TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

Tutoraggio di Sistemi Operativi

Lezione 1

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Chi sono io

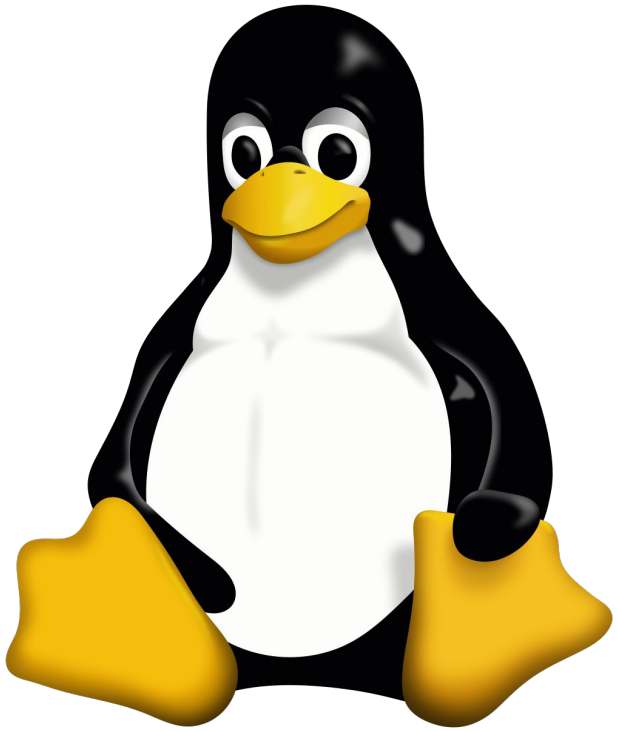
- Pasquale Caporaso, phd student, security researcher for CNIT
- Ex-Malware Analyst for Leonardo spa
- Research in cyber security, malware and operating systems
- Addicted to CTFs
- Finalist in CC Sapienza 2020

Linux

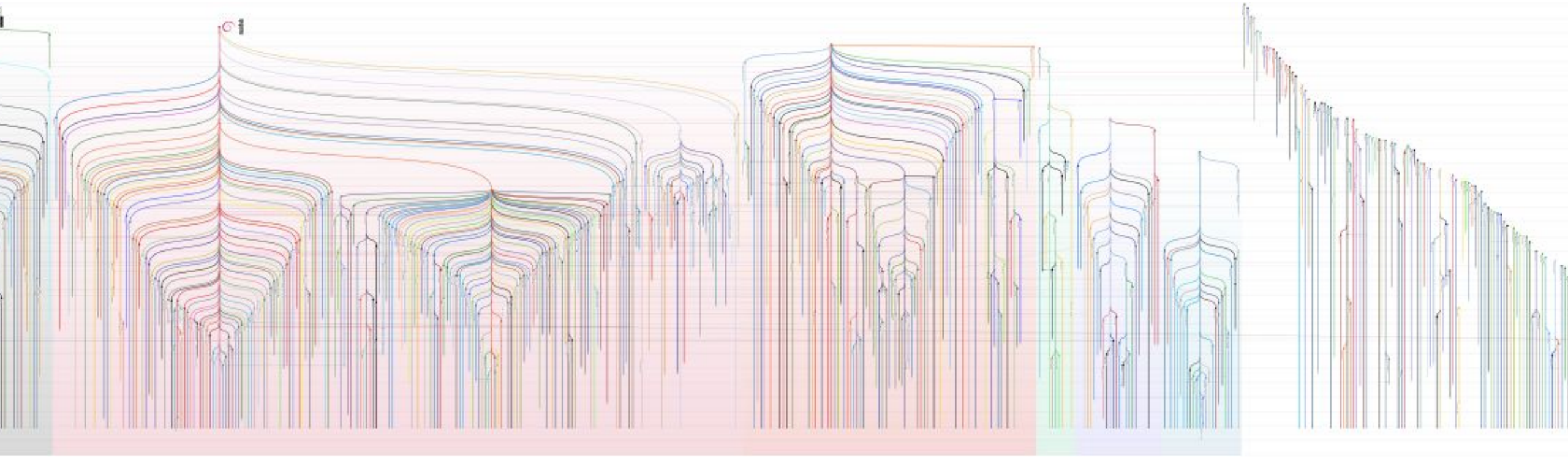
Sistema operativo Open-Source

Una storia molto complicata…

Un solo kernel, tante distribuzione



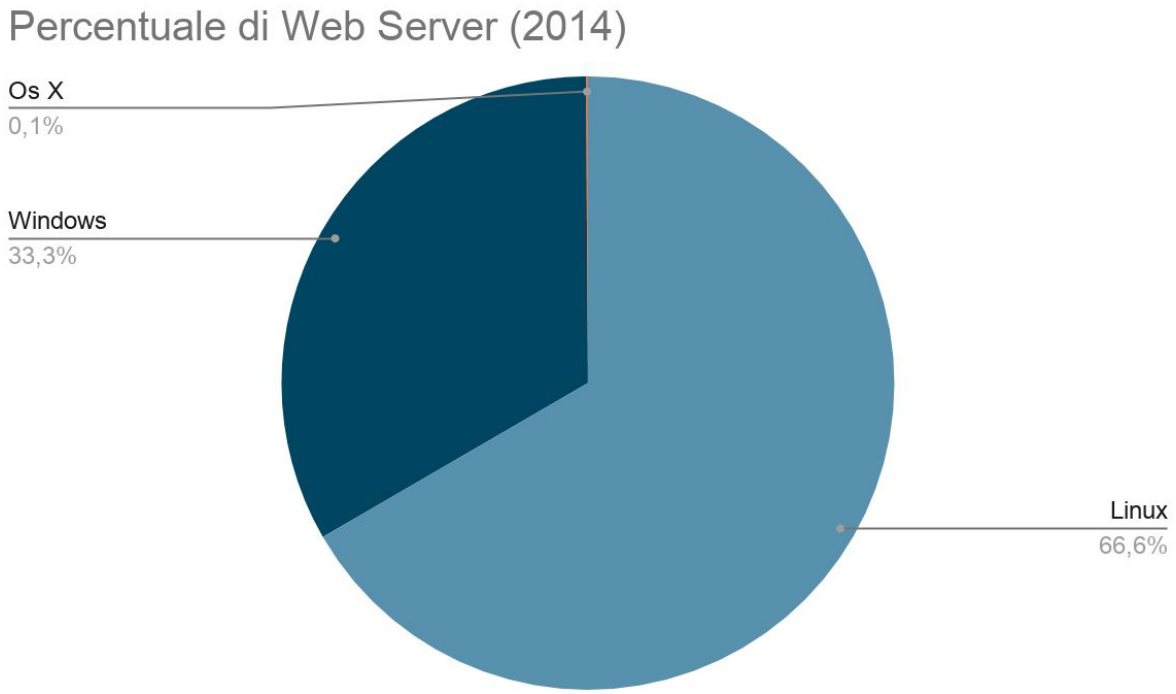
Linux



Ma perchè?

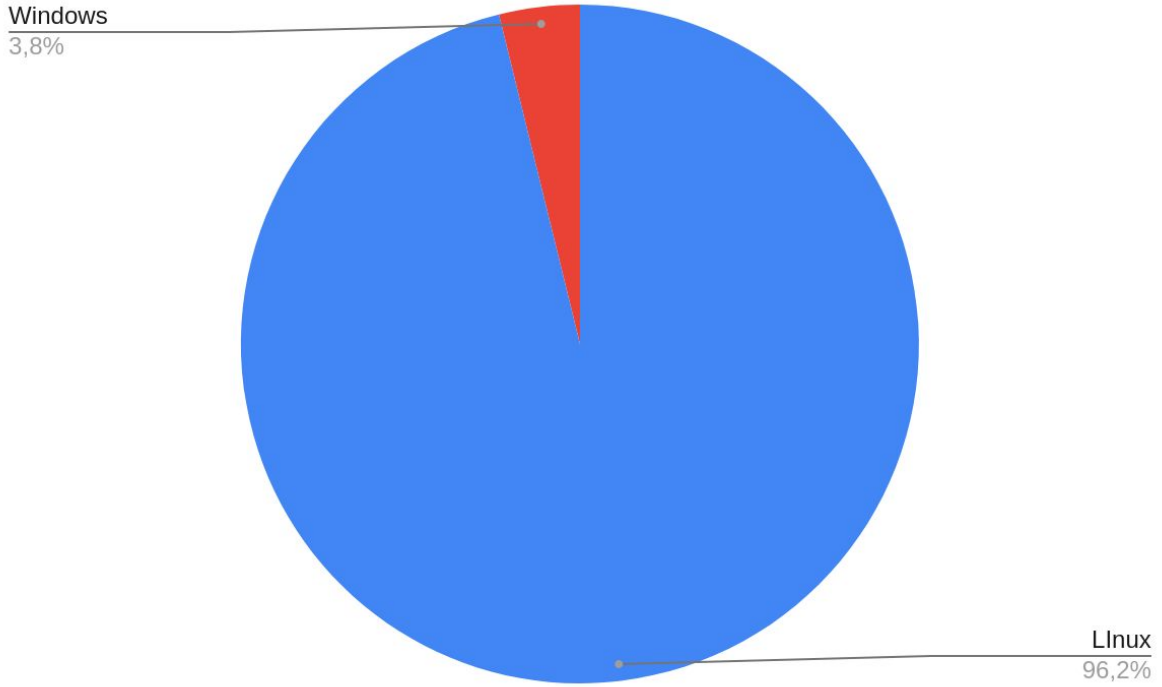
Molto comodo

Linux domina Internet (e i super computer)



Ma perchè?

All’esame usate tutti Linux



Setup your Linux machine

- Step 0:

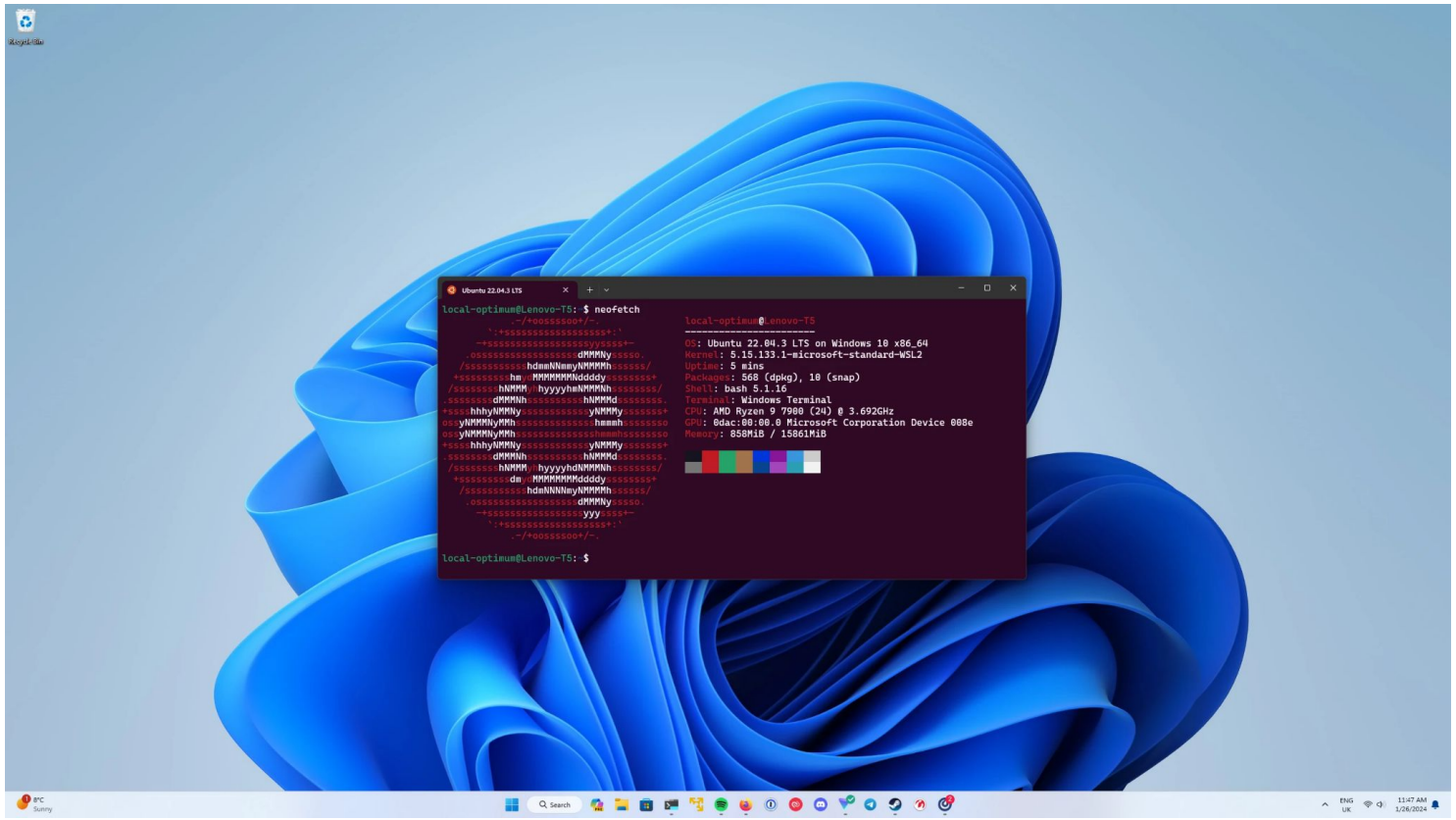
https://francescoquaglia.github.io/TEACHING/SISTEMI-OPERATIVI/CURRENT/index.html

Link utili

- Link alla pagina dell'ambiente **Microsoft Visual Studio** (Express Edition - Now Community) per lo sviluppo di applicazioni software in tecnologia C/Windows (Win-API)
- Link alla pagina **Microsoft Learn**
- Link alla pagina dell'ambiente **VirtualBox** per la virtualizzazione delle macchine - NOTA: per utilizzare correttamente il software di virtualizzazione attivare nel BIOS il relativo supporto hardware (VT-x/AMD-v)
- Link per il dowload di una immagine di sistema **Linux/Suse/x86-64 (VDI virtual disk)** - formato compresso da 2.5 GB - credenziali dell'utente amministratore: username="so" - password="sistemioperativi"
- Link alla pagina dell'ambiente **Wine** per lo sviluppo e l'esecuzione di applicazioni Windows su sistemi Linux/MacOS.

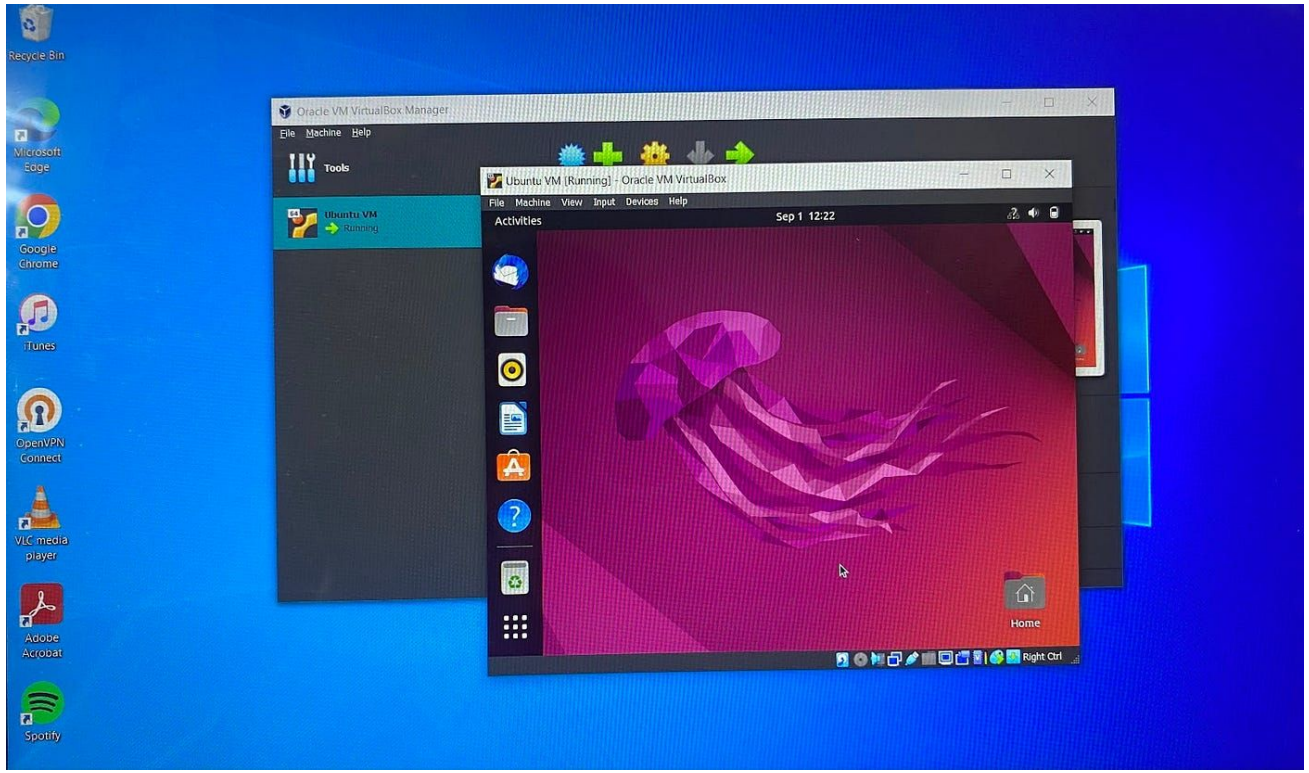
Setup your Linux machine

- Choice 1: WSL



Setup your Linux machine

- Choice 2: Virtual Machine



Setup your Linux machine

- Choice 3: Dual boot

Which distro

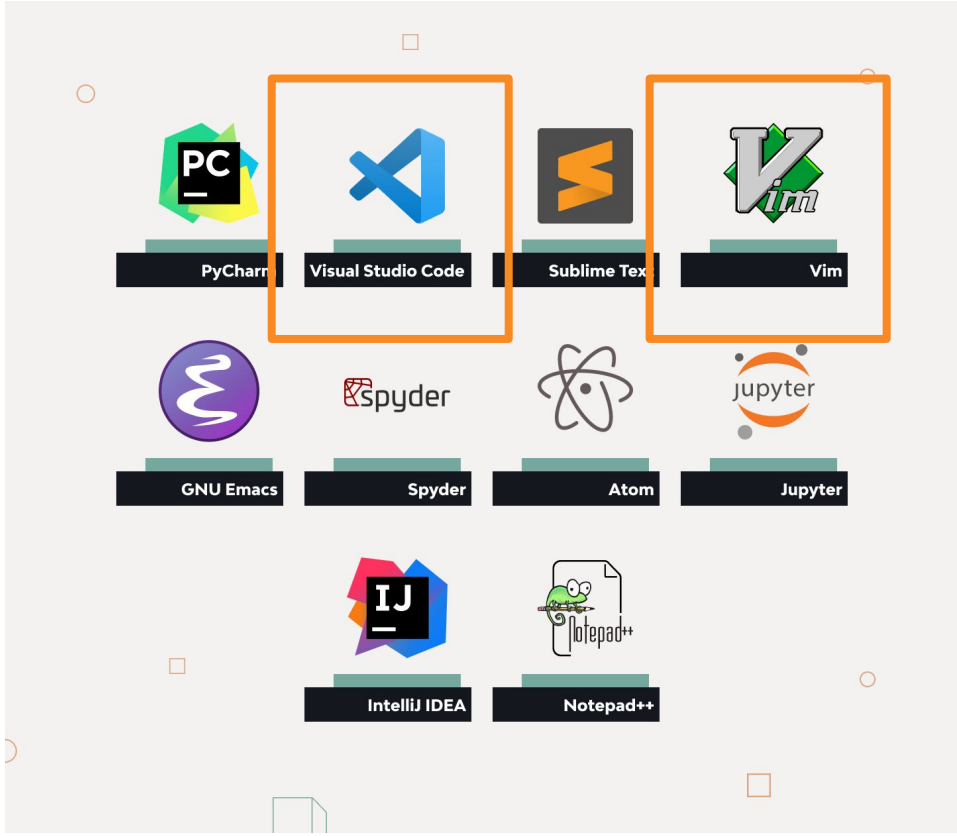
Linux users discussing which distro is the best

Which distro

- My choice:

Where to write code

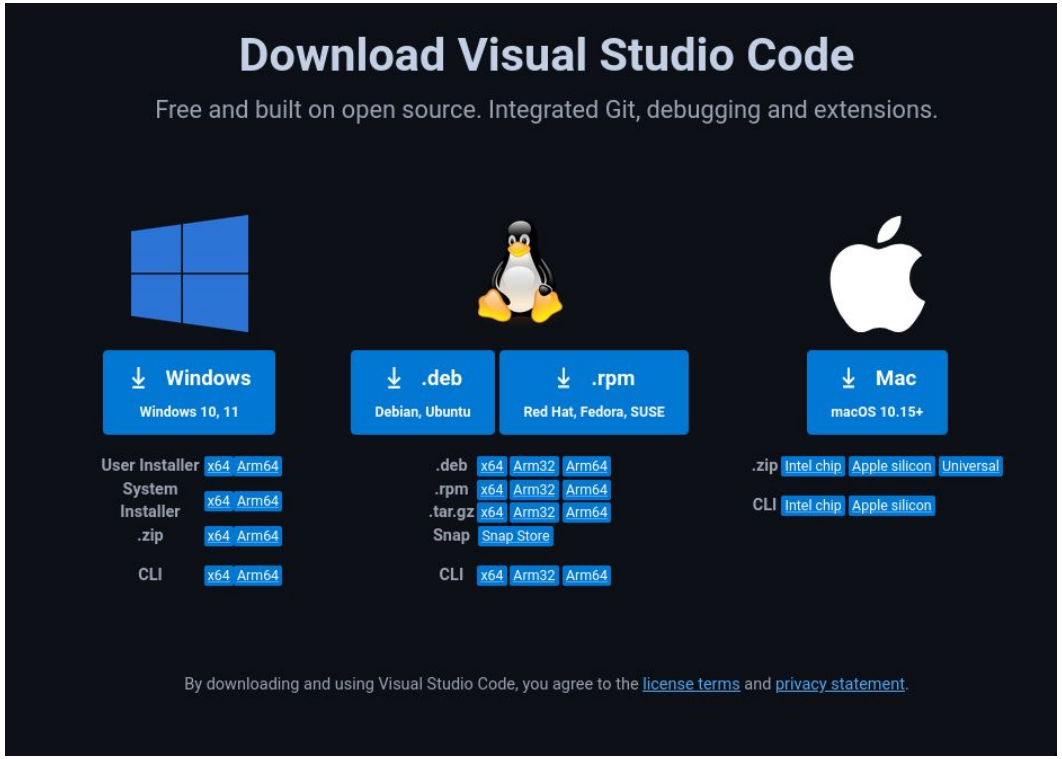
- Wherever you want



Where to write code

- Vscode

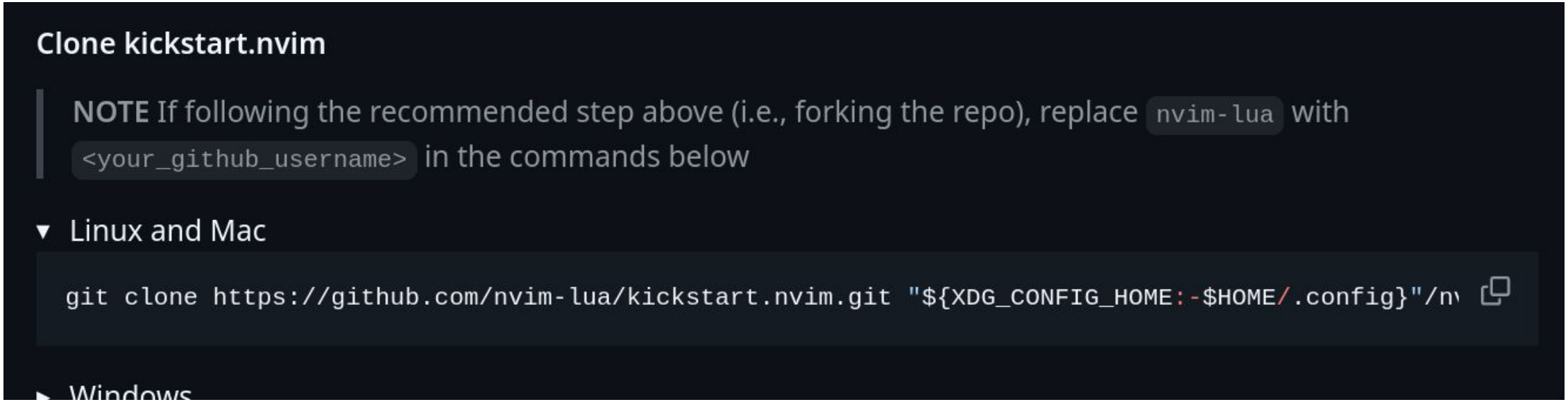
https://code.visualstudio.com/download



Where to write code

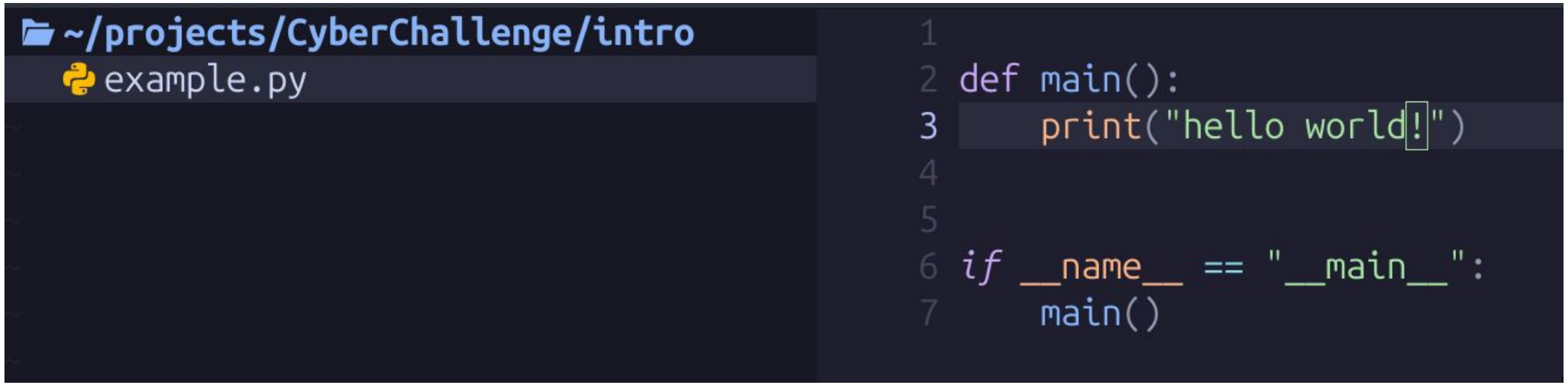
- Nvim

https://github.com/nvim-lua/kickstart.nvim



How to run code

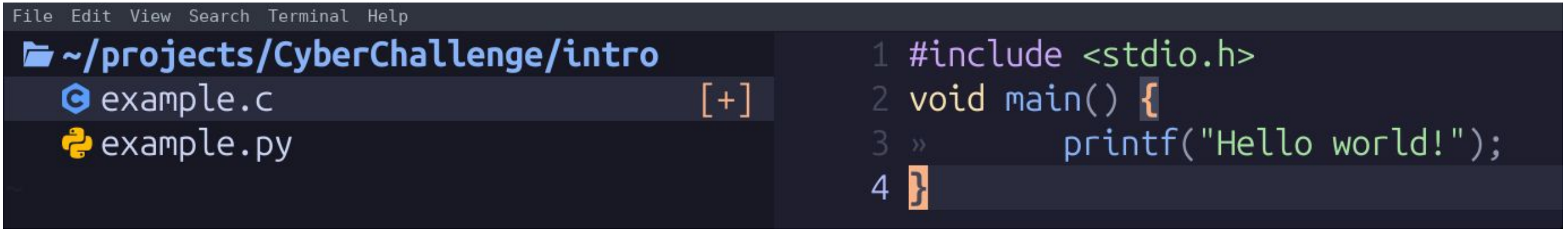
- python




```
~/projects/CyberChallenge/intro sudo apt install python3
~/projects/CyberChallenge/intro python3 example.py
hello world!
~/projects/CyberChallenge/intro
```

How to run code

- c

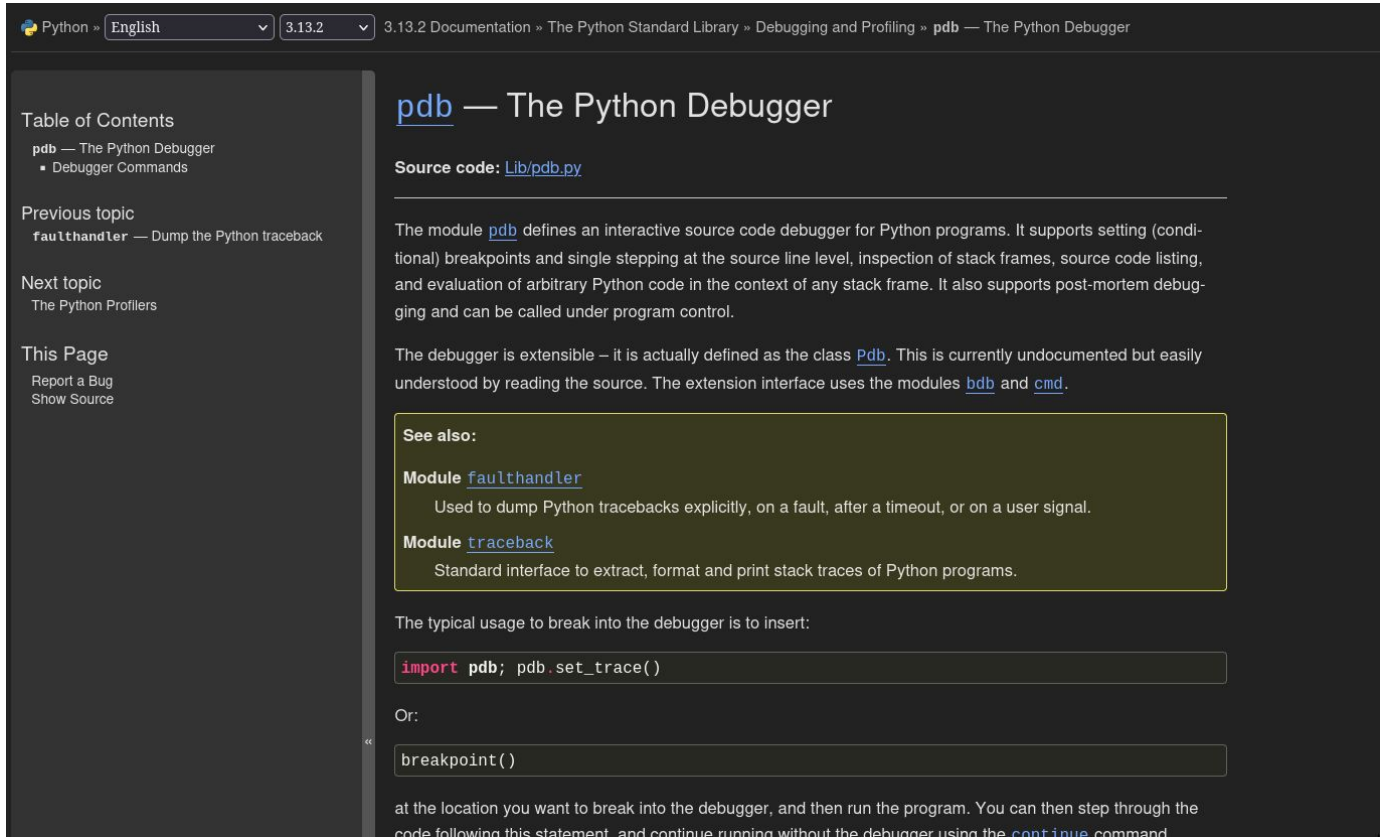


How to debug code

- python

How to debug code

- python



How to debug code

- c

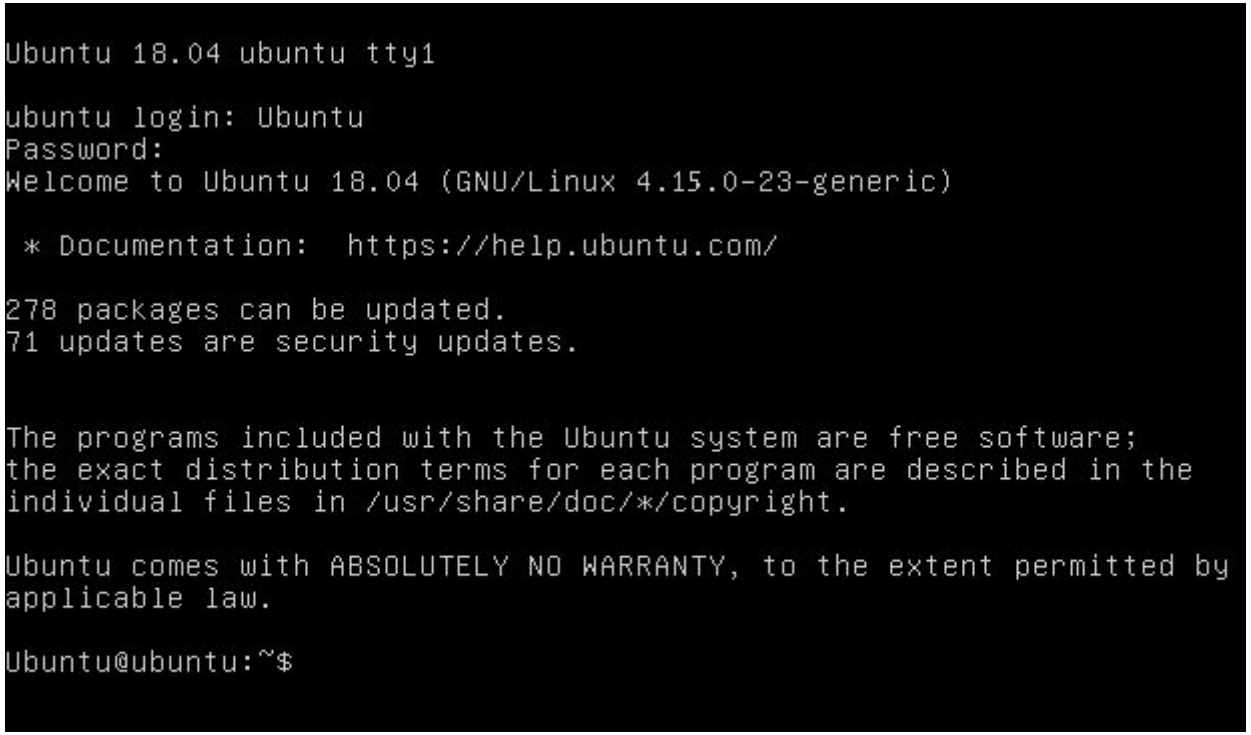
GDB + GEF

Linux OS – Filesystem

- Tree structure
  - /
    - /boot/ → system boot files
    - /dev/ → hardware devices (each device is a file! more or less…)
    - /etc/ → system configuration
    - /home/ → user home directories
    - /lib/ → system libraries
    - /mnt/ → removable devices (e.g. usb)
    - /proc/ → kernel interaction (file abstraction) [now deprecated but still in use]
    - /sys/ → kernel interaction
    - /tmp/ → temporary files
    - /usr/ → universal system resources → mostly user installed programs
    - /var/ → variable files

Linux OS – tty

- tty = virtual terminal
  - It's the main interface to the OS
    - Try to install Linux without any graphical interface, you'll be welcomed by a tty ☺
  - It's called virtual because it's a virtual version of old *teletypes*
  - *tty = text input/output interface provided by the kernel*
    - *input → processing → output*
  - tty files are located in */dev*
- Console = terminal + physical tools (e.g. keyboard, screen)



Linux OS – shell and file descriptors

- shell = command line interpreter
  - *input → shell → output*
- There are 3 default files (with associated **file descriptors**) the shell works with:
  - 0 – stdin
  - 1 – stdout
  - 2 – stderr
- On a virtual terminal, by default
  - fd 0 is connected to the keyboard
  - fd 1 and 2 are connected to the screen

Linux OS – GUI

- GUI = Graphical User Interface
  - Windows, Icons, Mouse
  - User-friendly interface to the OS
  - Runs on top of a tty
  - Allows ***pseudo-tty*** thanks to programs called ***terminal emulators***

Linux OS – shell /2

- The shell can be used in 2 ways:
  - Interactively
  - By executing a file, written in the “shell language”
- There are many programs which implement a shell:
  - sh, bash, zsh, …
- A shell welcomes the user with a **shell prompt**
  - It means that the shell is ready to accept commands to be executed
  - Whatever is written at the shell prompt is
    - A program to be executed
    - A shell command
- The shell makes use of **environmental variables**
  - Global, OS-level variables which configure the system environment (e.g. *$PATH)*
  - Global, run-time variables defining the local environment (e.g. *$USER*, $TERM)

Linux OS – shell /3

- The program **echo**
  - prints back whatever it finds as *command line argument*
    - Command line arguments are strings following the program name, separated by spaces
  - can also be used to print env vars
    - echo $PATH
- Why does “echo $PATH” works? Where is the executable file “echo”?
- The program **pwd**
  - prints the current working directory
  - How to change directory? use **cd**
  - How to list files/directories inside a directory? Use **ls**
    - play with ls arguments
    - Notice that “.” and “..” folders inside every folder?

Linux OS – shell /4

- The program **cat** *(concatenate)*
  - cat file.txt
  - cat file1.txt file2.txt
  - cat –
- CLI editors
  - nano
  - vim
  - …

Linux OS – redirection

- Input and Output of a program can be redirected an can be used to feed other programs.
  - operator “>” redirects **output**
    - By default it redirects **stdout** (i.e. fd 1)
  - operator “<“ redirects **input**
    - By default it redirects **stdin** (i.e. fd 0)

- The general syntax for redirection
  - fd1 [operator] &fd2 □ redirects *fd1* to *fd2* (watch the “&”!)
  - fd1 [operator] filename □ redirects *fd1* to *filename*
    - cat file.txt > output.txt is equivalent to cat file.txt 1> output.txt

Linux OS – redirection/2

- Redirect multiple fds to same destination
  - *cat file.txt > output.txt 2>&1 [cat file.txt 1>output.txt 2>&1]*
    - redirects **stdout** to **output.txt** and **stderr** to **stdout** (so to output.txt). Result: stdout and stderr redirected to txt file

- The special file */dev/null*
  - Bytes written to this file are simply trashed
  - Useful when you want to ignore some output
  - *find / -type f –name sudo 2>/dev/null*
    - Hey, ignore stderr and show just stdout!

Linux OS – pipes

- Pipes are (guess what?) *files* used by processes to intercommunicate (IPC)
  - A *named pipe* or *fifo* exists on the filesystem
  - An *anonymous pipe* is managed directly by the kernel and doesn't exist on the filesystem

- Suppose that you want to use the output of a program as input to another program
  - You can use redirection
    - program1 > output
    - program2 < output
  - Or you can use an anonymous pipe!
    - program1 | program2
    - program1 | program2 | program3 | …

Linux OS – pipes /2

- Named pipes or fifos need to be created before they can be used
  - *mkfifo /tmp/myfifo*
  - *echo “let’s try” > /tmp/mkfifo*
    - notice that the program is blocked!
  - *[on another terminal] cat /tmp/mkfifo*
    - Look at the output. And notice that the echo process is now unlocked
- You get the same result if you first spawn the reader process and then the writer process.
- Pipes are closed when there is no writer associated
  - cat /tmp/myfifo
  - echo “test” > /tmp/myfifo
    - The cat process is now terminated, because there is no writer associated.

Linux OS – shell /5

- The program **grep**
  - filters the input based on rules
    - Very complex command, you can learn everything by reading the linux manual: **man grep**
- Example: See if any of the txt files inside the current directory contains the string “user”
  - cat *.txt | grep “user”
- Other text filtering programs
  - **awk** extract tokens
  - **sed** replace strings
  - **cut** split strings and grab only some parts
  - …

Linux OS – shell /6

- Examples
  - ls –l | grep ‘user’ | awk ‘{print $1}’
  - ls –l | grep –iE ‘ic$’
  - ls –l | awk ‘{print $9}’ | grep –iE ‘^P’
  - …

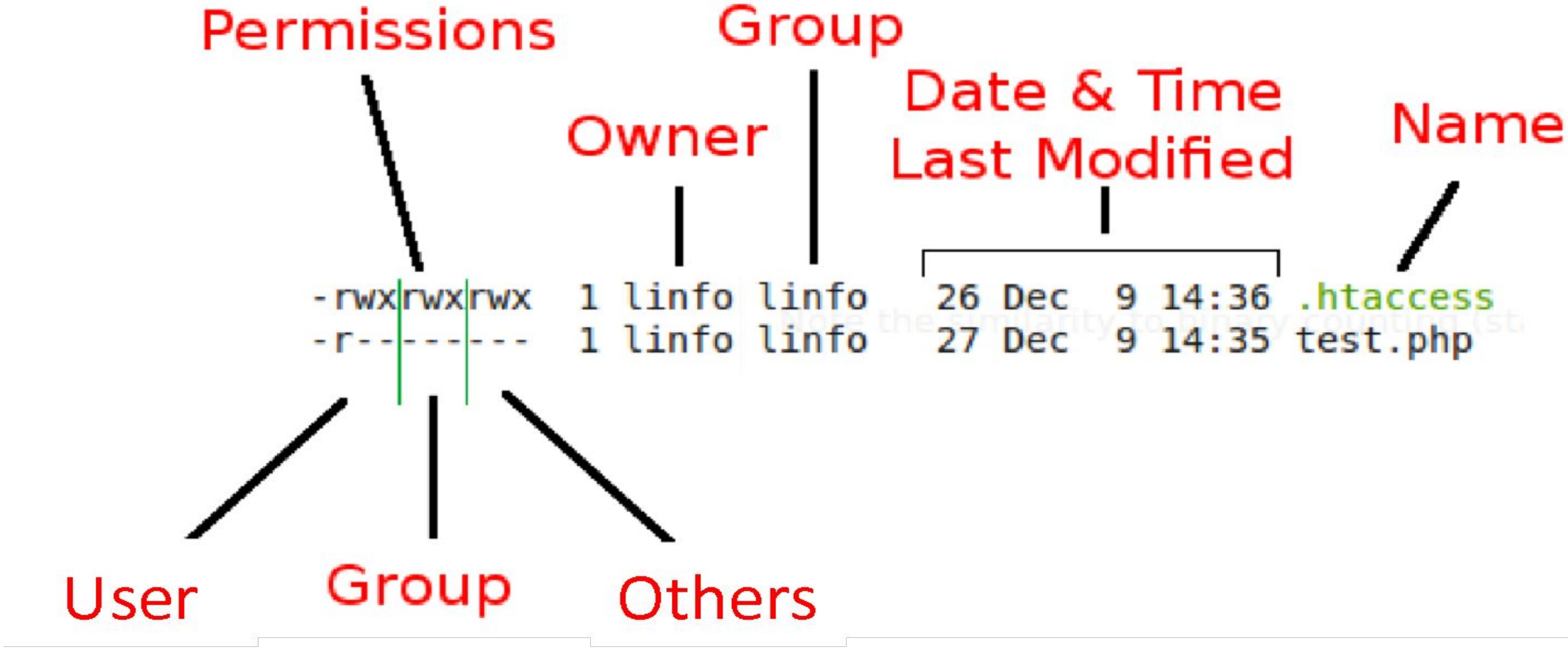
Linux OS – strings

- Strings are sequences of characters enclosed in quotes (single or double).
  - You can omit quotes when the string doesn't contain spaces or *other characters*
  - You must use quotes otherwise!
- Examples
  1. ls –l "file.txt"
  2. ls –l file.txt
  3. cat file with spaces.txt
  4. cat "file with spaces.txt"
- You can use ' inside " " and " inside ' '
- What if there is a file named: hey"joh'n.txt?
  - Cat "hey\"joh'n.txt"

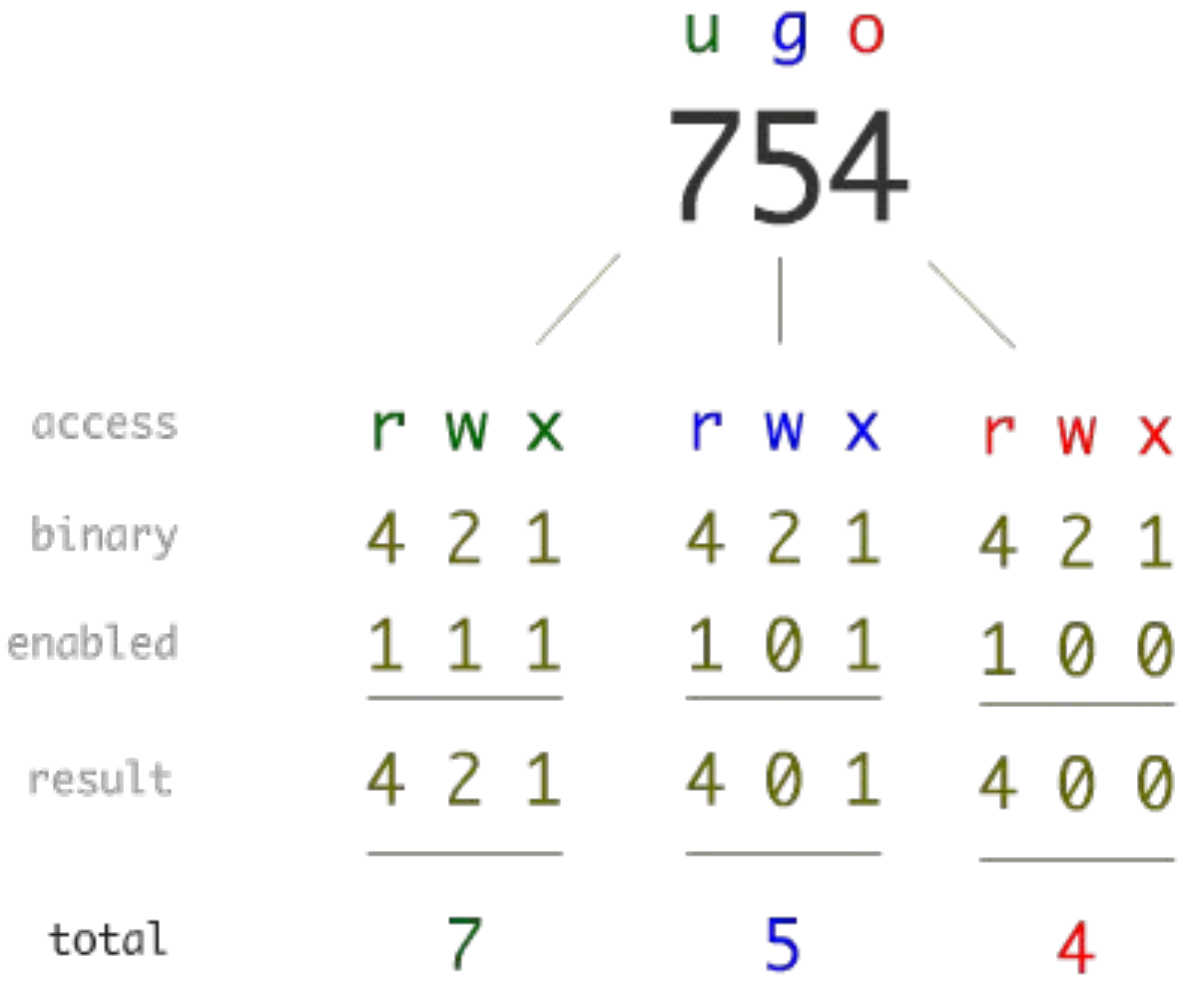
Linux OS – escape sequence

- \” is an **escape sequence**
  - A string is *escaped* when all dangerous characters are replaced with the corresponding escape sequence
- Dangerous characters?
  - cat file with spaces.txt cat file\ with\ spaces.txt
    - Here the space is dangerous because it is used as separator for command line arguments. So it can’t be used to specify file names containing spaces.
  - “ inside “ ” and ‘ inside ‘ ‘
  - unprintable characters (\n, \r, \t, …)
- Hey, I want to print “\n” (and not a newline)
  - echo –e “\n”
  - echo –E “\n”

Linux permissions



Linux permissions



root@kali# chown user:root test

root@kali# chown user:user test

root@kali# chmod 600 test

root@kali# chmod o+x test

root@kali# chmod g+rwx test

Sudoers

- root@kali# adduser user *(unprivileged user)*
- root@kali# *cat /etc/passwd* | *grep "bash\|sh”* *(get users of the system)*
- root@kali# id user (information about the user user)
- *root@kali# su user (log as user user)*
- *user@kali$ cat /etc/shadow PERMISSION DENIED*

Sudoers

- root@kali# visudo (edit /etc/sudoers file)

  user ALL=(root) NOPASSWD: /bin/cat *

- user@kali# sudo –l (what can I sudo?!)

- user@kali# sudo cat /etc/shadow (we can cat everything?! As root user!)

- How can we bypass when sudoers has user ALL=(root) NOPASSWD: /bin/less /var/log/*
- What about this? user ALL=(root) NOPASSWD: /tmp/myprogram

Setuid/Setgid

- Normally, the ownership of files and directories is based on the default uid (user-id) and gid (group-id) of the user who created them.
- When a process is launched it runs with the effective user-id and group-id of the user who started it, and with the corresponding privileges.
- This behavior can be modified by using special permissions.
- When the **setuid/setgid** bit are used, the executable does not run with the privileges of the user who launched it, but with that of the file owner/group instead.
- root@kali# ls -la /usr/bin/passwd (-rwsr-xr-x)

Setuid/Setgid

- root@kali# chmod +s sh
- root@kali# chown root:vdsi sh
- root@kali# chmod u+s sh
- root@kali# chmod -s sh
- root@kali# chmod g+s sh

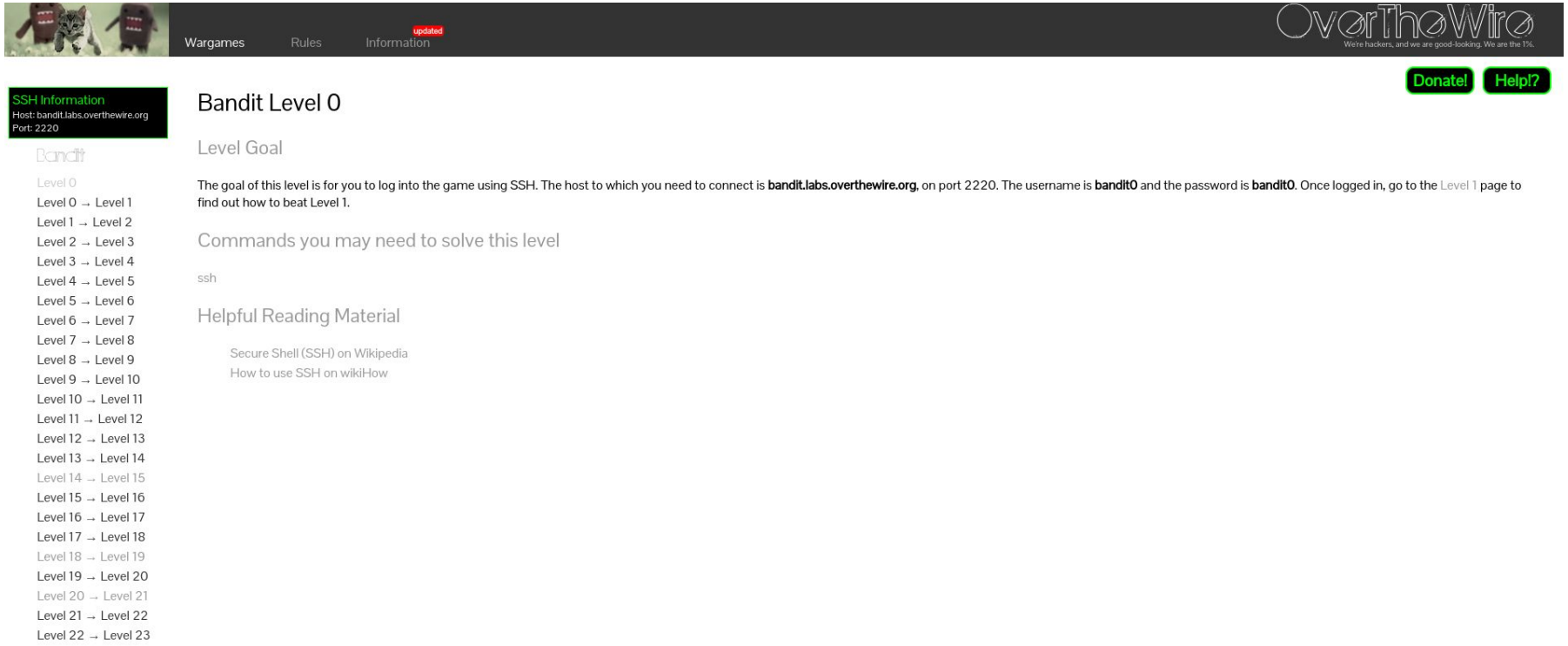
Setuid/Setgid

- Try it with /bin/bash binary….it does not work?! Just use –p (preserve privileges)
- What about creating our own binary that preserves suid/gid?

- root@kali# cat > suid.c <<EOF
- #include <stdio.h>
- #include <sys/types.h>
- #include <unistd.h>
- int main(void) { setuid(0); setgid(0); system("/bin/bash"); }
- EOF

Linux Training

https://overthewire.org/wargames/bandit



Domande?