Getting around on the command line

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Digital Security, Radboud University

COVID-19 online edition

∼ $ whoami

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- PhD candidate with Digital Security
  - Research into applying post-quantum cryptography
  - Supervisor: Peter Schwabe
- Teaching *Hacking in C* next quarter
- https://thomwiggers.nl/

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Kernel vs Userspace

- Kernel

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- Kernel
    - Interacts with hardware

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  - System administration and services like `systemd`, `sudo`, `passwd`
  - Graphics stuff like X11, Wayland, Gnome, GDM

Kernel vs Userspace (cont.)

Kernel: Linux

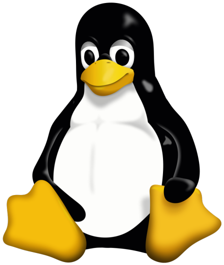

Figure: Tux

System management, access control, file systems, drivers, power management, . . .

Kernel vs Userspace (cont.)

Kernel: Linux

Figure: Linus Torvalds

Kernel vs Userspace (cont.)

Kernel: Linux

Figure: Linus Torvalds being frustrated with NVIDIA

Userspace: GNU

Figure: GNU logo

GCC, Emacs, Coreutils, GPL license, GTK, Gnupg, Bash, . . .

Kernel vs Userspace (cont.)

Kernel: Linux

Figure: Linus Torvalds being frustrated with NVIDIA

Userspace: GNU

Figure: Richard Stallman

Kernel vs Userspace (cont.)

Kernel: Linux

Figure: Linus Torvalds being frustrated with NVIDIA

Userspace: GNU

Figure: Richard Stallman insists on calling Linux `GNU/Linux`

Kernel vs Userspace (cont.)

Kernel: Linux

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Kernel vs Userspace (cont.)

Kernel: Linux

Figure: Linus Torvalds being frustrated with NVIDIA

Userspace: GNU

Figure: Richard Stallman picks stuff from between his toes and smells it, and eats it

Kernel vs Userspace (cont.)

Kernel: Linux

Figure: Linus Torvalds being frustrated with NVIDIA

Userspace: GNU

Figure: Richard Stallman quit after he defended someone related to Jeffery Epstein stuff

Linux Distribution

- Usually you obtain Linux bundled with a userspace and bunch of programs as a *Linux distribution*

Figure: Ubuntu logo

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- Other (popular) distributions: Debian, Arch Linux, Fedora, Kali, CentOS

Figure: Ubuntu logo

Linux Distribution

- Usually you obtain Linux bundled with a userspace and bunch of programs as a *Linux distribution*
- Most popular one: Ubuntu
- Popular commercial one: Redhat Enterprise Linux
- Many distribution vendors ship a desktop and a server variants
- Other (popular) distributions: Debian, Arch Linux, Fedora, Kali, CentOS
- if you're a masochist try installing "Linux from Scratch"

Figure: Ubuntu logo

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The shell

- `/bin/bash`: **B**ourne **a**gain **sh**ell
  - Improved version of the classic Bourne shell `/bin/sh`
  - Other shells exist, but we'll use the default for now.
  - Thom uses something fancy himself but they all work more-or-less the same

What is a shell

- Program to interact with your computer and the software on

Figure: Different kind of shell

What is a shell

- Program to interact with your computer and the software on
- Graphical interface is also such a program!

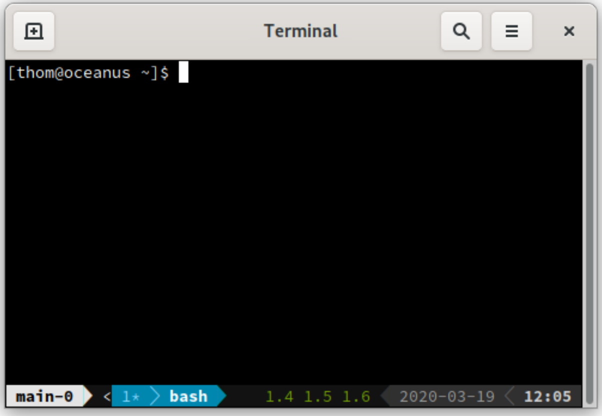
Figure: Different kind of shell

What is a shell

- Program to interact with your computer and the software on
- Graphical interface is also such a program!
- Typically synonymous with command line though

Figure: Different kind of shell

The shell prompt

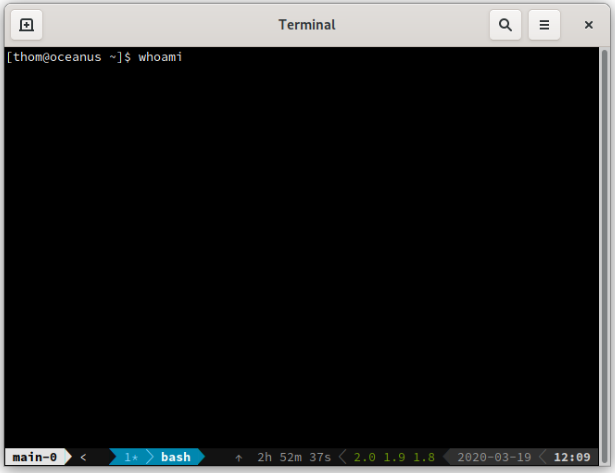


```
[thom@oceanus ~]$ 
```

```
main-0 > < 1* > bash        1.4 1.5 1.6 < 2020-03-19 < 12:05
```

Figure: The shell prompt

Running programs

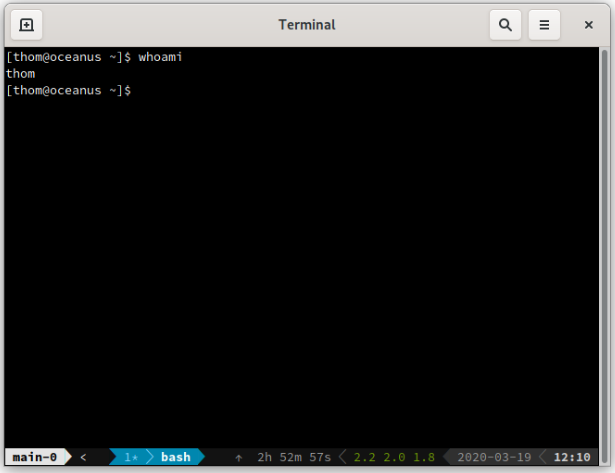


```
[thom@oceanus ~]$ whoami
```

```
main-0 < 1* bash ↑ 2h 52m 37s 2.0 1.9 1.8 2020-03-19 12:09
```

Figure: Running `whoami`

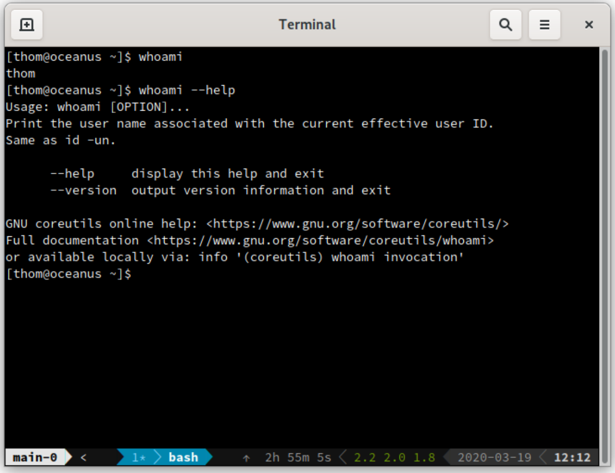
Running programs



```
[thom@oceanus ~]$ whoami
thom
[thom@oceanus ~]$
```

Figure: Running whoami

Running programs

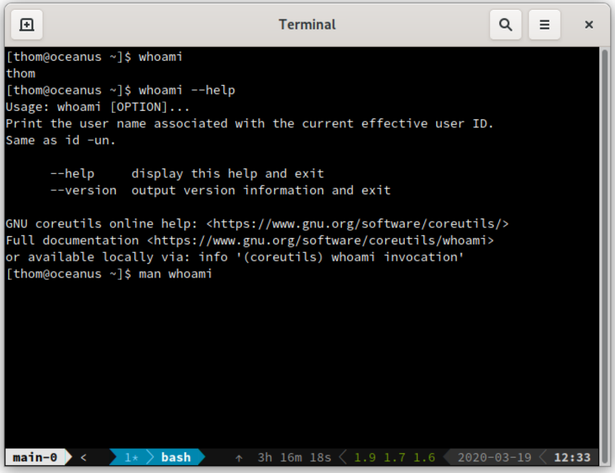


```
[thom@oceanus ~]$ whoami
thom
[thom@oceanus ~]$ whoami --help
Usage: whoami [OPTION]...
Print the user name associated with the current effective user ID.
Same as id -un.

      --help     display this help and exit
      --version  output version information and exit

GNU coreutils online help: <https://www.gnu.org/software/coreutils/>
Full documentation <https://www.gnu.org/software/coreutils/whoami>
or available locally via: info '(coreutils) whoami invocation'
[thom@oceanus ~]$
```

```
main-0  <   1*  bash    ↑  2h 55m 5s  2.2 2.0 1.8  2020-03-19  12:12
```

Figure: Running `whoami`

Running programs



```
[thom@oceanus ~]$ whoami
thom
[thom@oceanus ~]$ whoami --help
Usage: whoami [OPTION]...
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GNU coreutils online help: <https://www.gnu.org/software/coreutils/>
Full documentation <https://www.gnu.org/software/coreutils/whoami>
or available locally via: info '(coreutils) whoami invocation'
[thom@oceanus ~]$ man whoami
```
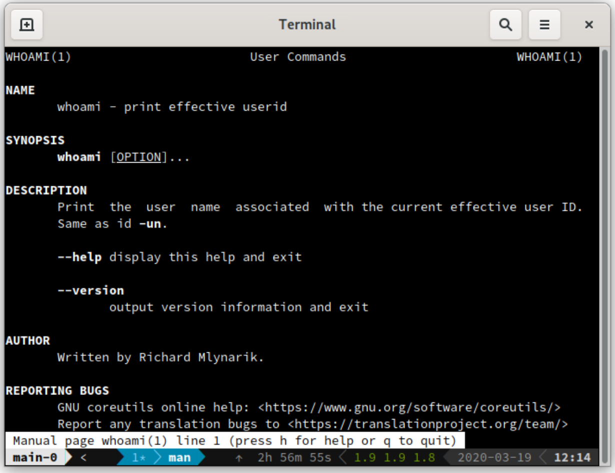

```
main-0  <   1*  bash      ↑ 3h 16m 18s  1.9 1.7 1.6  2020-03-19  12:33
```

Figure: Running `whoami`

Running programs



```
WHOAMI(1)                        User Commands                        WHOAMI(1)

NAME
       whoami - print effective userid

SYNOPSIS
       whoami [OPTION]...

DESCRIPTION
       Print  the  user  name  associated  with the current effective user ID.
       Same as id -un.

       --help display this help and exit

       --version
              output version information and exit

AUTHOR
       Written by Richard Mlynarik.

REPORTING BUGS
       GNU coreutils online help: <https://www.gnu.org/software/coreutils/>
       Report any translation bugs to <https://translationproject.org/team/>
 Manual page whoami(1) line 1 (press h for help or q to quit)
 main-0 > <    1* > man      ↑ 2h 56m 55s < 1.9 1.9 1.8 < 2020-03-19 < 12:14
```

Figure: Running `whoami`

The manual

- There is a manual that should be available for most programs
- usage: `man <topic>`
- Manual for the manual: `man man`
- Googling for “man something” usually finds these man pages as well

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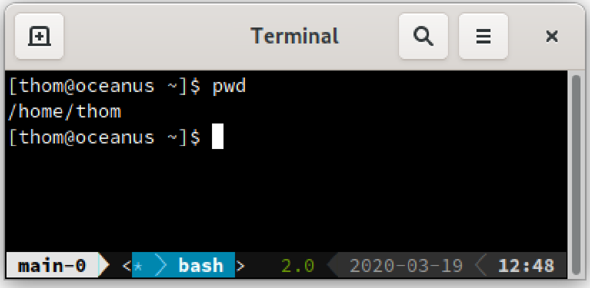
Where am I: pwd

pwd: Print Working Directory

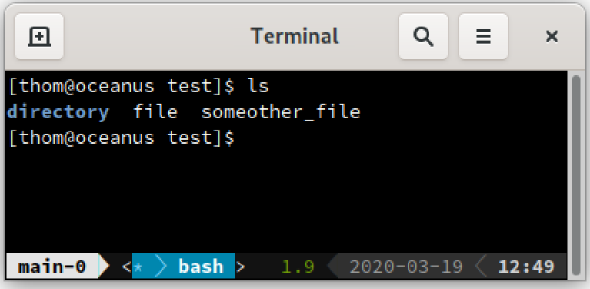


```
[thom@oceanus ~]$ pwd
/home/thom
[thom@oceanus ~]$ 
```

Figure: pwd

What is here: `ls`

`ls`: list files in folder

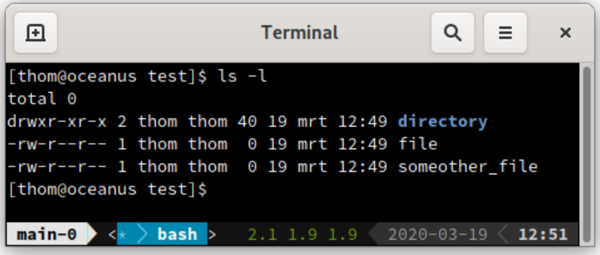


```
[thom@oceanus test]$ ls
directory  file  someother_file
[thom@oceanus test]$
```

Figure: `ls`

What is here with more detail: `ls -l`

`ls -l`: list files in folder with sizes, permissions, access times

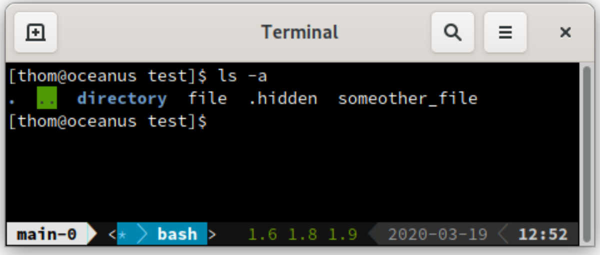


```
[thom@oceanus test]$ ls -l
total 0
drwxr-xr-x 2 thom thom 40 19 mrt 12:49 directory
-rw-r--r-- 1 thom thom  0 19 mrt 12:49 file
-rw-r--r-- 1 thom thom  0 19 mrt 12:49 someother_file
[thom@oceanus test]$
 main-0  <*  bash >   2.1 1.9 1.9  2020-03-19  12:51
```

Figure: `ls -l`

What is here with hidden files: `ls -a`

`ls -a`: list files in folder including hidden files and folders



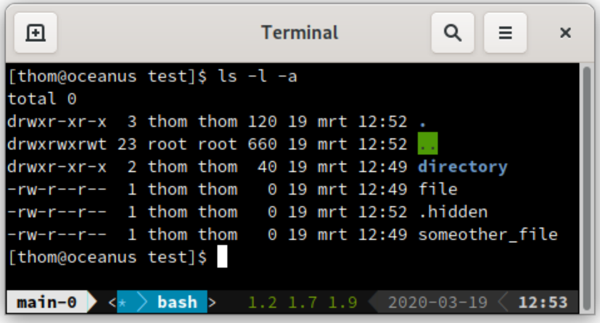
```
[thom@oceanus test]$ ls -a
.  ..  directory  file  .hidden  someother_file
[thom@oceanus test]$
```

Figure: `ls -a`

Hidden files start with a dot. Two special filenames are `.` current directory and `..` parent directory.

What is here, in detail, with hidden files: `ls -l -a`

`ls -l -a`: list files in folder, in detail, including hidden files and folders



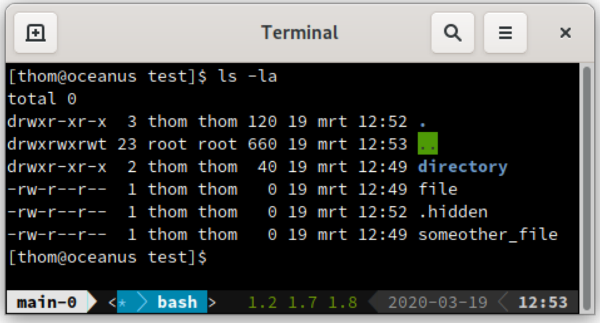
```
[thom@oceanus test]$ ls -l -a
total 0
drwxr-xr-x  3 thom thom 120 19 mrt 12:52 .
drwxrwxrwt 23 root root 660 19 mrt 12:52 ..
drwxr-xr-x  2 thom thom  40 19 mrt 12:49 directory
-rw-r--r--  1 thom thom   0 19 mrt 12:49 file
-rw-r--r--  1 thom thom   0 19 mrt 12:52 .hidden
-rw-r--r--  1 thom thom   0 19 mrt 12:49 someother_file
[thom@oceanus test]$ 
main-0 > <* > bash >  1.2 1.7 1.9 < 2020-03-19 < 12:53
```

Figure: `ls -l -a`

Can also be written as `ls -la`

What is here, in detail, with hidden files: `ls -la`

`ls -la`: list files in folder, in detail, including hidden files and folders
Uses the abbreviated syntax for command line flags

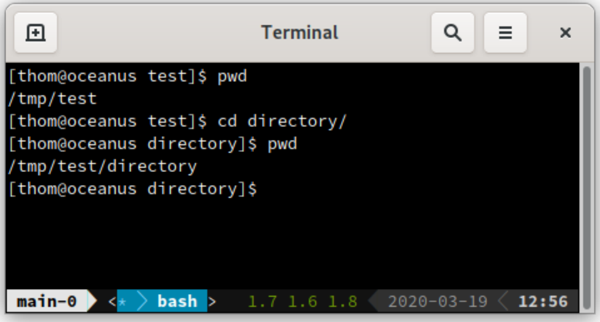


```
[thom@oceanus test]$ ls -la
total 0
drwxr-xr-x  3 thom thom 120 19 mrt 12:52 .
drwxrwxrwt 23 root root 660 19 mrt 12:53 ..
drwxr-xr-x  2 thom thom  40 19 mrt 12:49 directory
-rw-r--r--  1 thom thom   0 19 mrt 12:49 file
-rw-r--r--  1 thom thom   0 19 mrt 12:52 .hidden
-rw-r--r--  1 thom thom   0 19 mrt 12:49 someother_file
[thom@oceanus test]$
 main-0 > <* > bash >   1.2 1.7 1.8 < 2020-03-19 < 12:53
```

Figure: `ls -la`

Moving around: cd

cd dir: change into directory dir

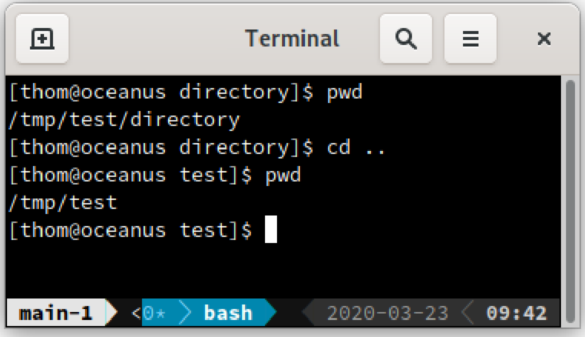


```
[thom@oceanus test]$ pwd
/tmp/test
[thom@oceanus test]$ cd directory/
[thom@oceanus directory]$ pwd
/tmp/test/directory
[thom@oceanus directory]$
```

Figure: Changing into directory

Moving to the parent directory: `cd ..`

`cd ..`: move to parent directory.

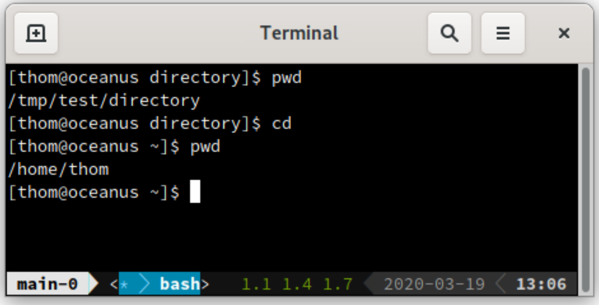


```
[thom@oceanus directory]$ pwd
/tmp/test/directory
[thom@oceanus directory]$ cd ..
[thom@oceanus test]$ pwd
/tmp/test
[thom@oceanus test]$
```

Figure: Changing into parent directory

Moving to your home dir: cd

cd: change directory to home

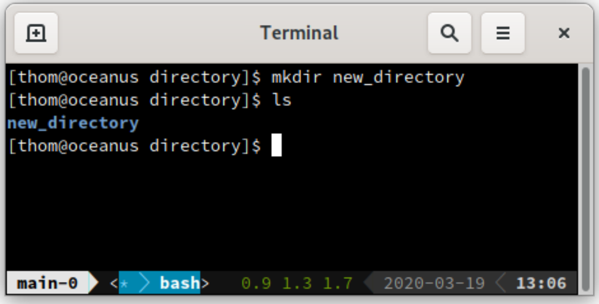


```
[thom@oceanus directory]$ pwd
/tmp/test/directory
[thom@oceanus directory]$ cd
[thom@oceanus ~]$ pwd
/home/thom
[thom@oceanus ~]$
main-0  <* > bash>   1.1 1.4 1.7  2020-03-19  13:06
```

Figure: Changing into /home/thom

Creating a new folder: mkdir

mkdir dir: Create folder dir

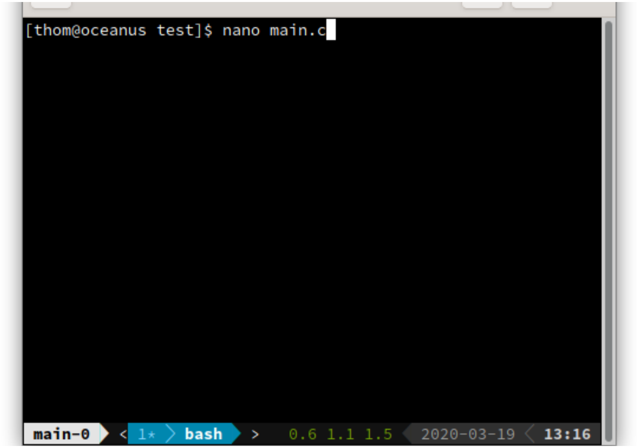


```
[thom@oceanus directory]$ mkdir new_directory
[thom@oceanus directory]$ ls
new_directory
[thom@oceanus directory]$ 
 main-0  <* bash>   0.9 1.3 1.7  2020-03-19  13:06
```

Figure: Create new_directory

Editing a file

`nano file`: Edit `file` using `nano`

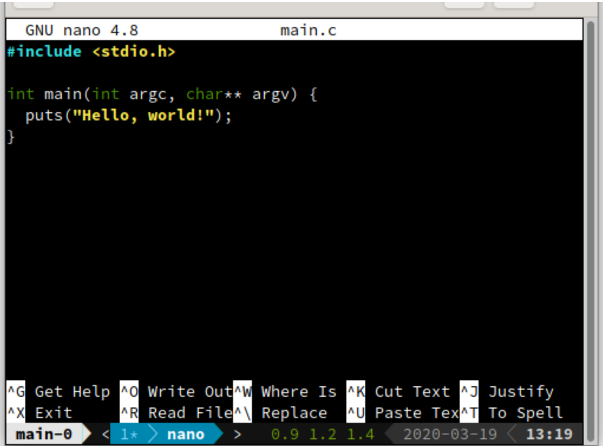


```
[thom@oceanus test]$ nano main.c
```

Figure: Edit `main.c`

Editing a file

`nano file`: Edit `file` using `nano`

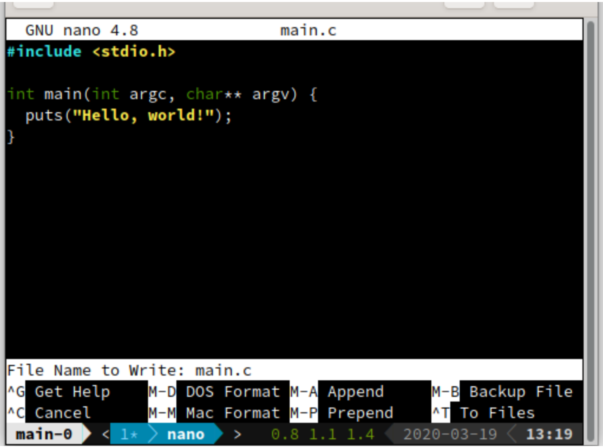


```
  GNU nano 4.8                        main.c
#include <stdio.h>

int main(int argc, char** argv) {
  puts("Hello, world!");
}













^G Get Help ^O Write Out^W Where Is ^K Cut Text ^J Justify
^X Exit     ^R Read File^\ Replace  ^U Paste Tex^T To Spell
 main-0  < 1* nano  >   0.9 1.2 1.4  2020-03-19  13:19
```

Figure: Edit `main.c`

Editing a file

`nano file`: Edit `file` using `nano`



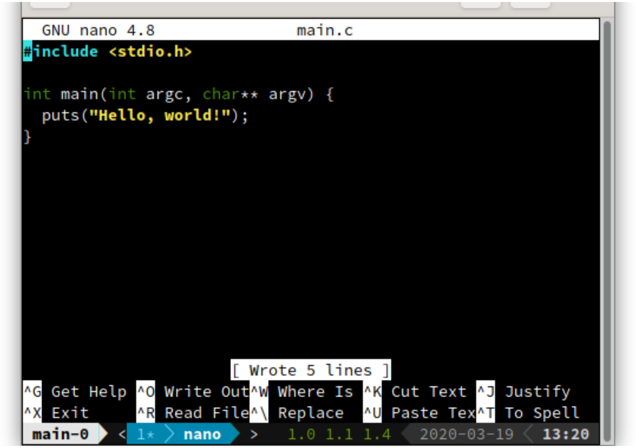
```
 GNU nano 4.8                    main.c
#include <stdio.h>

int main(int argc, char** argv) {
  puts("Hello, world!");
}











File Name to Write: main.c
^G Get Help      M-D DOS Format M-A Append      M-B Backup File
^C Cancel        M-M Mac Format M-P Prepend     ^T To Files
 main-0  < 1* nano >   0.8 1.1 1.4  2020-03-19  13:19
```

Figure: Edit `main.c`

I've pressed `Ctrl+O (^O)`

Editing a file

`nano file`: Edit `file` using `nano`

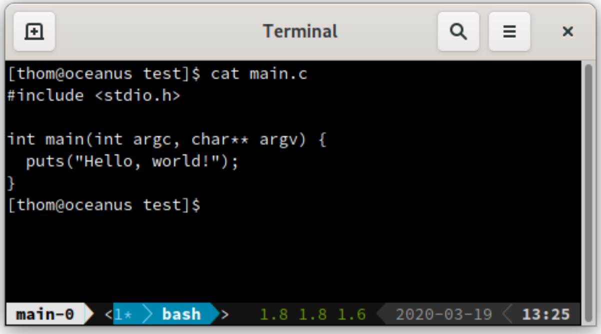


```
  GNU nano 4.8                     main.c
#include <stdio.h>

int main(int argc, char** argv) {
  puts("Hello, world!");
}





                       [ Wrote 5 lines ]
^G Get Help  ^O Write Out^W Where Is  ^K Cut Text  ^J Justify
^X Exit      ^R Read File^\ Replace   ^U Paste Tex^T To Spell
 main-0 > < 1* > nano  >   1.0 1.1 1.4  2020-03-19 < 13:20
```

Figure: Edit `main.c`

Reading `main.c`: `cat`

`cat file`: Read file `file`



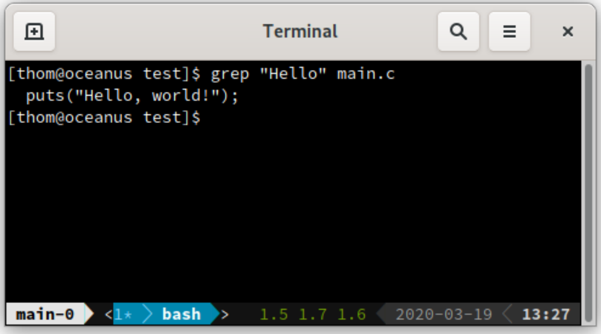
```
[thom@oceanus test]$ cat main.c
#include <stdio.h>

int main(int argc, char** argv) {
  puts("Hello, world!");
}
[thom@oceanus test]$
```

```
main-0  <1*  bash >    1.8 1.8 1.6  2020-03-19  13:25
```

Figure: Read file

Searching in a file: grep

`grep pattern file`: Search for `pattern` in `file`
Supports regexes, case insensitive search, search in folders (recursively), see `man grep` and Google.



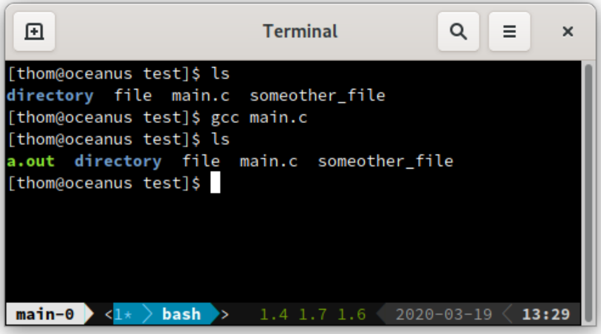
```
[thom@oceanus test]$ grep "Hello" main.c
  puts("Hello, world!");
[thom@oceanus test]$
```

```
main-0 <1* bash >  1.5 1.7 1.6  2020-03-19  13:27
```

Figure: Search for `Hello` in `main.c`

Compiling a C program

`gcc file.c`: GNU C Compiler
Without options, compiles `file.c` to executable `a.out`

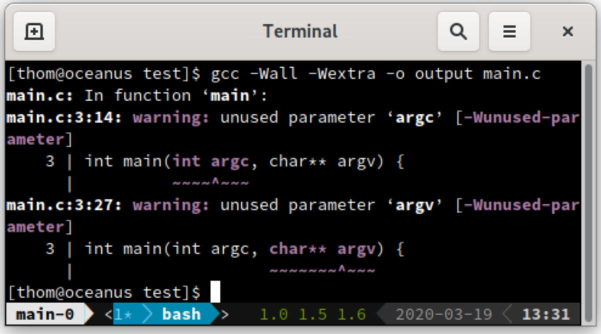


```
[thom@oceanus test]$ ls
directory  file  main.c  someother_file
[thom@oceanus test]$ gcc main.c
[thom@oceanus test]$ ls
a.out  directory  file  main.c  someother_file
[thom@oceanus test]$ 
```

Figure: Compiling `main.c` to `a.out`

Compiling a C program, recommended settings

`gcc -Wall -Wextra -o output file.c`: Compile with warnings
Compiles `file.c` to executable `output`. Warnings are enabled



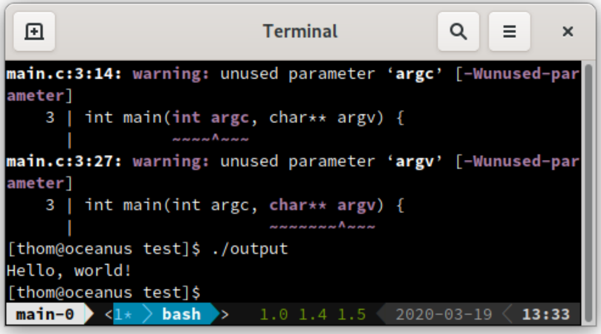
```
[thom@oceanus test]$ gcc -Wall -Wextra -o output main.c
main.c: In function ‘main’:
main.c:3:14: warning: unused parameter ‘argc’ [-Wunused-par
ameter]
    3 | int main(int argc, char** argv) {
      |          ~~~~~^~~~
main.c:3:27: warning: unused parameter ‘argv’ [-Wunused-par
ameter]
    3 | int main(int argc, char** argv) {
      |                    ~~~~~~~^~~~
[thom@oceanus test]$ 
 main-0 > <1* > bash >>   1.0 1.5 1.6 < 2020-03-19 < 13:31
```

Figure: Compiling `main.c` to `output`

Running a program in the current directory

`./file`: Run file

Necessary for programs that are not in a directory listed in the `$PATH` variable: for those you always need to specify *some* path.



```
main.c:3:14: warning: unused parameter ‘argc’ [-Wunused-par
ameter]
    3 | int main(int argc, char** argv) {
      |          ~~~~^~~~
main.c:3:27: warning: unused parameter ‘argv’ [-Wunused-par
ameter]
    3 | int main(int argc, char** argv) {
      |                    ~~~~~~~^~~~
[thom@oceanus test]$ ./output
Hello, world!
[thom@oceanus test]$
 main-0  <1*  bash >   1.0 1.4 1.5  2020-03-19  13:33
```

Figure: Run the `output` program

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Exercise

1. Open a terminal
2. Create a folder `workshop` in your home directory
3. Create a file `hello.c` in this folder
4. Write your best `hello world` program
5. Compile it to a `hello` executable
6. Rename it to `helloworld`
7. Run it.
8. Make sure there's no other files in the folder
   - Delete them otherwise

I didn't show you all of the necessary commands to do all of this; use Google ("do something terminal linux" or "do something bash" usually works).
No cheating using the graphical interface!

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Standard Output

When a program writes out (e.g. using `printf`, `puts`, `cout`, ...), it ends up in the terminal. This is called *standard output* or `stdout`.

Standard Output

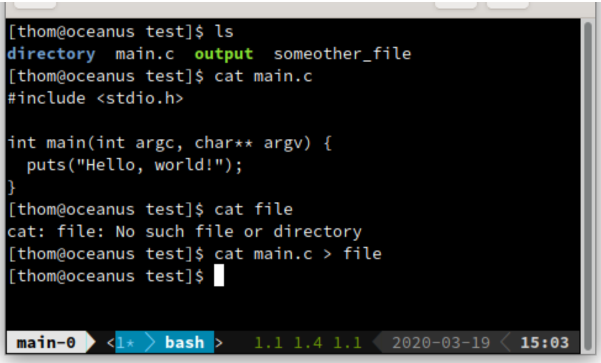
When a program reads in (e.g. using `gets`, `cin`, `readline`, . . .), it reads from the terminal. This is called *standard input* or `stdin`.

Standard Error

There is another special form of output that a program can write, `stderr`. This also ends up in the terminal, but can be treated differently. Usually, this is used for errors or informational messages.

Redirecting output to a file

We can redirect standard output of a program to another file using `program > file`. This creates or, if it already existed, *truncates* `file`.



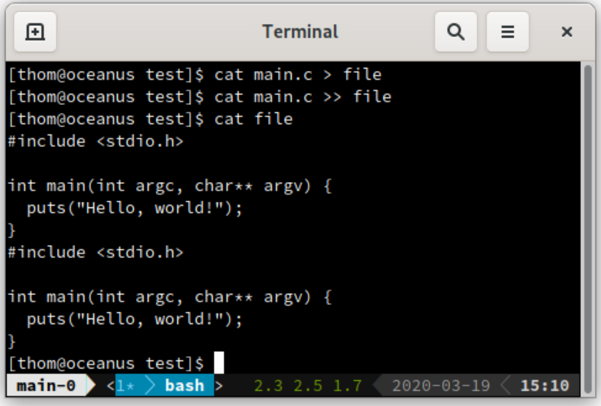
```
[thom@oceanus test]$ ls
directory  main.c  output  someother_file
[thom@oceanus test]$ cat main.c
#include <stdio.h>

int main(int argc, char** argv) {
  puts("Hello, world!");
}
[thom@oceanus test]$ cat file
cat: file: No such file or directory
[thom@oceanus test]$ cat main.c > file
[thom@oceanus test]$ 
```

Figure: Redirecting the output of `cat main.c` to `file`

Appending output to a file

If we want to append the output to a file instead of truncating it, we can use `program >> file`.



```
[thom@oceanus test]$ cat main.c > file
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[thom@oceanus test]$ cat file
#include <stdio.h>

int main(int argc, char** argv) {
  puts("Hello, world!");
}
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int main(int argc, char** argv) {
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[thom@oceanus test]$ 
 main-0  <1*  bash >   2.3 2.5 1.7   2020-03-19 < 15:10
```
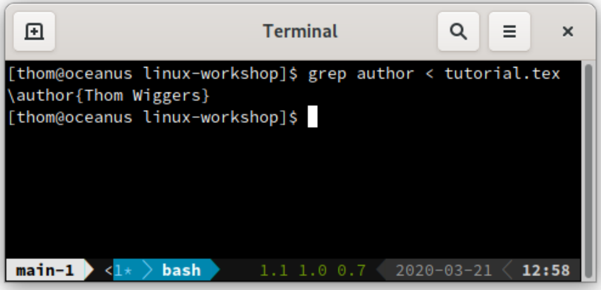

Figure: Appending the output of `cat main.c` to `file`

Providing a file as input to a program

If we want to take the contents of a file and provide it as input to a program, we can use `program < file`.

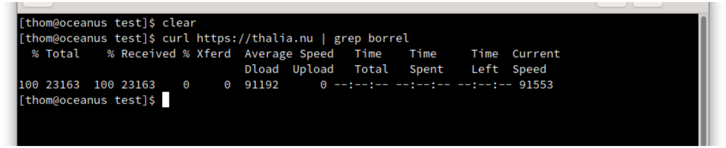


```
[thom@oceanus linux-workshop]$ grep author < tutorial.tex
\author{Thom Wiggers}
[thom@oceanus linux-workshop]$
```

Figure: Providing `tutorial.tex` as input to grep

Redirecting output to a different program

It may also be useful to redirect output of one program to another program's `stdin`.
Imagine we want to check if thalia.nu mentions `borrel`. We use `curl` to get the webpage. Then we use | (pipe character) to redirect (pipe) `curl`'s `stdout` to `grep`'s `stdin`.



```
[thom@oceanus test]$ clear
[thom@oceanus test]$ curl https://thalia.nu | grep borrel
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100 23163  100 23163    0     0  91192      0 --:--:-- --:--:-- --:--:-- 91553
[thom@oceanus test]$ 
```

Figure: Checking Thalia's front page for Borrels: none found

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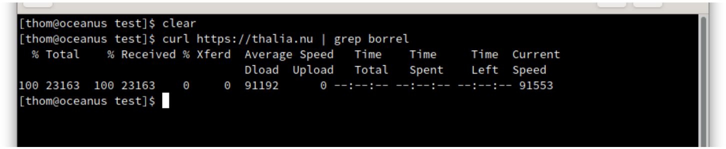

```
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[thom@oceanus test]$ 
```

Figure: Checking Thalia's front page for Borrels: none found

The output about downloading the webpage is still printed, because it was printed to `stderr`!

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  - `/tmp` **Temporary files**

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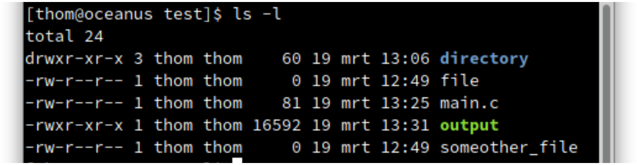


```
[thom@oceanus test]$ ls -l
total 24
drwxr-xr-x 3 thom thom    60 19 mrt 13:06 directory
-rw-r--r-- 1 thom thom     0 19 mrt 12:49 file
-rw-r--r-- 1 thom thom    81 19 mrt 13:25 main.c
-rwxr-xr-x 1 thom thom 16592 19 mrt 13:31 output
-rw-r--r-- 1 thom thom     0 19 mrt 12:49 someother_file
```

Figure: `ls -l` shows ownership and permission information

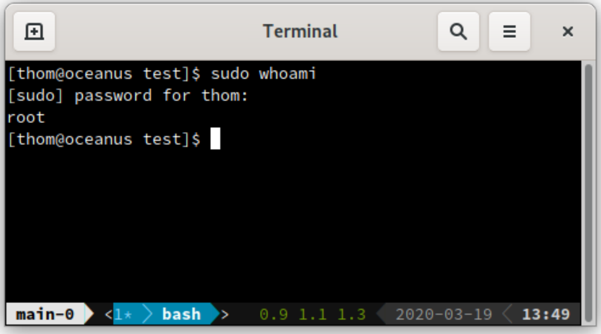
Changing owners and permissions

- Change owner of a file using `chown`
  - `chown otheruser file`
- Change group of a file using `chgrp`
  - `chgrp othergroup file`
- Change permissions (*mode*) of a file `chmod`
  - `chmod u+x file`
  - `chmod g+w file`
  - `chmod o-rwx file`

Putting on your robe and wizard hat: `sudo`

`sudo`: Super User Do

Run the specified command as `root`. Your user needs to be on a special list to do so (`/etc/sudoers`, edit using `visudo`). Get a root shell using `sudo -i`.



```
[thom@oceanus test]$ sudo whoami
[sudo] password for thom:
root
[thom@oceanus test]$ 
```

Figure: Runing a command as `root`

Installing applications: `apt`

- `apt update`: Update the cached index of packages
- `apt search`: Search for applications (searches in cached index)
- `apt install`: Install an application
- `apt upgrade`: Upgrade the installed applications

For non-Debian based distributions (so unlike Ubuntu), the package managers usually have equivalent commands.

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Vim

Someone told you that you should really try Vim, first hit is free.

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Figure: Nancy Reagan

Seriously though, what's up with `Vim`

Vim is a super-powerful editor, but it has a very weird model behind it that makes it hard to use.
Stick to `nano` or `gedit` unless you want to invest a lot of time.
If you do want to learn it, consider one or more of the following:

- `vimtutor` (usually comes with your Vim installation)
- `https://vim-adventures.com/` fun game, not free after first few levels
- `https://openvim.com` Another online tutorial
- `https://github.com/jmoon018/PacVim` teaches you Vim's movements
- `https://missing.csail.mit.edu/2020/editors/`
- `https://vimeo.com/user1690209` or whatever video tutorial you can find

Exiting Vim

Just memorize these fourteen contextually dependant instructions
Exiting Vim
Eventually
O RLY?
@ThePracticalDev

Figure: Exiting Vim

https://github.com/hakluke/how-to-exit-vim

Finding this presentation

This presentation can be found at https://thomwiggers.nl/teaching/hacking-in-c-2020/shell-tutorial/. I will also link it on the Hacking in C Brightspace page.

An alternative tutorial that goes a bit further is this one by MIT's "Missing Semester".

See you at Hacking in C!