TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

Tutoraggio di Sistemi Operativi

Lezione 1

Pasquale Caporaso

Chi sono io

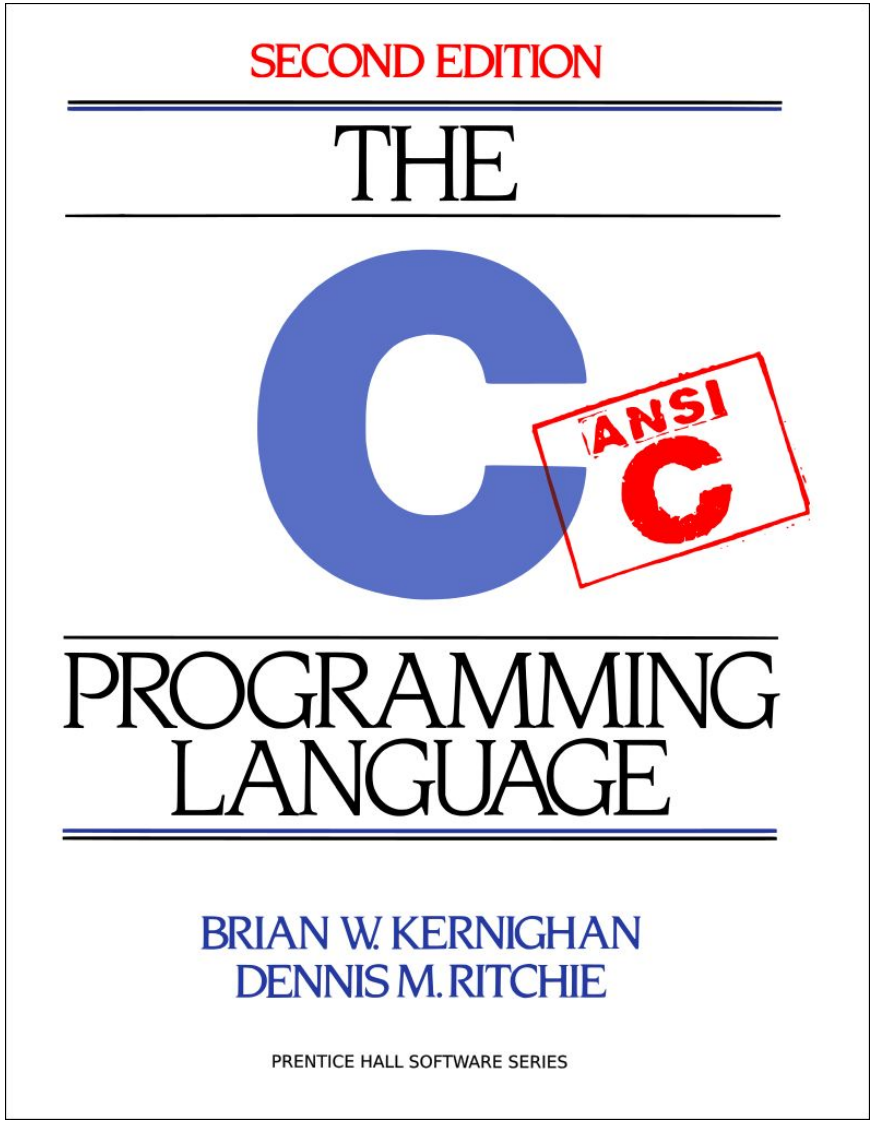
- Pasquale Caporaso, phd student, security researcher for CNIT
- Ex-Malware Analyst for Leonardo spa
- Research in cyber security, malware and operating systems
- Addicted to CTFs
- Part of hAOckers, TRX and mHACKeroni

Che faremo

Heavy Focus on C

Focus on OS interactions

Many exercises

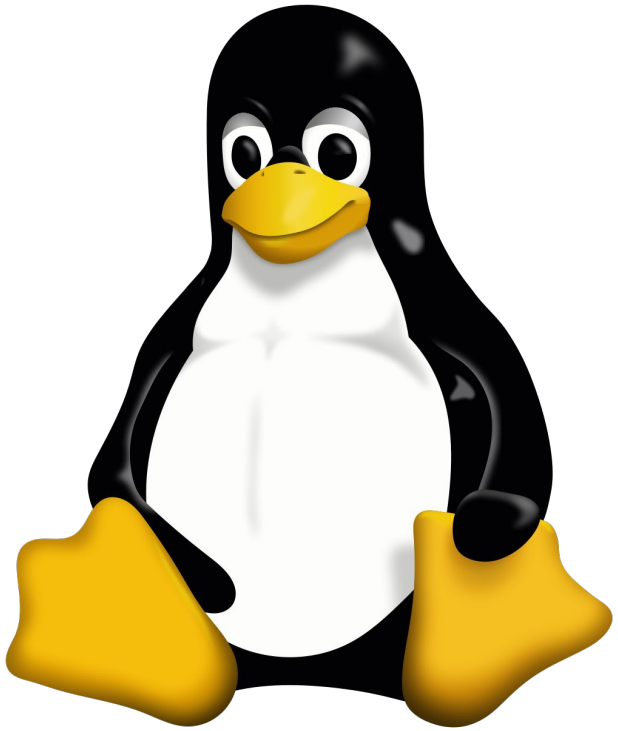


Linux

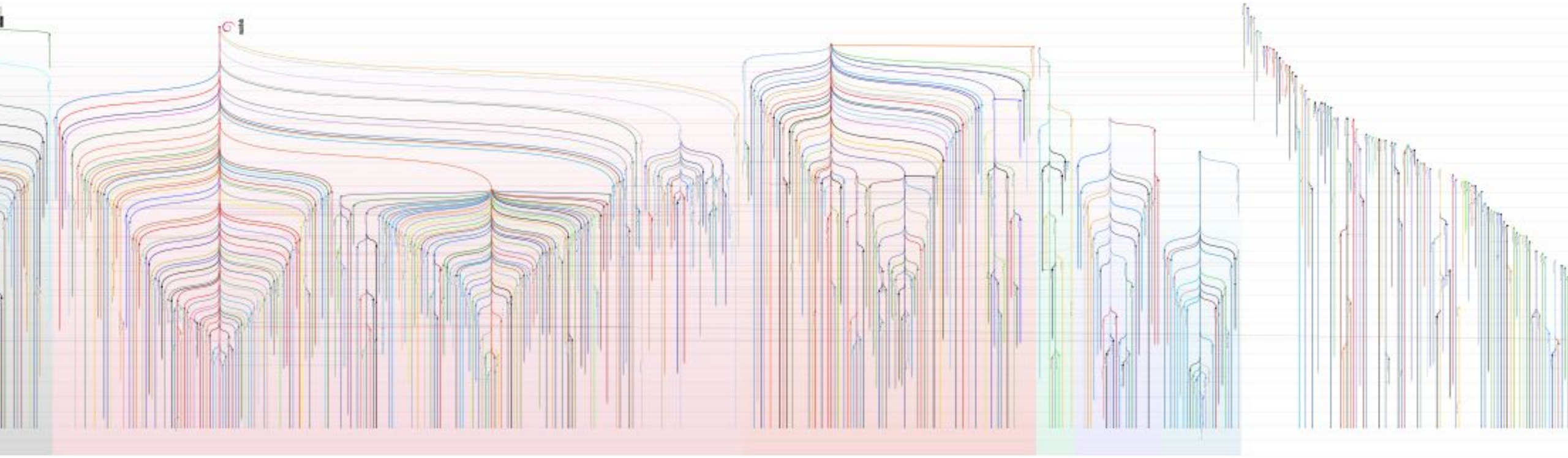
Sistema operativo Open-Source

Una storia molto complicata…

Un solo kernel, tante distribuzione



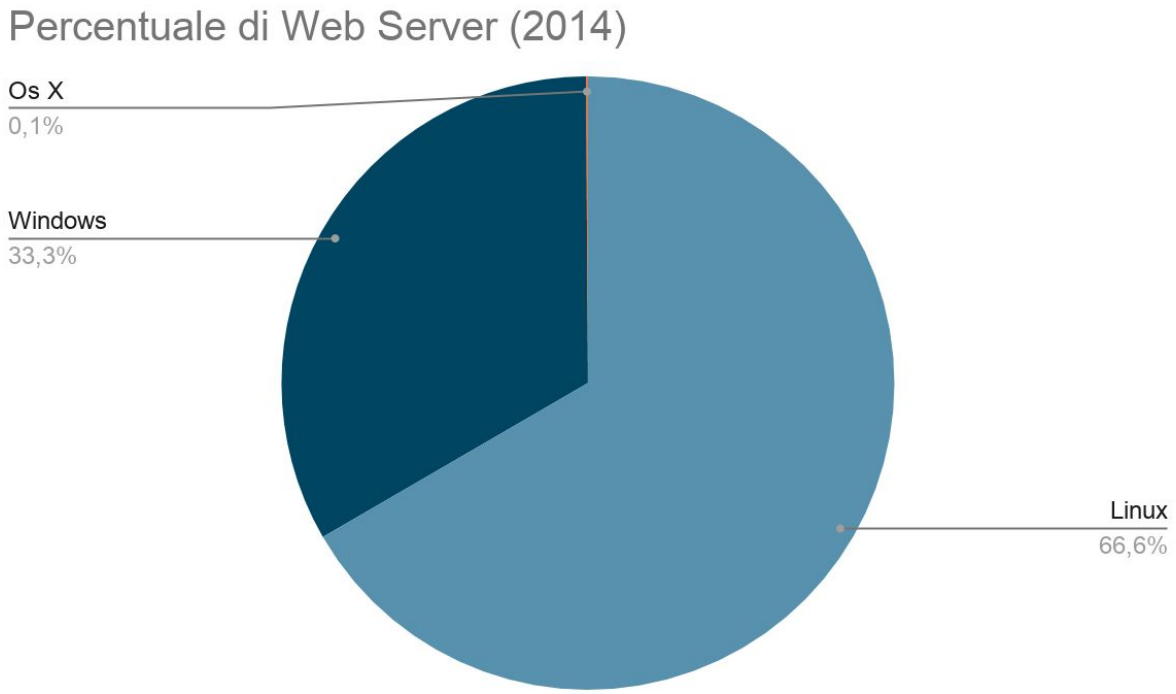
Linux



Ma perchè?

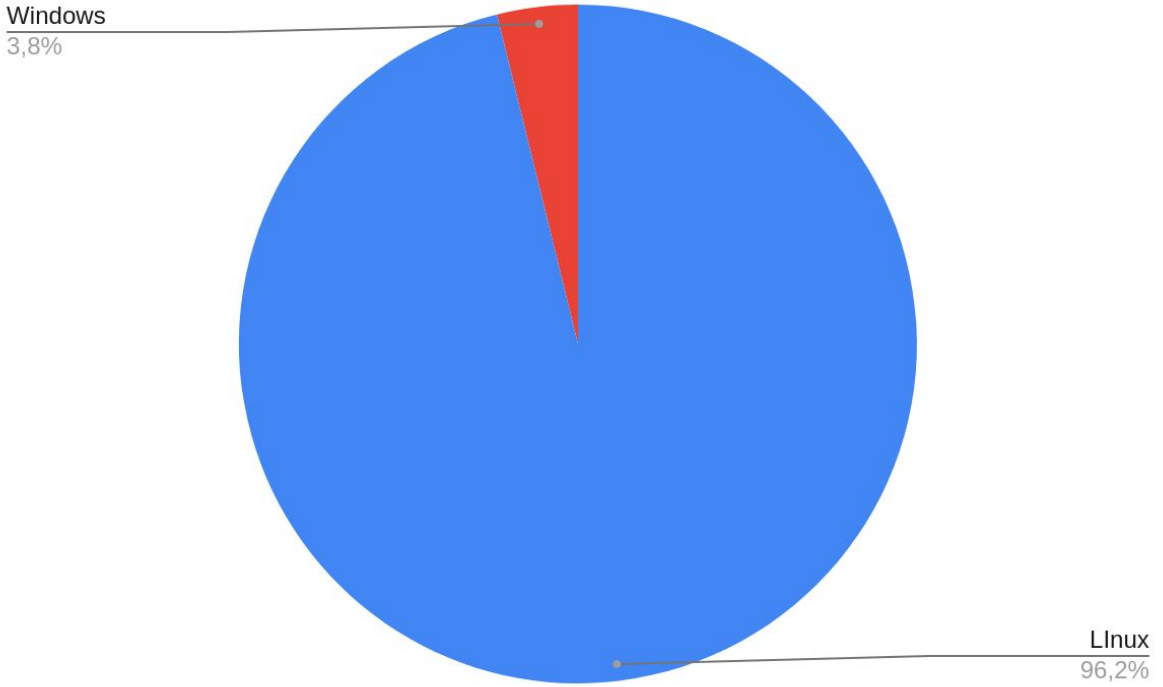
Molto comodo

Linux domina Internet (e i super computer)



Ma perchè?

All’esame usate tutti Linux



Setup your Linux machine

- Step 0:

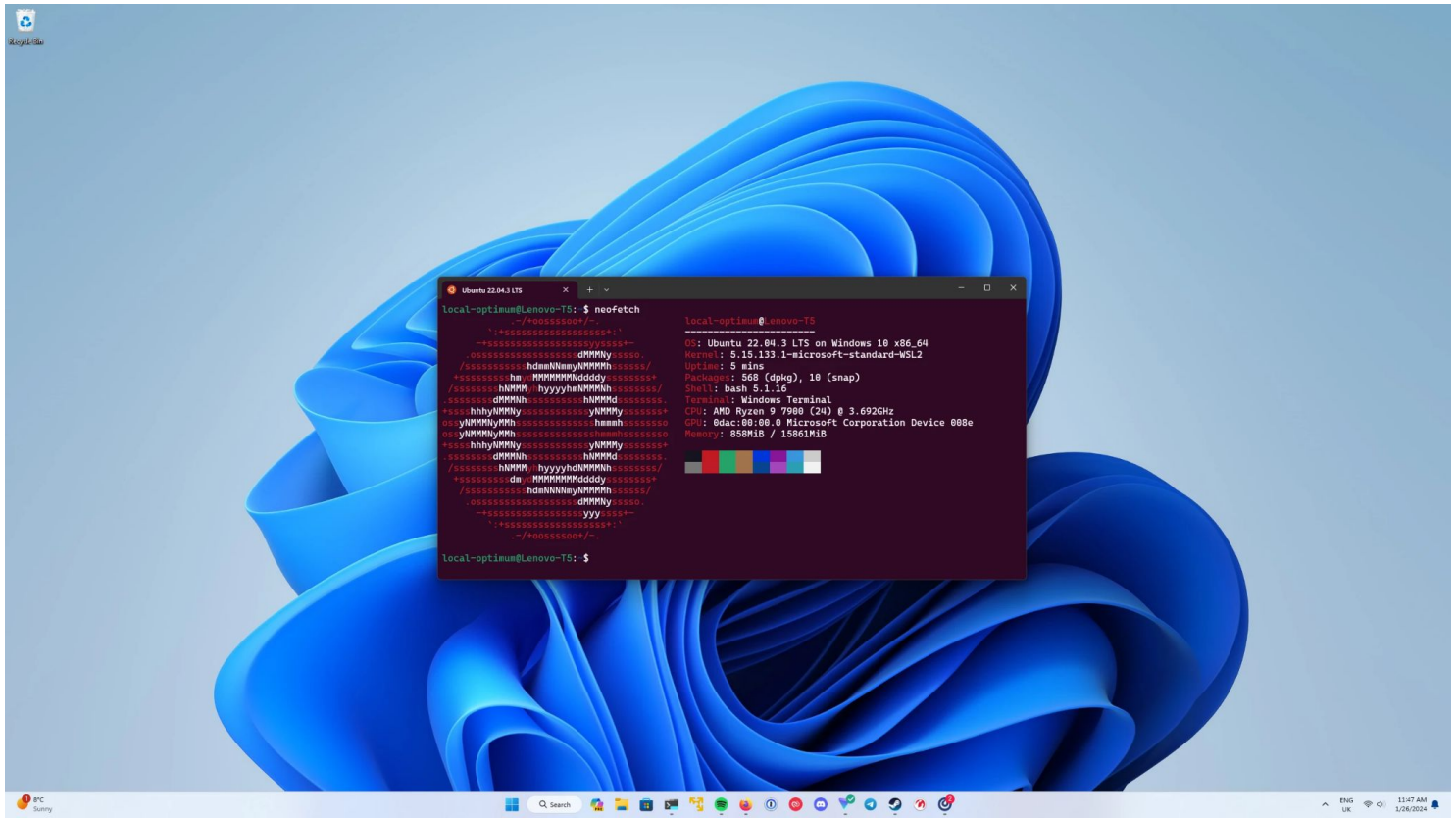
https://francescoquaglia.github.io/TEACHING/SISTEMI-OPERATIVI/CURRENT/index.html

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.

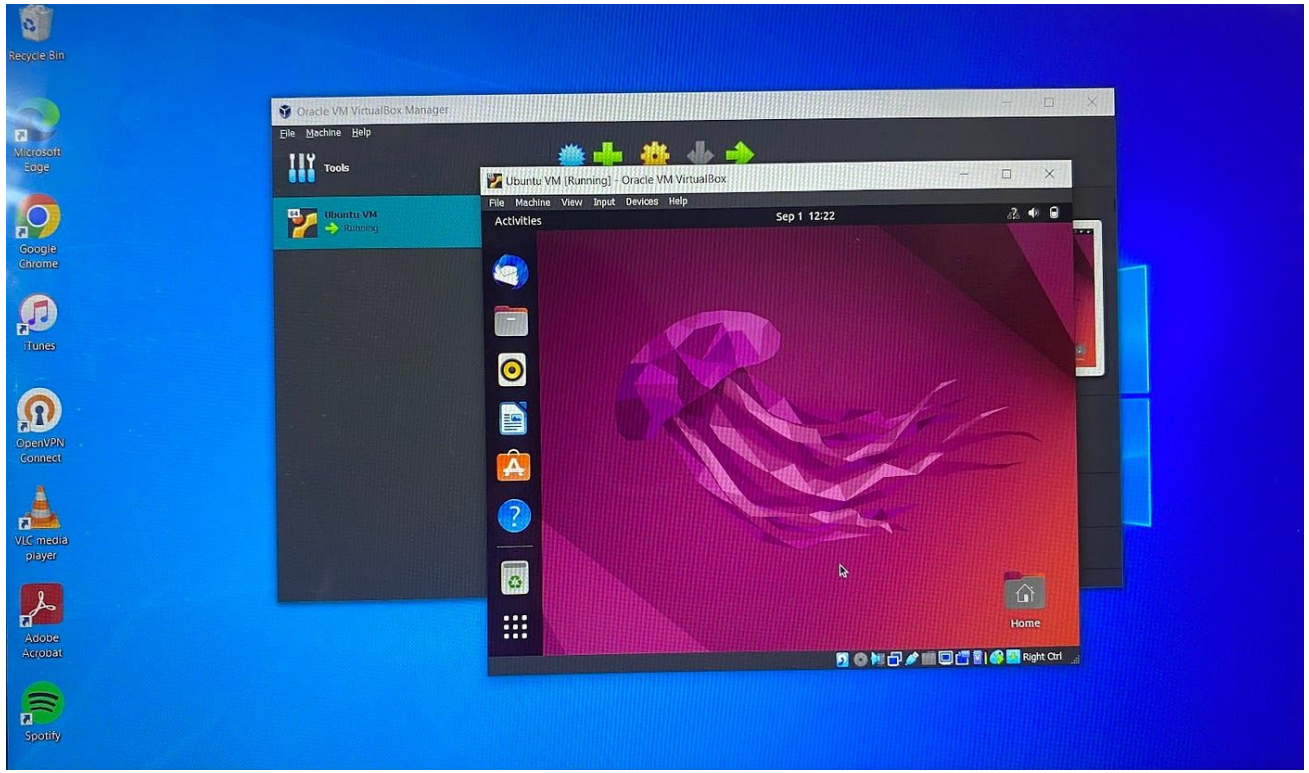
Setup your Linux machine

- Choice 1: WSL



Setup your Linux machine

- Choice 2: Virtual Machine



Setup your Linux machine

- Choice 3: Dual boot

Which distro

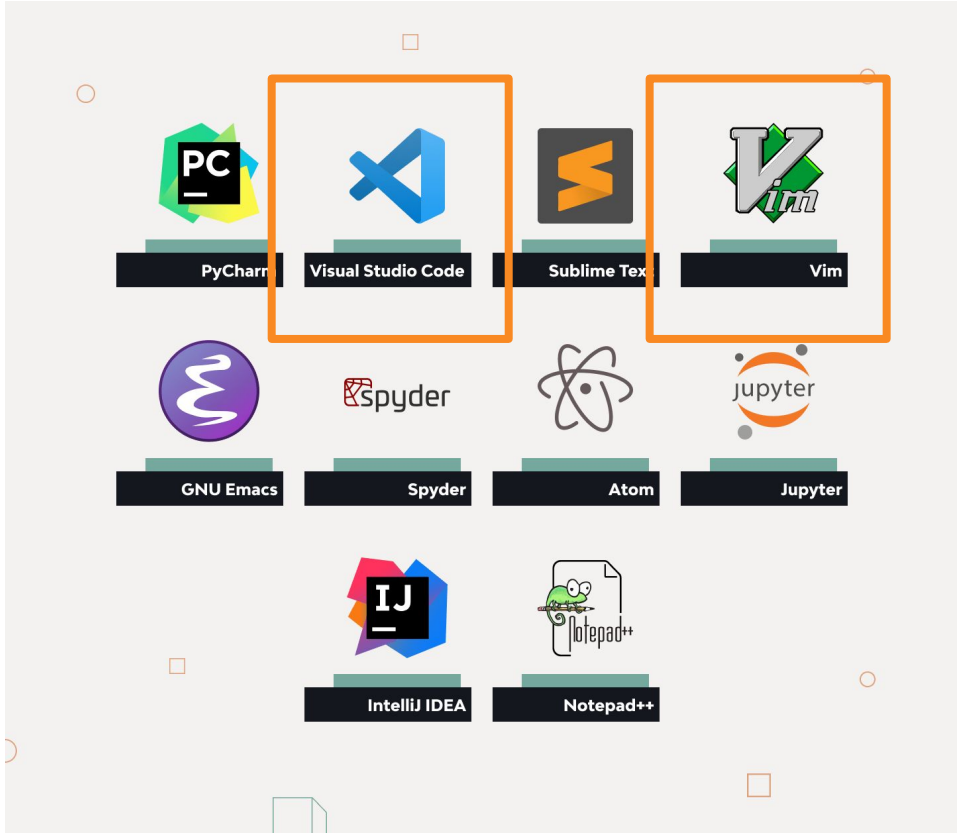
Linux users discussing which distro is the best

Which distro

- My choice:

Where to write code

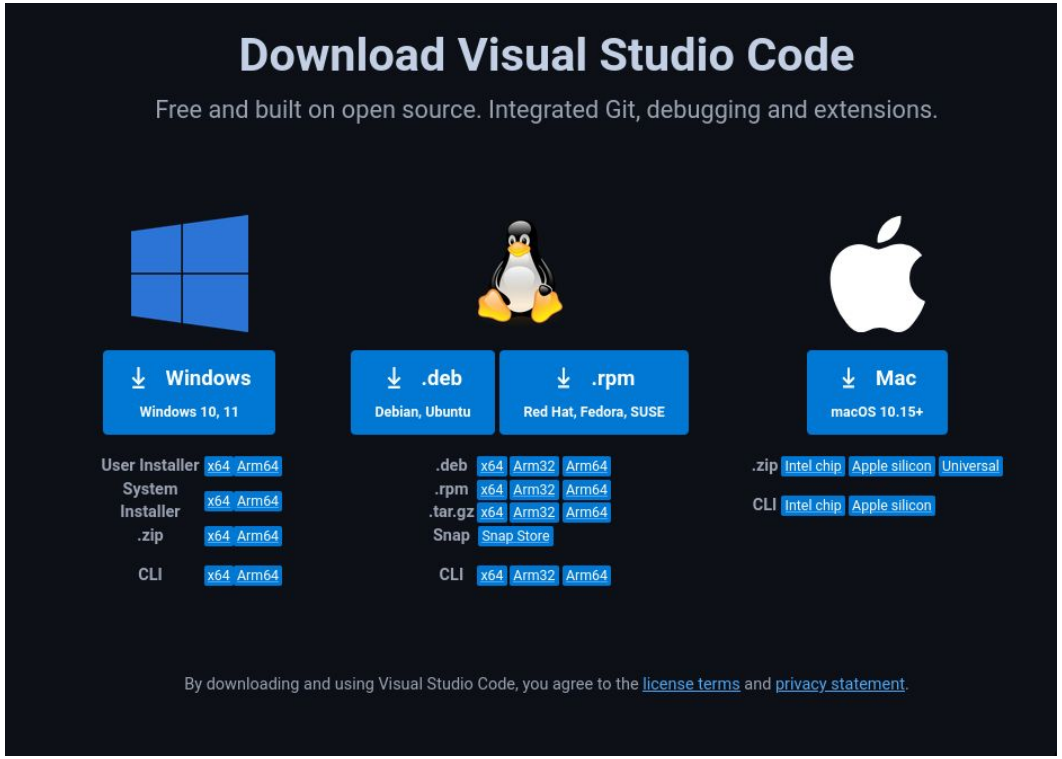
- Wherever you want



Where to write code

- Vscode

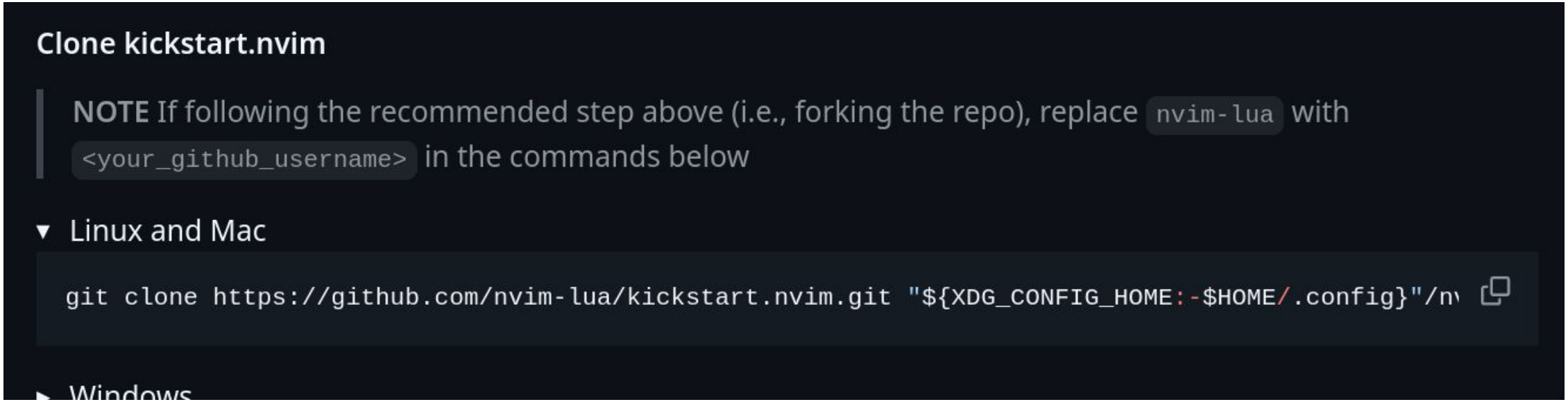
https://code.visualstudio.com/download



Where to write code

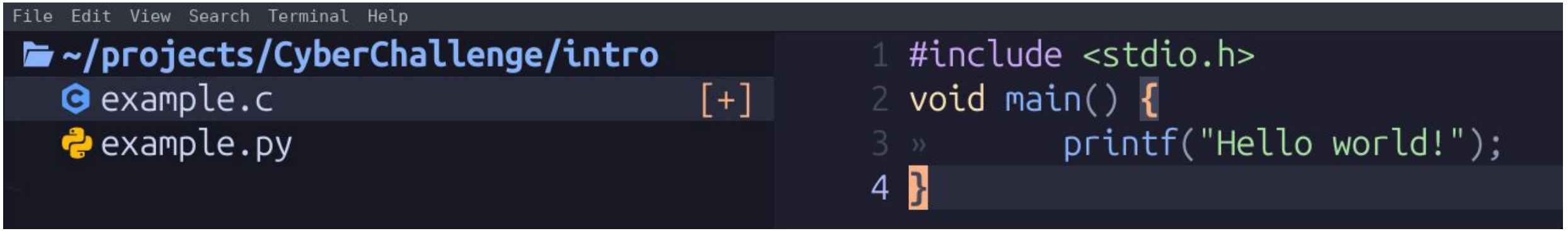
- Nvim

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



How to run code

- c



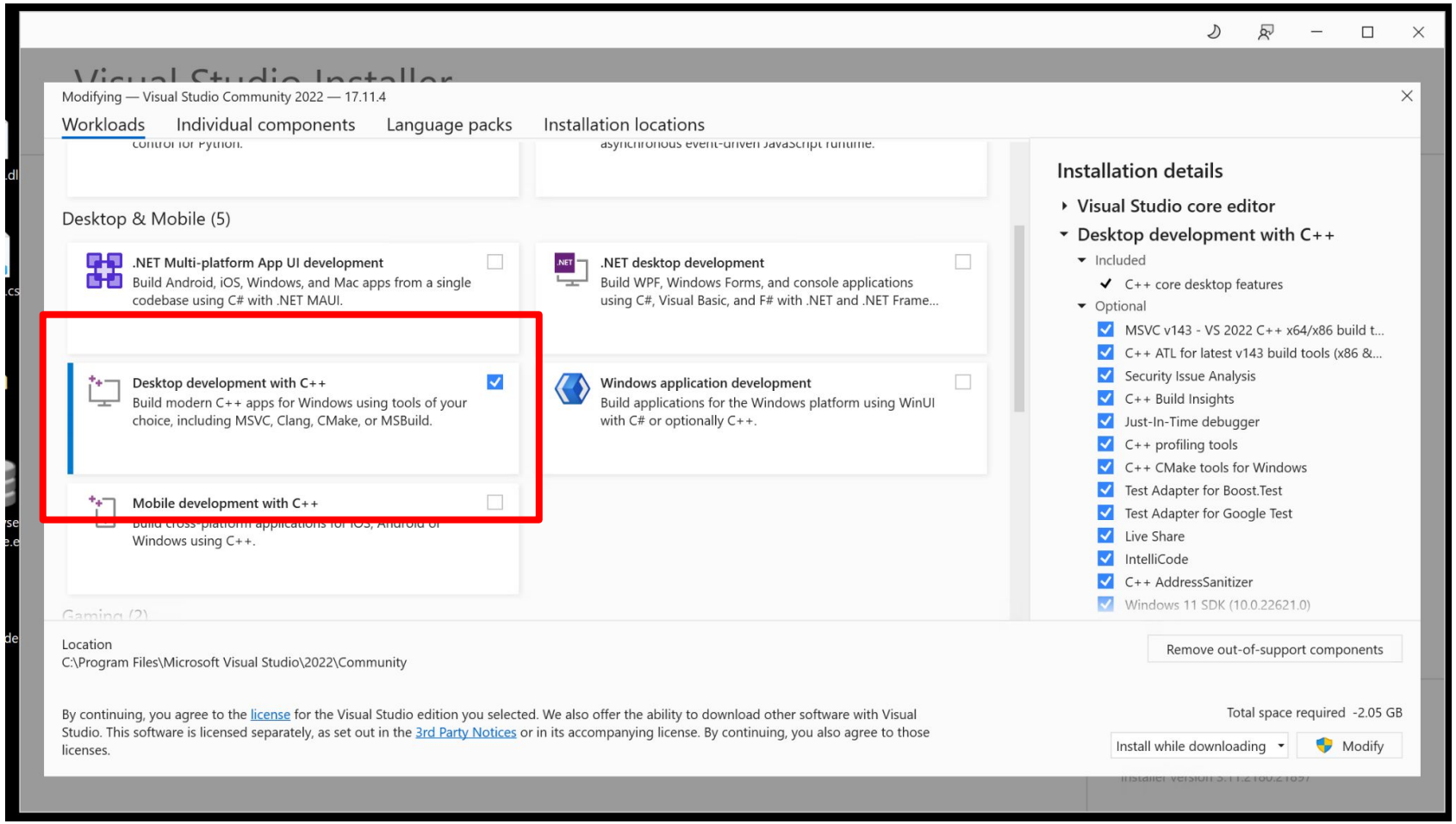
How to debug code

- c

GDB + GEF

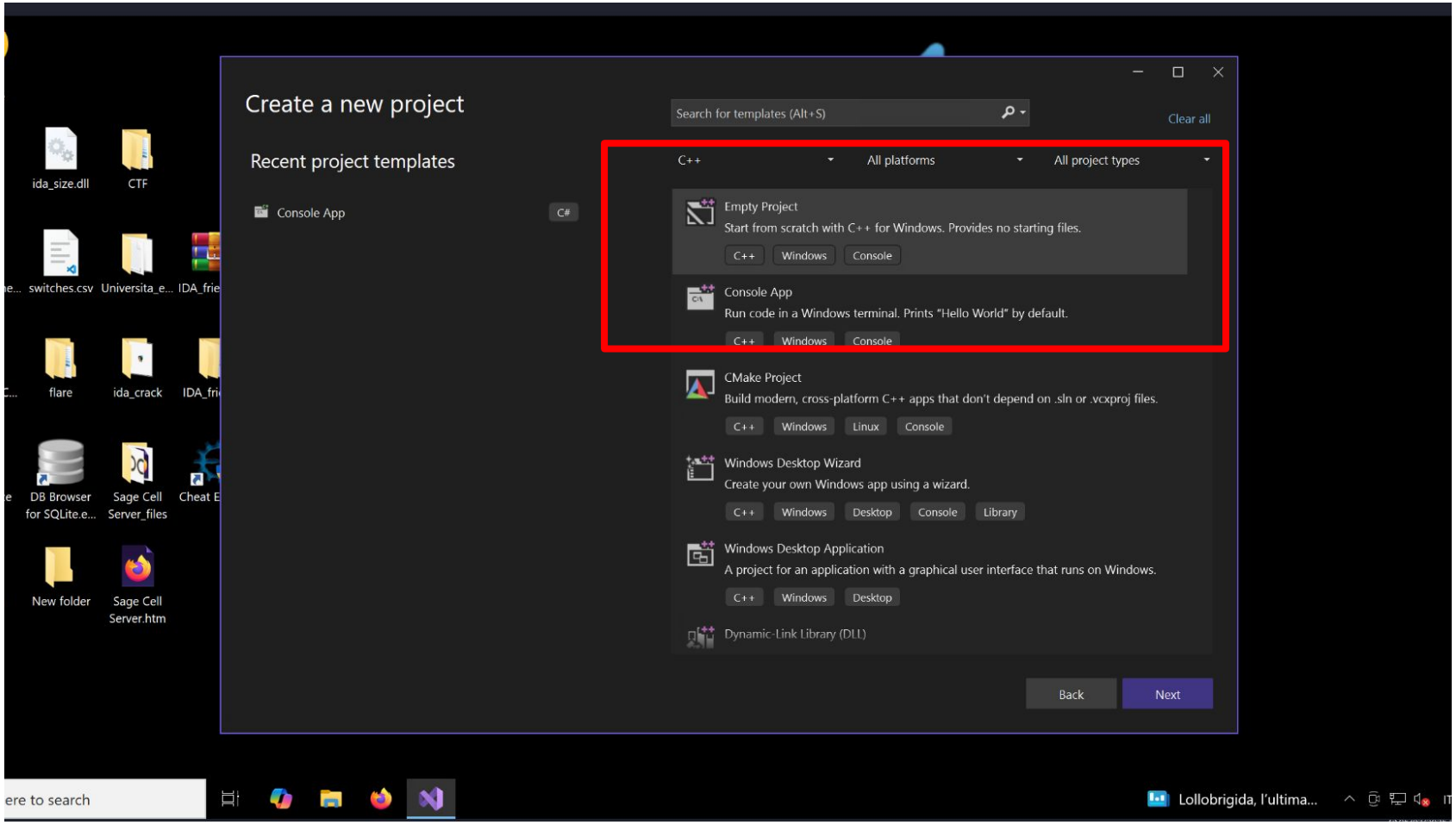
How to run Windows code

- Option 1: use Windows Visual Studio Community



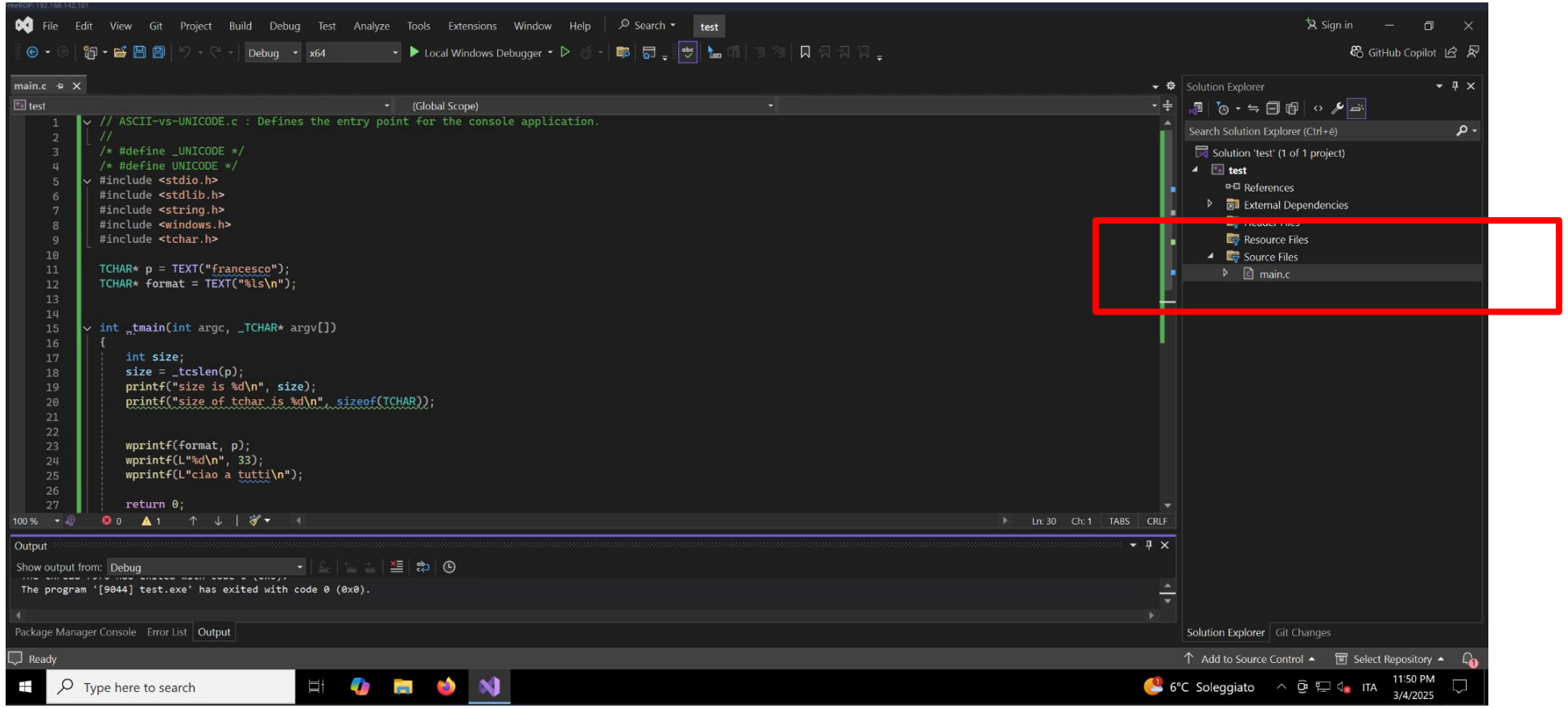
How to run Windows code

- Option 1: use Windows Visual Studio Community



How to run Windows code

- Option 1: use Windows Visual Studio Community



How to run Windows code

- Option 2: Linux -> Windows Cross-Compilation

```
~/projects/sistemi_operativi/PROCESSES-AND-THREADS/WINDOWS sudo apt install mingw-w64
~/projects/sistemi_operativi/PROCESSES-AND-THREADS/WINDOWS x86_64-w64-mingw32-gcc ascii-vs-unicode.c -municode
~/projects/sistemi_operativi/PROCESSES-AND-THREADS/WINDOWS
```

```
~/projects/sistemi_operativi/PROCESSES-AND-THREADS/WINDOWS x86_64-w64-mingw32-gcc ascii-vs-unicode.c -municode
ascii-vs-unicode.c: In function 'main':
ascii-vs-unicode.c:18:24: warning: passing argument 1 of 'strlen' from incompatible pointer type [-Wincompatible-pointer-types]
   18 |         size = _tcslen(p);
      |                        ^
      |                        |
      |                        TCHAR * {aka short unsigned int *}
In file included from ascii-vs-unicode.c:7:
/usr/share/mingw-w64/include/string.h:64:37: note: expected 'const char *' but argument is of type 'TCHAR *' {aka 'short unsigned
   64 |   size_t __cdecl strlen(const char *_Str);
      |                          ~~~~~~~~~~~~~^~~~
/usr/bin/x86_64-w64-mingw32-ld: /usr/lib/gcc/x86_64-w64-mingw32/13-win32/../../../../x86_64-w64-mingw32/lib/libmingw32.a(lib64_lib
ain':
/usr/src/mingw-w64-11                                                                    o `wWinMain'
collect2: error: ld r
~/projects/sistemi_c
```

```
1 // ASCII-vs-UNICODE.c : Defines the entry point for the console a
2 //
3 #define _UNICODE
4 /* #define UNICODE */
5 #include <stdio.h>
6 #include <stdlib.h>
7 #include <string.h>
8 #include <windows.h>
9 #include <tchar.h>
10
11 TCHAR *p = TEXT("francesco");
```

How to run Windows code

- Option 2: Run code with wine

https://gitlab.winehq.org/wine/wine/-/wikis/Debian-Ubuntu

Debian/Ubuntu

Last edited by **Floris Renaud** 2 months ago

Nederlands 简体中文

Although Debian and Ubuntu offer their own Wine packages, they are often several versions behind. To make installing the latest version of Wine as easy as possible, WineHQ has its own Debian/Ubuntu repository. Should a newer version of Wine cause problems, it is also possible to install an older version of your choice.

The WineHQ repository only offers packages for AMD64 and i386. If you need the ARM version, you can use the Debian/Ubuntu packages.

Preparation

- If your system is 64 bit, enable 32 bit architecture:

```
sudo dpkg --add-architecture i386
```

- Make a note of your distribution name:
  Look for the line with either `UBUNTU_CODENAME` or `VERSION_CODENAME`. If both are present, use the name after `UBUNTU_CODENAME`.

```
cat /etc/os-release
```

Add the repository

- Download and add the repository key:

```
sudo mkdir -pm755 /etc/apt/keyrings
wget -O - https://dl.winehq.org/wine-builds/winehq.key | sudo gpg --dearmor -o /etc/apt/keyrings/winehq-archi
```

- Add the repository:
  If your distribution name is not on the list, older packages may be available on the download server. Add **one** repository.

Distribution name	Command
oracular Ubuntu 24.10	`sudo wget -NP /etc/apt/sources.list.d/ https://dl.winehq.org/wine-builds/ubuntu/dists/oracular/winehq-oracular.sources`
noble Ubuntu 24.04 Linux Mint 22	`sudo wget -NP /etc/apt/sources.list.d/ https://dl.winehq.org/wine-builds/ubuntu/dists/noble/winehq-noble.sources`
jammy Ubuntu 22.04	`sudo wget -NP /etc/apt/sources.list.d/ https://dl.winehq.org/wine-builds/ubuntu/dists/jammy/winehq-jammy.sources`

How to run Windows code

- Option 2: Run code with wine

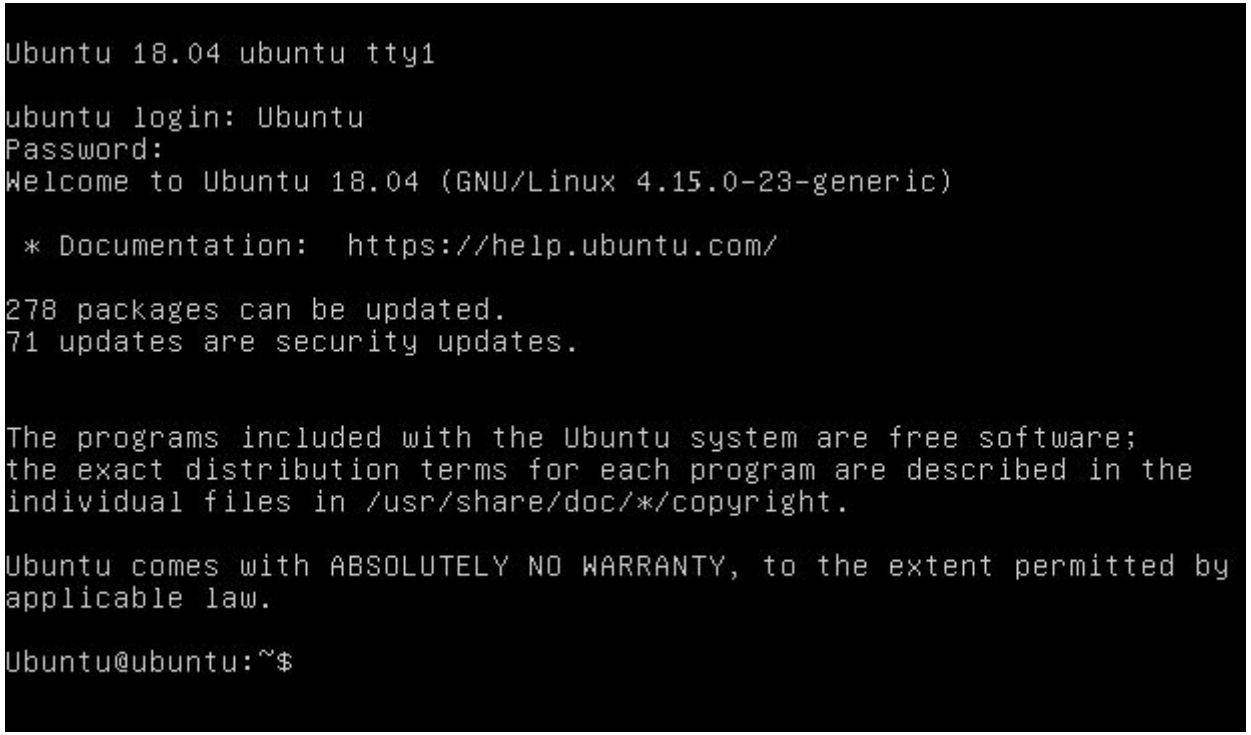
```
~/projects/sistemi_operativi/PROCESSES-AND-THREADS/WINDOWS  x86_64-w64-mingw32-gcc ascii-vs-unicode.c -municode
~/projects/sistemi_operativi/PROCESSES-AND-THREADS/WINDOWS  wine ./a.exe
size is 9
size of tchar is 2
francesco
33
ciao a tutti
~/projects/sistemi_operativi/PROCESSES-AND-THREADS/WINDOWS
```

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’
  - …

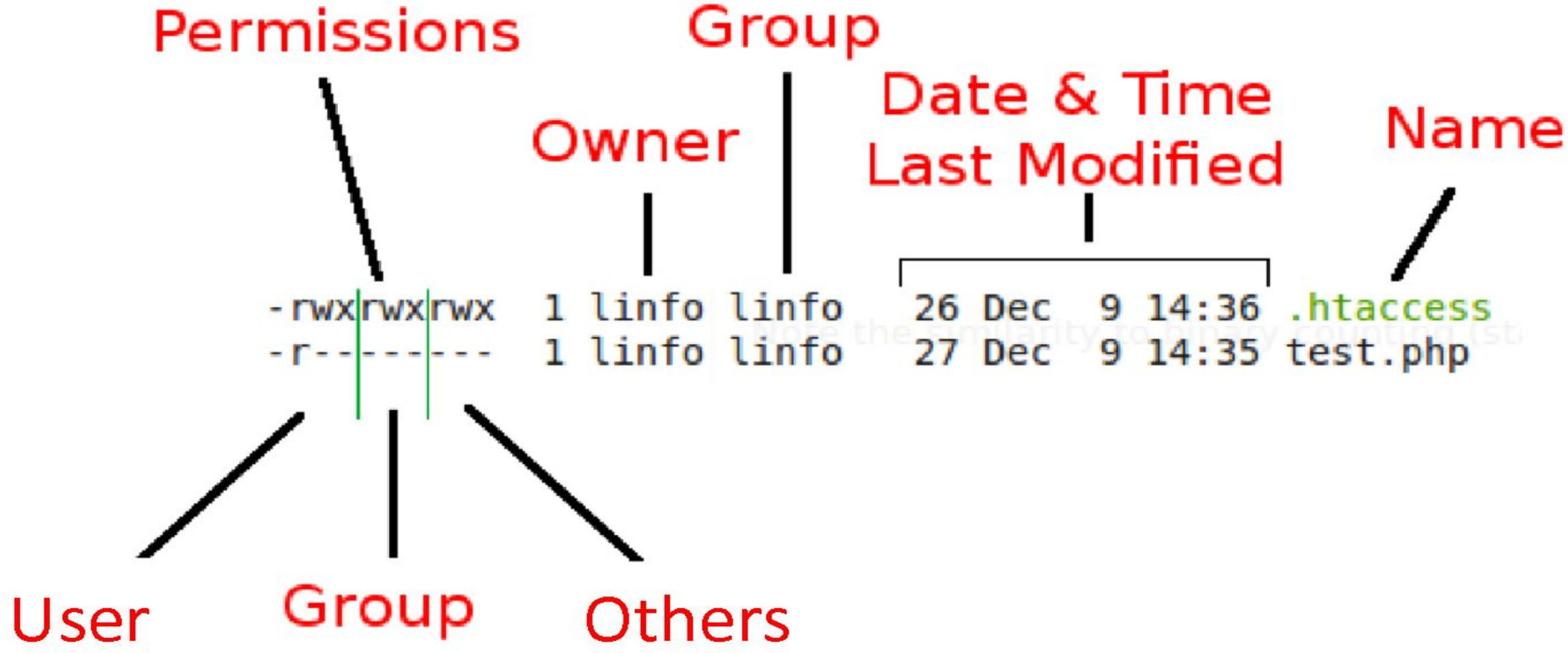
Linux OS – strings

- 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"

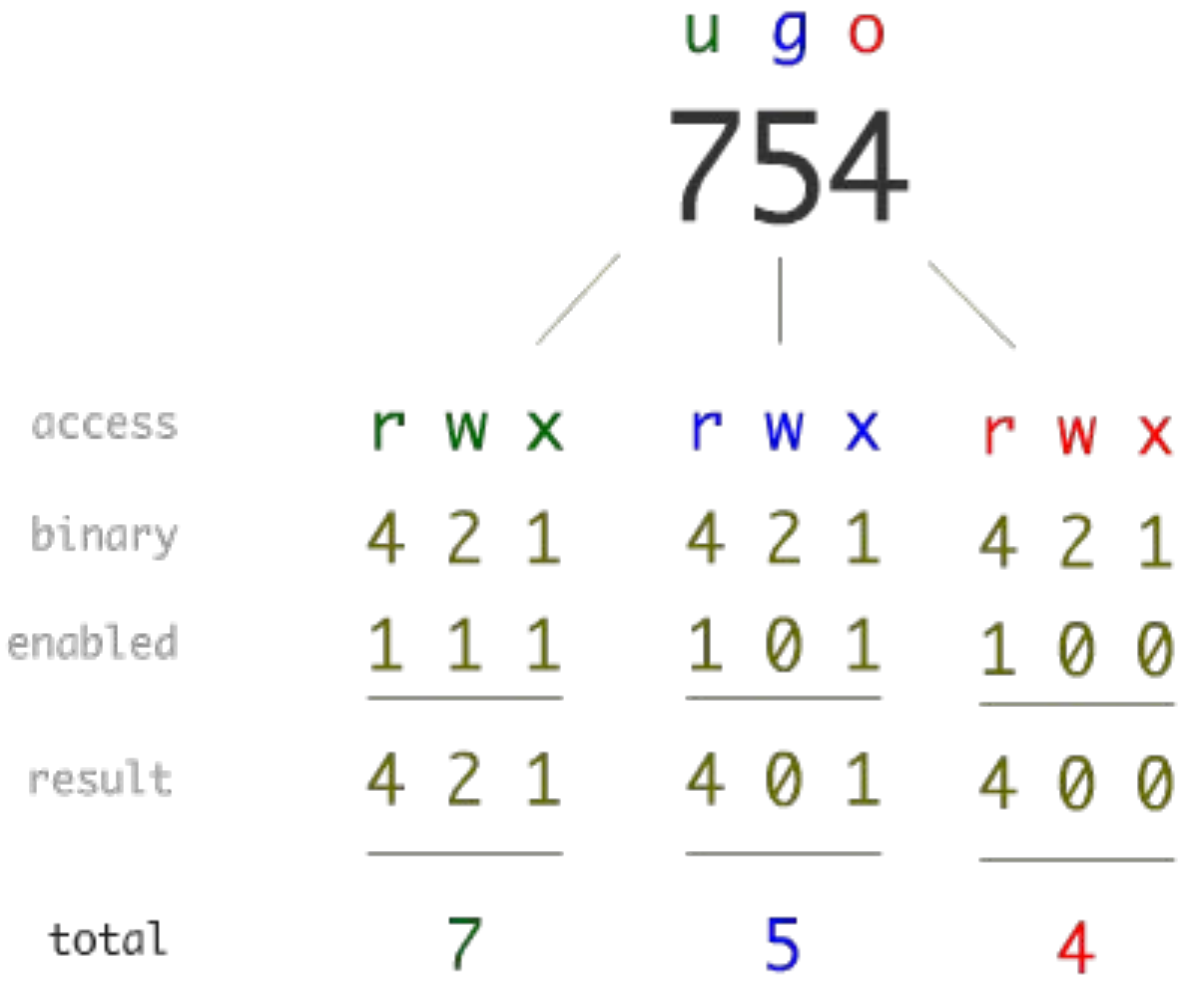
Linux OS – escape sequence

- \” 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

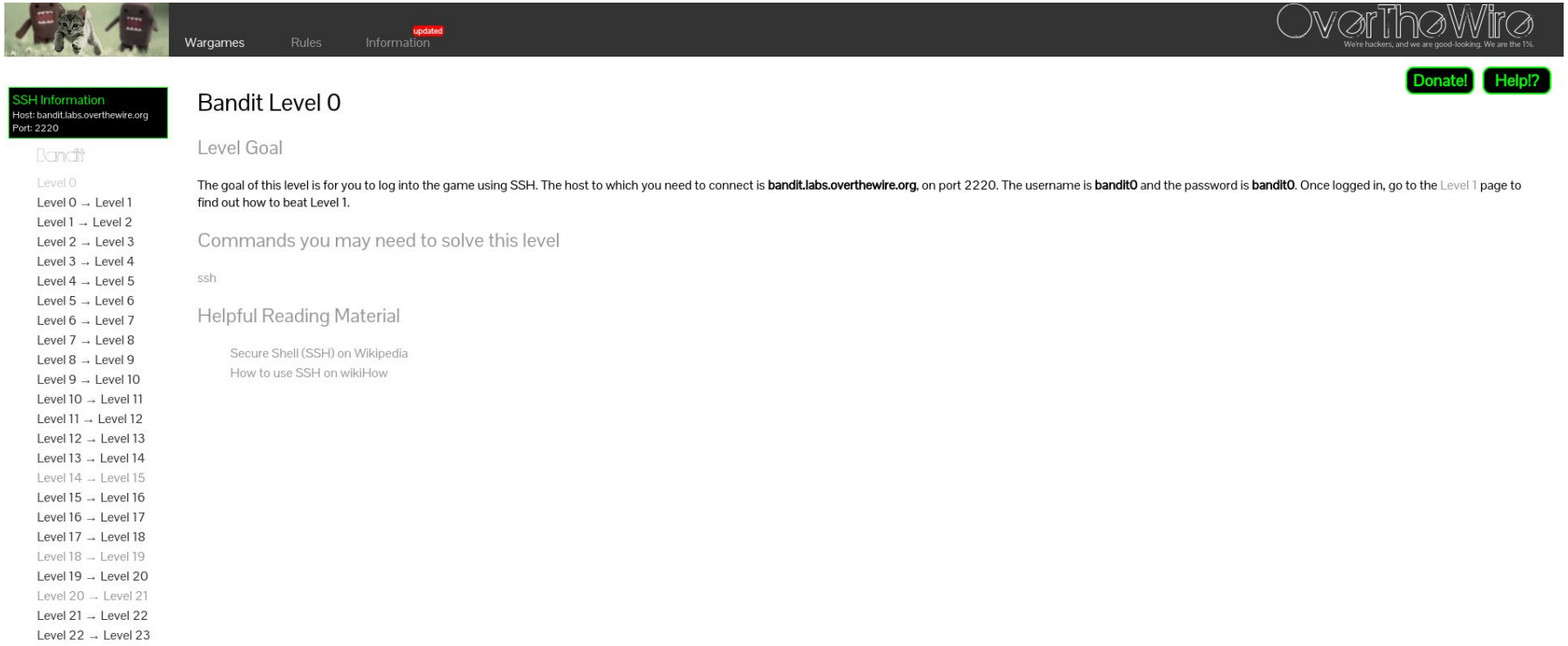
Setuid/Setgid

- 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?