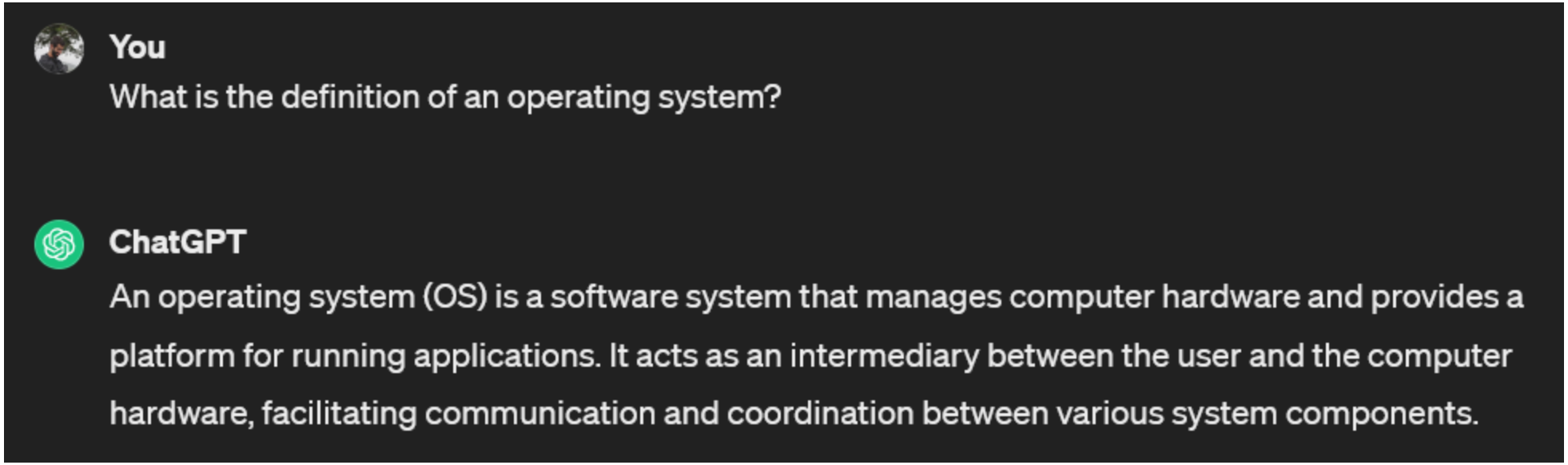
Introduction to UNIX/Linux or:
How I learned to Stop Worrying and Love the Command Line

Presentation by Eftyhios Kirbizakis

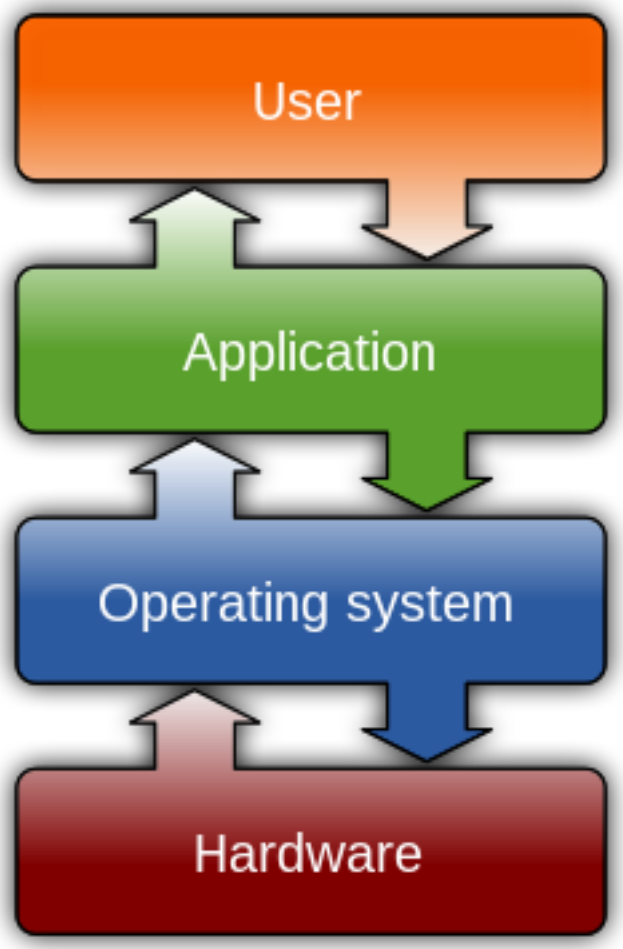
What is an operating system (OS)?

What is an operating system?



What is an operating system?

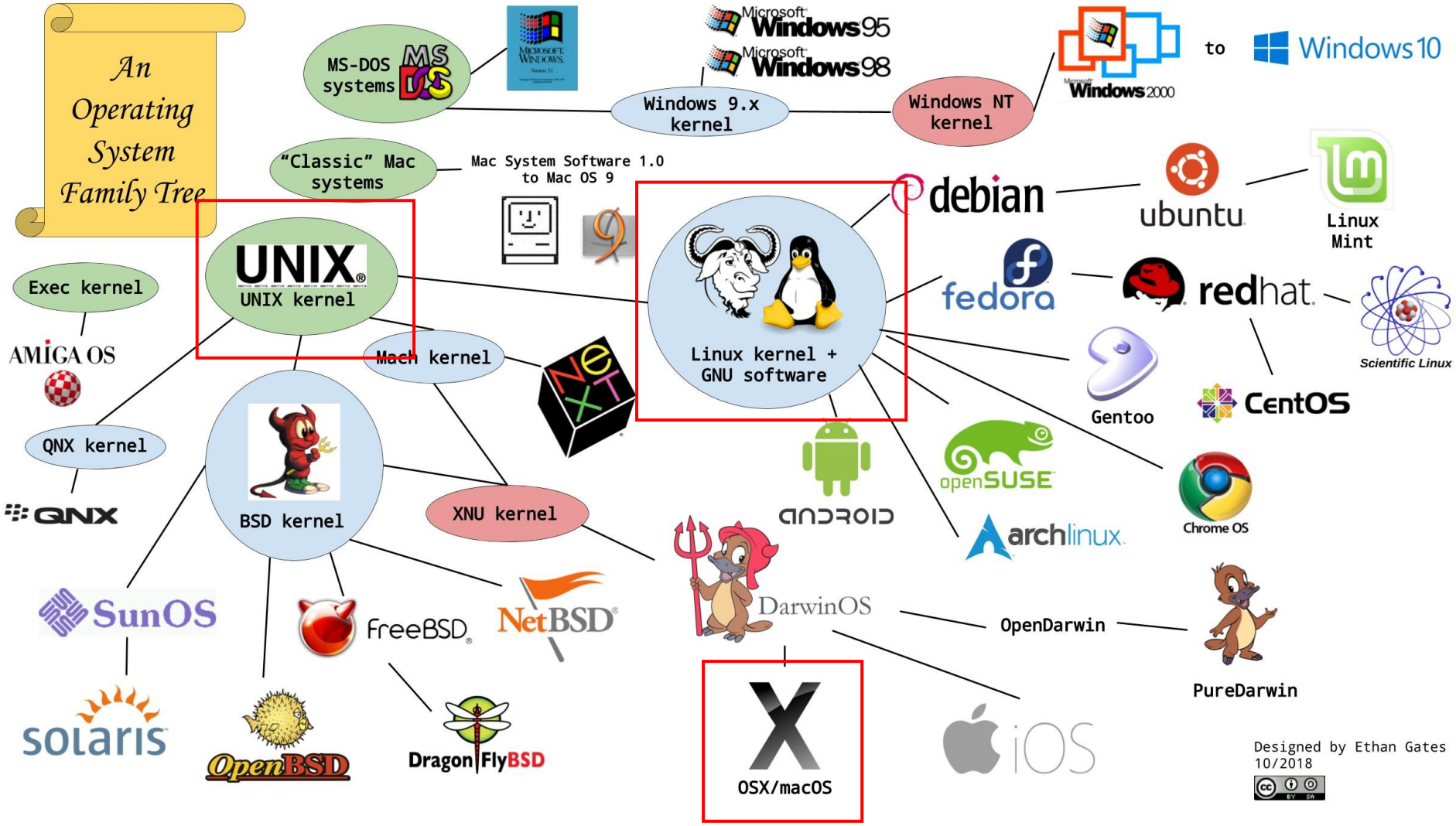
- Abstraction layer between the computer hardware and software
- Allows the developers to write software that runs on an operating system without being concerned about hardware-specific details



What is UNIX/Linux

- Both are OS
- UNIX is a commercial product developed in 1969 at the AT&T Bell Labs
- Linux is freeware developed in 1991 by Linus Torvalds
- No major differences

What is UNIX/Linux



UNIX/Linux philosophy

Write programs that do one thing and do it well.

Write programs to work together.

Write programs to handle text streams, because that is a universal interface.

-Doug McIlroy, summarized by Peter H. Salus

Why UNIX/Linux ?

- Stability
- Multitasking
- Flexibility
- Science focus – free
  - Barrier to creating is lower
- Data storage: Handles lots of files well
- Historical reasons: Early software written on UNIX

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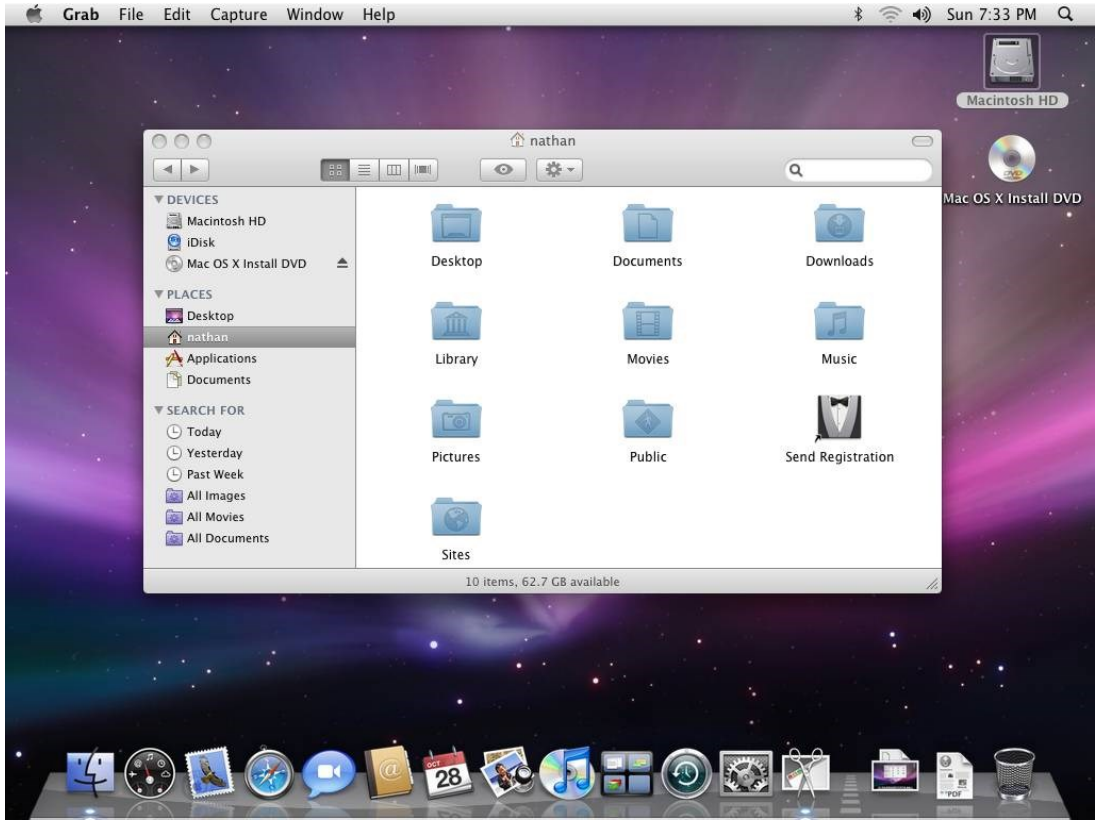
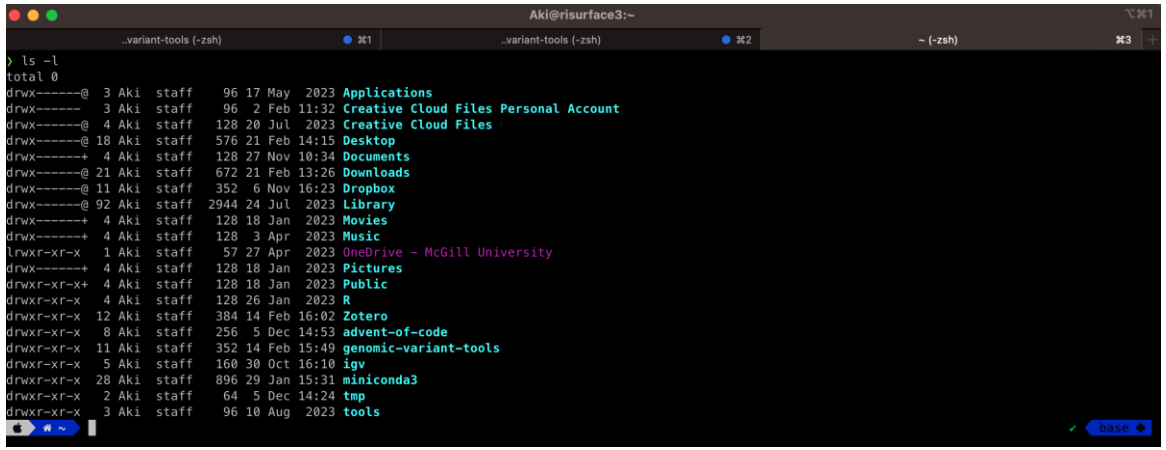
Unix/Linux systems have become the de facto standard in bioinformatics and genomic data analysis due to their flexibility, scalability, and robust command-line interface.

Graphical User Interface

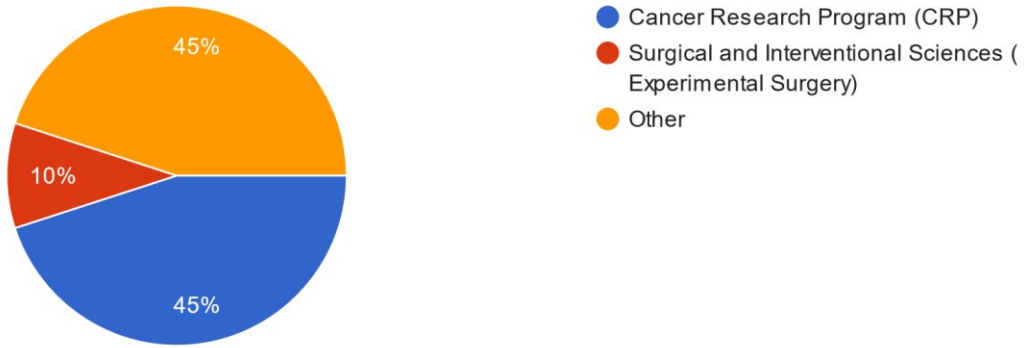


Command line interface (CLI)



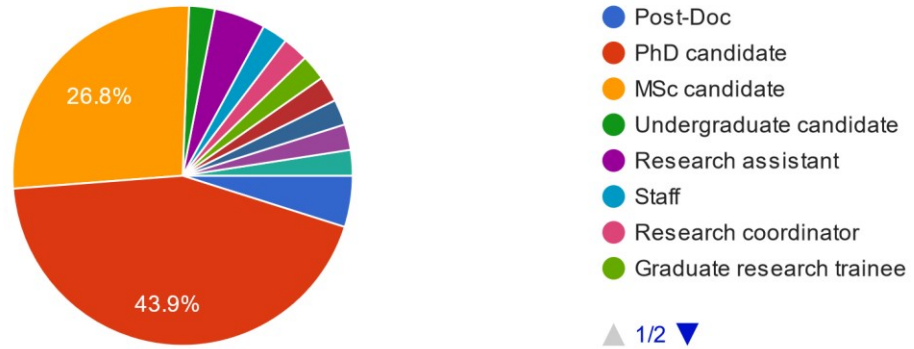
Choose your program

40 responses



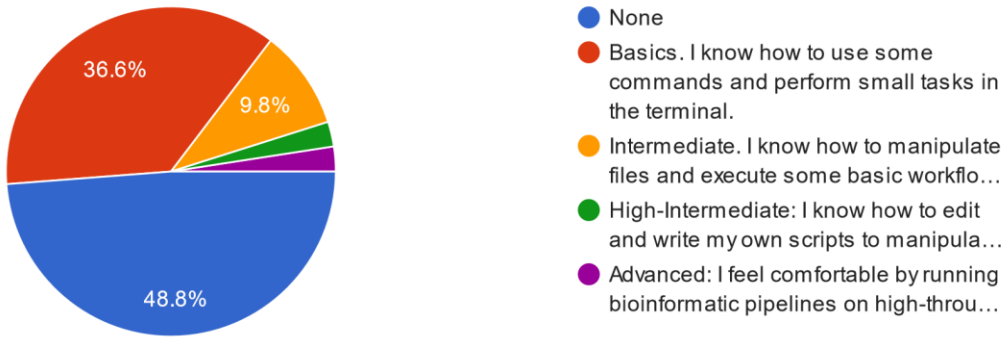
Student status

41 responses



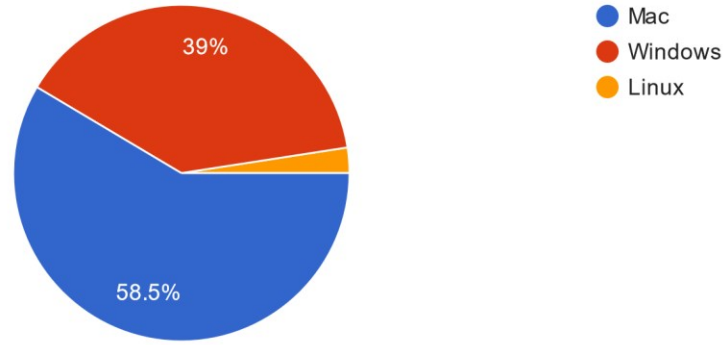
What is your experience level in Unix/Linux programming language?

41 responses



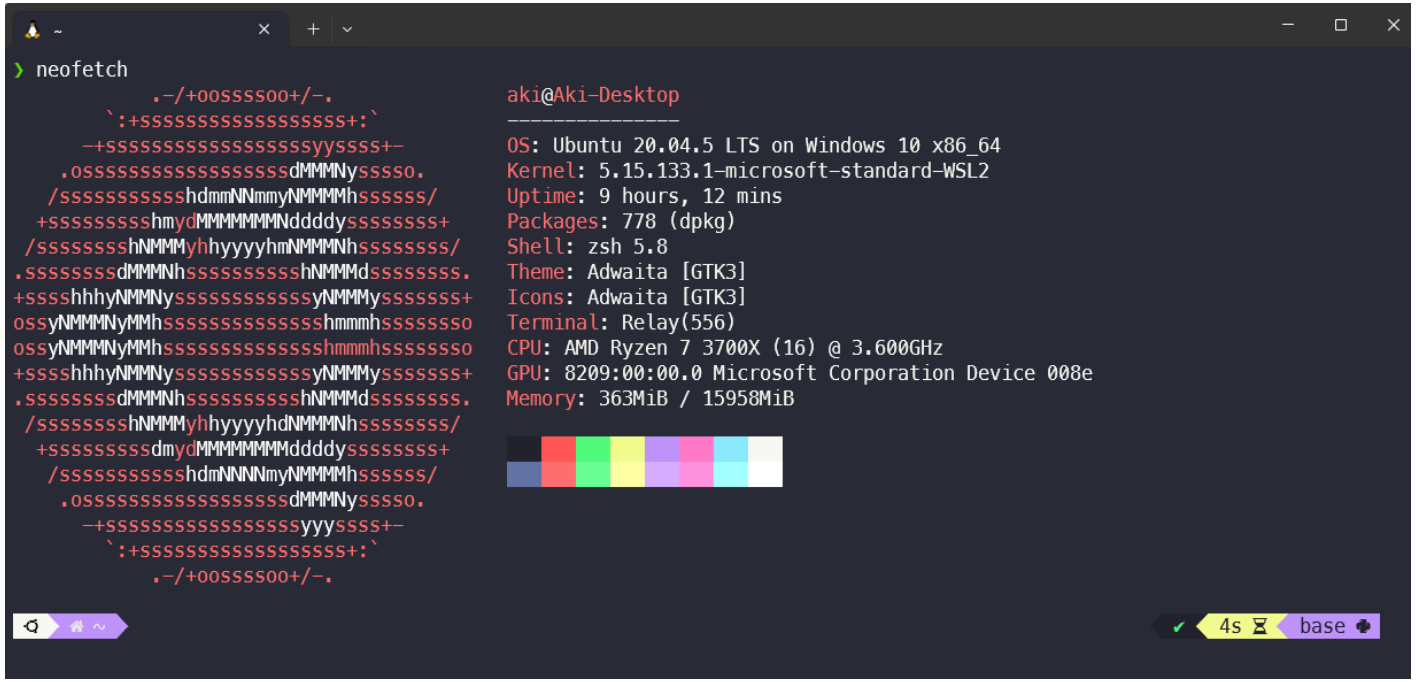
Could you please indicate what is your operative system software?

41 responses



How to proceed

- OSX/Linux users: Good to go!
- Windows: Windows Subsystem for Linux (WSL) + Windows Terminal



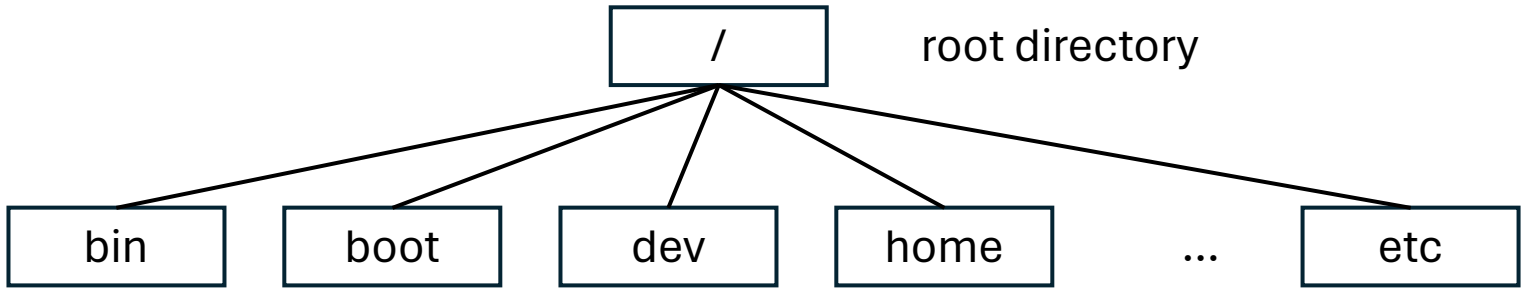
Realistic bioinformatics

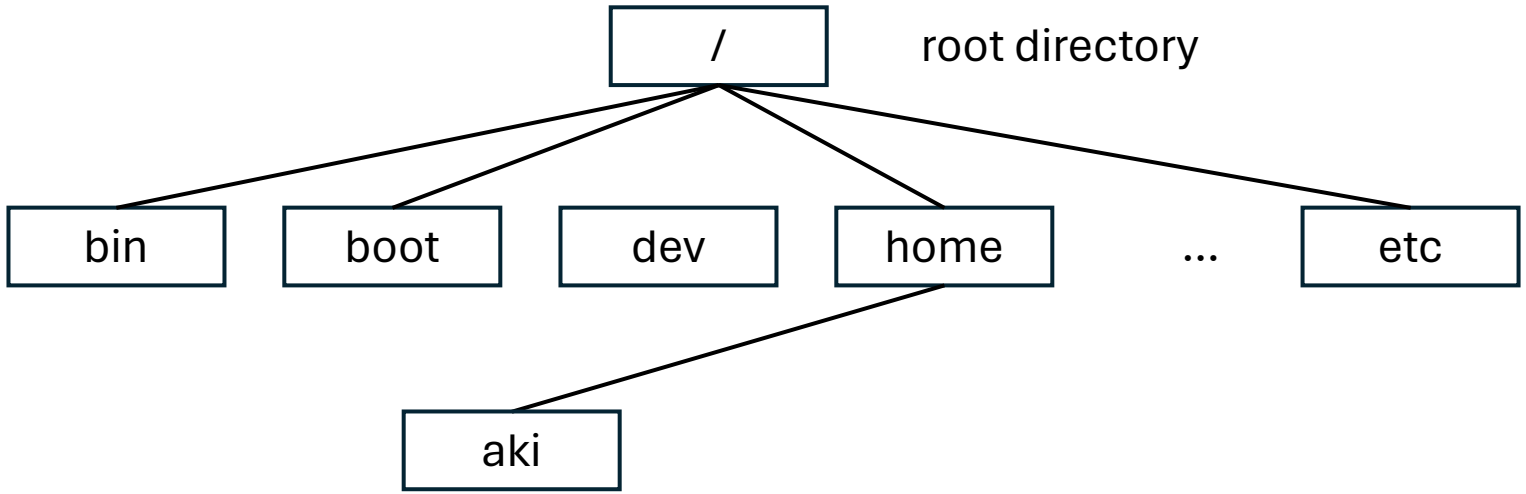
- Your computer will not be enough for serious bioinformatics
- Remote server/cluster
  - Compute Canada
  - Private servers
  - Amazon web services (AWS)

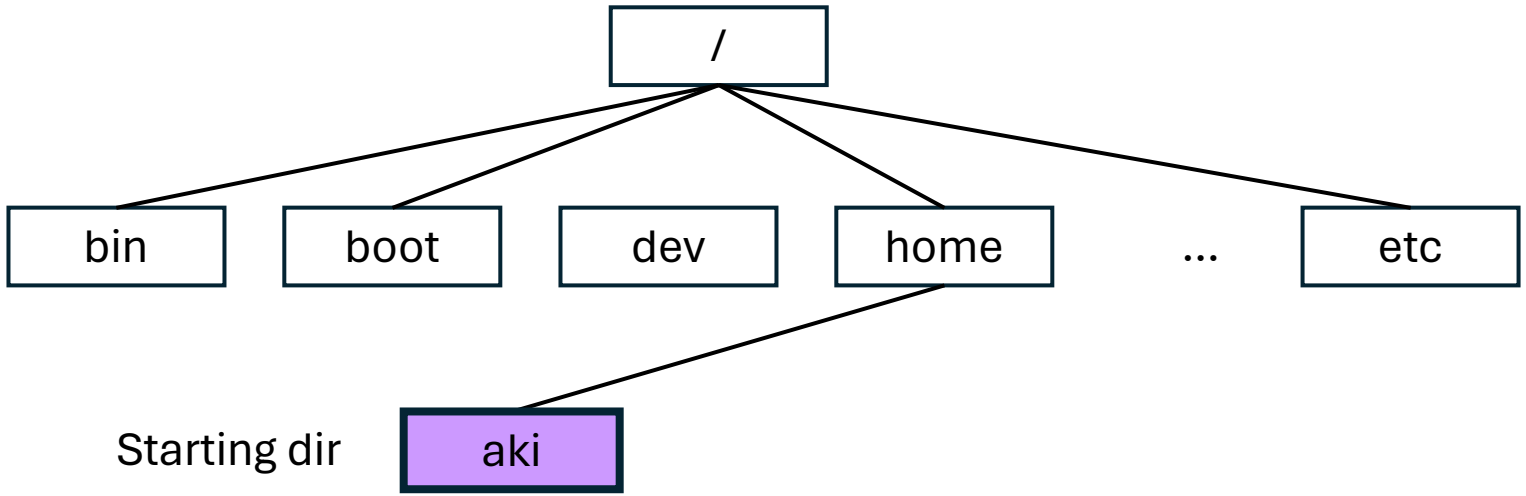
Unix file system

root directory

Unix file system: Upside down tree




/
root directory
bin
boot
dev
home
...
etc
aki


/
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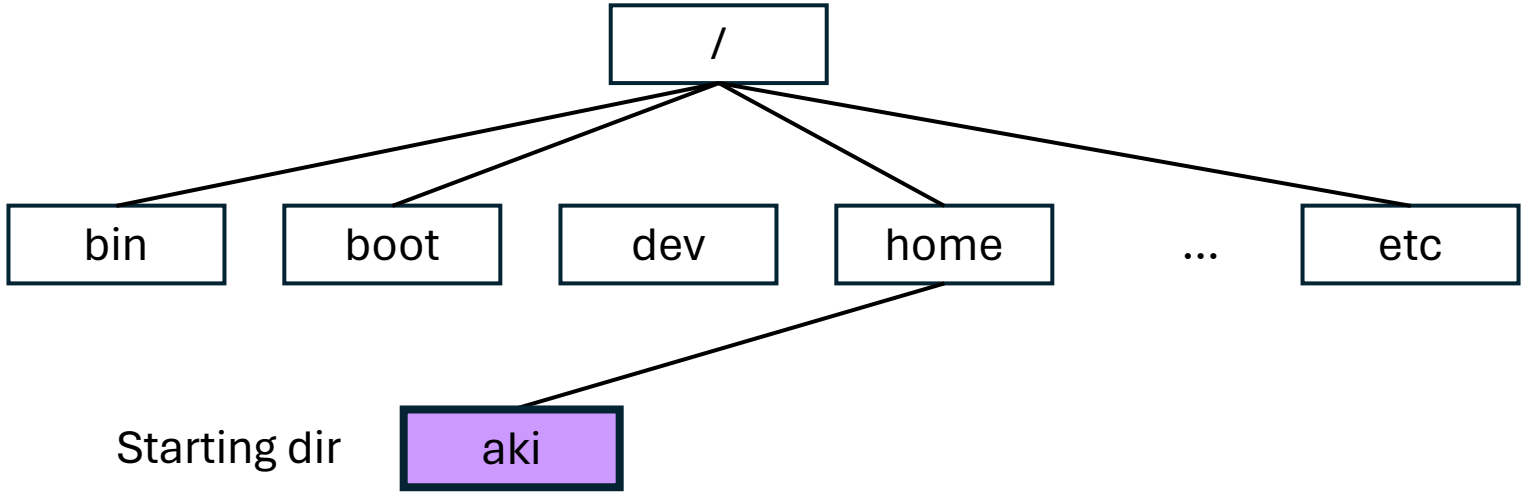
Starting dir
aki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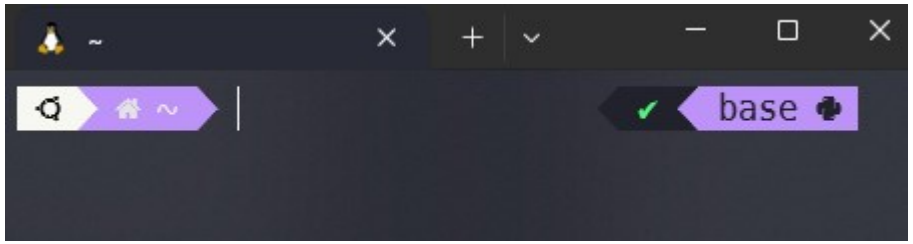
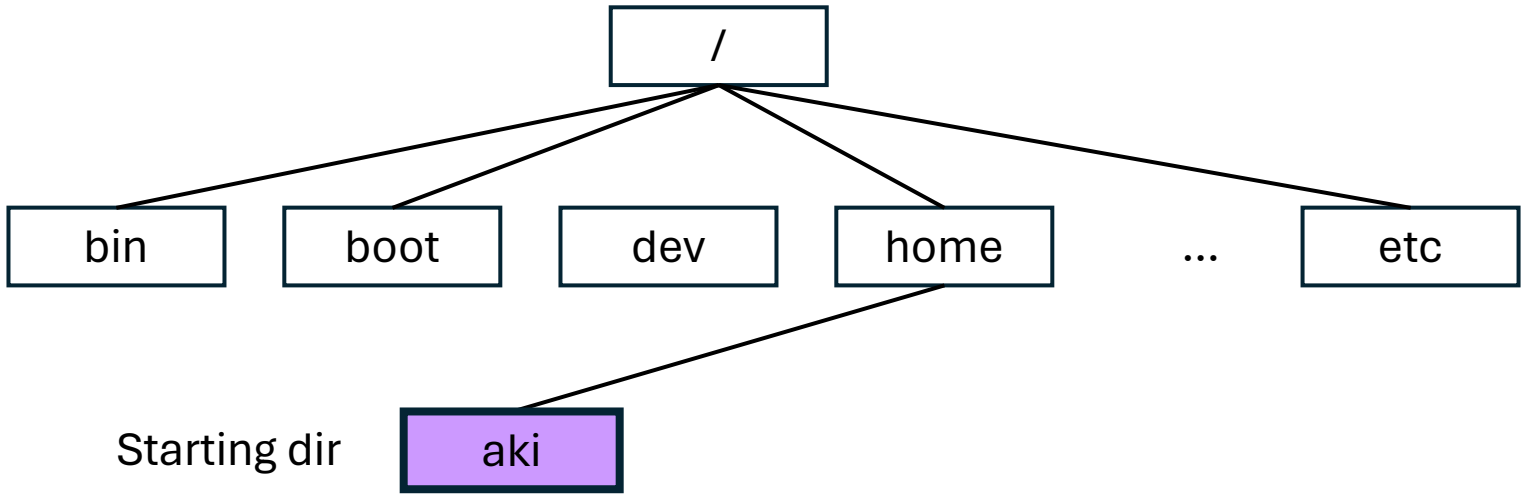
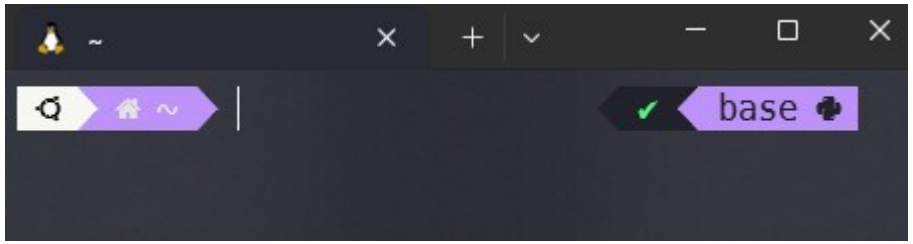
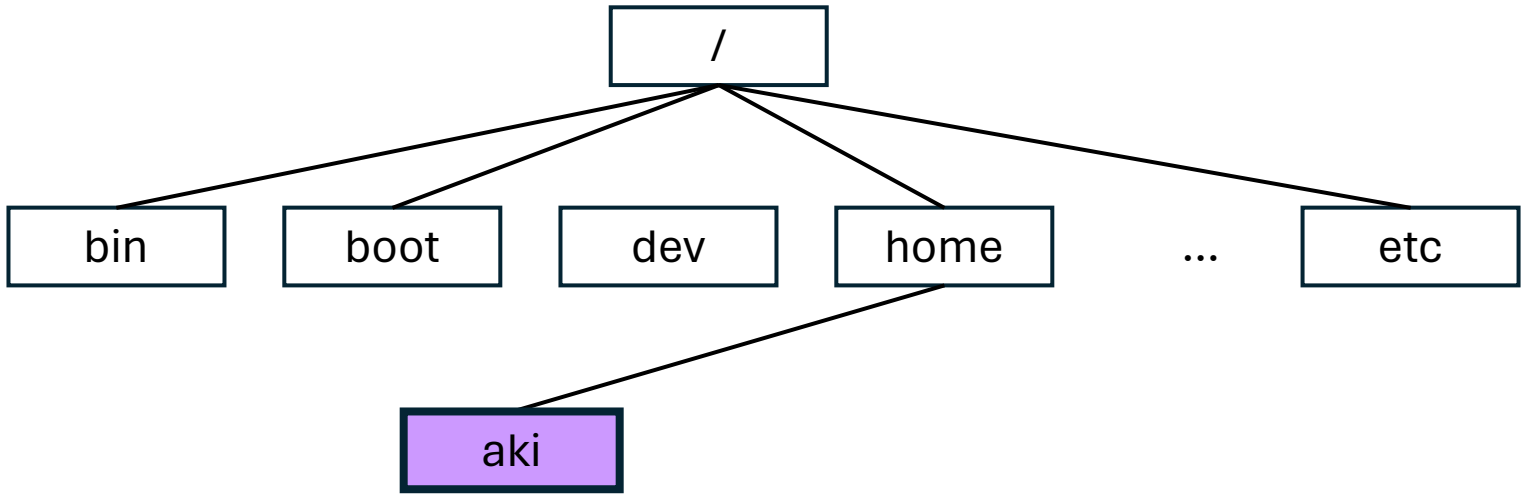

~
base

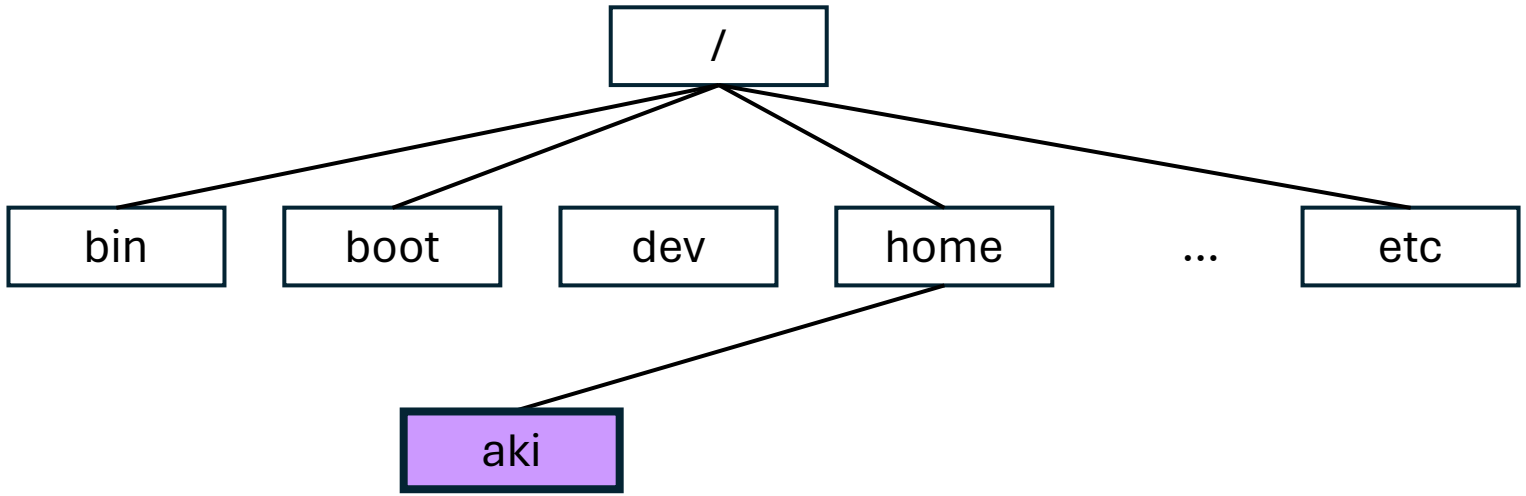




Tilde (~): Shortcut denoting user’s home directory

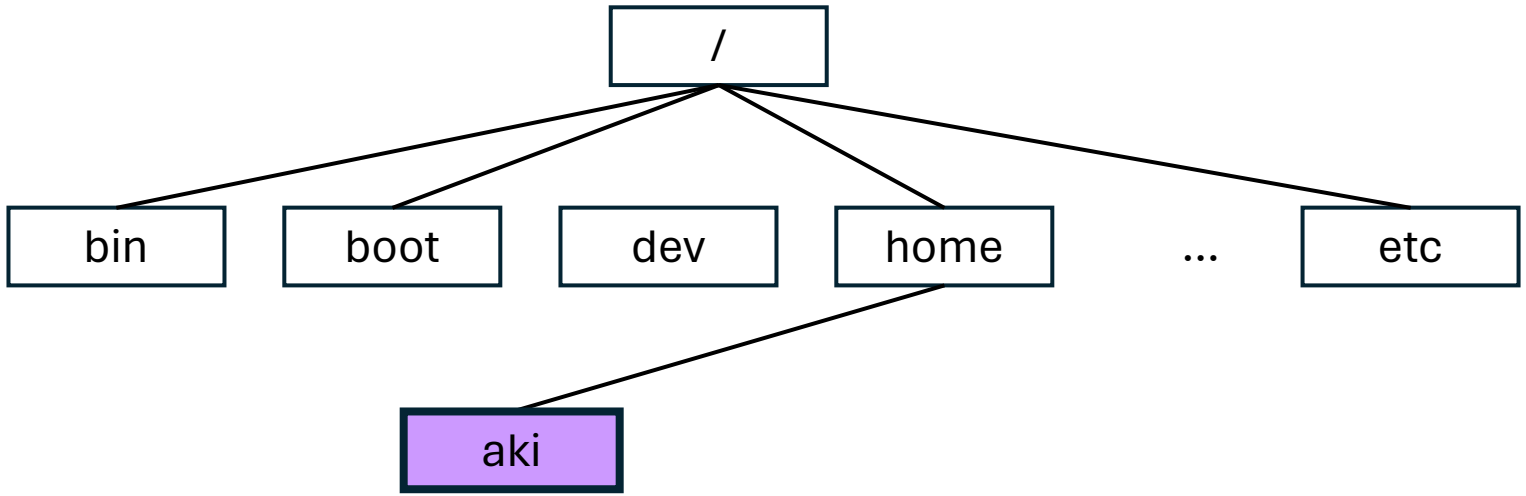


/ is a path separator



/ is a path separator

What is the path to my user folder?



/ is a path separator

What is the path to my user folder?

/home/aki

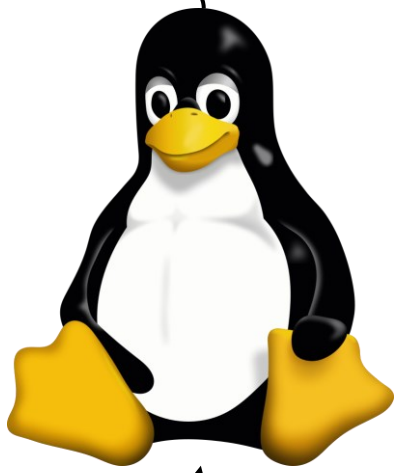
UNIX shell

4. Executes command

1. Display prompt
$

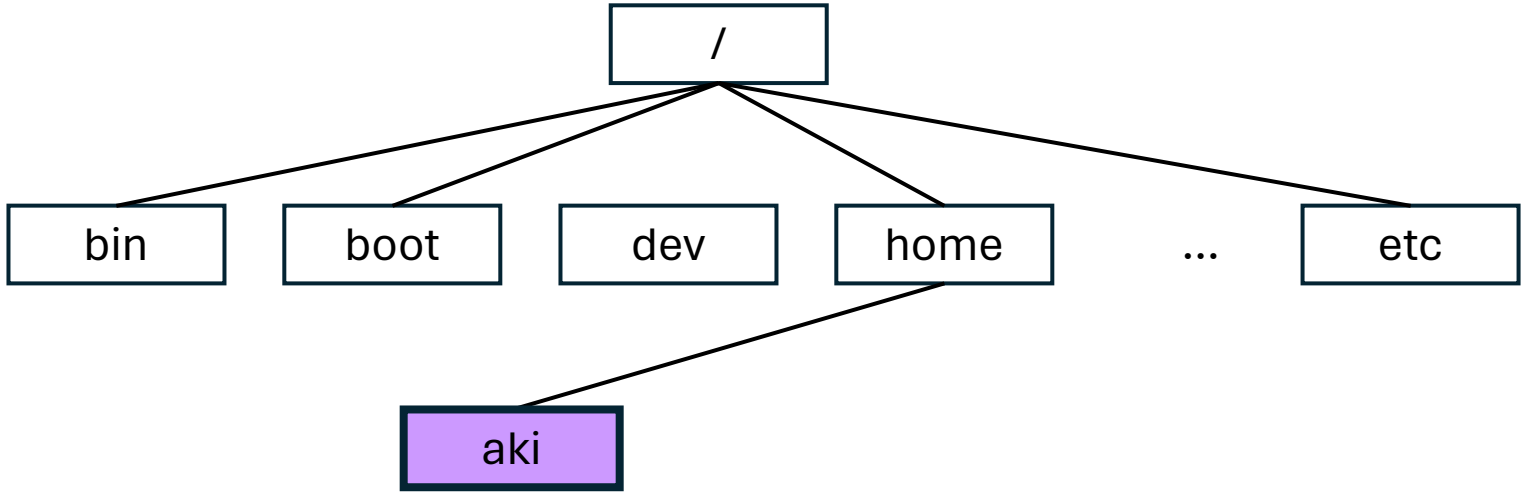
User

2. Enters command



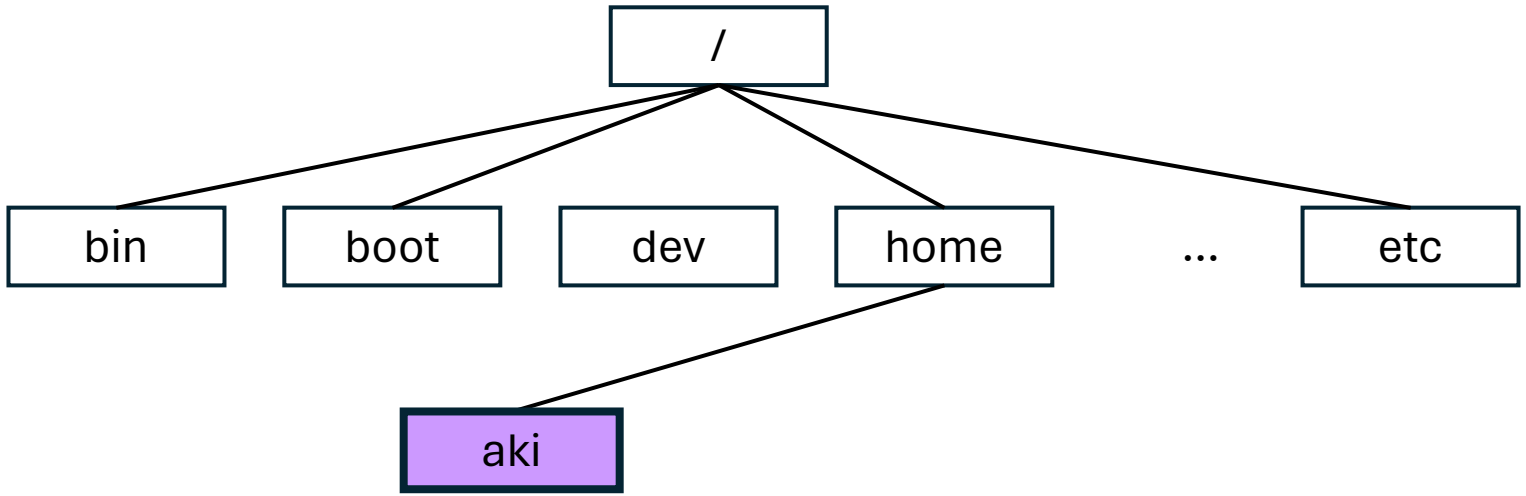
3. Interprets command

```
$ command
output
```




```
$ pwd
```

Print work directory




```
$ pwd
/home/aki
```

Basic command structure

```
$ ls -l folder
```

- Prompt
  - Shell is ready to receive command
- Command
  - Program being executed
- Options (or flags)
  - Configurations for the program
- Argument(s)
  - Target(s) of command

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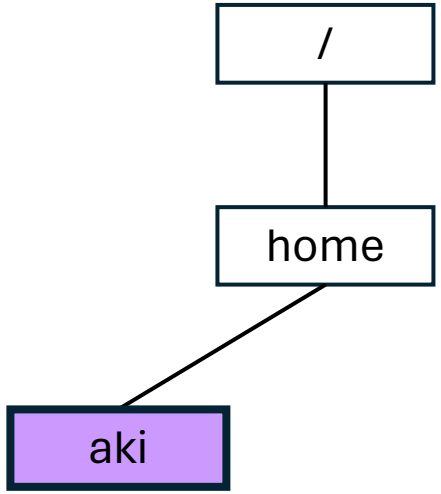
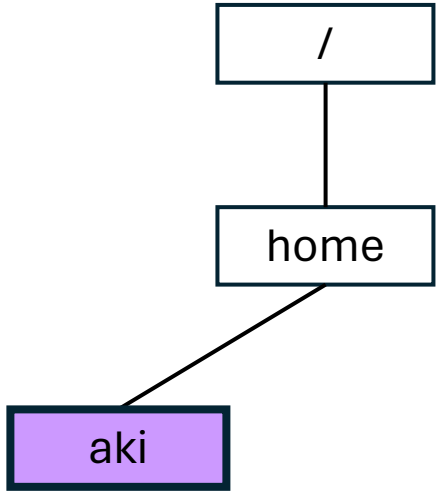
Watch out for spelling and whitespace errors!



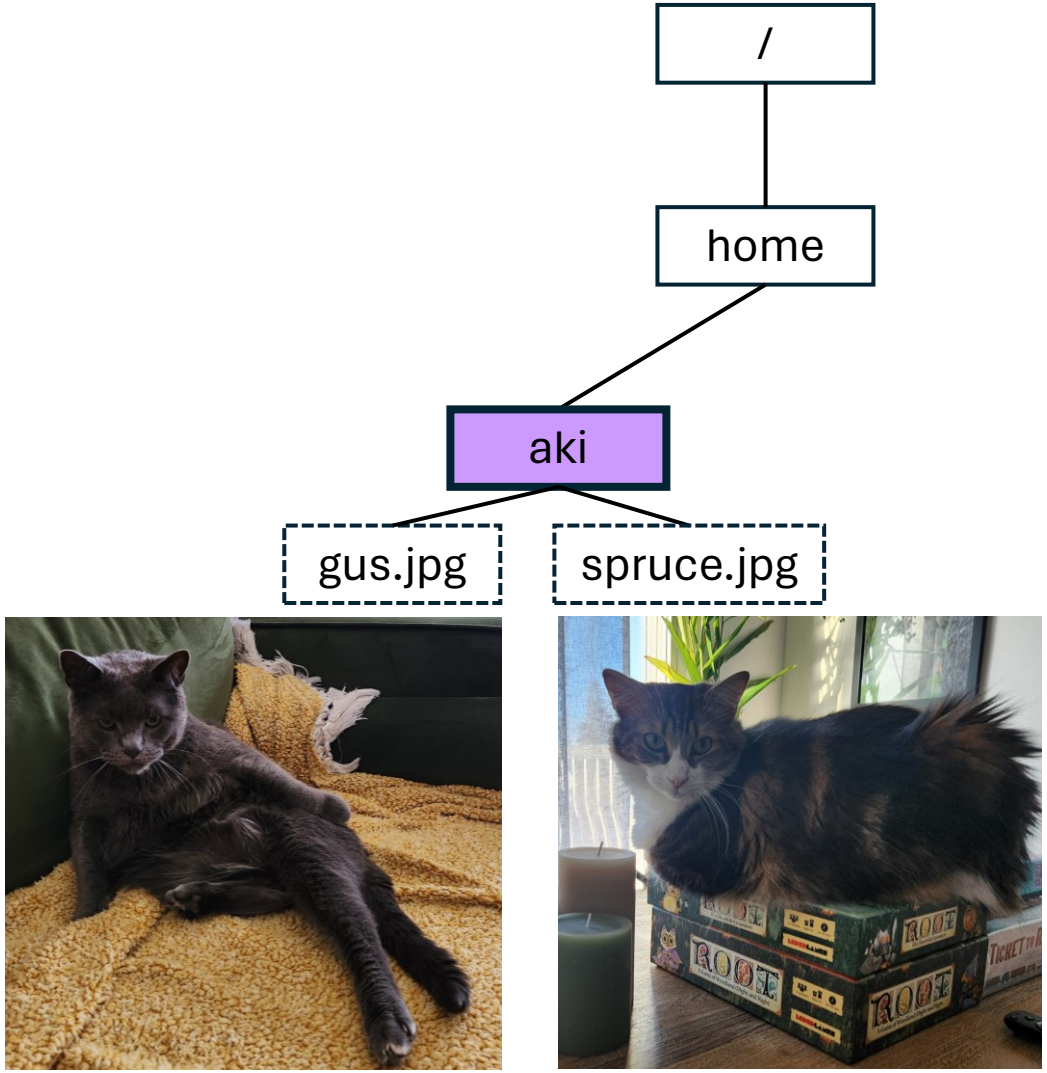
Current directory:/home/aki




```
$ ls
```

List directory contents

Current directory:/home/aki




```
$ ls
 gus.jpg spruce.jpg
```

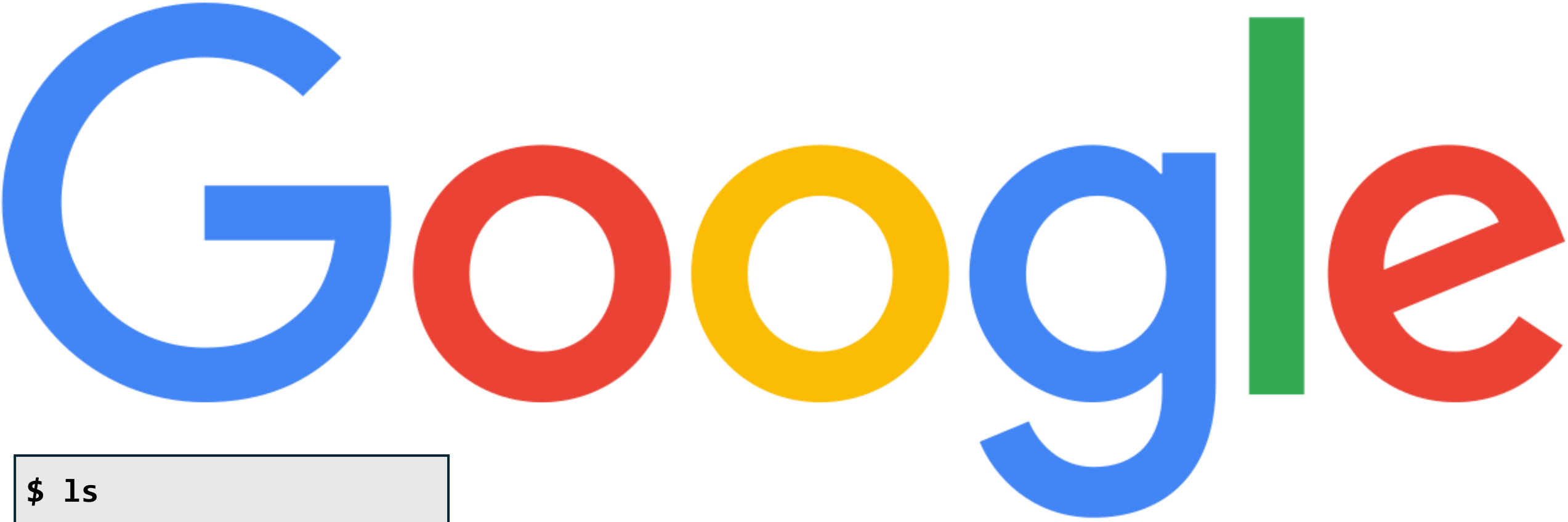
Current directory:/home/aki

How do we find out what a command does?

```
$ ls
```

```
Current directory:/home/aki
```

How do we find out what a command does?




```
$ ls
```

```
Current directory:/home/aki
```

How do we find out what a command does?

We read the manual

```
$
```

```
Current directory:/home/aki
```

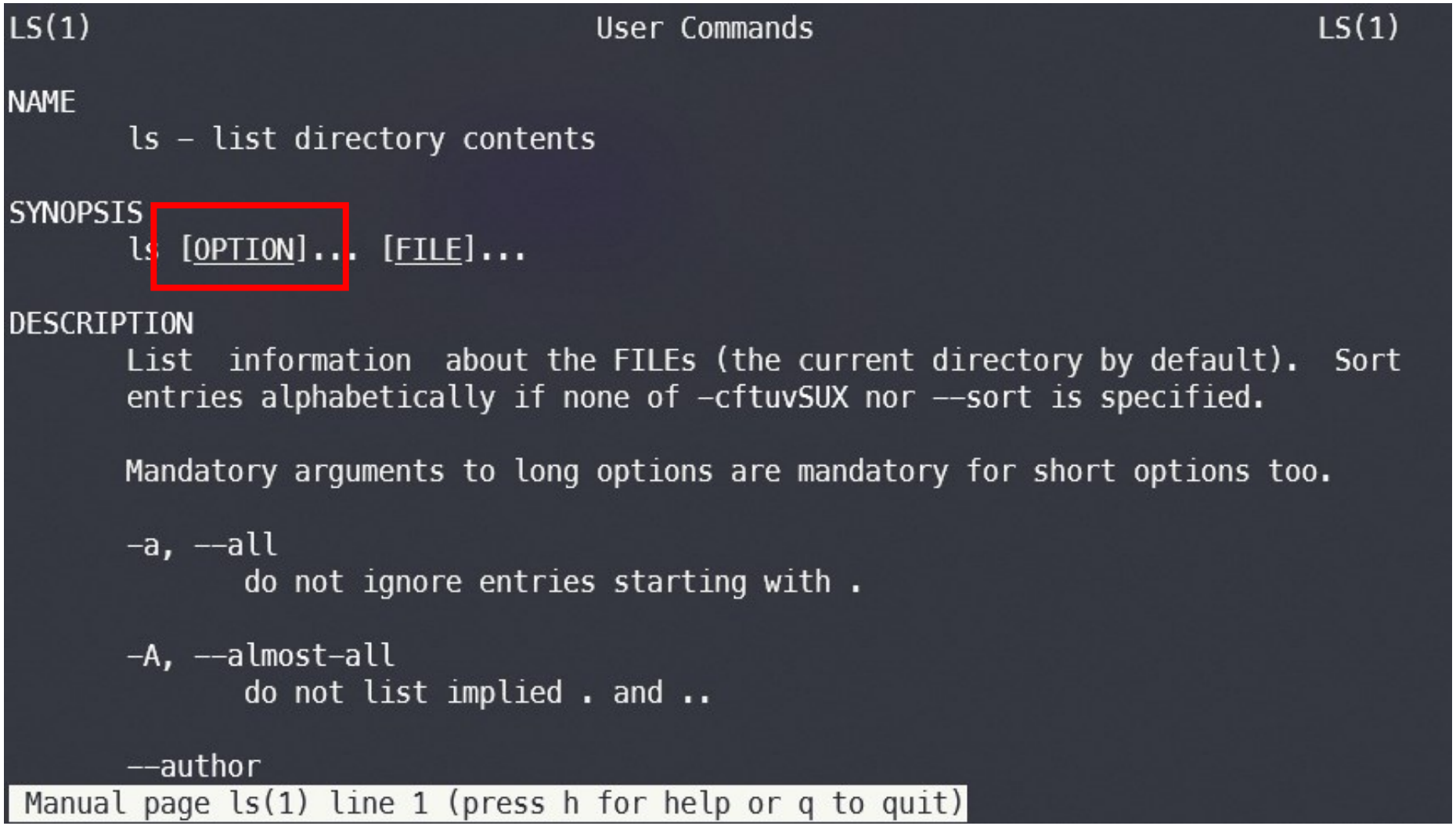
How do we find out what a command does?

We read the manual

```
$ man ls
```

```
Current directory:/home/aki
```

```
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 alphabetically if none of -cftuvSUX nor --sort is specified.

       Mandatory arguments to long options are mandatory for short options too.

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

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

       --author
 Manual page ls(1) line 1 (press h for help or q to quit)
```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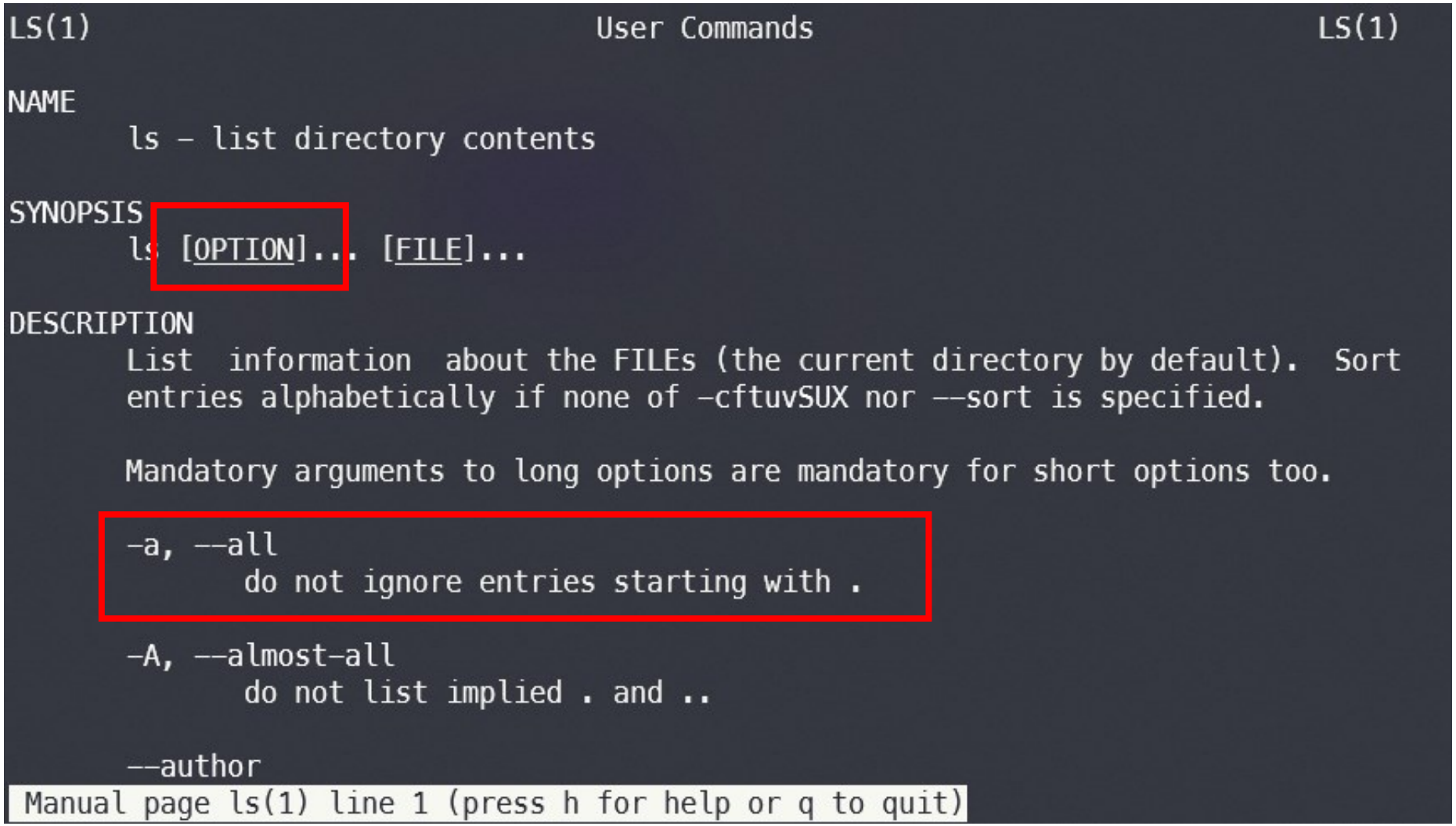
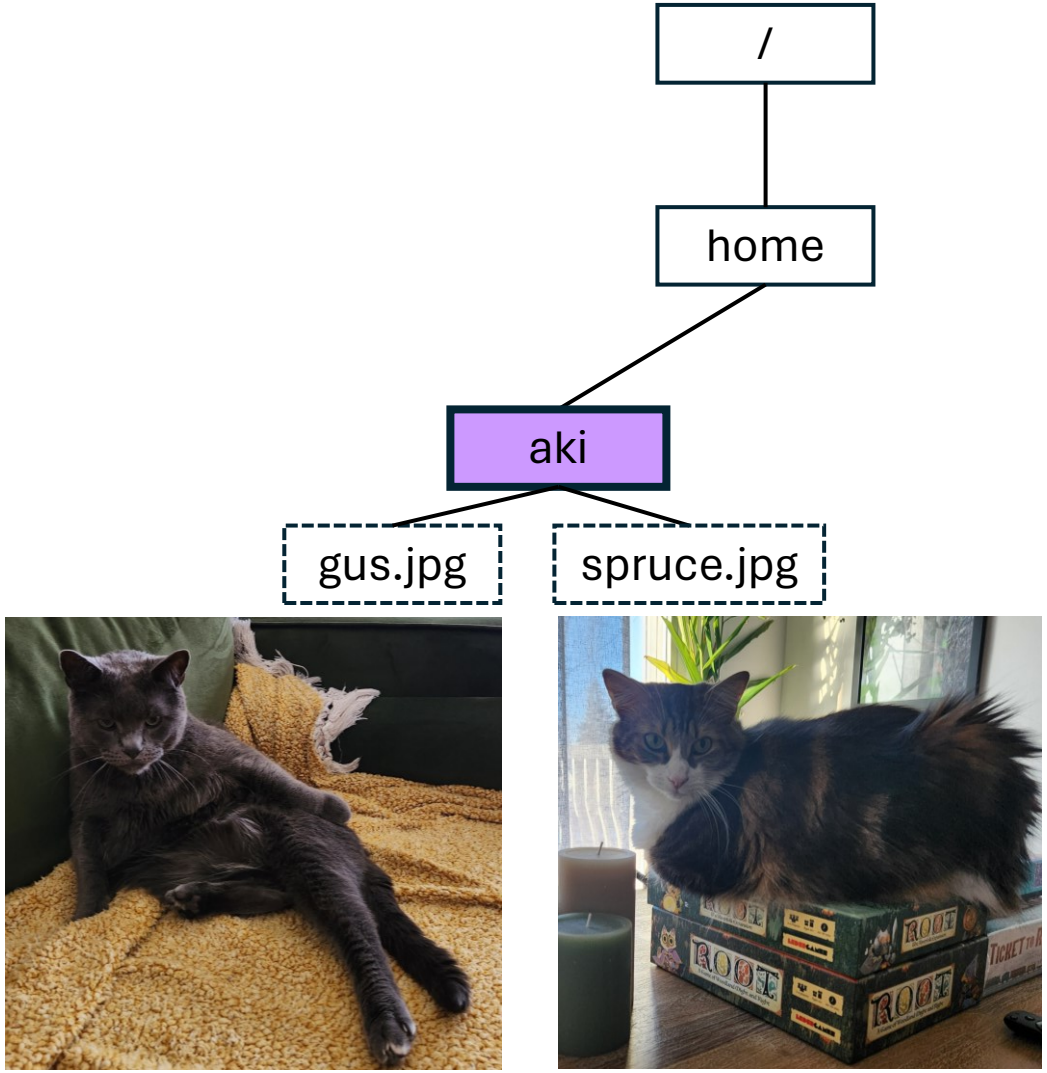
Manual page ls(1) line 1 (press h for help or q to quit)

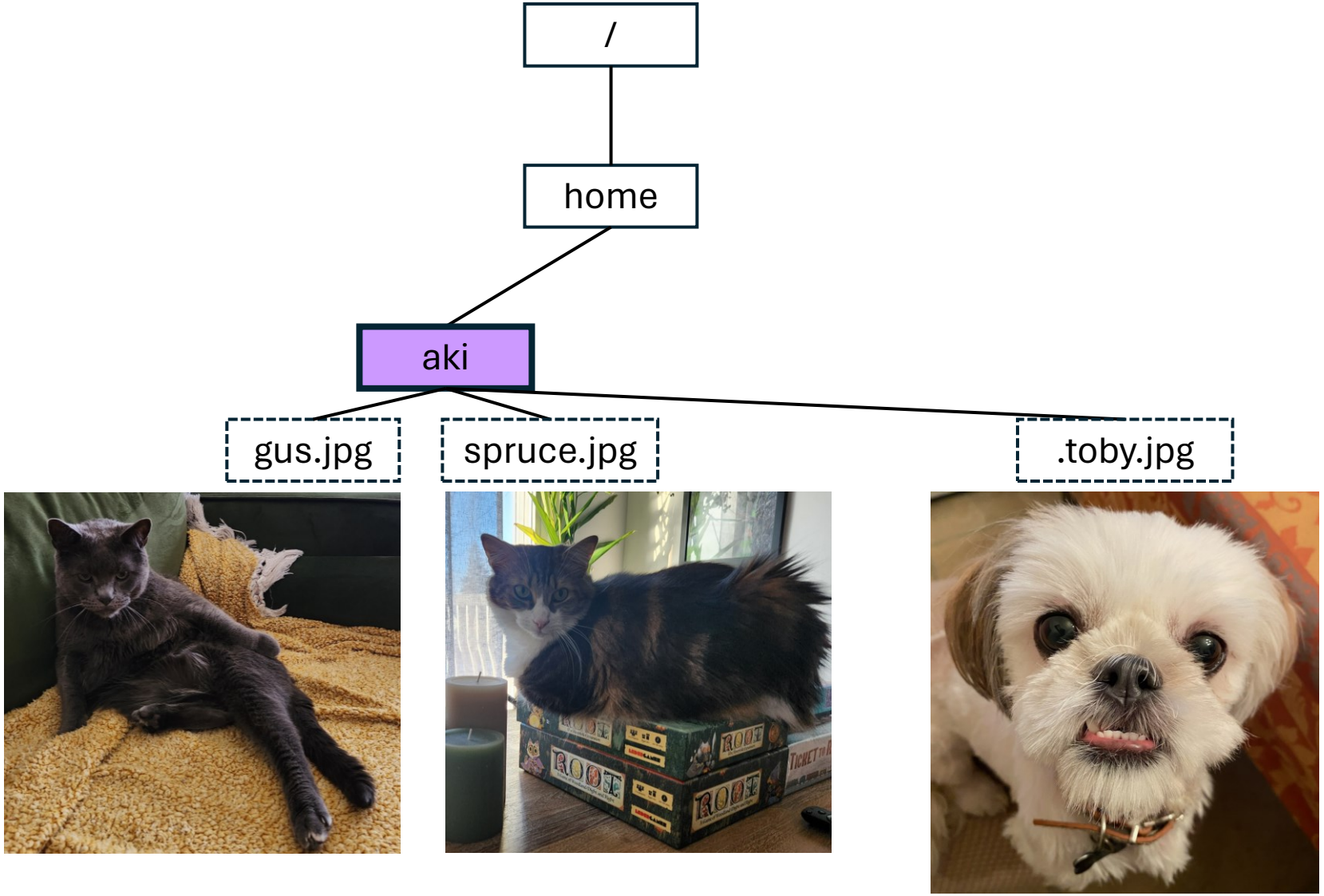
Flags allow us to pass options to commands





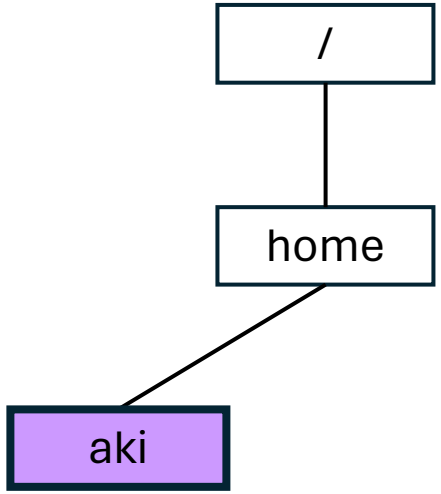

```
$ ls
 gus.jpg spruce.jpg
```

Current directory:/home/aki




```
$ ls -a
gus.jpg spruce.jpg
.toby.jpg
```

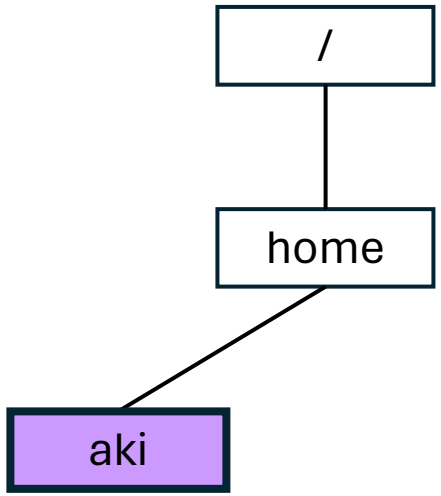
Current directory:/home/aki



$ mkdir

Make directory

Current directory:/home/aki

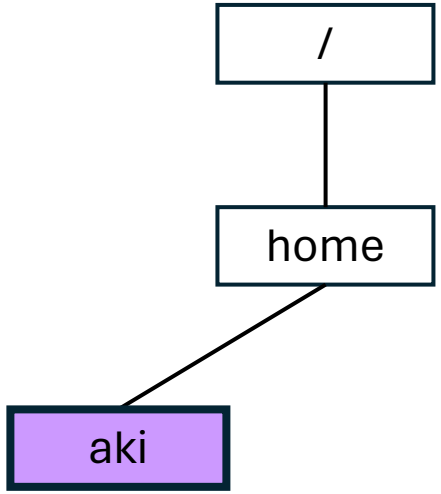


$ mkdir

```
mkdir: missing operand
```

Make directory

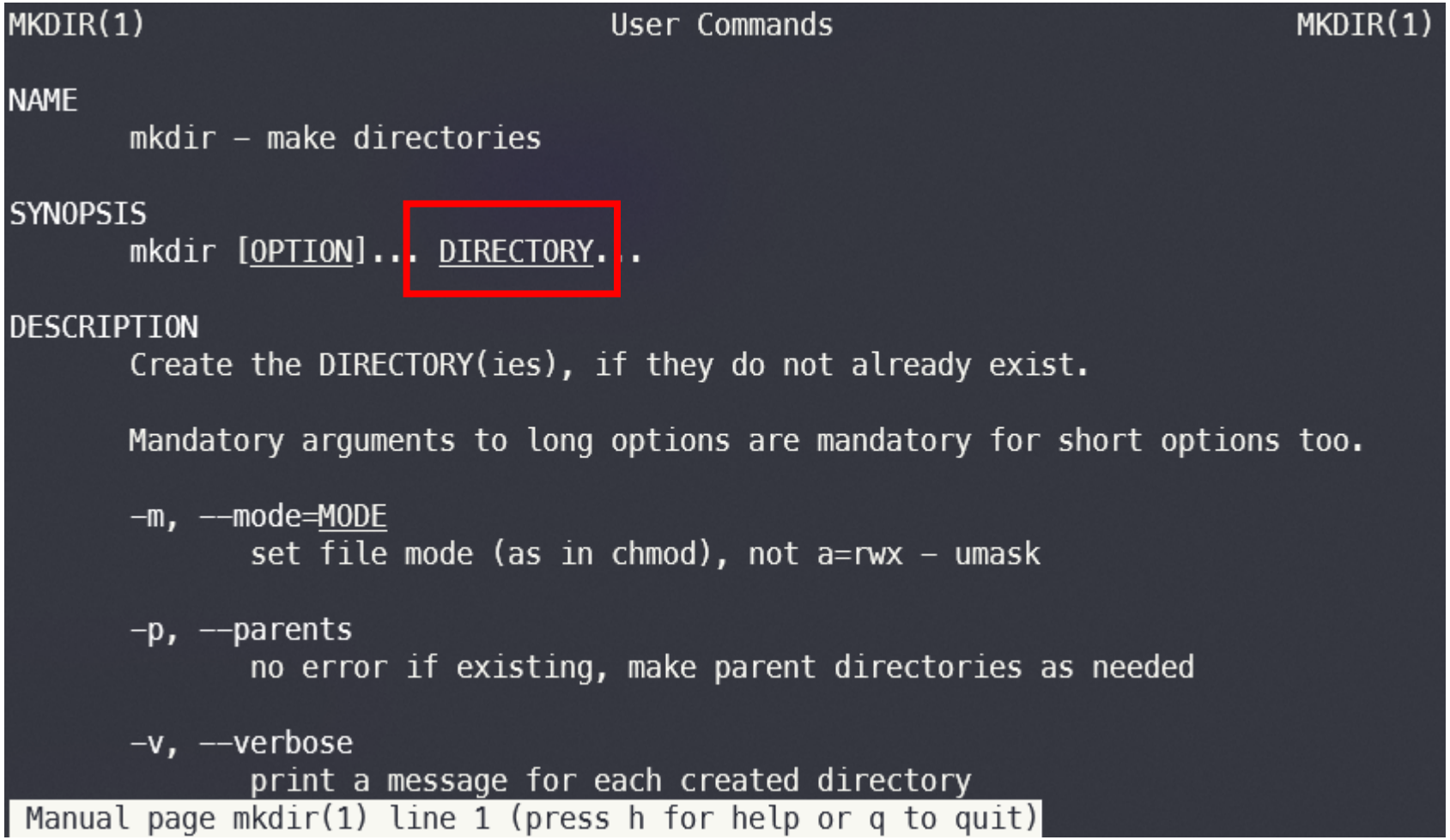
Current directory:/home/aki



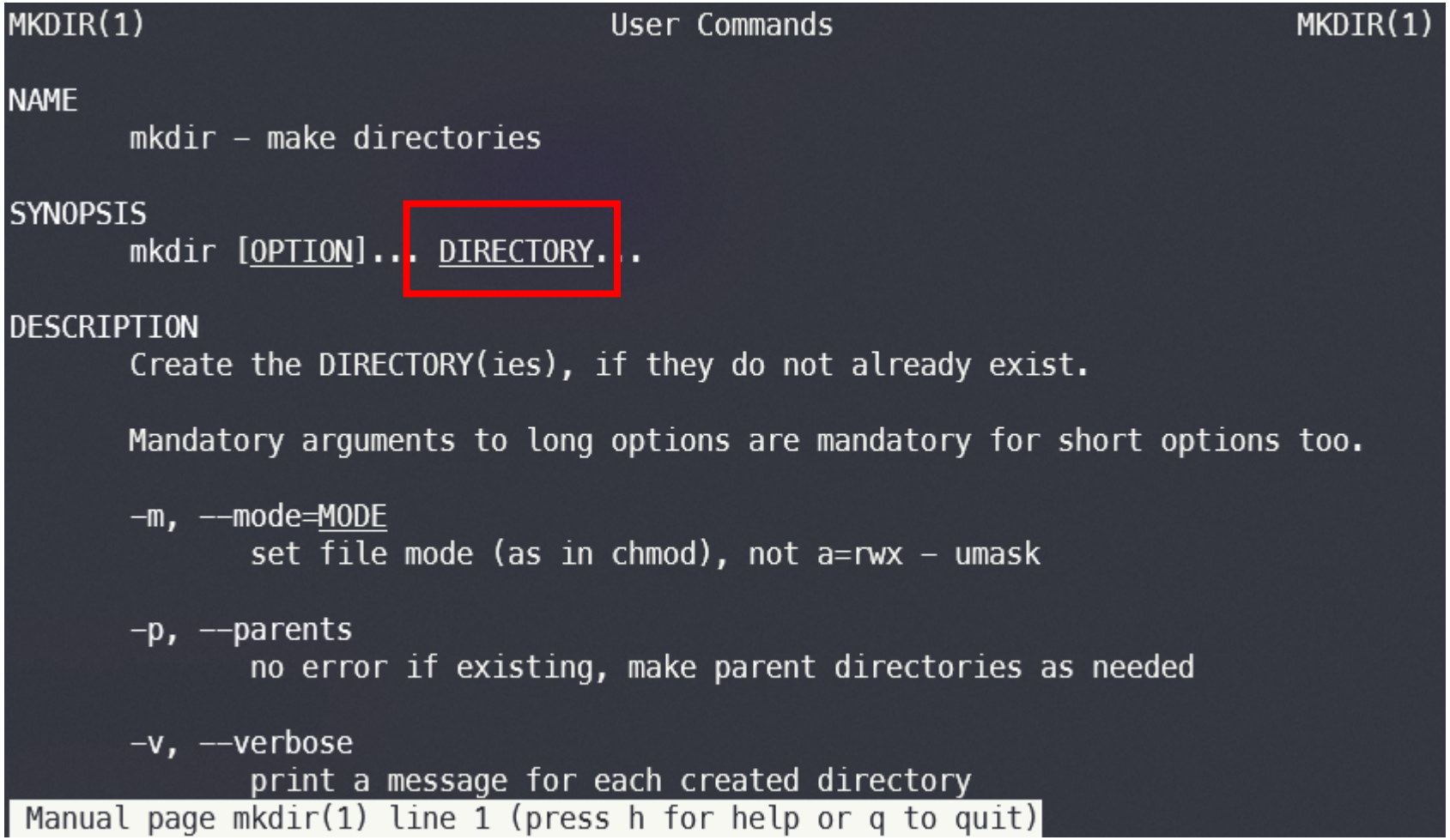

```
$ man mkdir
```

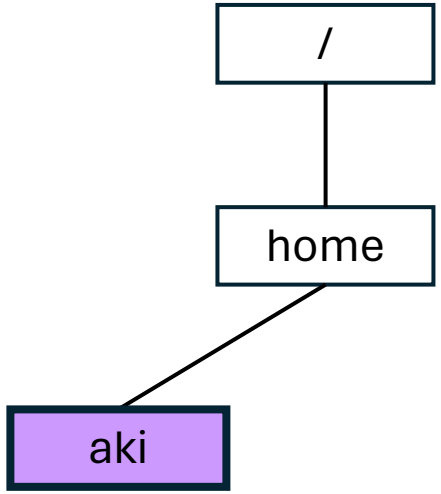
Check the manual

Current directory:/home/aki


MKDIR(1) User Commands MKDIR(1)
NAME
mkdir - make directories
SYNOPSIS
mkdir [OPTION]... DIRECTORY...
DESCRIPTION
Create the DIRECTORY(ies), if they do not already exist.
Mandatory arguments to long options are mandatory for short options too.
-m, --mode=MODE
set file mode (as in chmod), not a=rwx - umask
-p, --parents
no error if existing, make parent directories as needed
-v, --verbose
print a message for each created directory
Manual page mkdir(1) line 1 (press h for help or q to quit)

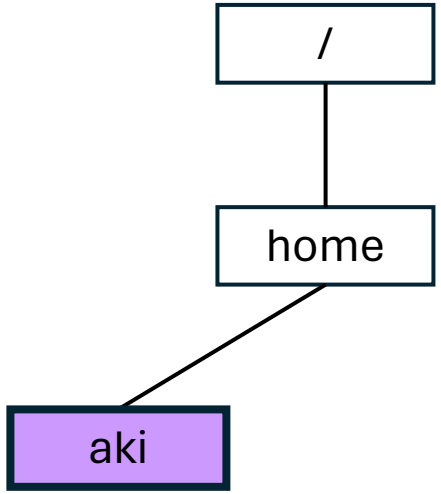
No square brackets. Missing directory name





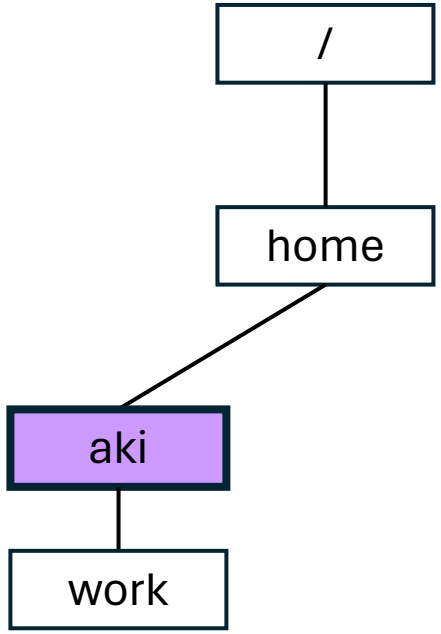

```
$ mkdir work
```

```
Current directory:/home/aki
```



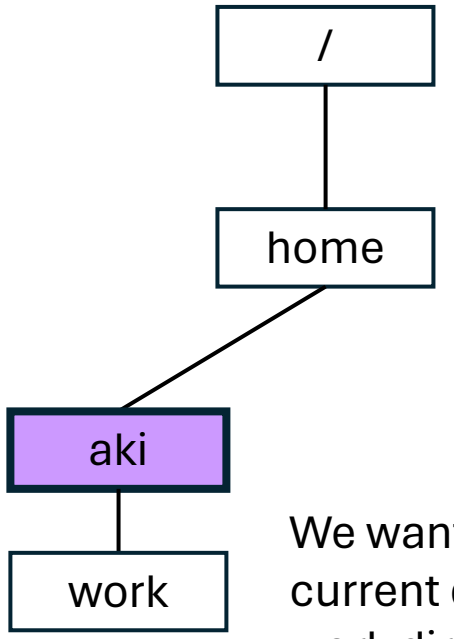

```
$
```

Current directory:/home/aki




```
$ ls
work gus.jpg
spruce.jpg
```

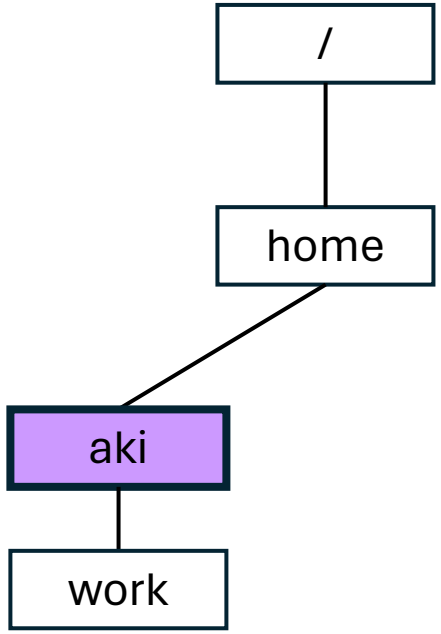
Current directory:/home/aki



We want to change our current directory to the work directory.
How?

```
$
```

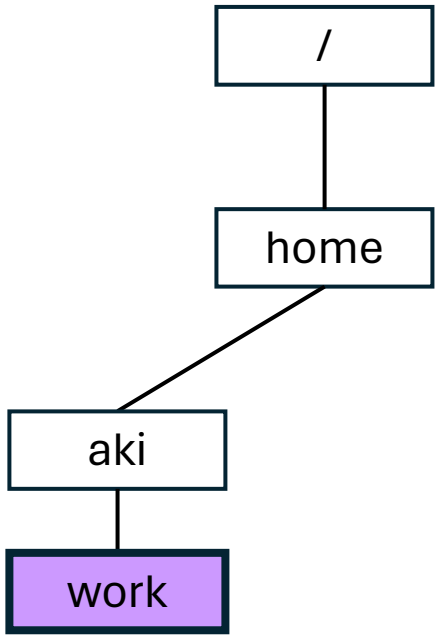
```
Current directory:/home/aki
```




```
$ cd work
```

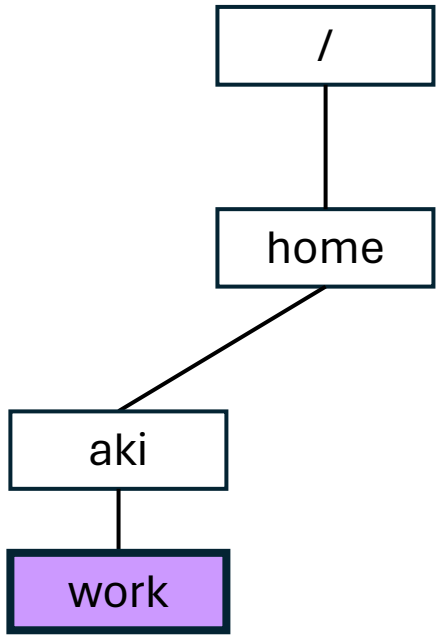
Change directory

```
Current directory:/home/aki
```




```
$
```

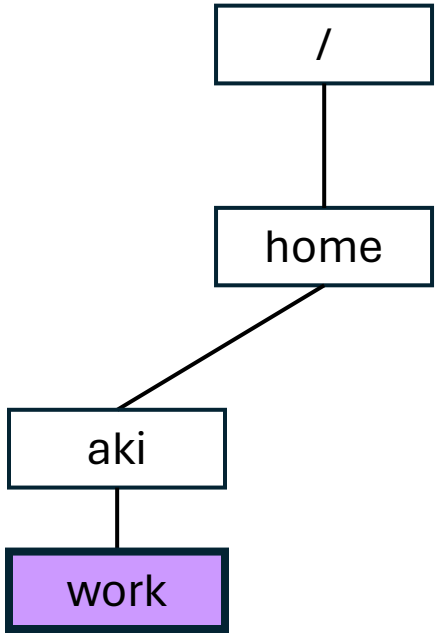
Current directory:/home/aki/work



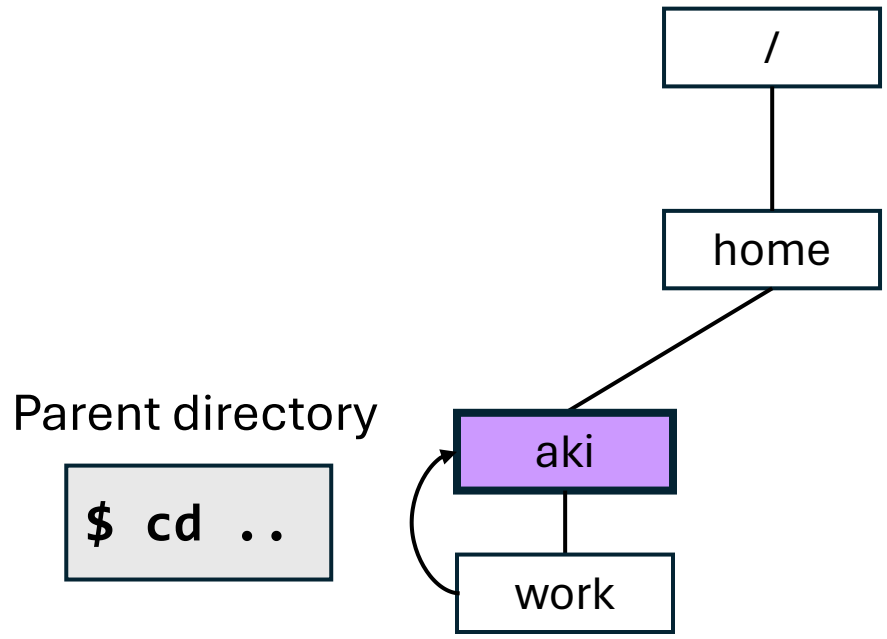

```
$ pwd
 /home/aki/work
```

Current directory:/home/aki/work

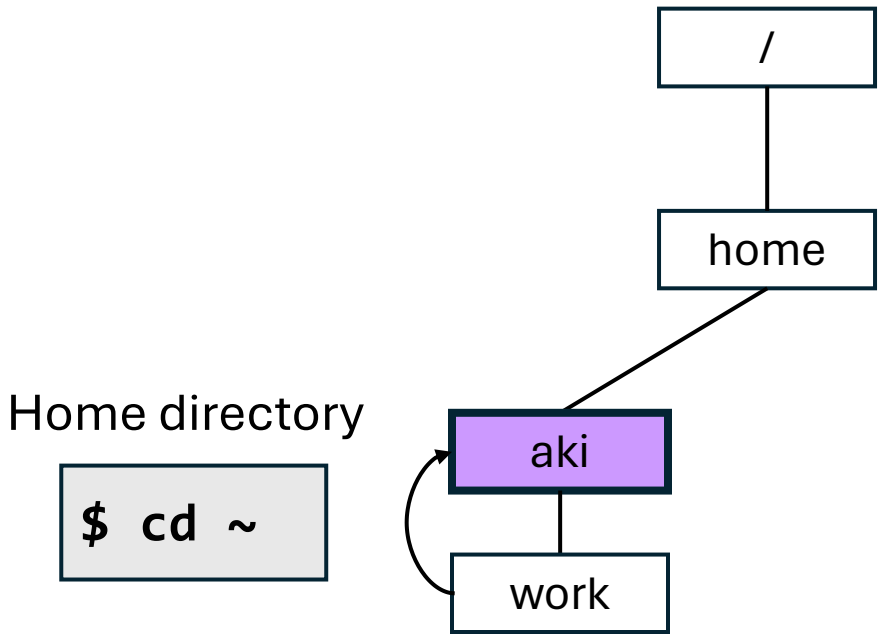
Navigating through directories



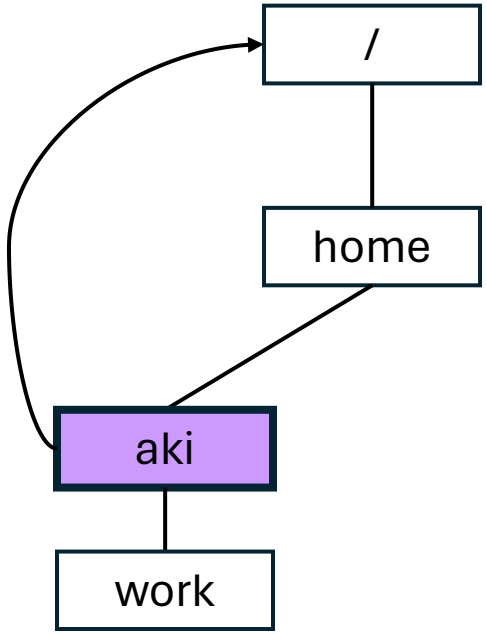
Navigating through directories



Navigating through directories



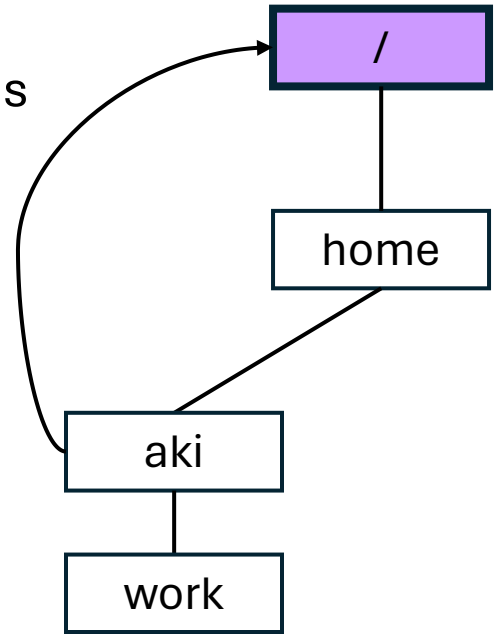
Navigating through directories



Navigating through directories

Up two parent directories

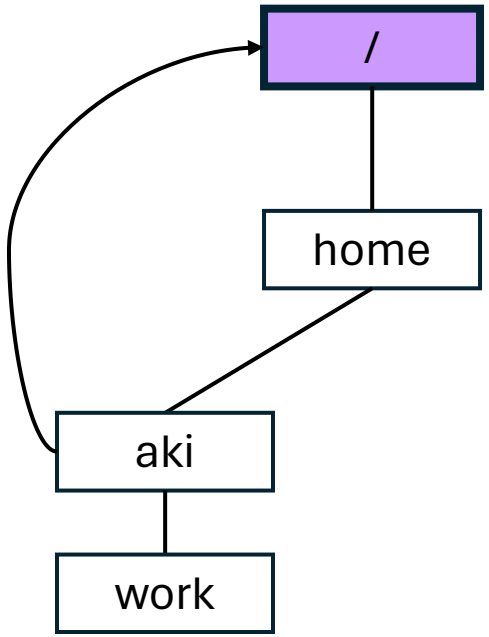
```
$ cd ../..
```



Navigating through directories

Root directory

```
$ cd /
```



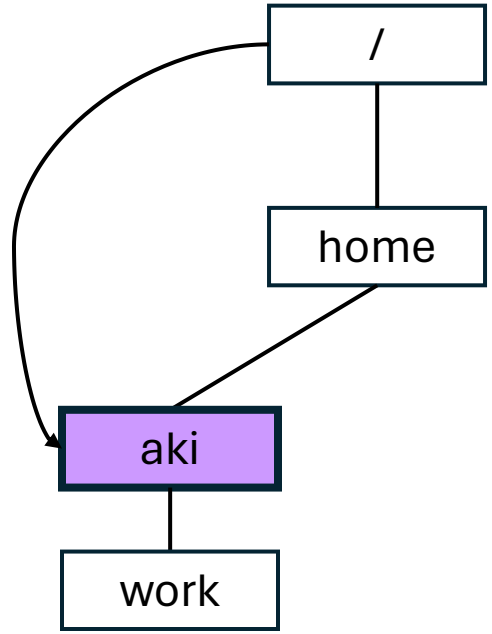
Navigating through directories

Home directory

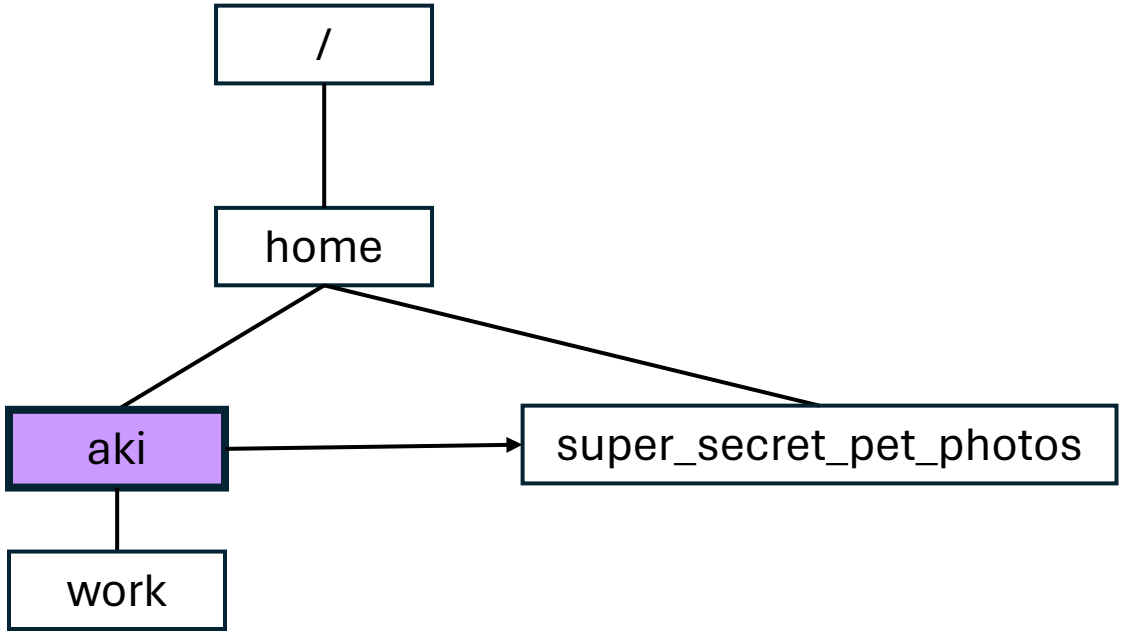
```
$ cd ~
```

or

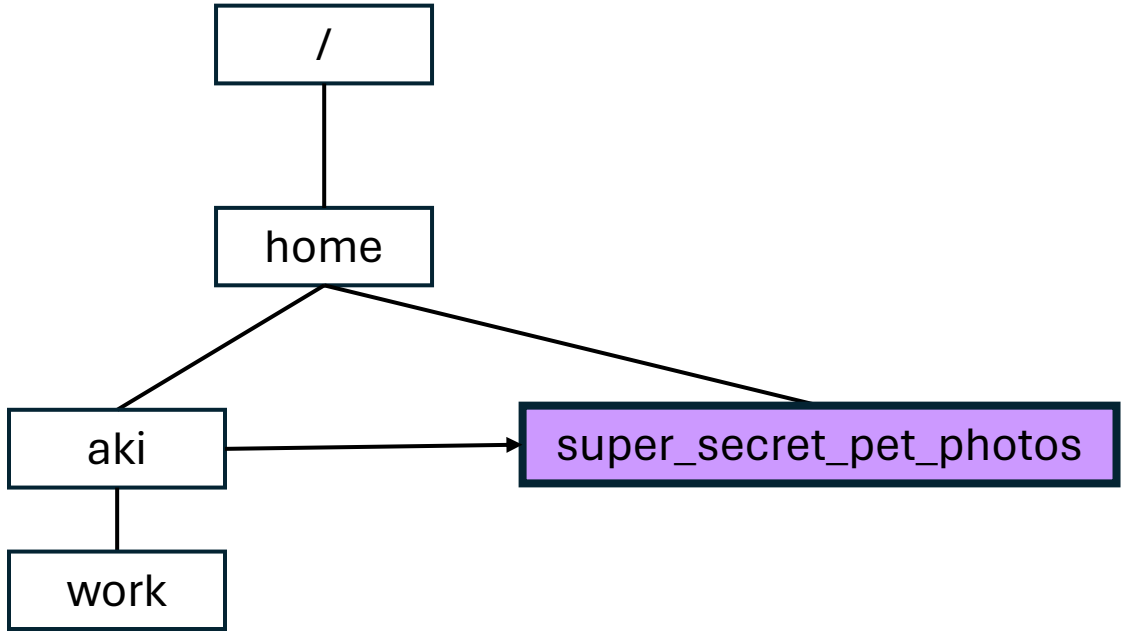
```
$ cd home/aki
```



Navigating through directories



Navigating through directories



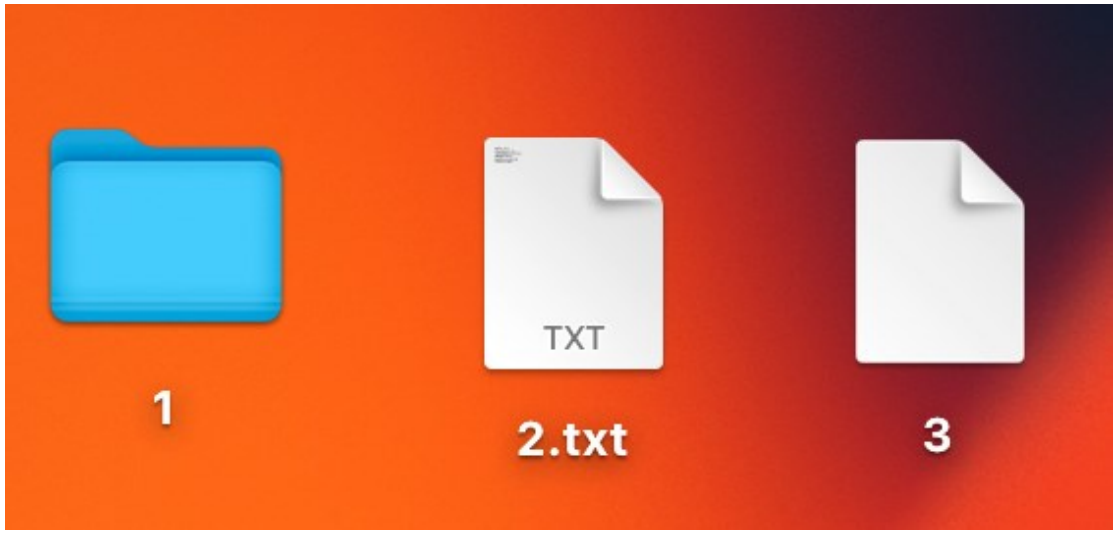
Relative path

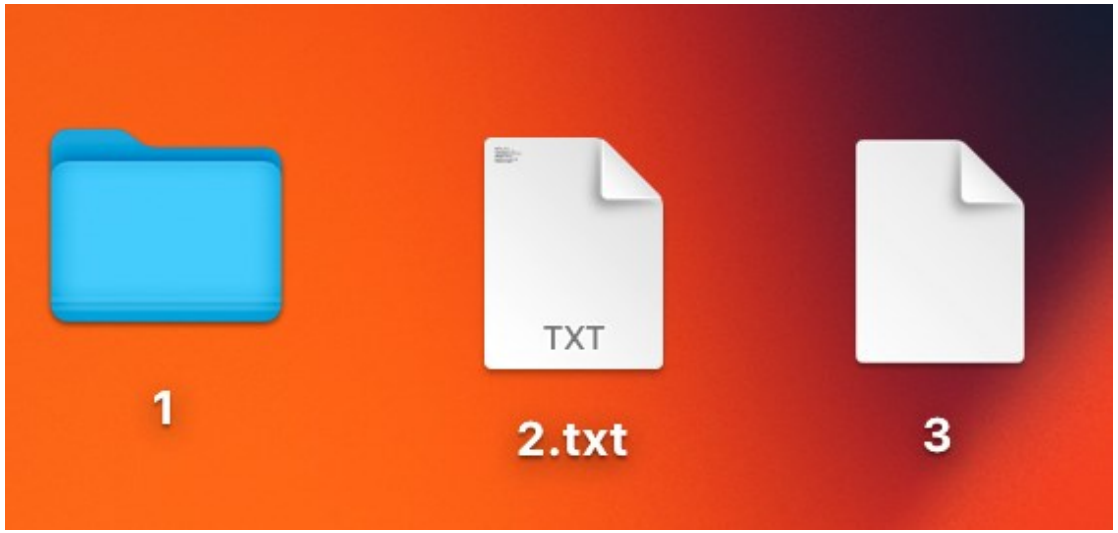
```
$ cd ../super_secret_pet_photos
```

or

Absolute path

```
$ cd /home/super_secret_pet_photos
```


TXT
1
2.txt
3



Folder Text file Binary file

File types

- All objects are files
- File names can be anything, however
  - Avoid whitespace
    - new file.txt looks like new\ file.txt -> Not pleasant to work with
  - Avoid special characters. Use – or _
  - Remember that files are case-sensitive
- Extensions do not matter (.txt, .tsv, etc)
  - Only for humans. Some software looks to perform function based on extension
  - Not enforced by the shell

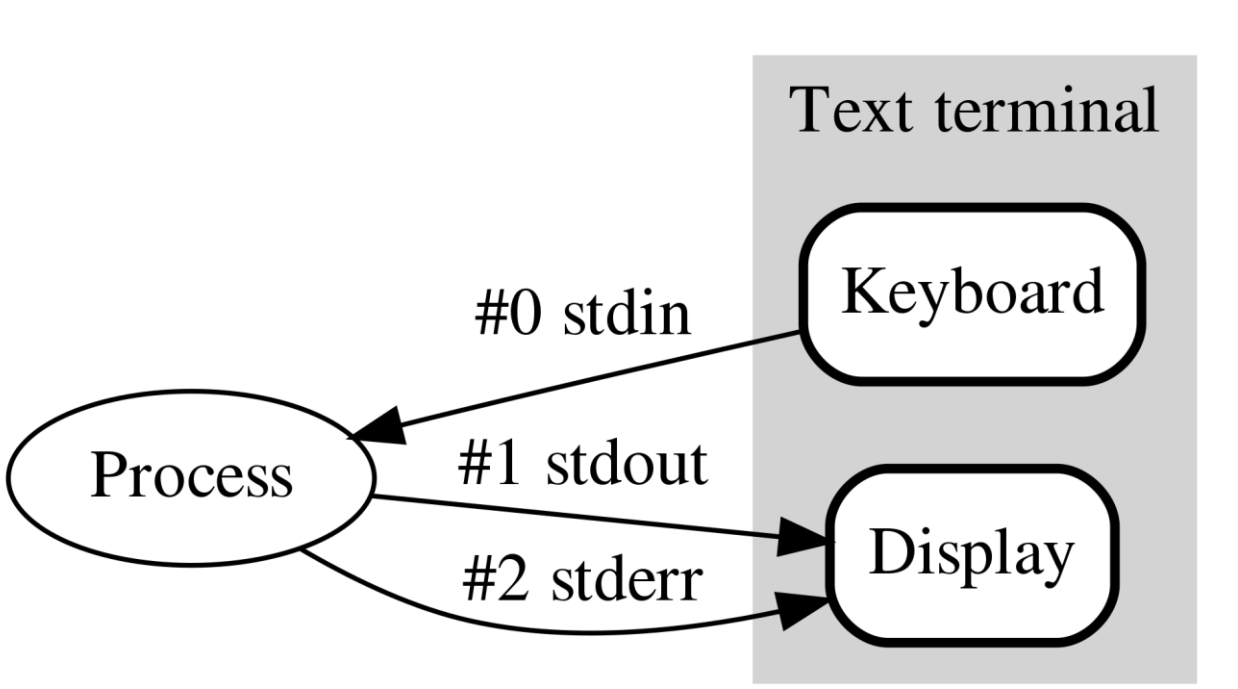
File types

Generally, you will work with two file types:

1. Plain text files
   - Human readable
   - Portable and can be read by many programs
   - Take more space
2. Binary files
   - Not human readable
   - Read by specific programs
   - More efficient with size

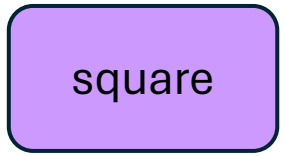
Input/output streams

- Allow the program to interact with its environment

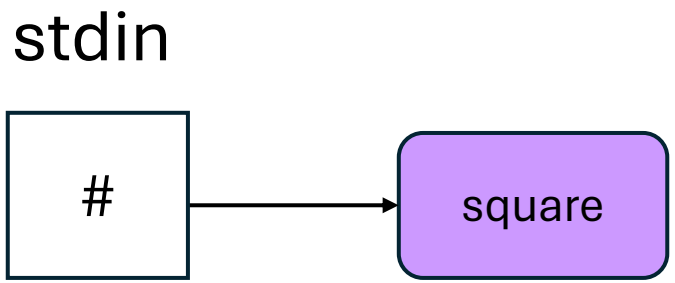


Input/output streams

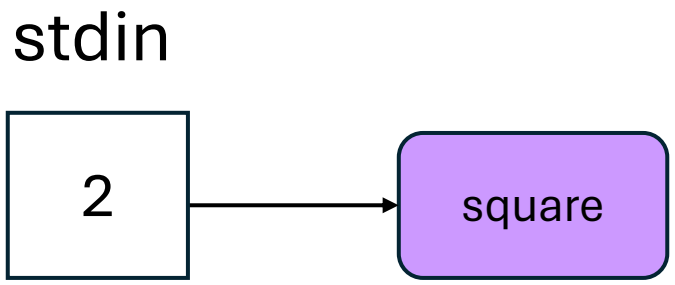
- Allow the program to interact with its environment



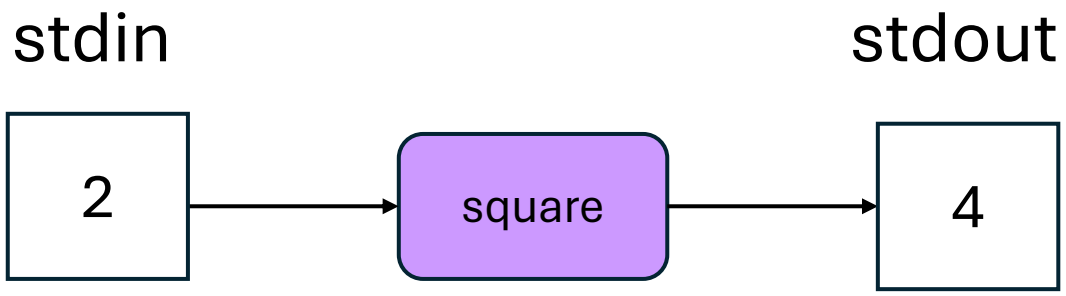
Input/output streams



Input/output streams

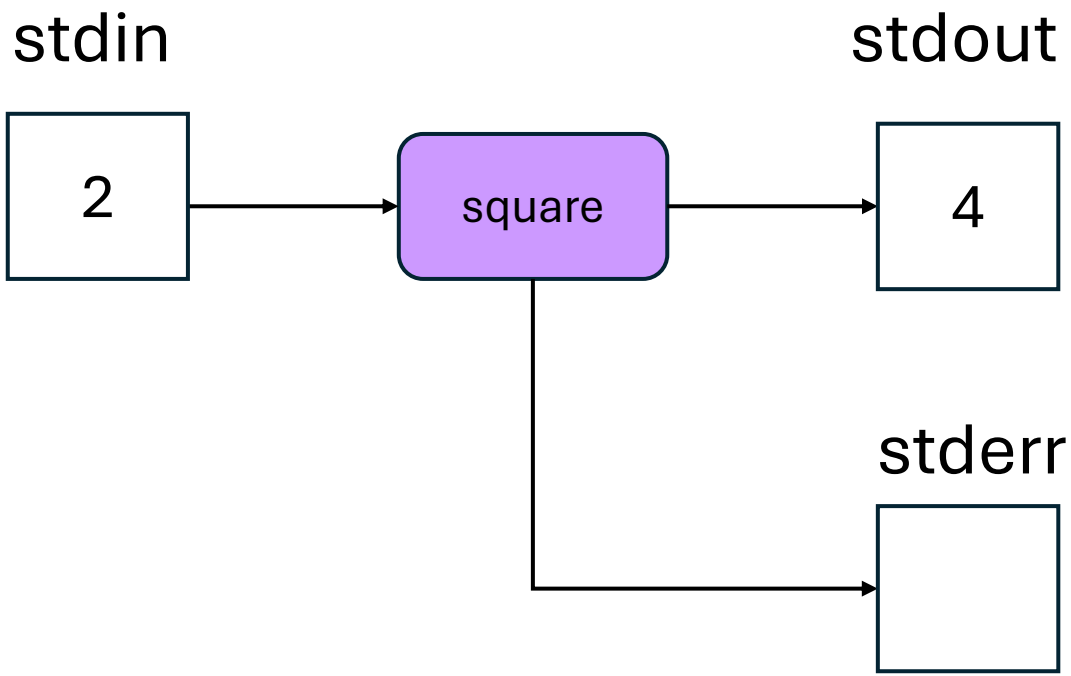


Input/output streams



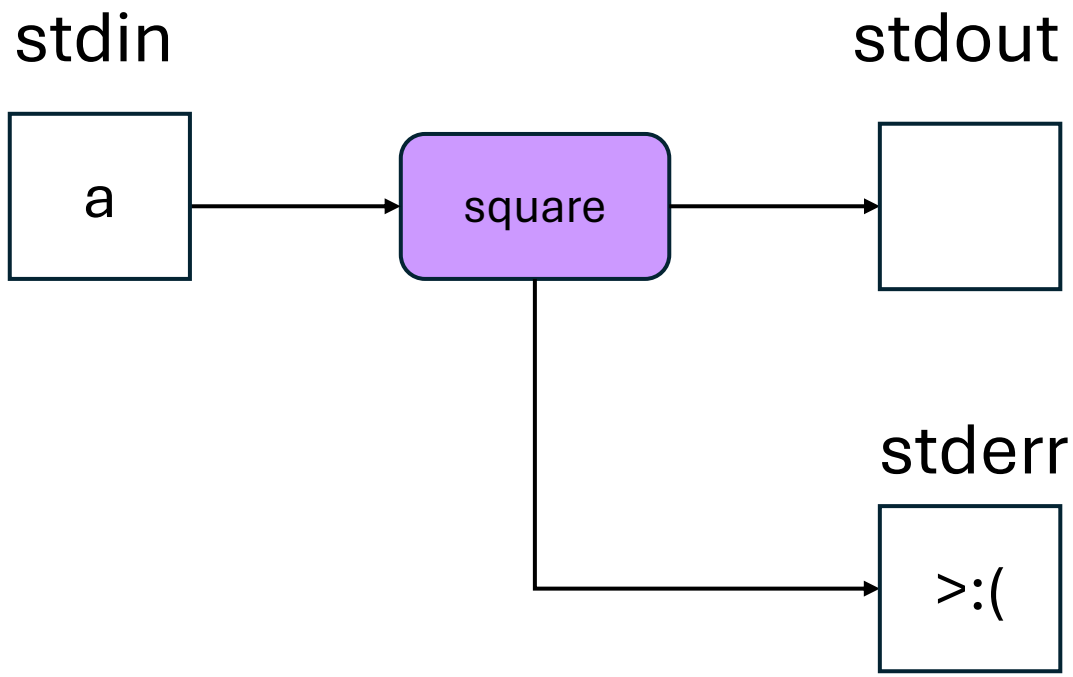

```
$ square 2
```

Input/output streams



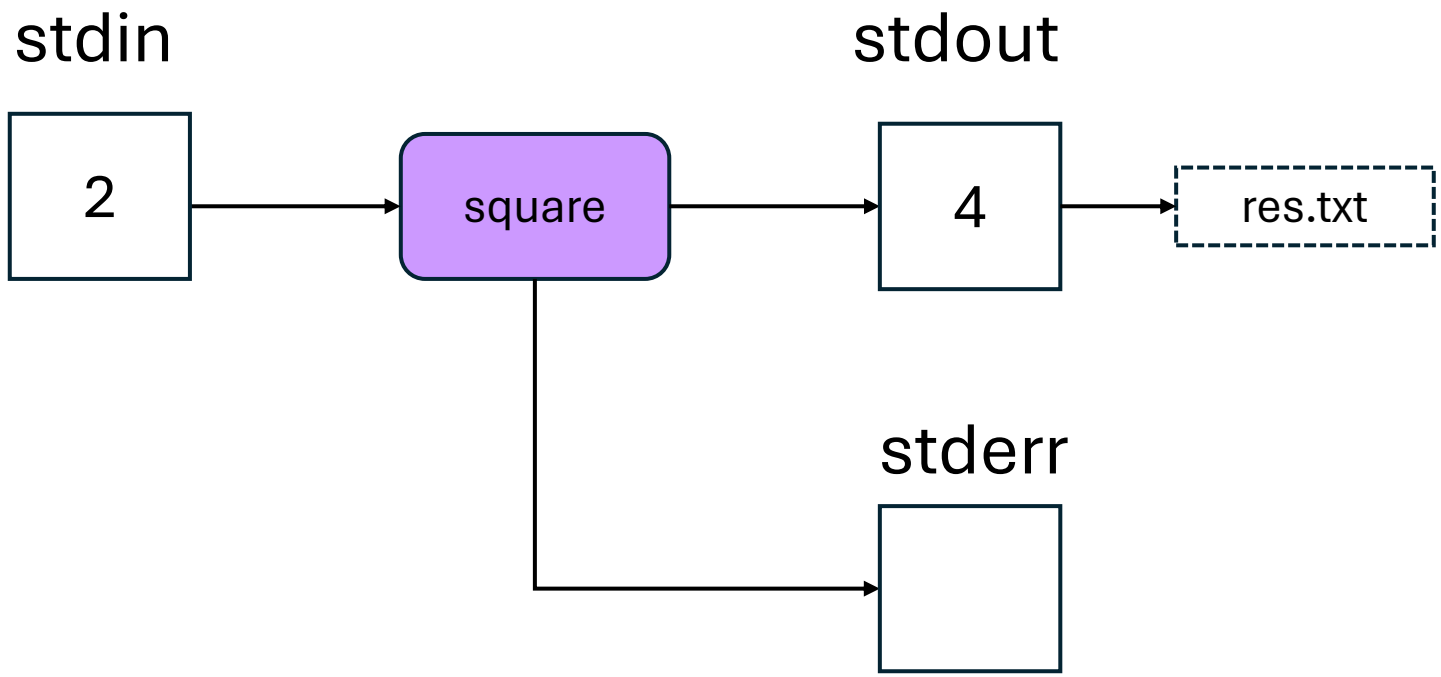

```
$ square 2
```

Input/output streams




```
$ square a
```

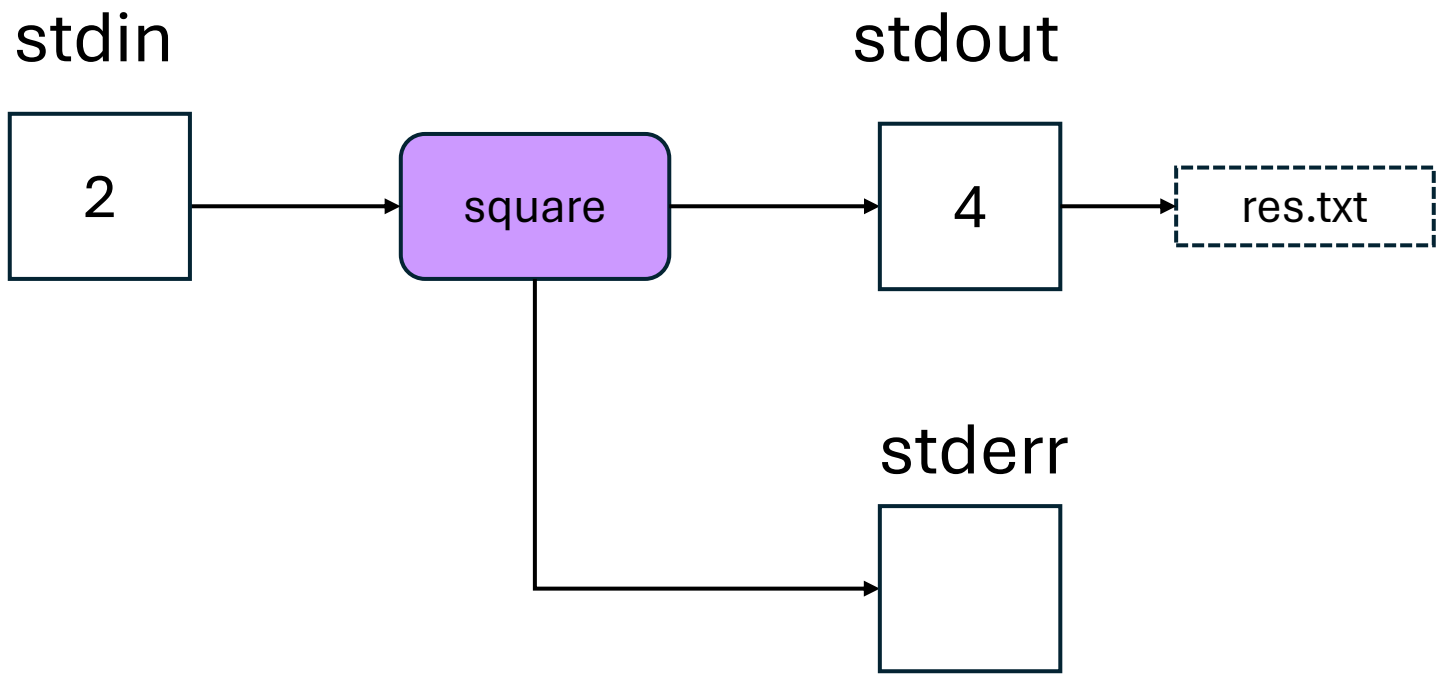
Input/output streams




```
$ square 2 > res.txt
```

overwrite

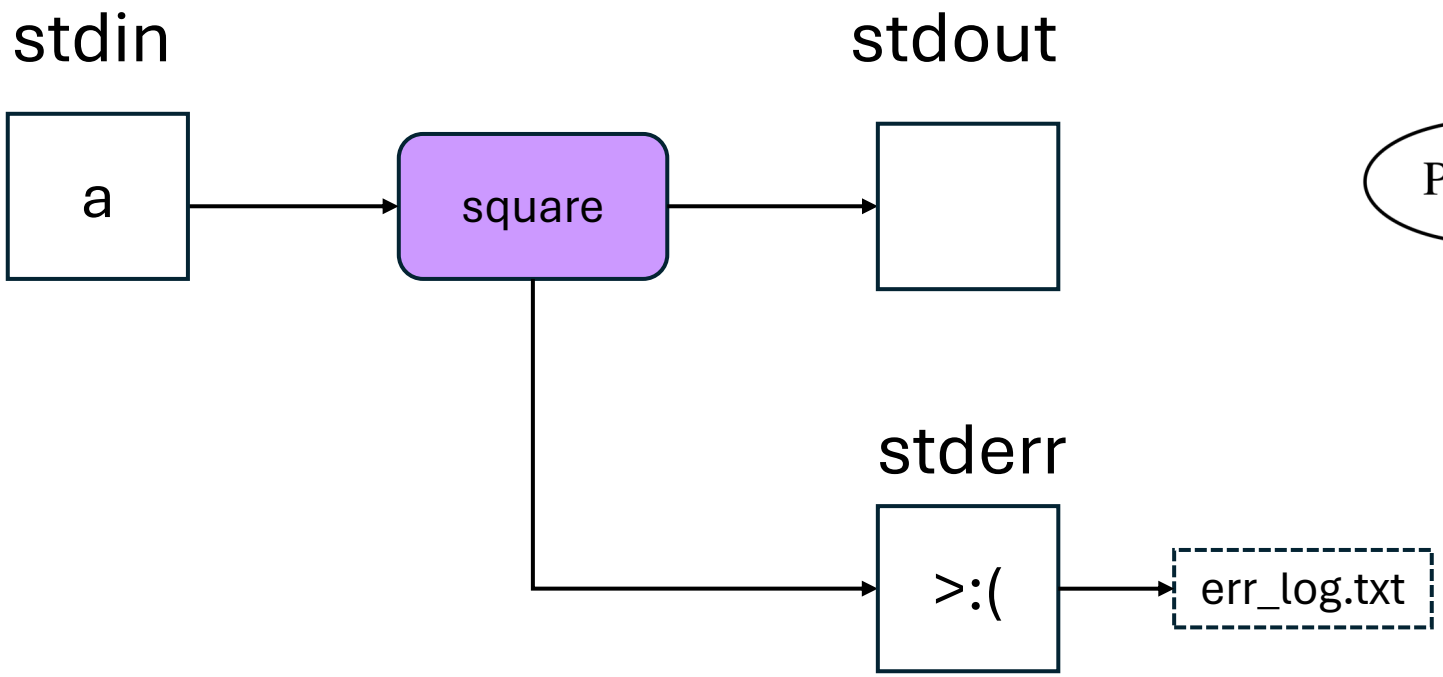
Input/output streams

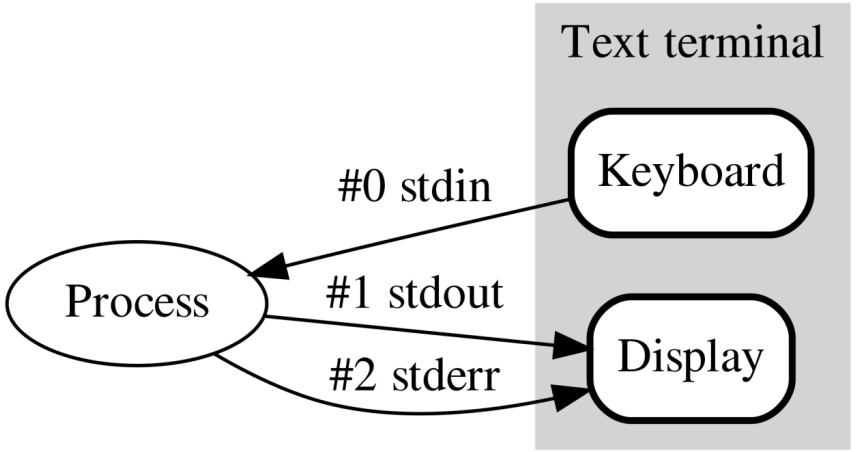



```
$ square 2 >> res.txt
```

append

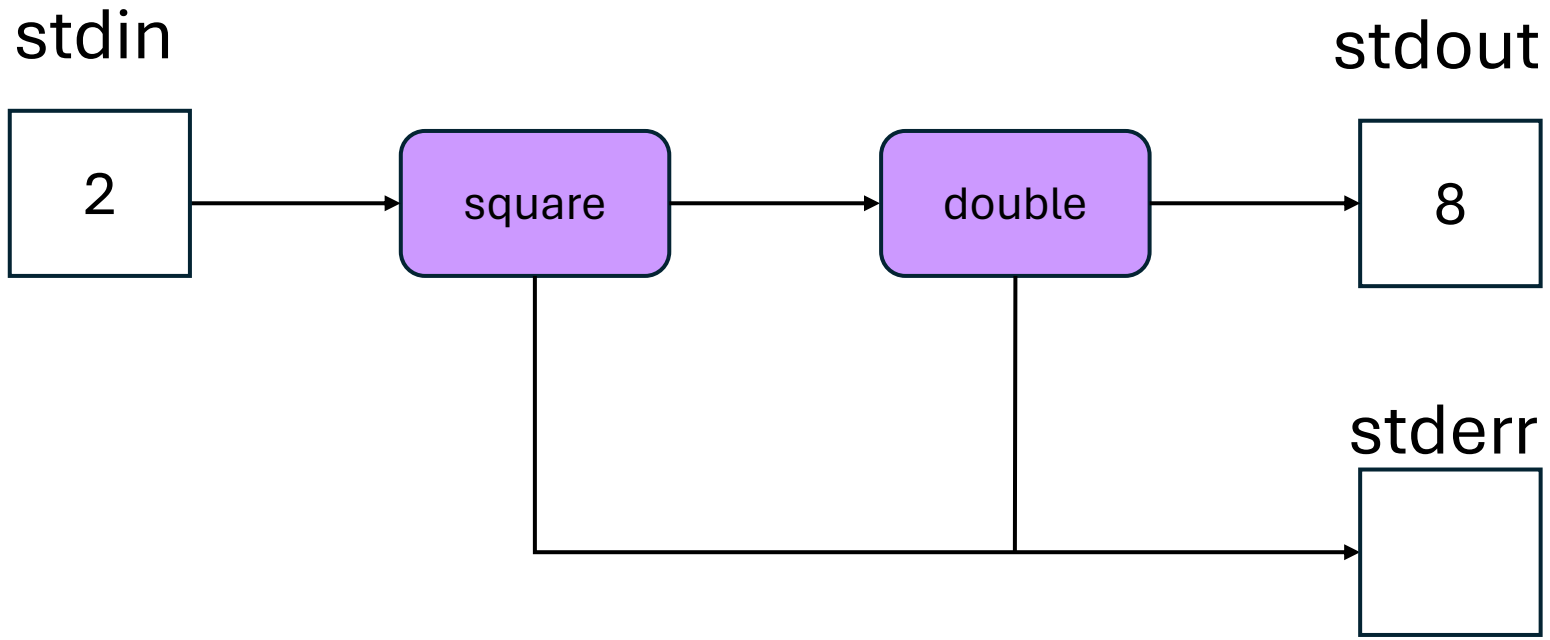
Input/output streams





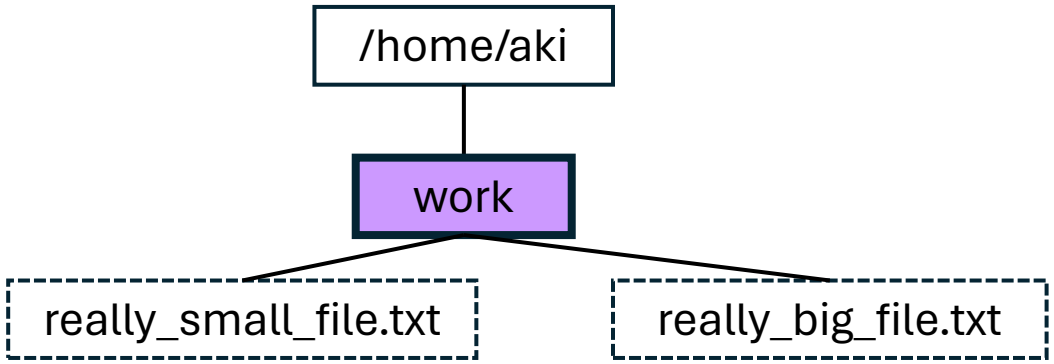

```
$ square a 2> err_log.txt
```

Input/output streams



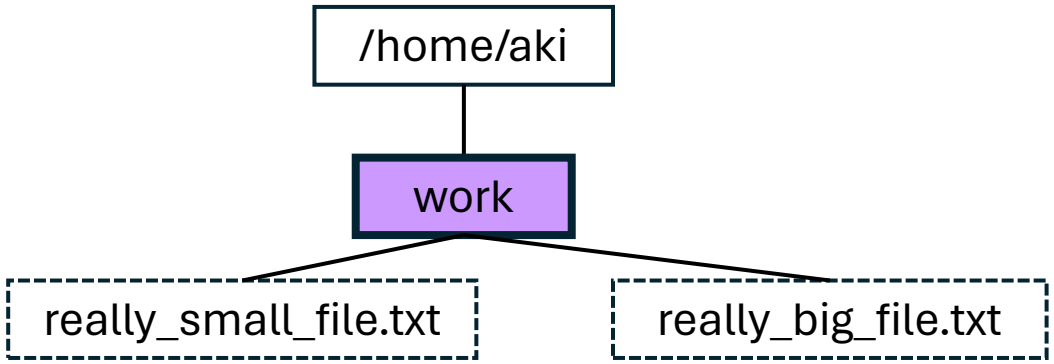

```
$ square 2 | double
```

Redirect stdout with pipe |



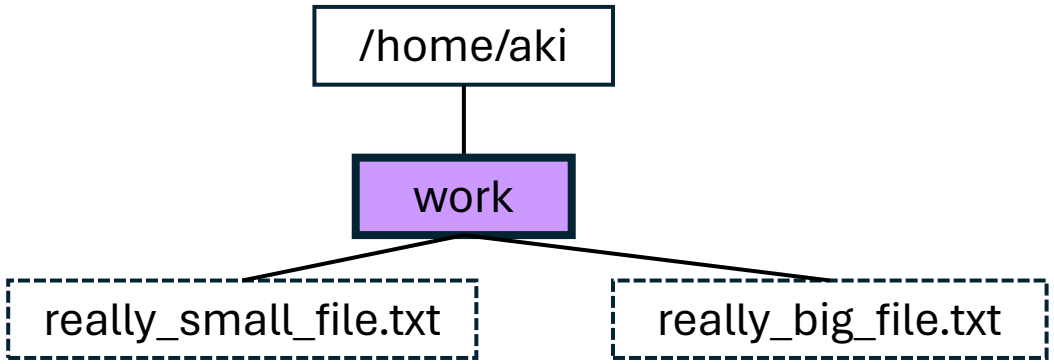

```
$ ls
 really_big_file.txt
 really_small_file.txt
```

Current directory:/home/aki/work




```
$ cat really_small_file.txt
```

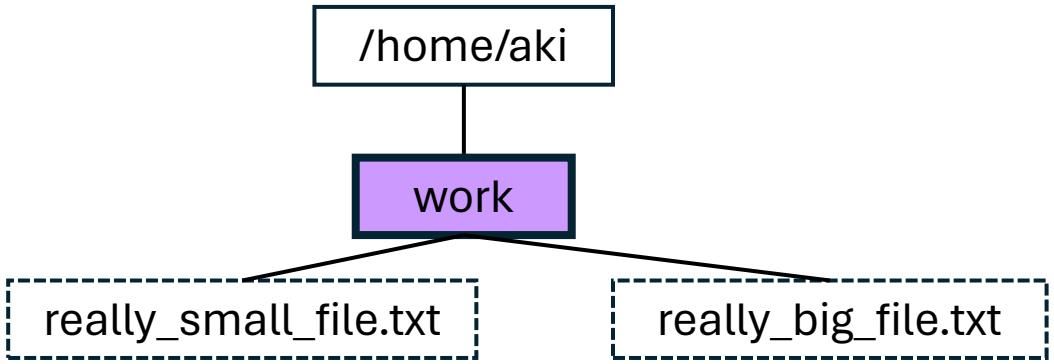
Current directory:/home/aki/work




```
$ cat really_small_file.txt
Hello, I am a really small file ☺
Don’t cat the big file, or your computer will
explode
```

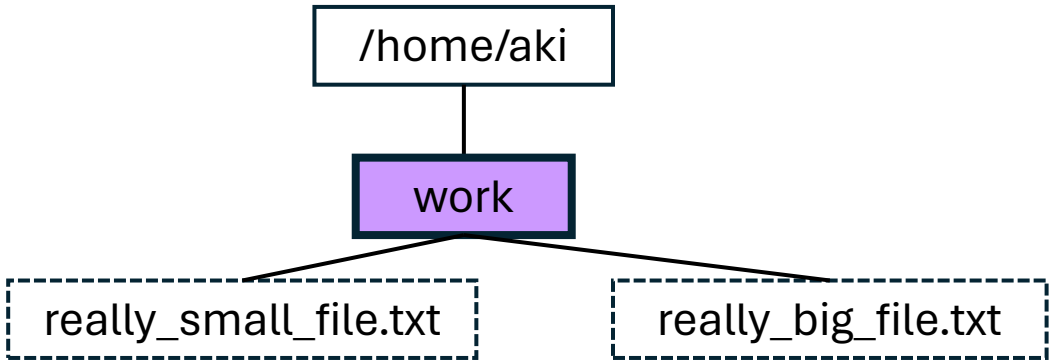
Concatenate

Current directory:/home/aki/work



```
$ cat really_small_file.txt
Hello, I am a really small file ☺
Don’t cat the big file, or your computer will
explode
```

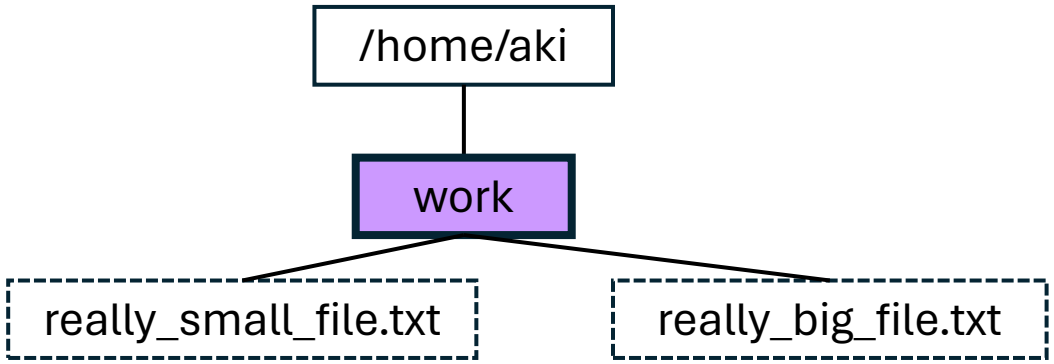
Current directory:/home/aki/work




```
$ head really_big_file.txt
 I hope you didn’t cat this file!
 Qwjeiojqhweroijqfoqjwfoqwjfqw
 Qwerqwoihrjqwoihjrqiowjrqiowr
 Qiodjfnuiohesguiowqfgqwiongqw …
```

```
Output first part of file
Default: 10 lines
-n: number of lines
```

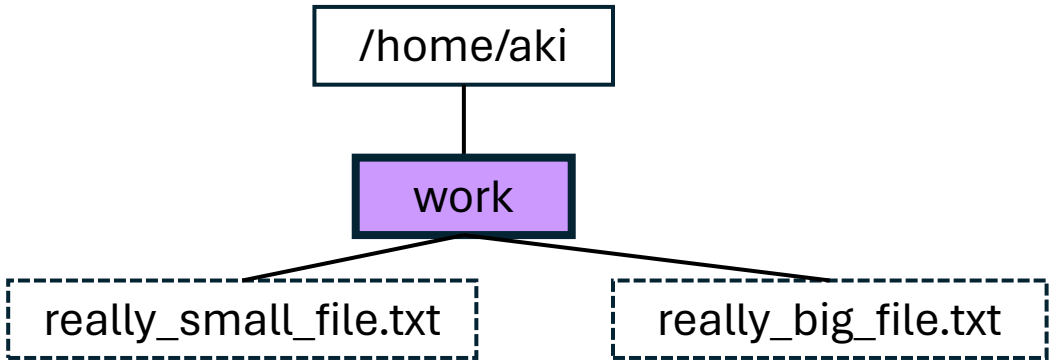
Current directory:/home/aki/work




```
$ tail really_big_file.txt
 …
 Asd0iahjdoiqwjf0i9qjwgoqwgoqwj
 Qwjogfijqwogijqwiogjqwiogjqwiog
 I lied. The file isn’t that big ☺
```

```
Output last part of file
Default: 10 lines
-n: number of lines
```

Current directory:/home/aki/work

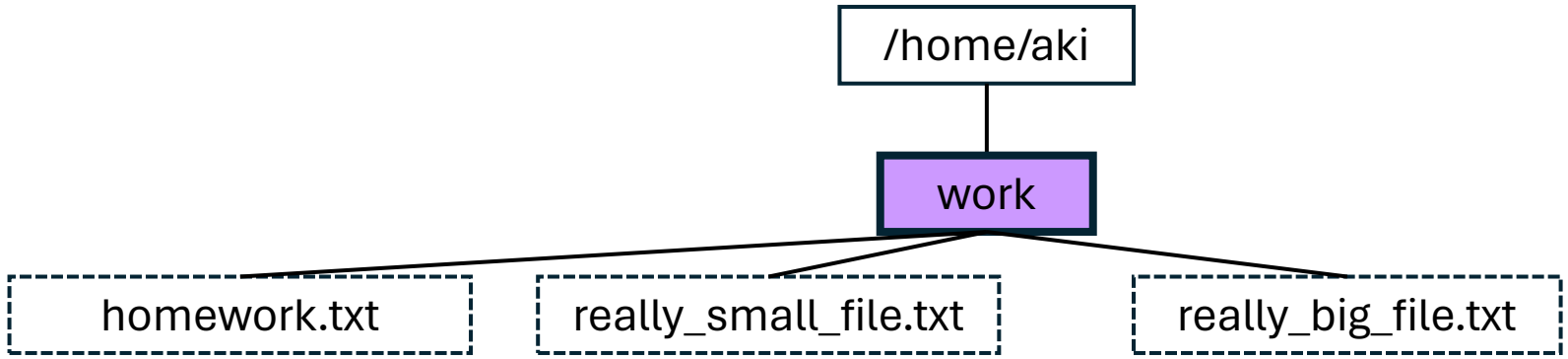



```
$ wc -l really_big_file.txt
 15 really_big_file.txt
```

Word count
-l: number of lines
-n: number of words

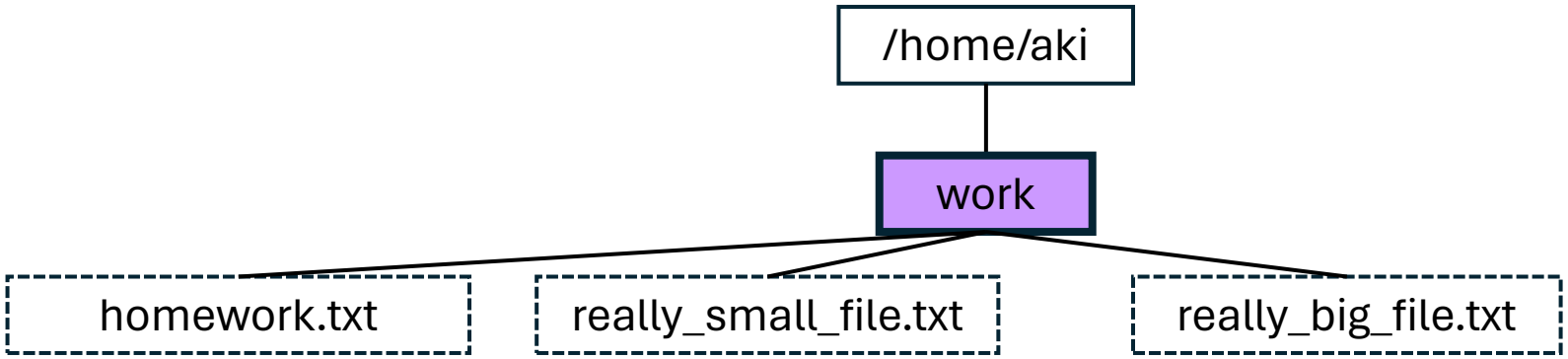
Current directory:/home/aki/work


$ wc -l really_big_file.txt
15 really_big_file.txt



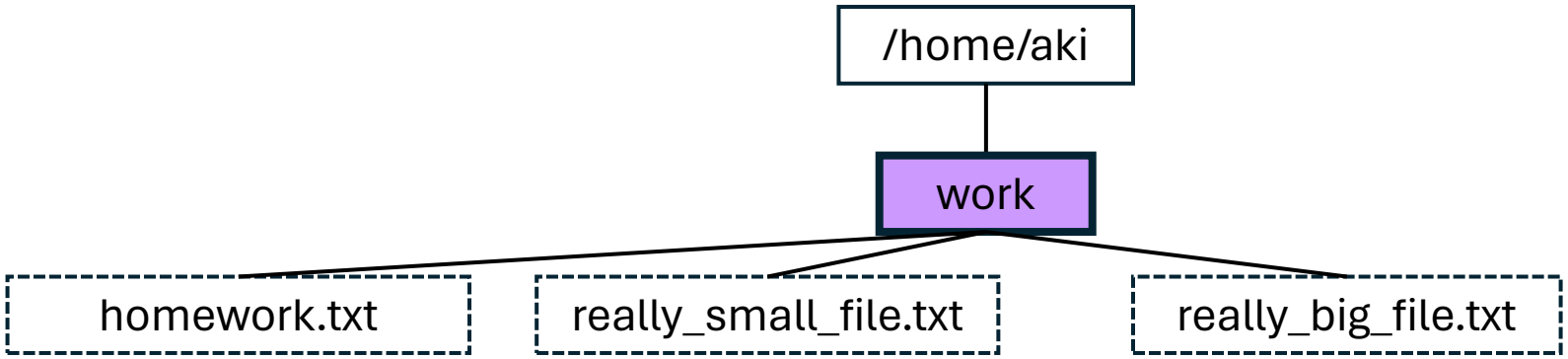

```
$ ls
 really_big_file.txt
 really_small_file.txt
 homework.txt
```

Current directory:/home/aki/work




```
$ cat homework.txt
Do this:
1. Make new directory called homework
2. Make a copy of homework.txt and move it to
homework dir
3. Delete really_big_file.txt from work dir
4. Rename really_small_file.txt to small.txt
5. Write DONE at the end of homework/homework.txt
```

Current directory:/home/aki/work



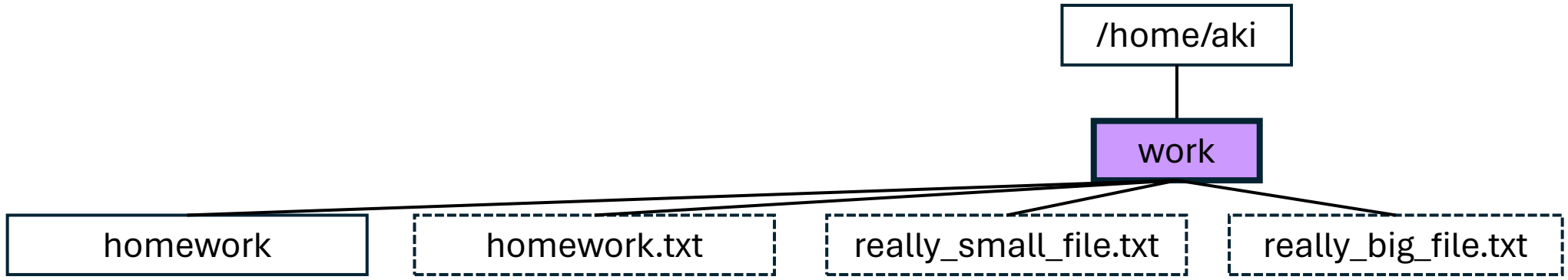

```
$
```

Do this:

1. Make new directory called homework

2. Make a copy of homework.txt and move it to homework dir
3. Delete really_big_file.txt from work dir
4. Rename really_small_file.txt to small.txt
5. Write DONE at the end of homework/homework.txt

Current directory:/home/aki/work

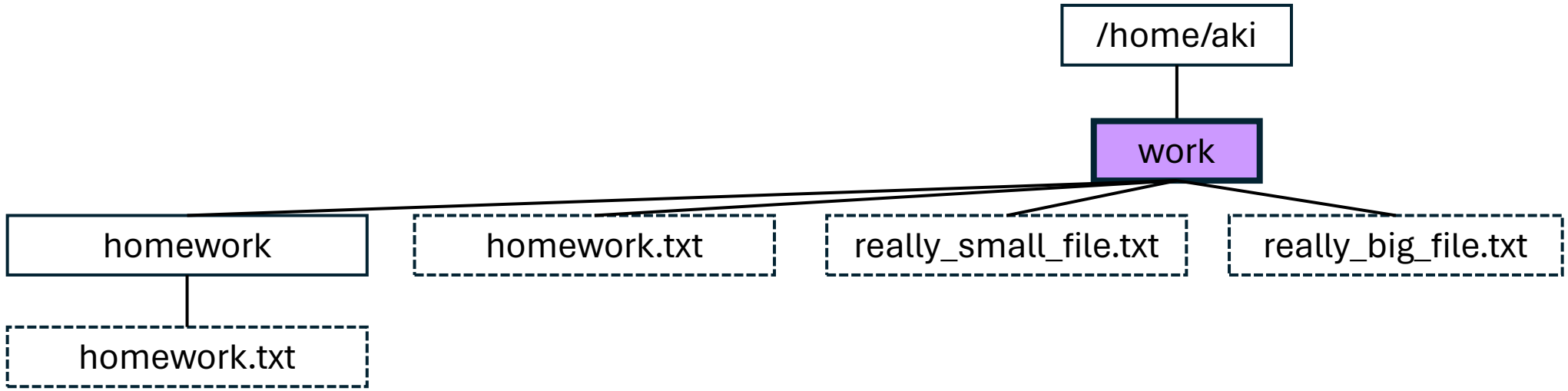



```
$ mkdir homework
```

Do this:

1. Make new directory called homework
2. **Make a copy of homework.txt and move it to homework dir**
3. Delete really_big_file.txt from work dir
4. Rename really_small_file.txt to small.txt
5. Write DONE at the end of homework/homework.txt

Current directory:/home/aki/work

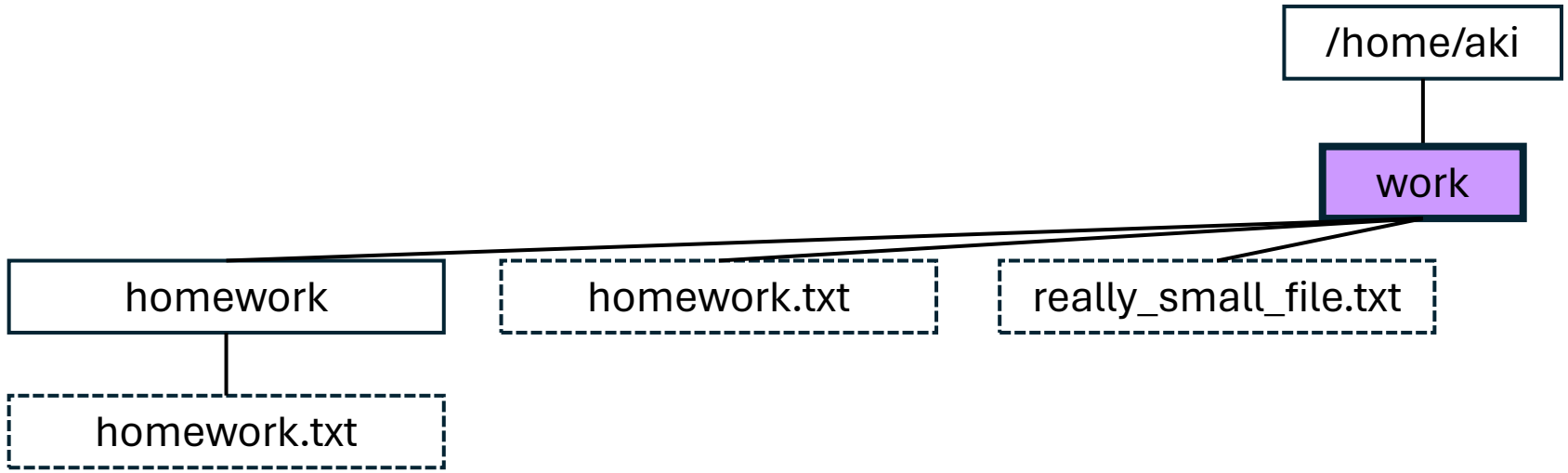



```
$ cp homework.txt homework/
```

Do this:

1. Make new directory called homework
2. Make a copy of homework.txt and move it to homework dir
3. **Delete really_big_file.txt from work dir**
4. Rename really_small_file.txt to small.txt
5. Write DONE at the end of homework/homework.txt

Current directory:/home/aki/work

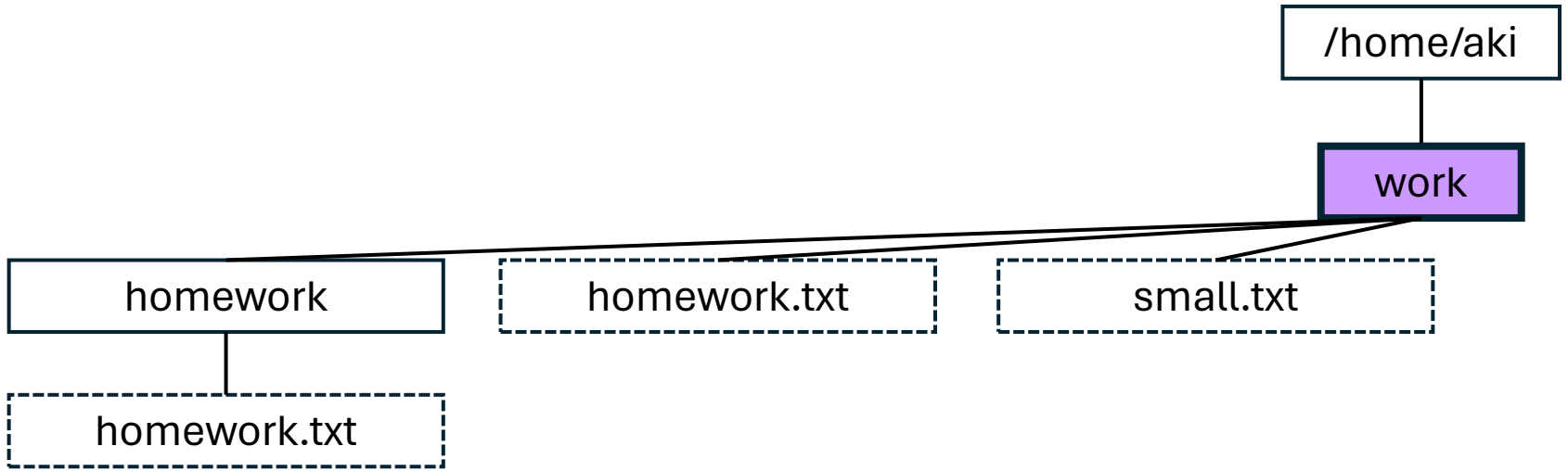



```
$ rm really_big_file.txt
```

Do this:

1. Make new directory called homework
2. Make a copy of homework.txt and move it to homework dir
3. Delete really_big_file.txt from work dir
4. **Rename really_small_file.txt to small.txt**
5. Write DONE at the end of homework/homework.txt

Current directory:/home/aki/work

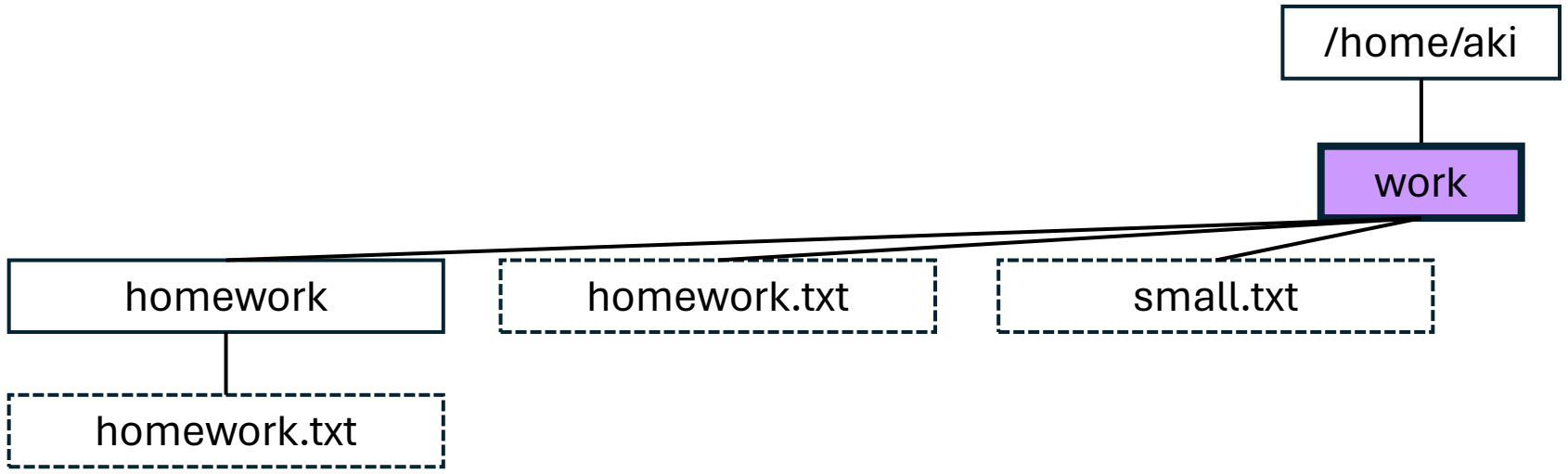



```
$ mv really_small_file.txt small.txt
```

Do this:

1. Make new directory called homework
2. Make a copy of homework.txt and move it to homework dir
3. Delete really_big_file.txt from work dir
4. Rename really_small_file.txt to small.txt
5. **Write DONE at the end of homework/homework.txt**

Current directory:/home/aki/work



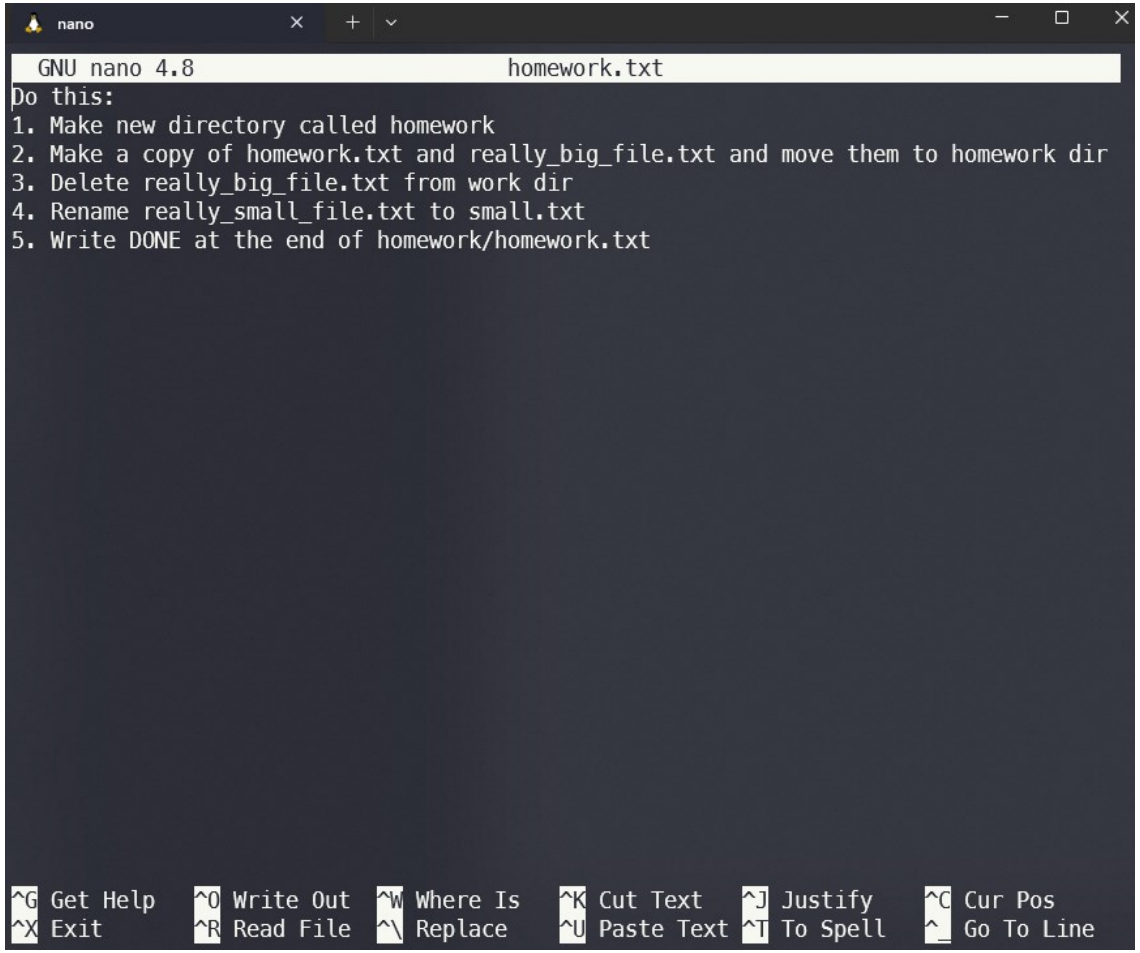

```
$ nano homework/homework.txt
                or
$ vim homework/homework.txt
```

Do this:

1. Make new directory called homework
2. Make a copy of homework.txt and move it to homework dir
3. Delete really_big_file.txt from work dir
4. Rename really_small_file.txt to small.txt
5. **Write DONE at the end of homework/homework.txt**

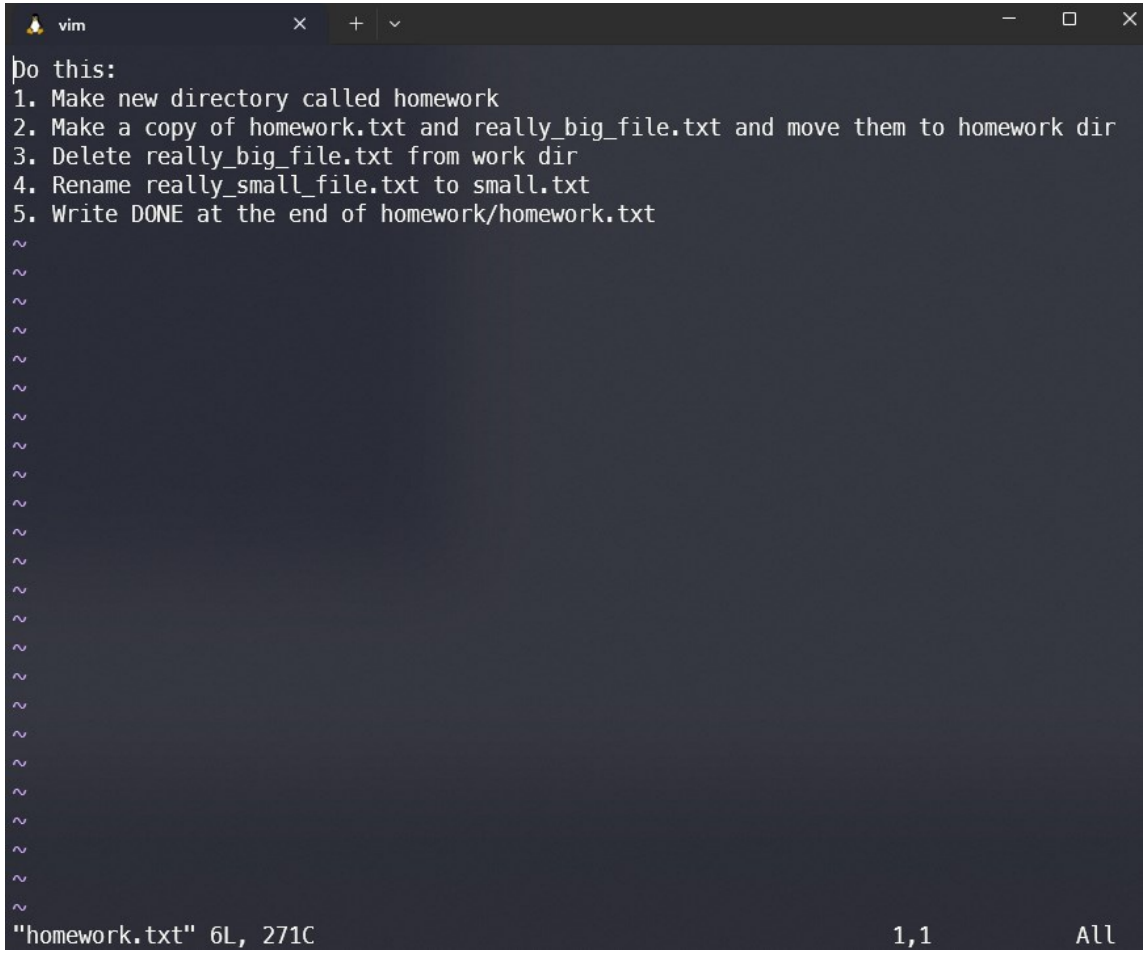
Current directory:/home/aki/work

nano



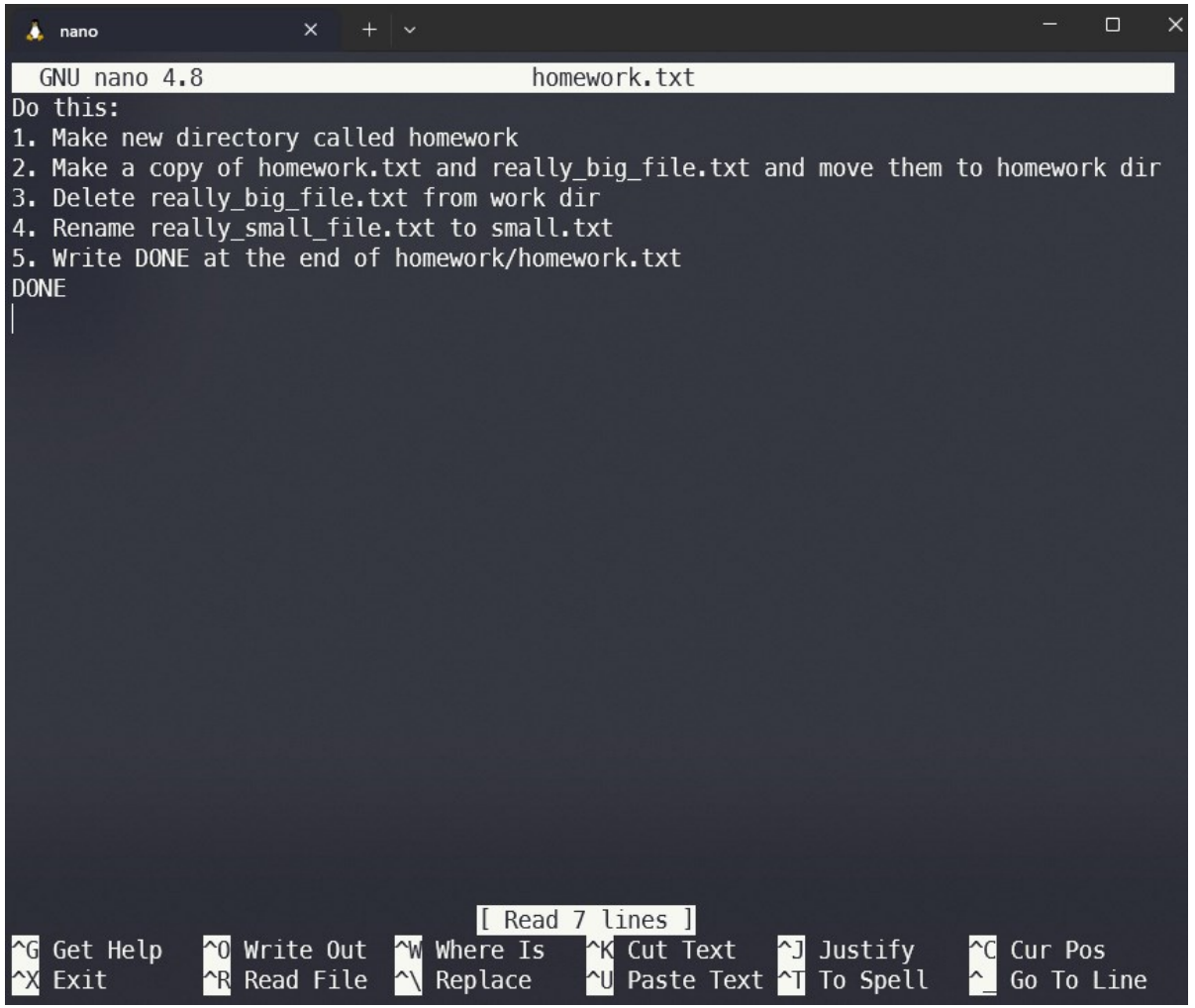
Basic, easy-to-use

vim

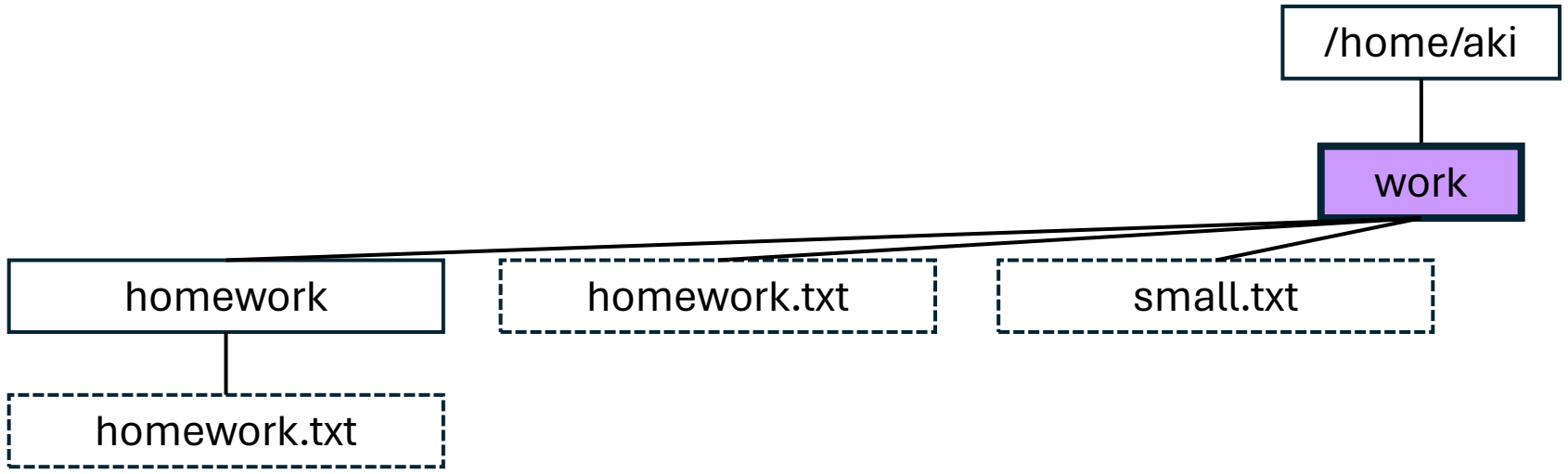


Powerful, steep learning curve

nano



1. Move cursor with arrow keys to EOF (end of file)
2. Type DONE
3. Ctrl (^) + X to exit
4. Y to save
5. Enter to not change file name




```
$
```

Do this:
1. Make new directory called homework
2. Make a copy of homework.txt and move it to homework dir
3. Delete really_big_file.txt from work dir
4. Rename really_small_file.txt to small.txt
5. Write DONE at the end of homework/homework.txt

Current directory:/home/aki/work

Navigation

cd: change directory
ls: list directory contents
pwd: path to working directory

File manipulation

cp: copy file(s)
mv: move or rename a file
rm: permanently remove a file

Reading text files

cat: output contents of file to stdout
head: output first 10 lines to stdout
tail: output last 10 lines to stdout

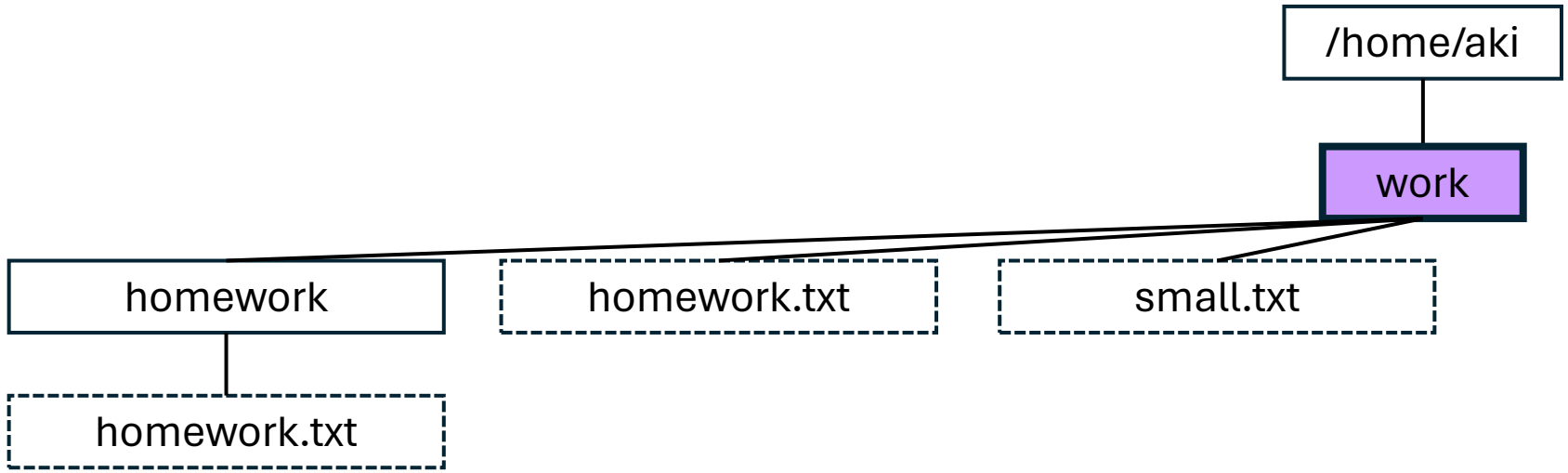
wc -l: output number of lines
wc -w: output number of words

Looking stuff up

man: manual
Google ☺

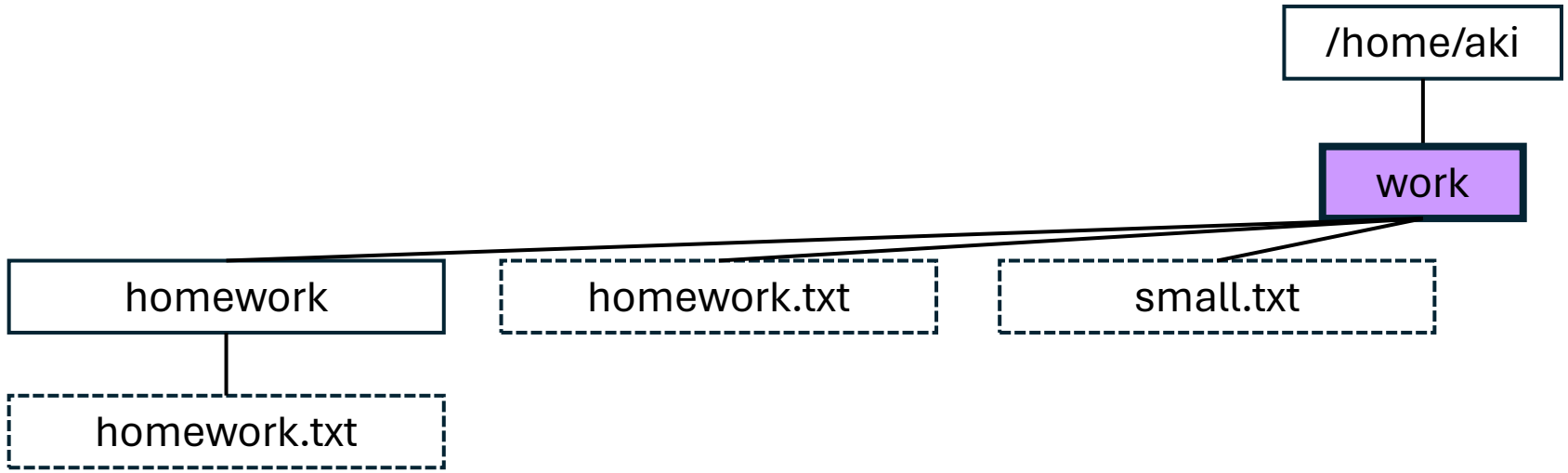
Editing text files

nano: basic, easy-to-use text editor
vim: powerful, steep learning curve



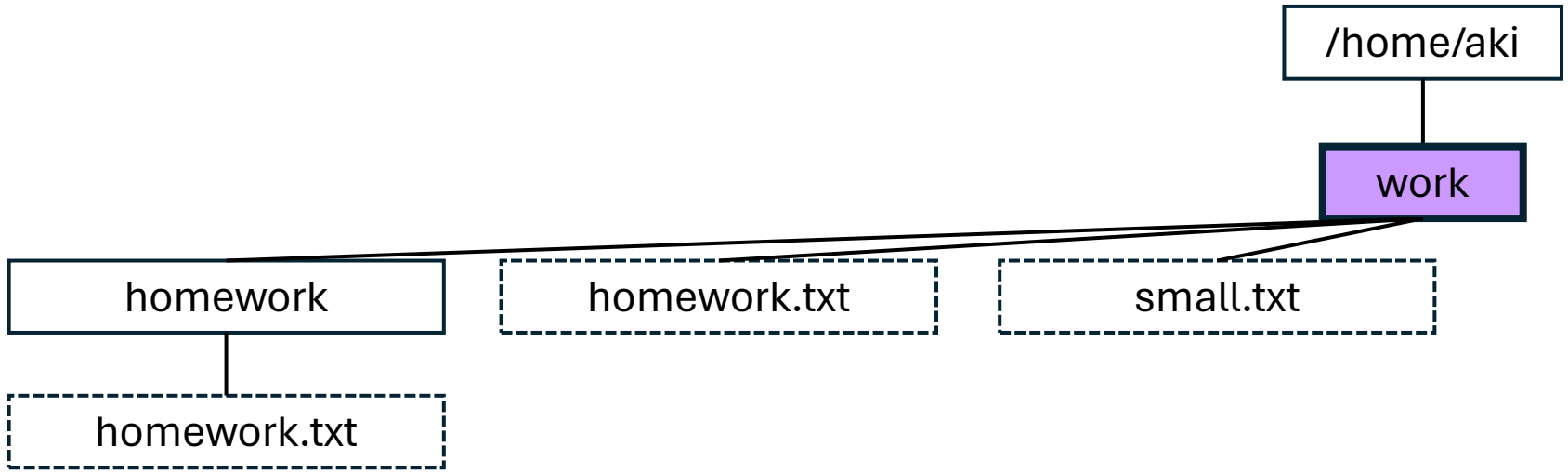

```
$ ls
 homework
 homework.txt
 small.txt
```

Current directory:/home/aki/work




```
$ ls *
 homework
 homework.txt
 small.txt
```

Current directory:/home/aki/work

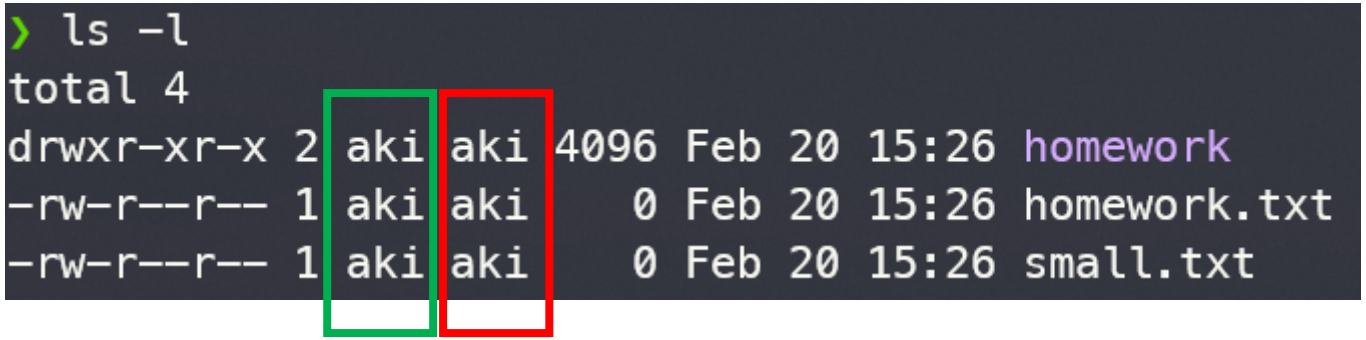



```
$ ls *.txt
 homework.txt
 small.txt
```

Current directory:/home/aki/work

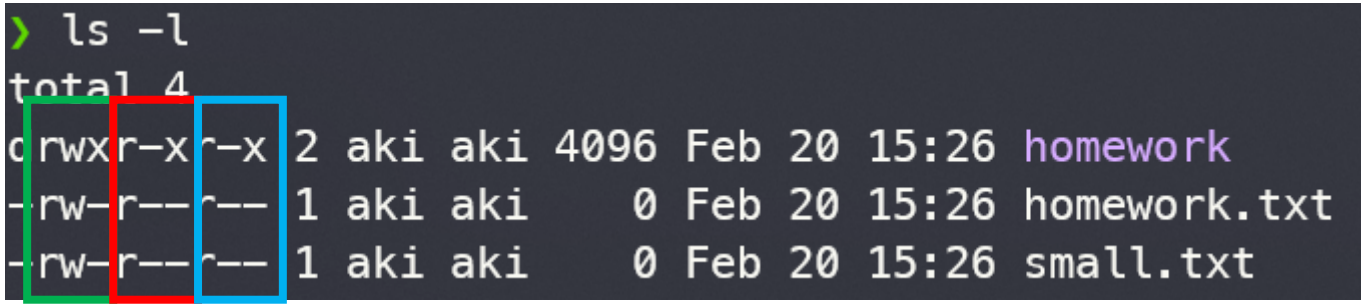
UNIX file permissions

- Files have an owner and a group determining who has access to the file
  - Default: File is owned by the user or program who created it.
  - File group is usually one of the groups the owner belongs to.



UNIX file permissions

- Files permissions are shown in the following order:
  - Owner (u)
  - Group (g)
  - Other/all (o)
- Each group has (or does not have) permission to:
  - Read (r)
  - Write (w)
  - Execute (x)



UNIX file permissions

To change the mode (permissions) of a file/directory

chmod

- **+**: add the following permissions
- **-**: remove the following permissions
- **=**: permissions are exactly as follows

UNIX file permissions

chmod

- **+**: add the following permissions
- **-**: remove the following permissions
- **=**: permissions are exactly as follows

```
$ chmod o+rw file.txt
```

- Files permissions are shown in the following order:
  - Owner (u)
  - Group (g)
  - Other/all (o)
- Each group has (or does not have) permission to:
  - Read (r)
  - Write (w)
  - Execute (x)

UNIX file permissions

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- **+**: add the following permissions
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- Files permissions are shown in the following order:
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  - Other/all (o)
- Each group has (or does not have) permission to:
  - Read (r)
  - Write (w)
  - Execute (x)

```
$ chmod o+rw file.txt
```

Give others (o) read and write permissions

UNIX file permissions

chmod

- **+**: add the following permissions
- **-**: remove the following permissions
- **=**: permissions are exactly as follows

```
$ chmod u-w,g-w,o-w file.txt
```

- Files permissions are shown in the following order:
  - Owner (u)
  - Group (g)
  - Other/all (o)
- Each group has (or does not have) permission to:
  - Read (r)
  - Write (w)
  - Execute (x)

UNIX file permissions

chmod

- **+**: add the following permissions
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- Files permissions are shown in the following order:
  - Owner (u)
  - Group (g)
  - Other/all (o)
- Each group has (or does not have) permission to:
  - Read (r)
  - Write (w)
  - Execute (x)

```
$ chmod u-w,g-w,o-w file.txt
```

Remove write permissions for user, group, and others

UNIX file permissions

chmod

- **+**: add the following permissions
- **-**: remove the following permissions
- **=**: permissions are exactly as follows

```
$ chmod g=rx file.txt
```

- Files permissions are shown in the following order:
  - Owner (u)
  - Group (g)
  - Other/all (o)
- Each group has (or does not have) permission to:
  - Read (r)
  - Write (w)
  - Execute (x)

UNIX file permissions

chmod

- **+**: add the following permissions
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- **=**: permissions are exactly as follows

- Files permissions are shown in the following order:
  - Owner (u)
  - Group (g)
  - Other/all (o)
- Each group has (or does not have) permission to:
  - Read (r)
  - Write (w)
  - Execute (x)

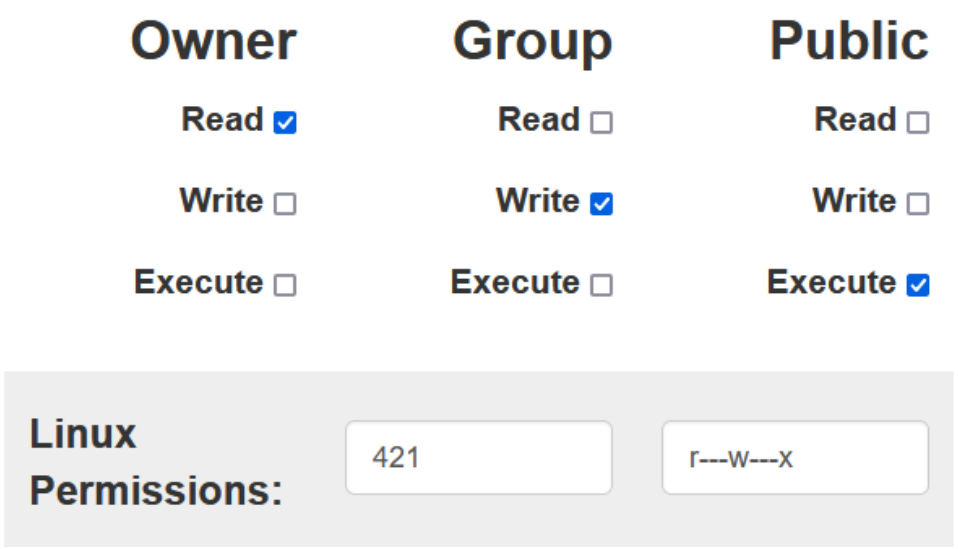
```
$ chmod g=rx file.txt
```

Set group permissions to read and execute (not write)

UNIX file permissions

chmod

- Set all permissions with number
  - Use a Chmod Calculator
    - https://chmod-calculator.com/



- Files permissions are shown in the following order:
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- Each group has (or does not have) permission to:
  - Read (r)
  - Write (w)
  - Execute (x)

What have we learned so far?

- Navigation
- Reading text files
- Editing text files
- Manipulating files
- Changing permissions

- READ THE DOCS

Let’s talk bioinformatics

- Common file types

Let’s talk bioinformatics

- Common file types
  - FASTQ
  - BED
  - VCF
  - MAF
  - SAM
  - BAM
  - GFF/GFT
  - CSV
  - TSV

Let’s talk bioinformatics

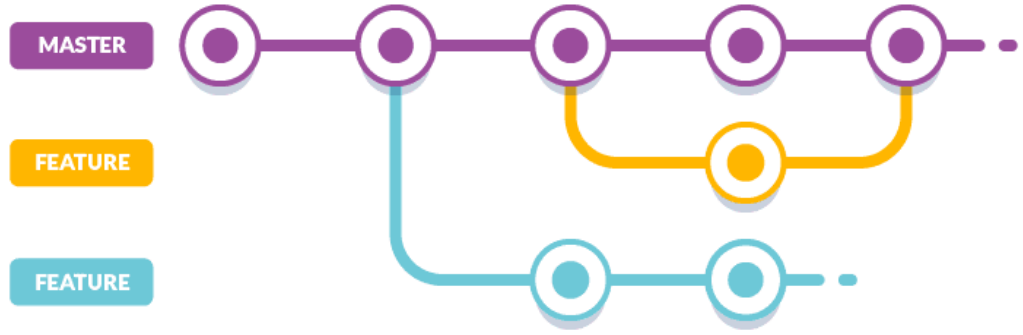
- Common file types
  - FASTQ
  - BED
  - VCF
  - MAF
  - SAM
  - BAM
  - GFF/GFT
  - CSV
  - TSV

Plain text file

Binary file

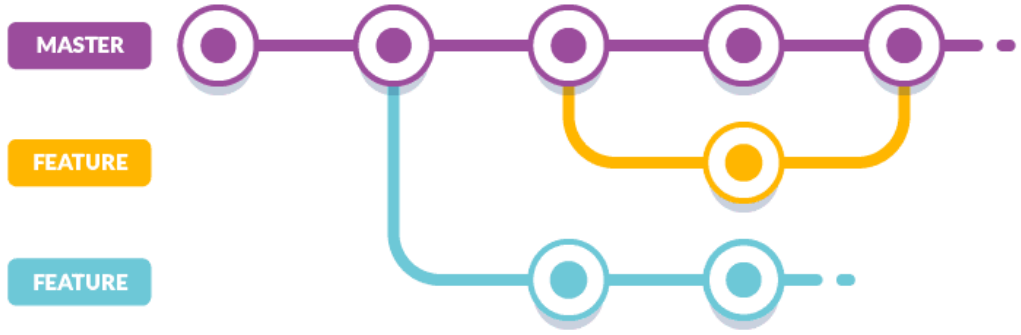
Git

- Popular version control system
- Created by Linus Torvalds in 2005



Git

- Popular version control system
- Created by Linus Torvalds in 2005
- What does Git do?
  - Manage projects with **Repositories**
  - **Clone** a project to work on a local copy
  - Control and track changes with **Staging** and **Committing**
  - **Branch** and **Merge** to allow for work on different parts and versions of a project
  - **Pull** the latest version of the project to a local copy
  - **Push** local updates to the main project



GitHub

- Not the same as Git
- GitHub makes tools that use Git
- GitHub is the largest host of source code in the world, and has been owned by Microsoft since 2018
- Other hosts exist
  - GitLab
  - Bitbucket

- Did you know: You have access to **free** GitHub pro as a student?
  - You should really look into it
  - https://education.github.com/pack

GitHub

- Most bioinformatic tools will be available through GitHub
- The rest of the workshop can be found in this repository:

https://github.com/5Aki1/UNIX-Linux-Workshop

```
$ git clone https://github.com/5Aki1/UNIX-Linux-Workshop
```

Slides will be available in the repository after the workshop. Run:

```
$ git pull
```