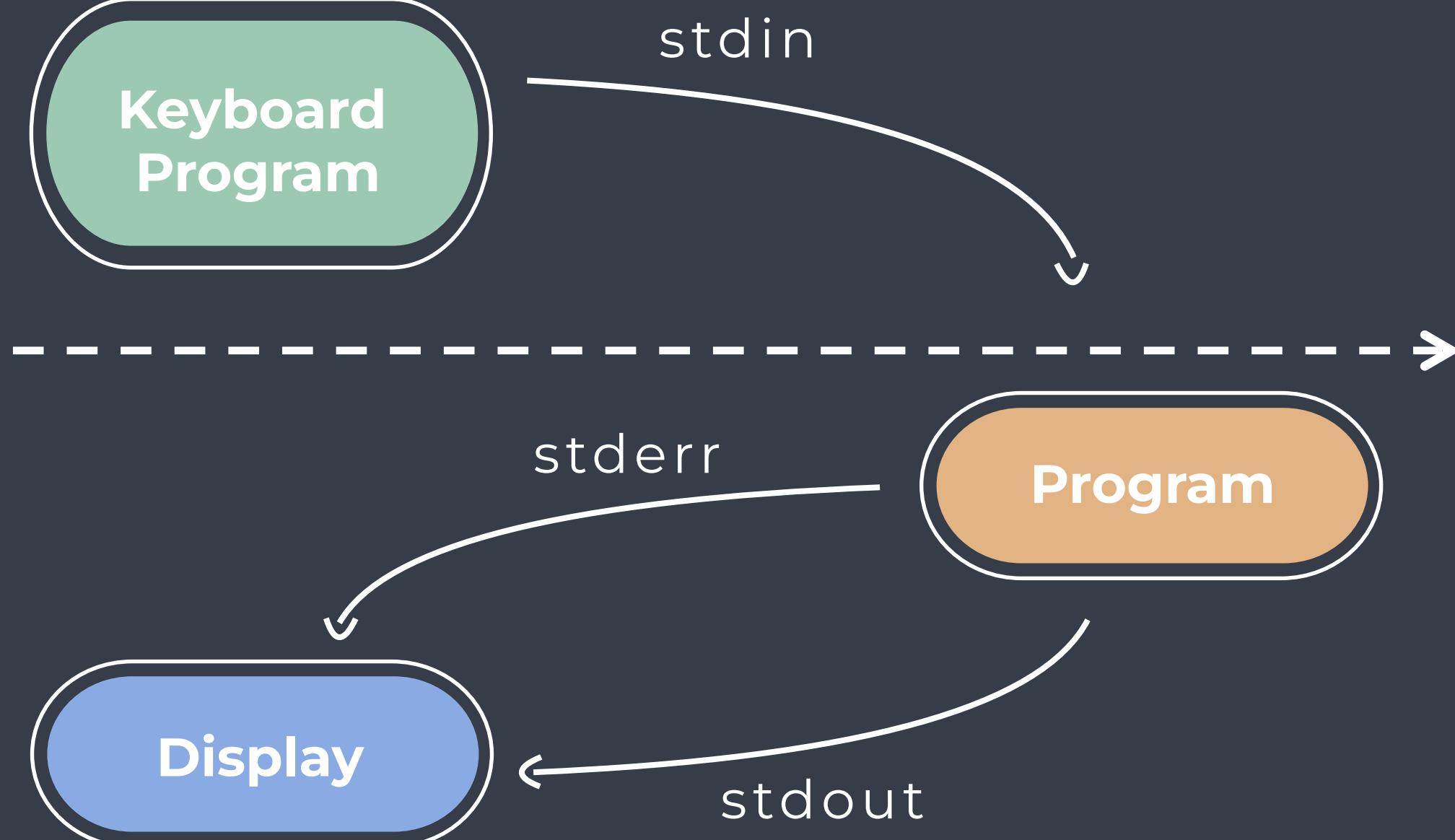
```
wc -[f] [file] # Count lines, characters, bits  
sort -[f] [file] # Sort file (by field/column)  
uniq -[f] [file] # Return unique values  
cut -[f] [file]: # Extract field/column  
paste -[f] [files]: # Merge file lines
```

```
sed -[f] 'command' [file] # Insertion, deletion, ...  
grep -[f] ['pattern'] [file] # Search for pattern  
awk '{pattern}' [file] # Search, replace, extract, ...  
find -[f] [path] ['pattern'] # Search pattern in file name
```

## 5. REDIRECTION & PIPES

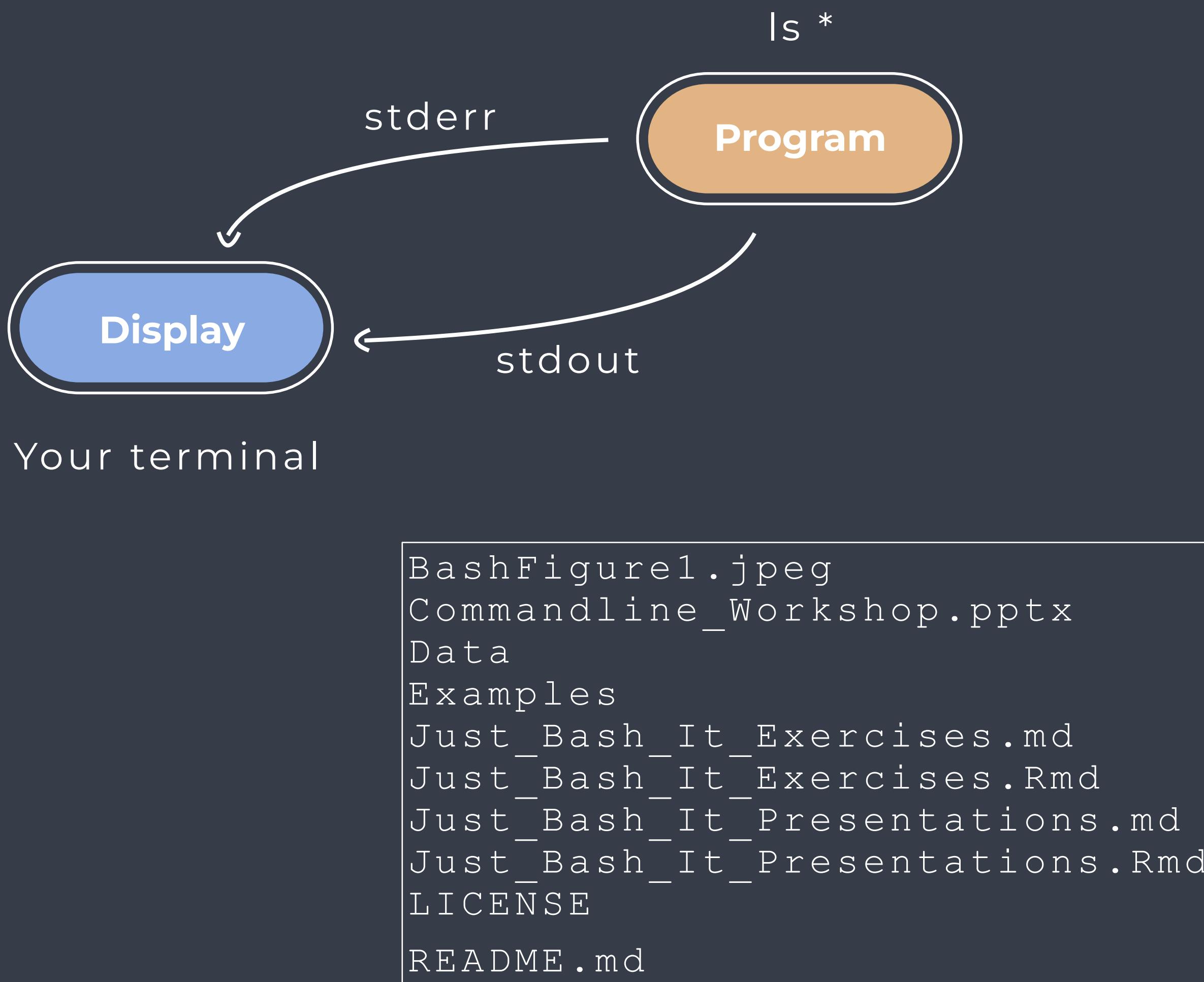


# A TALE OF THREE STREAMS



- Data in unix always moves along one of **three (data) streams**:
  - **stdin** (Standard In) – the stream along which input to commands moves
  - **stdout** (Standard out) - the output of commands moves along this stream
  - **stderr** (Standard error) – error messages move via this stream
- Each of the streams can be redirected separately.

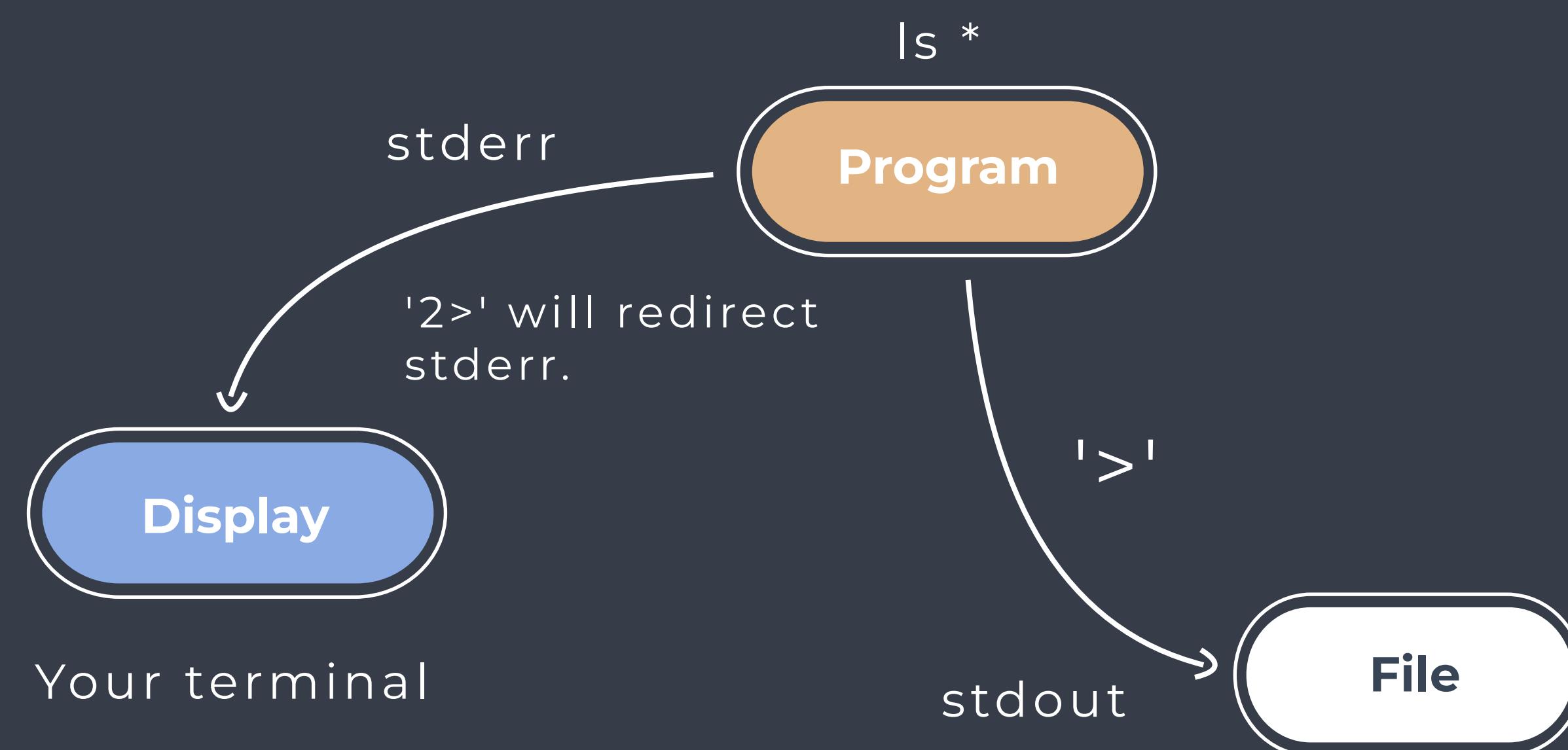
# A TALE OF THREE STREAMS



- **stdout** (standard out) - the output of commands moves along this stream
- **stderr** (standard error) – error messages move via this stream
- By default **stdout** points to the display, your terminal window

# A TALE OF THREE STREAMS

But **stdout** and **stderr** can be **redirected** to i.e. a file:



Redirect stdout:

```
$ ls > list_results.txt
```

Redirect stderr:

```
$ ls 2> err.txt
```

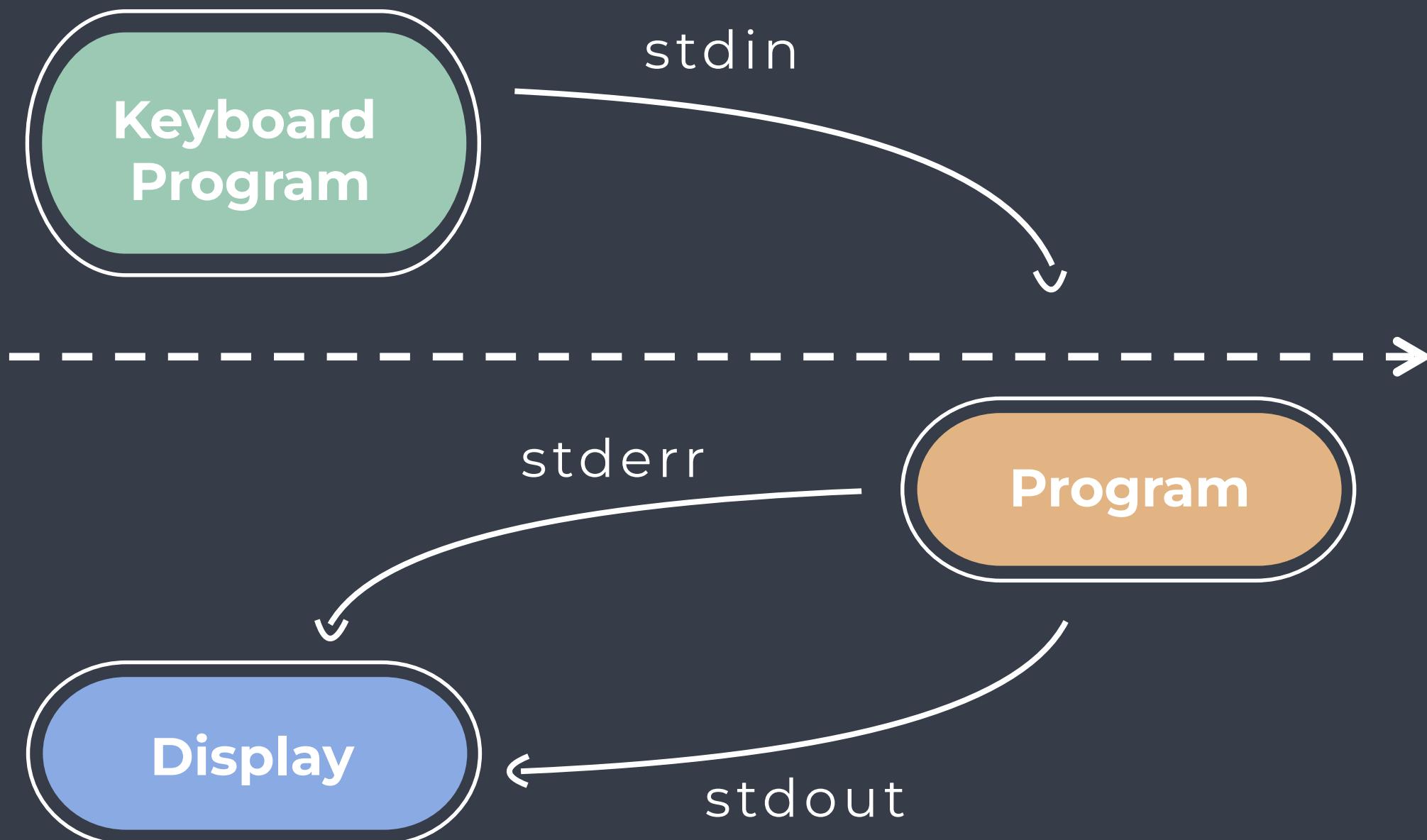
Redirect both into different files:

```
$ ls 2> err.txt > list_results.txt
```

Redirect both into the same file:

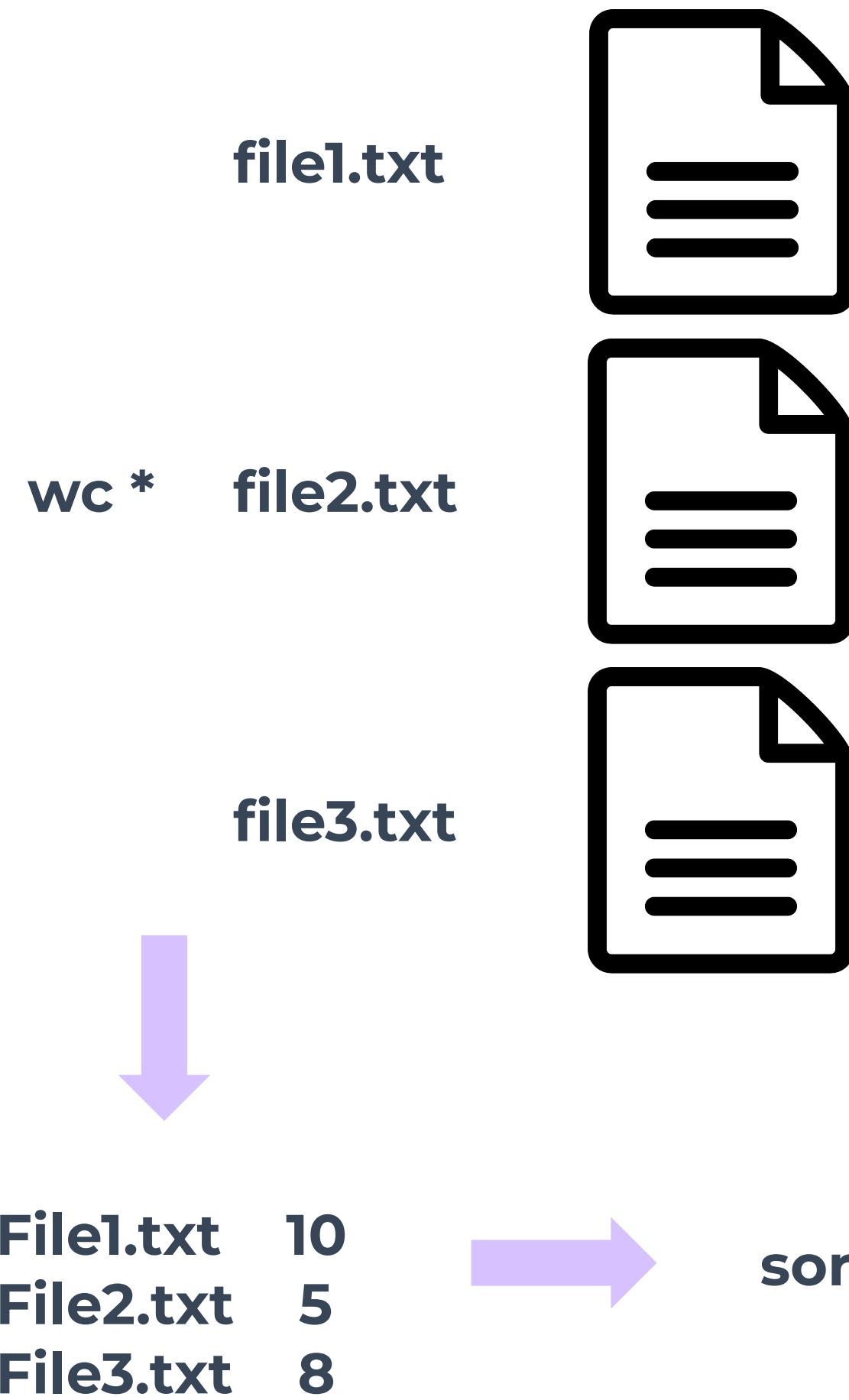
```
$ ls &> both
```

# A TALE OF THREE STREAMS



- Many commands require input data to work on, i.e. **wc** works on a file.
- Usually input data comes from the keyboard, i.e. the name of the file to word count.
- But it can also come directly from another program!

# CHAINING (PIPING) COMMANDS

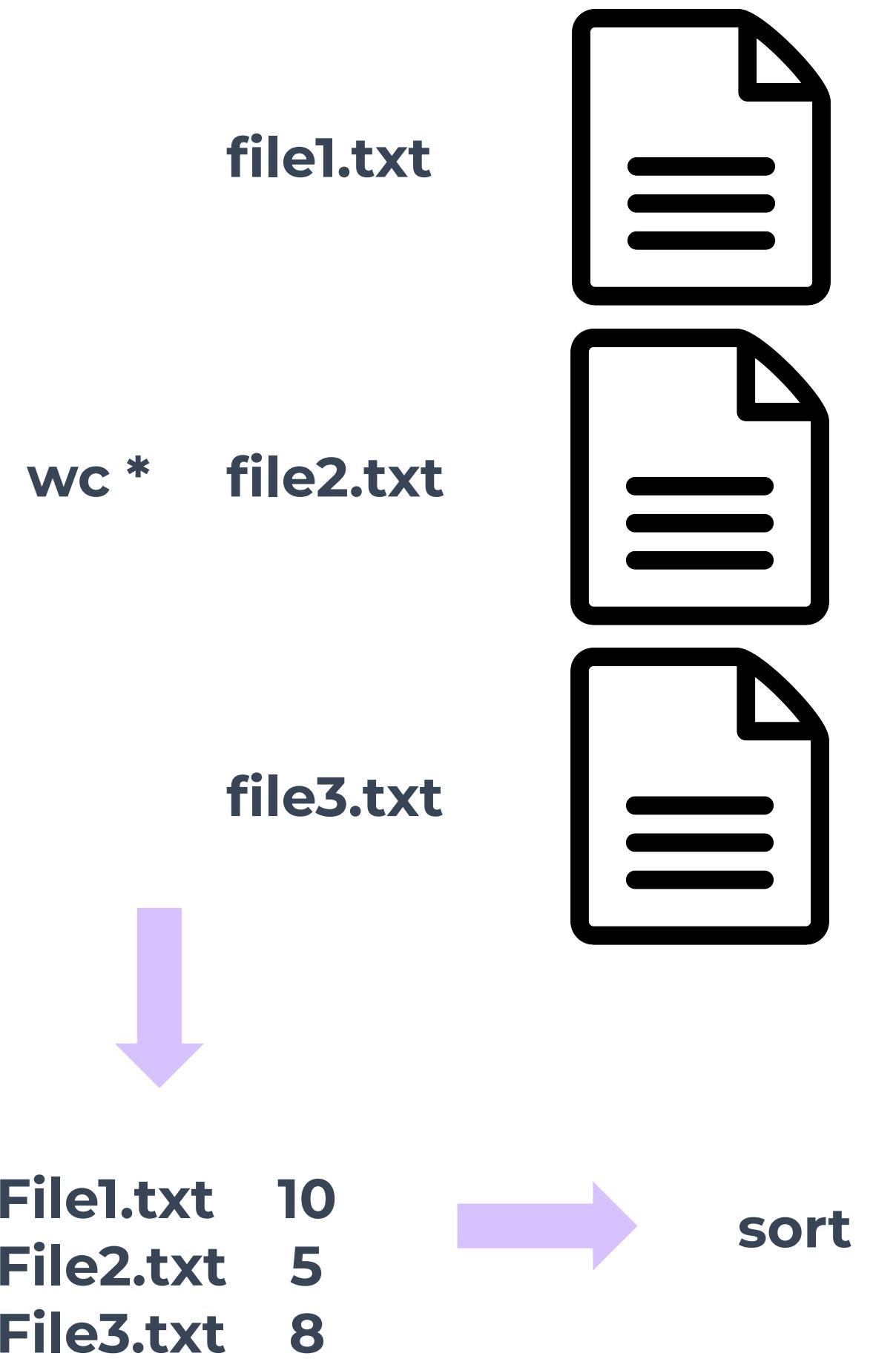


```
$ wc *.txt > file_lengths
```

```
$ sort -n file_lengths
```

But now we have an intermediate file we don't need!

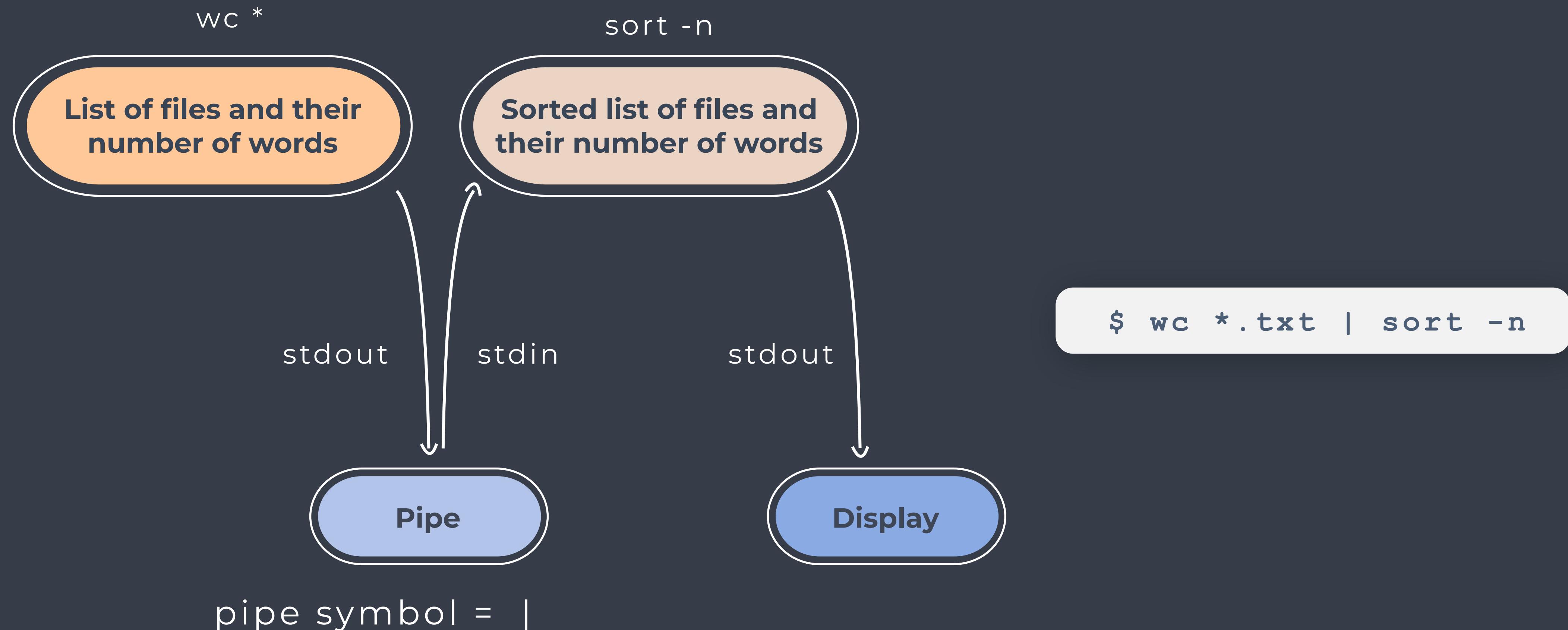
# CHAINING (PIPING) COMMANDS



Instead we can use a pipe:

```
$ wc *.txt | sort -n
```

# CHAINING (PIPING) COMMANDS



# CHAINING (PIPING) COMMANDS

## Some examples:

- Take the second column and count how often each element occurs:

```
$ cut -d ',' -f 2 patients.txt | sort | uniq -c
```

- Get only lines containing 'Herlev' and sort by age:

```
$ grep 'Herlev' patients.txt | sort -t ',' -n -k5
```

- If we don't want the entire line we could also cut out the age column before sorting:

```
$ grep 'Herlev' patients.txt | cut -d ',' -f 5 | sort -n
```

```
Last login: Thu Sep 29 17:30:26 on ttys000
[kgx936@SUN1007442 ~ % cd Desktop/HeaDS/GitHub_repos/Just-Ba
[kgx936@SUN1007442 docs % head patients.txt
patient_ID,technique,hospital,conv_days,age,satisfaction
402109,A,Rigshospitalet,15,68,3
092070,A,Rigshospitalet,13,74,5
994082,B,Herlev,27,76,2
843094,A,Herlev,30,65,5
369360,B,Rigshospitalet,21,68,5
688213,B,Rigshospitalet,29,77,3
197347,A,Herlev,25,65,5
759063,B,Rigshospitalet,16,75,4
121219,B,Herlev,27,68,4
kgx936@SUN1007442 docs %
```

# CHEAT SHEET 2

## View Files

```
less [file] # view file content  
cat [file] # view file content (full)  
head / tail -n 10 [file] # view n first/last lines  
nano [file] # https://www.nano-editor.org/dist/latest/cheatsheet.html  
vim [file] # https://vim.rtorr.com/
```

## Compressed Files

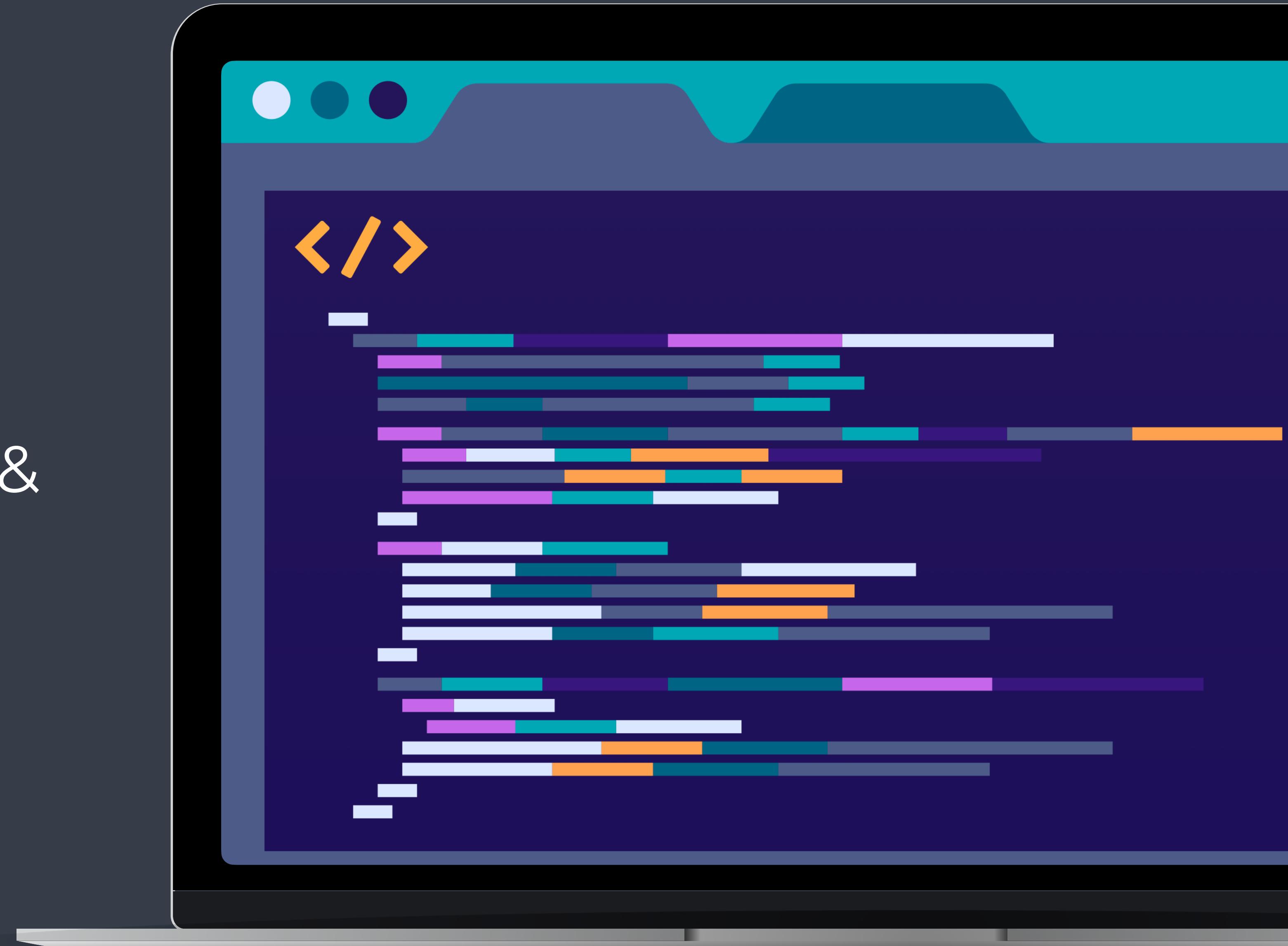
```
tar -[f] [file] # .tar files  
gzip -[f] [file] # decompress (.tar).gz files  
unzip -[f] [file] # decompress .zip files  
zless -[f] [file] # view .gz file w/o decompression  
  
others: zcat, zmore, gzcat
```

## Manipulating Files

```
wc -[f] [file] # Count lines, characters, bits  
sort -[f] [file] # Sort file (by field/column)  
uniq -[f] [file] # Return unique values  
cut -[f] [file]: # Extract field/column  
paste -[f] [files]: # Merge file lines
```

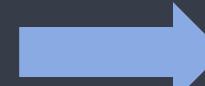
```
sed -[f] 'command' [file] # Insertion, deletion, ...  
grep -[f] ['pattern'] [file] # Search for pattern  
awk '{pattern}' [file] # Search, replace, extract, ...  
find -[f] [path] ['pattern'] # Search pattern in file name
```

## 6. SHELL SCRIPTS & LOOPS



# WRITING SCRIPTS

```
(base) henrike@henrike-ThinkPad-X390:~/Documents/Heads_center_management/courses/Just-Bash-It/Examples/docs$ cut -f 3 -d ',' patients.dat | sort | uniq -c
      1 herlev
      9 Herlev
      1 hospital
     10 Rigshospitalet
(base) henrike@henrike-ThinkPad-X390:~/Documents/Heads_center_management/courses/Just-Bash-It/Examples/docs$ head -n 1 patients.dat > herlev.dat
(base) henrike@henrike-ThinkPad-X390:~/Documents/Heads_center_management/courses/Just-Bash-It/Examples/docs$ grep 'Herlev' patients.dat | sort -n -k 5 -t ',' >> herlev.dat
```



```
x - my_script.sh (~/Documents/Heads_center_management/courses)
Open + ~/Documents/Heads_center_management/courses/Just-... Save
my_script.sh
1 cut -f 3 -d ',' patients.dat | sort | uniq -c
2 head -n 1 patients.dat > herlev.dat
3 grep 'Herlev' patients.dat | sort -n -k 5 -t ',' >>
herlev.dat
```



- Save your commands for later use!
- Re-run anytime, always same result
- Check your script if you don't remember the steps of an analysis
- Back-up your scripts on i.e. github, KU drive, ect.

```
(base) henrike@henrike-ThinkPad-X390:~/Documents/Heads_center_management/courses/Just-Bash-It/Examples/docs$ bash my_script.sh
      1 herlev
      9 Herlev
      1 hospital
     10 Rigshospitalet
(base) henrike@henrike-ThinkPad-X390:~/Documents/Heads_center_management/courses/Just-Bash-It/Examples/docs$
```

# COMMAND LINE INPUT

- Add **arguments** when you execute your script, these will be passed to it.
- Useful if you want to i.e. specify the file you want to run the script on.
- A script is called with **bash** (or simply **sh**).
- The **first argument** after the script name will be **\$1** inside the script.
- The **second argument** will be **\$2** and so on.

```
# Comment line script 1
# Usage: sort_this.sh file_name

sort $1 -n
```

```
$ bash sort_this.sh patients.txt
```

```
$ bash sort_this.sh my_textfile.txt
```

```
# Comment line script 2
# Usage: cut_col file_name column_number

cut -d ',' -f $2 $1
```

```
$ bash cut_col patients.txt 3
```

# LOOP IN BASH



```
#example of a for loop in bash

for file in *.txt
do
    echo $file
    wc $file
done

#the general syntax of a for loop is:

for [iterator] in [generator]
do
    commands
done
```

- Loops allow you to repeat the same action several times, once for each file for example.
- Many bash commands can be run on several files, i.e.  
  \$ wc \*.txt
- However, a loop is useful if you want to execute several commands for each file.

# OTHER SCRIPTING

---

```
$ bash my_script.sh
```

- This is a bash script. It's basically just a text file but we tell the computer to use bash to interpret it by calling it with 'bash my\_script.sh'
- We can also run scripts in other languages from the command line, i.e. python:

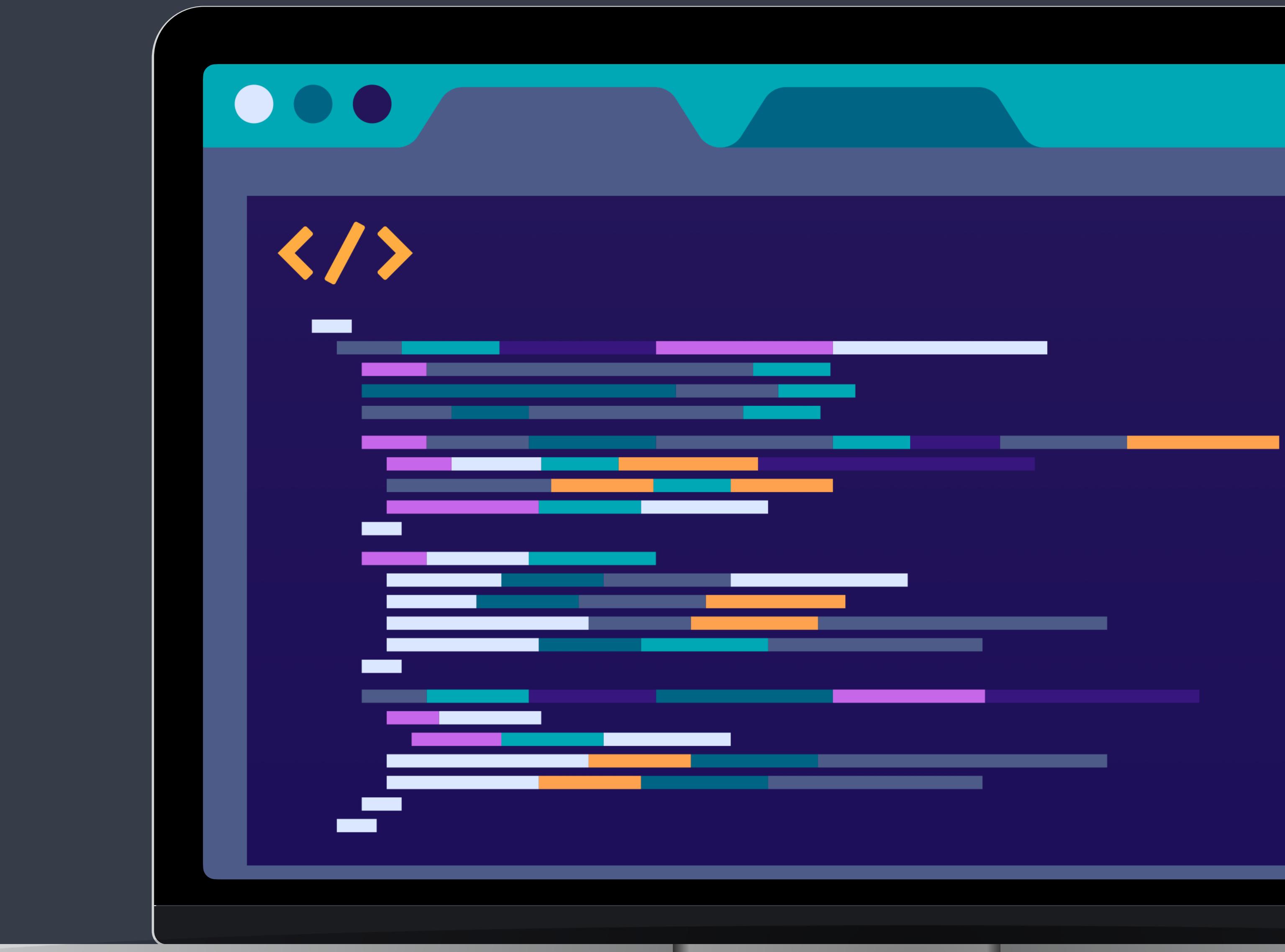
```
$ python align_reads.py
```

- Scripts in the R language are called with the command 'Rscript':

```
$ Rscript deSEQ_cancer_Data.R
```

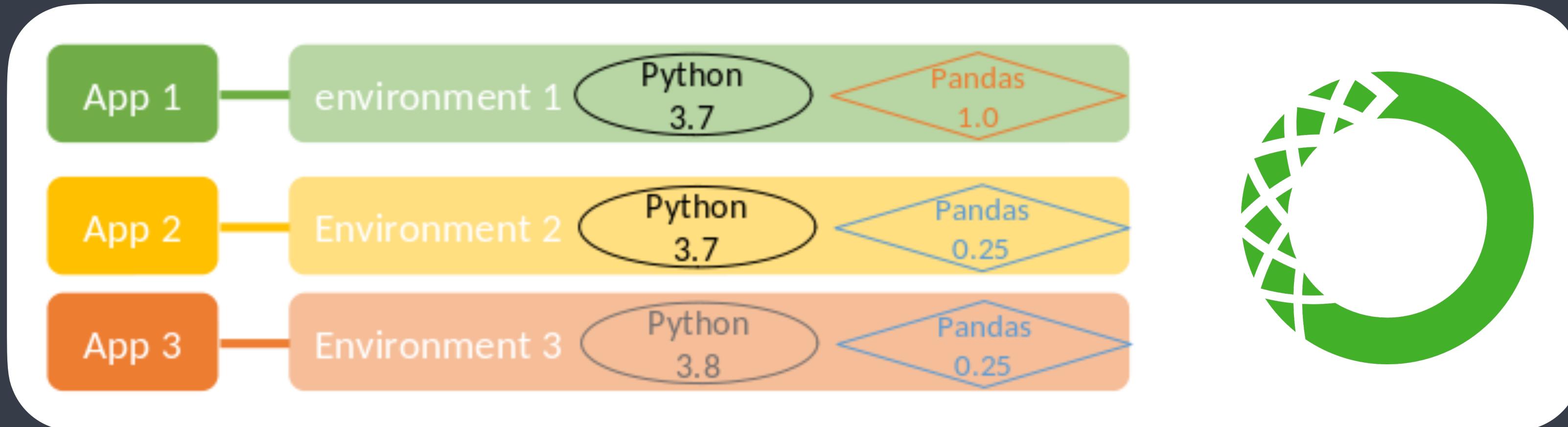
- You need to have R and python installed on your computer in order to be able to call them on the command line.

# 7. SOFTWARE INSTALLATION UPKEEP & MORE



# CONDA®

- **Conda** is an open source package & environment management system.
- Many softwares exist as conda packages, you can use conda to install them and their dependencies.
- **An environment** is a specific combination of packages in a specific version.
- If you do not update the packages, running an analysis in the same environment will give the same result.



## PROS

Comprehensive, many options  
Environment management  
Well documented

## CONS

Can be overwhelming



# Homebrew

- **Homebrew** - source software package management system, for OSX, Ubuntu (Linux).
- NOT an environment manager, package manager only.
- Creates separate directories for libs and configurations, adds symlinks to *user/local*.
- Manage all installed softwares via the terminal, install, check, update, remove...

## PROS

Easy to use  
Good documentation  
Commands a few and logical

## CONS

Packages, NOT environments

# APT-GET

- **apt-get** is a command-line tool for handling packages in Linux (Ubuntu, ‘Windows’).
- APT = *Advanced Packaging Tool*
- Upgrade and remove of packages along with their dependencies.
- NOT an environment manager, package manager only.

## PROS

Works like any linux command  
No installation (is default)  
Robust to OS updates

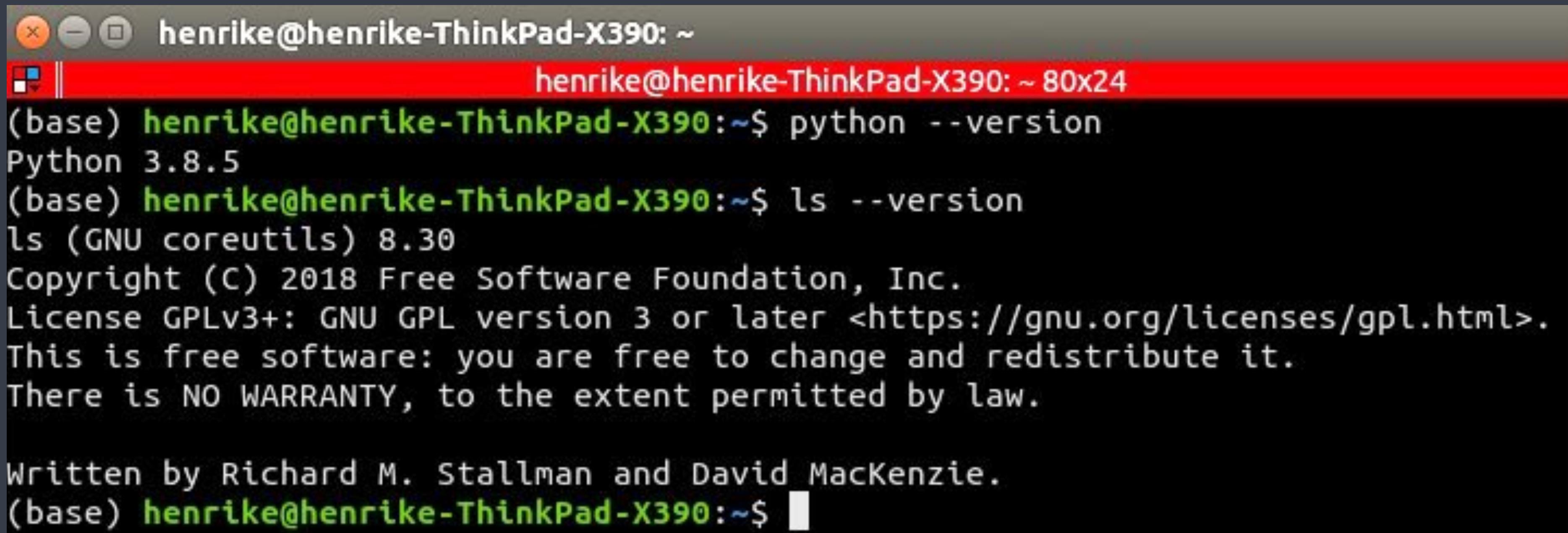
## CONS

Packages, NOT environments

# SOFTWARE VERSION

You can generally check the version of installed software with:

```
[name of software] --version
```



The screenshot shows a terminal window with a dark background and light-colored text. The title bar reads "henrike@henrike-ThinkPad-X390: ~". The terminal prompt "(base)" appears twice. The first instance is followed by the command "python --version" which outputs "Python 3.8.5". The second instance is followed by the command "ls --version" which outputs the GNU coreutils copyright notice, including the GPL license information and a statement that there is no warranty.

```
henrike@henrike-ThinkPad-X390: ~
(base) henrike@henrike-ThinkPad-X390:~$ python --version
Python 3.8.5
(base) henrike@henrike-ThinkPad-X390:~$ ls --version
ls (GNU coreutils) 8.30
Copyright (C) 2018 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <https://gnu.org/licenses/gpl.html>.
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.

Written by Richard M. Stallman and David MacKenzie.
(base) henrike@henrike-ThinkPad-X390:~$
```

# KEEPING THINGS UP TO DATE

Update your software with the same tool you used to install it:

- Installed with **conda**: (update only the current environment)

```
$ conda update -all
```



- Installed with **homebrew** (updates a software):

```
$ brew upgrade [software]
```



- Installed with **apt-get**:

```
$ apt-get update (apt-get dist-upgrade)
```

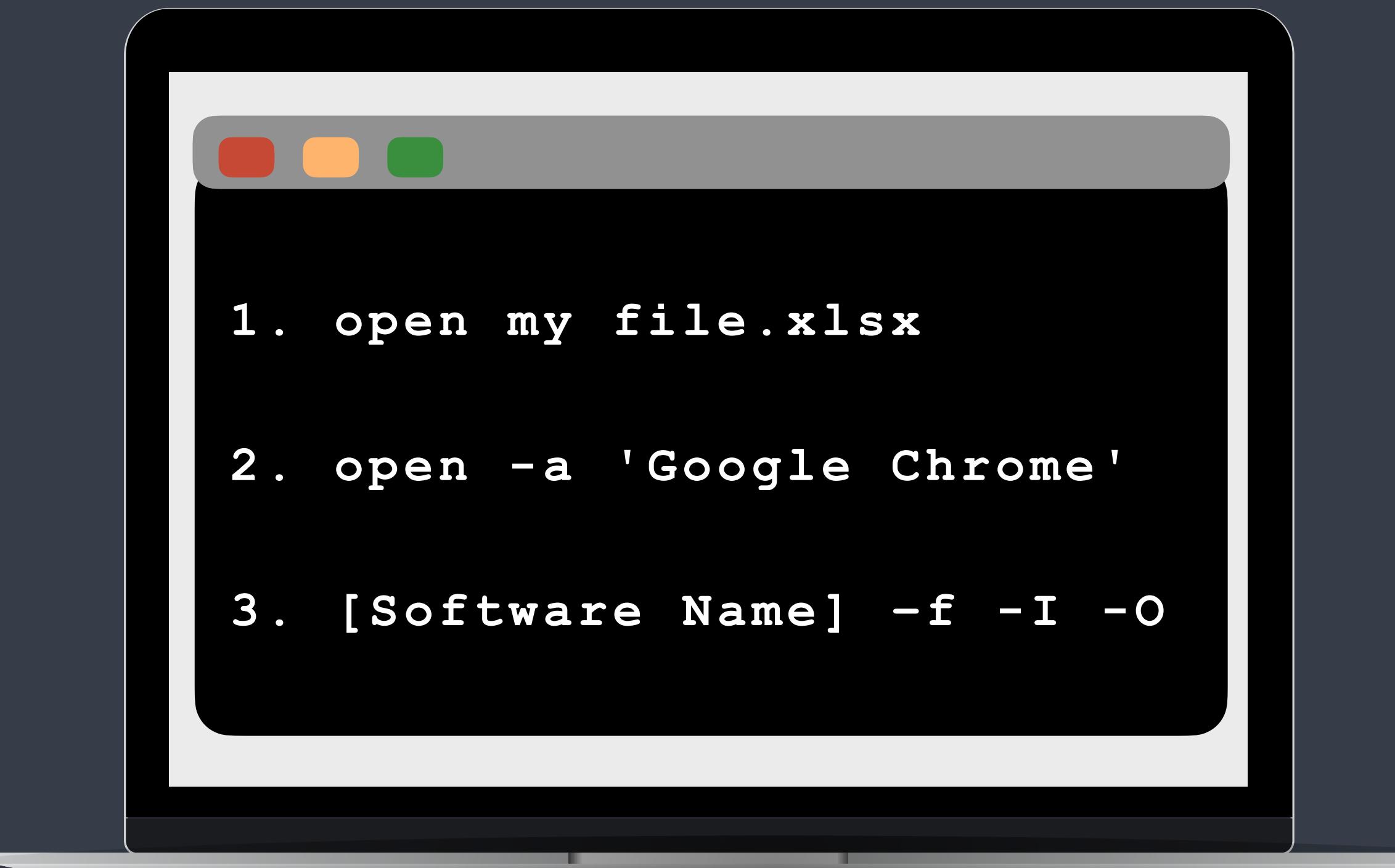


- With **Windows App store**:

*Update via  
Windows App store*



# OPENING APPS & RUNNING SOFTWARE



1. Some, but not all **files** can be **opened** without specifying an app.
2. Many **apps** can be **launched** with `open -a`.
3. Some **softwares** are designed to run on both the command line and in a GUI, while others are specific to one.

**Monitor processes, find them, check memory & ‘kill’ them when necessary:**

```
$ top  
$ ps aux  
$ kill [pid]
```

# CONFIGURATION FILES

- Configuration files (config files) are used to specify parameters and settings your OS and software.
- Types of config files; system-wide, program-specific, user-specific.
- Extension will pertain to what is configured.
- Rarely permission to change system-wide files.
- Software-specific files you can usually edit.
- **N.B** config files are ‘hidden’, i.e. ls -la (or similar) to see them.

## BASH SHELL



.profile  
.bashrc  
.bash\_profile

.profile  
.bashrc  
.bash\_profile

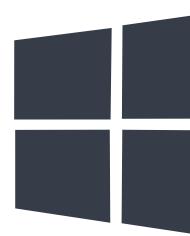
## Z SHELL (BASH +)



.zprofile  
.zshrc  
.zsh\_profile

.zprofile  
.zshrc  
.zsh\_profile

## WINDOWS (WSL)



# WORKFLOW LANGUAGES

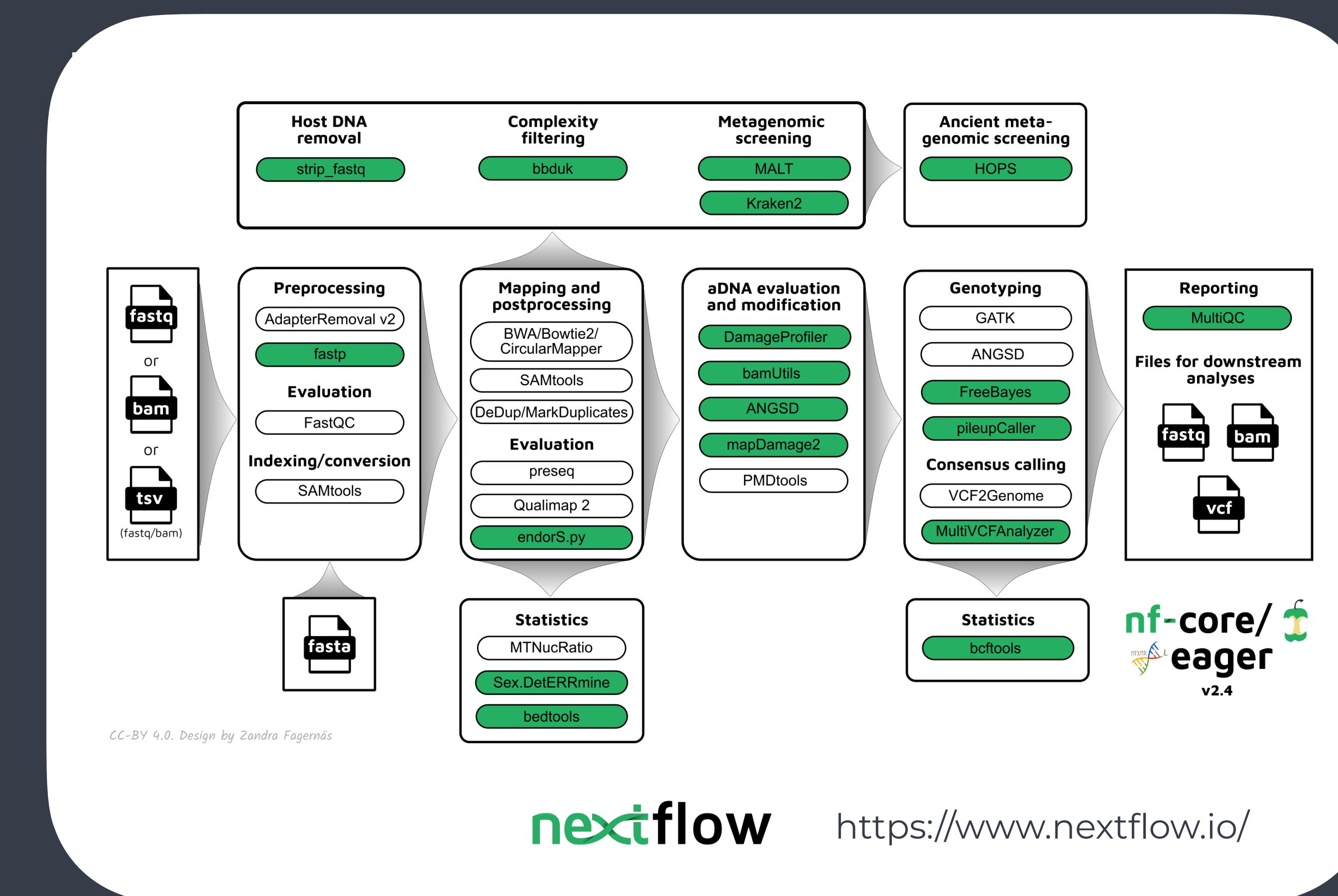
## . Workflow languages:

- . Tools to create reproducible pipelines - more robust than bash scripts.
- . Workflow languages allow you to:
  - . Control the flow of your pipeline
  - . Restart at various defined points.
  - . Ensure previous commands have. executed without error.
  - . Logging & Reporting of your job.



**snakemake**

<https://snakemake.readthedocs.io/en/stable/>



THANK YOU FOR TODAY

