Week 5 – Operating Systems

Student number: 576255

Assignment 5.1: Unix-like

a) Find out what the difference is between UNIX and unix-like operating systems?
  - The term UNIX is used to describe the first OS created at AT&T's Bell Laboratories in the 1960's/1970's and all of its directly certified derivatives; UNIX must meet a specific trademark certification process. The term "Unix-like", however, refers to those systems which act as UNIX and use UNIX type architectures and tools (such as Linux, FreeBSD, and Mac OS X), but may not be directly certified or contain the actual UNIX source code. These systems were "based on" UNIX

b) Study the image above named UNIX timeline. Find out who Ken Thompson, Dennis Ritchie, Bill Joy, Richard Stallman, and Linus Torvalds are and what they have contributed to the development of UNIX or unix-like systems and to IT in general. **TIP!** English-language sources often contain more detailed information about these individuals.
  - **Ken Thompson** was one of the original programmers who developed UNIX at Bell Laboratories; and in addition to this role he developed the B programming language (the predecessor to C), and most recently co-developed the Go programming language for Google.
  - **Dennis Ritchie** developed UNIX along with Ken Thompson. He made significant contributions by developing the C programming language. When Ritchie rewrote UNIX using his newly developed C programming language UNIX became a portable operating system that could run on a variety of hardware platforms.
  - **Bill Joy** is a founder of Sun Microsystems as well as being a primary developer of BSD (Berkeley Software Distribution) UNIX. Bill Joy created the vi text editor that remains a standard text editor found on nearly all Linux distributions.
  - **Richard Stallman** founded both the GNU Project and the Free Software Foundation. Richard Stallman spearheaded the development of a completely free UNIX-like operating system (GNU) as part of a broader movement to develop free software. As part of this movement, Richard Stallman developed many of the most commonly used GNU tools, including the GCC compiler and the Emacs editor.
  - **Linus Torvalds** developed the first version of the Linux kernel in 1991. The Linux kernel that Linus Torvalds developed can be combined with a number of GNU tools to produce the complete Linux operating system that is commonly distributed today (e.g., Ubuntu).

c) What is the philosophy of the GNU movement?
  - In terms of its philosophy, the movement advocates for "free software" (i.e., freedom, not cost). The movement believes that users should have the right to freely operate, duplicate, distribute, examine, modify and enhance the software. This view is in opposition to the restrictive practices associated with proprietary software.

d) Does Ubuntu as a Linux operating system conform to the philosophy of the GNU movement? Please explain your answer.

- In part. Ubuntu is based upon the Linux Kernel as well as the GNU toolset (thus it is an open source product). However, in order for users to have a better experience, ubuntu also contains proprietary blobs (drivers) as well as other non-free software products (e.g. codecs and steam). Therefore, while the core of the operating system is free, the Free Software Foundation (FSF) specifically through the GNU movement has no endorsement for Ubuntu due to its encouragement of the use of non-free software.

e) Find out what is the Windows Subsystem for Linux?

- WSL (Windows Subsystem for Linux) is a compatibility layer with which you can create a Linux Environment (like Ubuntu) within Windows 10 and 11 and run it on top of it (without using a Virtual Machine or having to dual boot).

f) Find out, which operating system family belongs to Android, iOS and ChromeOS?

- **Android**: Belongs to the Linux family (it uses a modified Linux kernel).
- **iOS**: Belongs to the Unix-like family (specifically based on Darwin/BSD, similar to macOS).
- **ChromeOS**: Belongs to the Linux family (built on top of the Linux kernel).

Assignment 5.2: Supercomputers and gameconsoles

a) Research on this site what supercomputers are used for and write a short summary of it: https://www.computerhistory.org/timeline/search/?q=Supercomputer

- Supercomputers are primarily used for complex simulations and calculations that require massive processing power. Common uses include:
  - **Weather forecasting** and climate modeling
  - **Scientific research** (e.g., simulating the evolution of the universe or drug discovery)
  - **National security** tasks like cryptology (breaking codes) and nuclear simulations

b) IBM is a company that has already built a number of supercomputers. One of them is IBM's Roadrunner. The CPU developed for this supercomputer was further developed at a later stage as the CPU for the PlayStation 3 console. Find out what a **PlayStation 3 cluster** is and what it was used for?

- The use of a number of interconnected PlayStation 3 consoles for a supercomputer is called a “PS3 cluster.” The use of this configuration was made feasible due to the fact that the PS3 employed a version of the Cell Broadband Engine (CBE) processor. This CBE processor is also used in IBM’s Roadrunner supercomputer.
  - **Example of use**: The United States Air Force created the “Condor Cluster,” which utilized 1,760 PlayStation 3 consoles to provide an analysis tool for high definition images from satellites. The Air Force chose this solution because it provided both cost savings and energy efficiency compared to building a supercomputer using standard architectures at that point in time.

c) You can build a supercomputer by putting a few computers together in a cluster. Here's what Oracle did with a collection of Raspberry Pi's, for example: https://blogs.oracle.com/developers/post/building-the-worlds-largest-raspberry-pi-cluster
What specific operating system is running on this cluster?

- The cluster runs **Oracle Autonomous Linux** (or simply Oracle Linux)
  - This is a version of the **Linux** operating system family I studied, optimized for the ARM architecture of the Raspberry Pi

d) Does Oracle's Raspberry Pi supercomputer appear in the list of the 500 fastest supercomputers in the world? Make a logical decision for this, without going through the entire list. https://www.top500.org/lists/top500/list/2023/06/

- **Reason for Logical Decision**: The 1,060 Raspberry Pis seem many, however, each is powered by an ARM-based mobile processor which is significantly slower than the massive processor of a typical Top500 machine. A Top500 supercomputer can perform at speeds of Petaflops or Exaflops, where as, a Raspberry Pi cluster would be performing at a Teraflop speed; thus, it is too slow to make the Top500.

e) What CPU architecture is used for the PlayStation 5 and Xbox Series X?

- Both the PlayStation 5 and the Xbox Series X utilize an x86-64 architecture (using custom AMD Zen 2 processors).

What operating systems run on these consoles?

- The Xbox Series X runs a proprietary operating system called Xbox System Software, which is heavily modified from a base of Windows
- The PlayStation 5 uses a proprietary operating system built upon FreeBSD (a Unix-like OS)

What conclusion can you draw from the answer to the previous question?

- In contrast to the original PlayStation 3 which utilized the unique “cell” architecture, today’s gaming consoles all use the same type of processor as computers (i.e., x86) which essentially make them just very powerful computer systems. Therefore, developers can easily create applications for these devices by writing code for a very specific platform (unlike the Cell-based architecture used in the original PS3, as explained in Week 5 in reference to “No OS”, versus “Modern OS”).

Assignment 5.3: Working with Windows

Take relevant screenshots of the assignments below

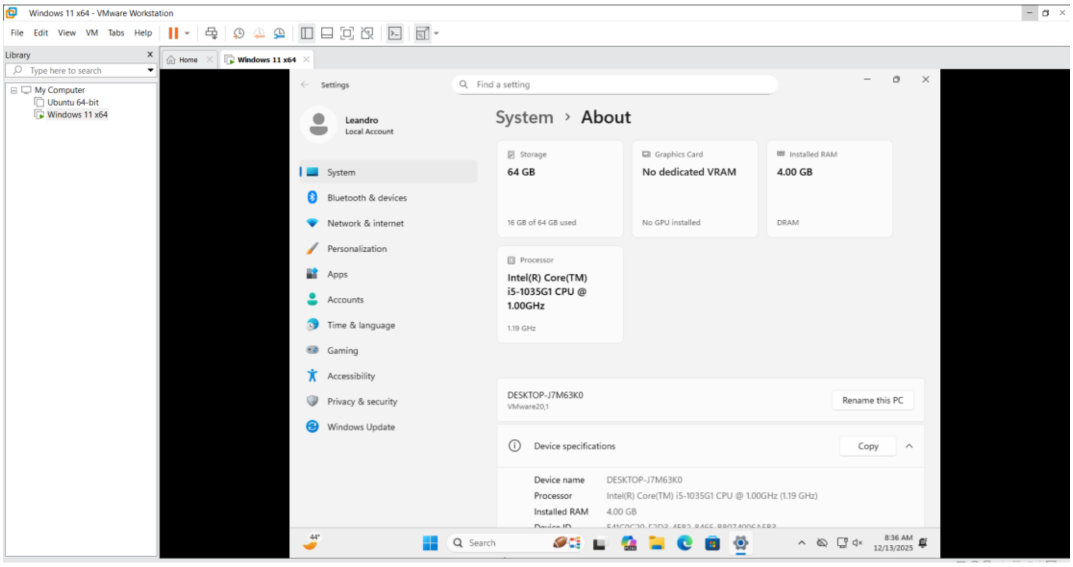
a) Practice for about 10 minutes with the ⊞ keyboard shortcuts combinations, skip the general shortcuts in this exercise. Take a look at which screens are opened.

- I practiced with several shortcuts, such as Win + D to minimize everything and show the desktop, and Win + A to open the Action Center.

b) The file explorer can be opened with ⊞ + E, Which key combination could you also use?

- Besides Win + E, I can also use the key combination **Win + X, then E**

c) Open the system properties with a ⊞ key combination, take a screenshot of the open screen. Paste this screenshot into this template.



System › About

Storage: 64 GB — 16 GB of 64 GB used

Graphics Card: No dedicated VRAM — No GPU installed

Installed RAM: 4.00 GB — DRAM

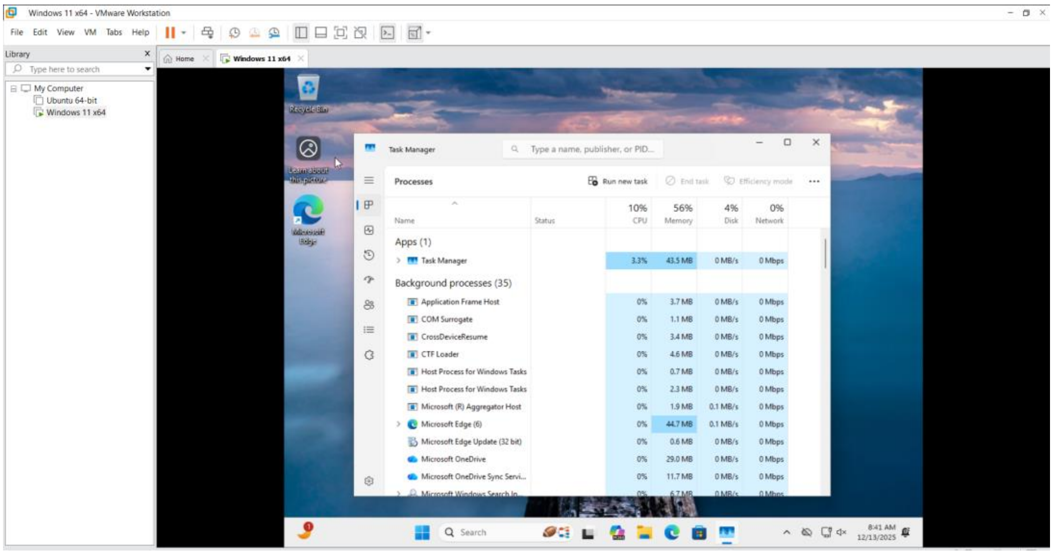
Processor: Intel(R) Core(TM) i5-1035G1 CPU @ 1.00GHz — 1.19 GHz

DESKTOP-J7M63K0
VMware20,1

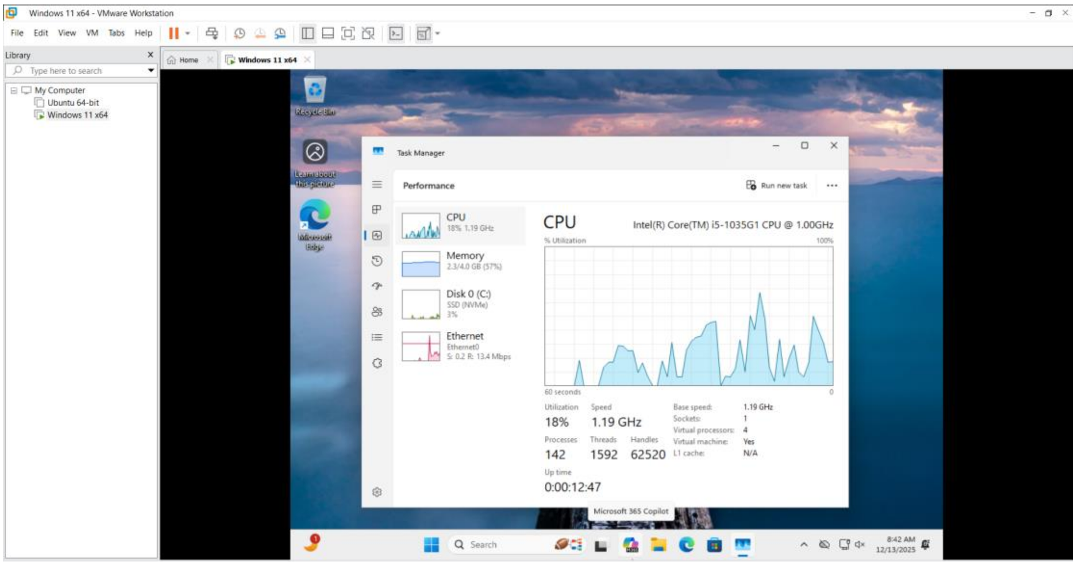
Device specifications

Device name DESKTOP-J7M63K0
Processor Intel(R) Core(TM) i5-1035G1 CPU @ 1.00GHz (1.19 GHz)
Installed RAM 4.00 GB

d) Open task manager with a key combination. Take screenshots of the tabs: processes (shows active processes), performance, and users. Place these three screenshots in this template.



Name	Status	10% CPU	56% Memory	4% Disk	0% Network
Apps (1)					
Task Manager		3.3%	43.5 MB	0 MB/s	0 Mbps
Background processes (35)					
Application Frame Host		0%	3.7 MB	0 MB/s	0 Mbps
COM Surrogate		0%	1.1 MB	0 MB/s	0 Mbps
CrossDeviceResume		0%	3.4 MB	0 MB/s	0 Mbps
CTF Loader		0%	4.6 MB	0 MB/s	0 Mbps
Host Process for Windows Tasks		0%	0.7 MB	0 MB/s	0 Mbps
Host Process for Windows Tasks		0%	2.3 MB	0 MB/s	0 Mbps
Microsoft (R) Aggregator Host		0%	1.9 MB	0.1 MB/s	0 Mbps
Microsoft Edge (6)		0%	44.7 MB	0.1 MB/s	0 Mbps
Microsoft Edge Update (32 bit)		0%	0.6 MB	0 MB/s	0 Mbps
Microsoft OneDrive		0%	29.0 MB	0 MB/s	0 Mbps
Microsoft OneDrive Sync Servi...		0%	11.7 MB	0 MB/s	0 Mbps
Microsoft Windows Search In...		0%	6.7 MB	0 MB/s	0 Mbps



CPU 18% 1.19 GHz

Memory 2.3/4.0 GB (57%)

Disk 0 (C:) SSD (NVMe) 3%

Ethernet Ethernet0 S: 0.2 R: 13.4 Mbps

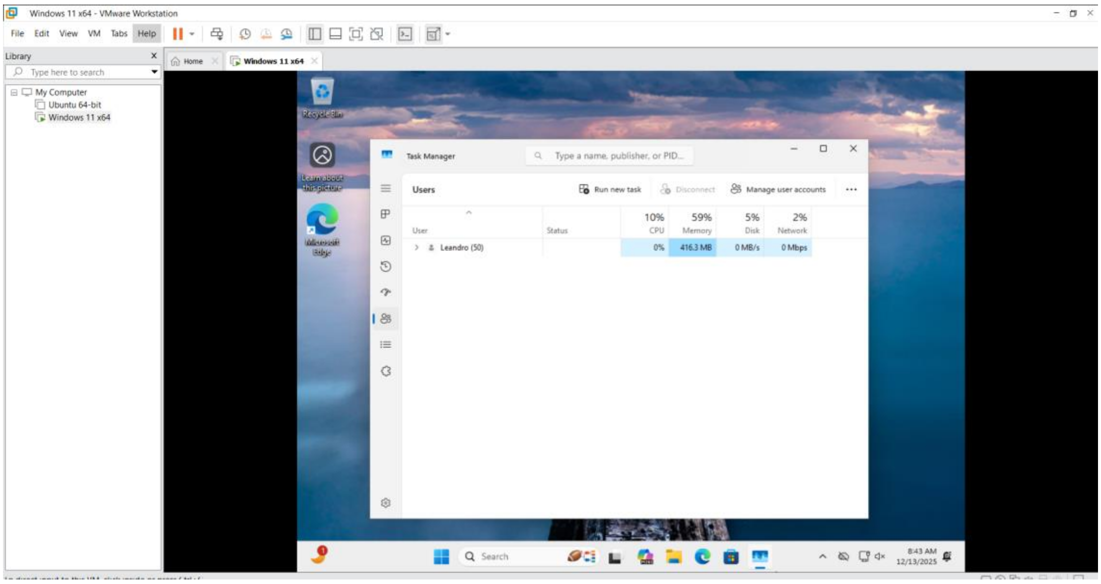
CPU Intel(R) Core(TM) i5-1035G1 CPU @ 1.00GHz

% Utilization 100%

60 seconds 0

Utilization	Speed		Base speed:	1.19 GHz
18%	1.19 GHz		Sockets:	1
			Virtual processors:	4
Processes	Threads	Handles	Virtual machine:	Yes
142	1592	62520	L1 cache:	N/A

Up time
0:00:12:47



User	Status	10% CPU	59% Memory	5% Disk	2% Network
Leandro (50)		0%	416.3 MB	0 MB/s	0 Mbps

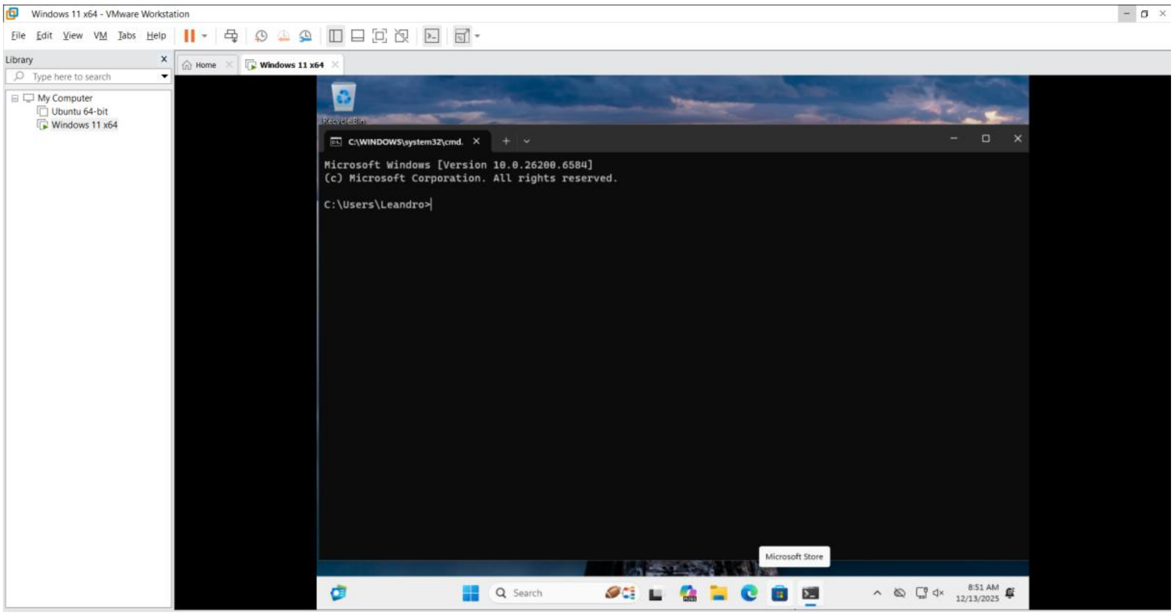
e) If you're giving a PowerPoint presentation and you connect your laptop to a projector, Windows can use the projector as a second screen. For example, you may have Outlook open on your first screen that you don't show over the projector, while the PowerPoint presentation is displayed on the projector, or the second screen. Which key combination should you use for this?

- I should use the key combination **Windows Key + P**

f) If you leave the classroom for a while and you leave your laptop behind, it is wise to lock the screen. Your Apps will continue to run in the background. So, for example, if you're waiting for a download that takes a while, lock the screen and get a cup of coffee. Which key combination do you use for this?

- I use the key combination **Windows Key + L**

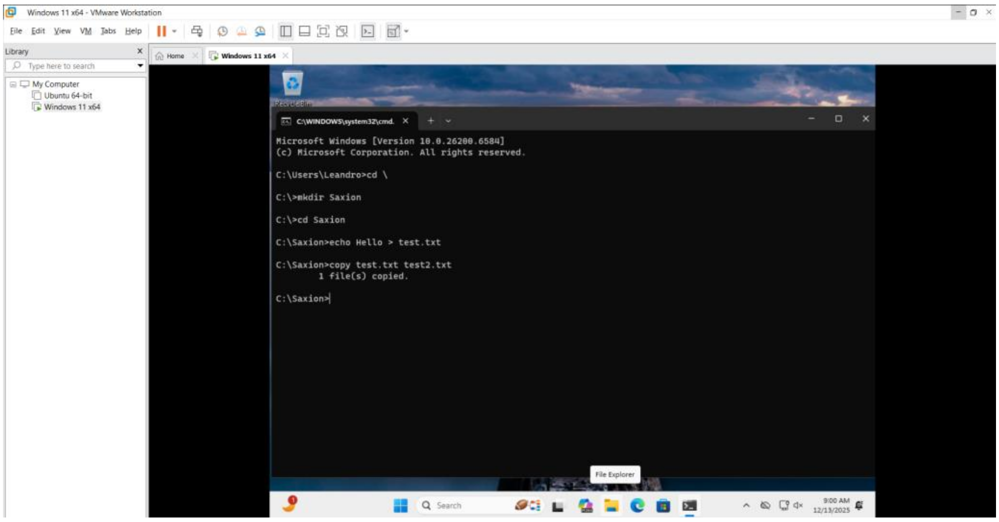
g) Open the Run screen with a key combination. On this screen, type CMD and press <enter>. Take a screenshot of this result and paste it into this template.



```
Microsoft Windows [Version 10.0.26200.6584]
(c) Microsoft Corporation. All rights reserved.

C:\Users\Leandro>
```

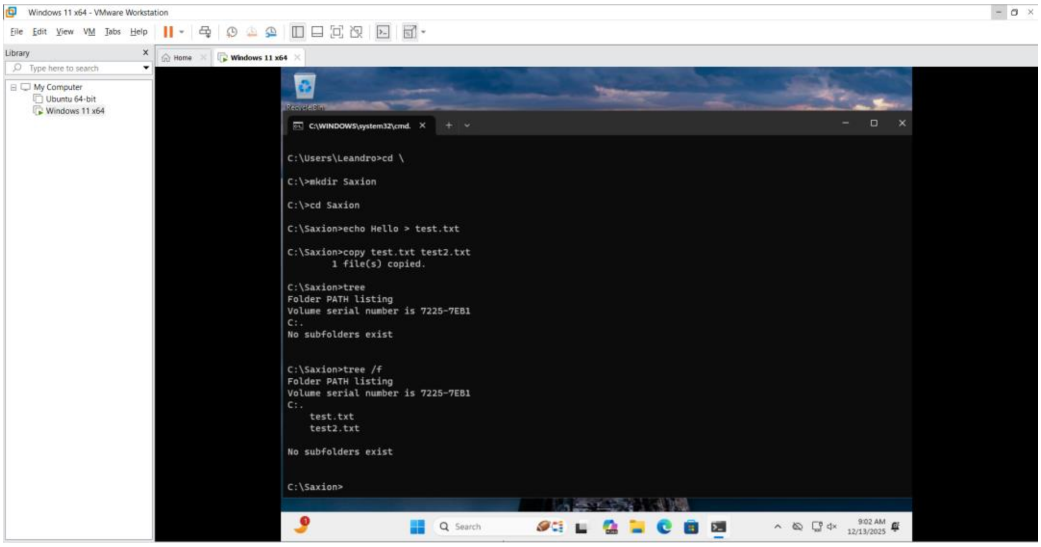
Working in the File Explorer

Relevant screenshots **copy** command:



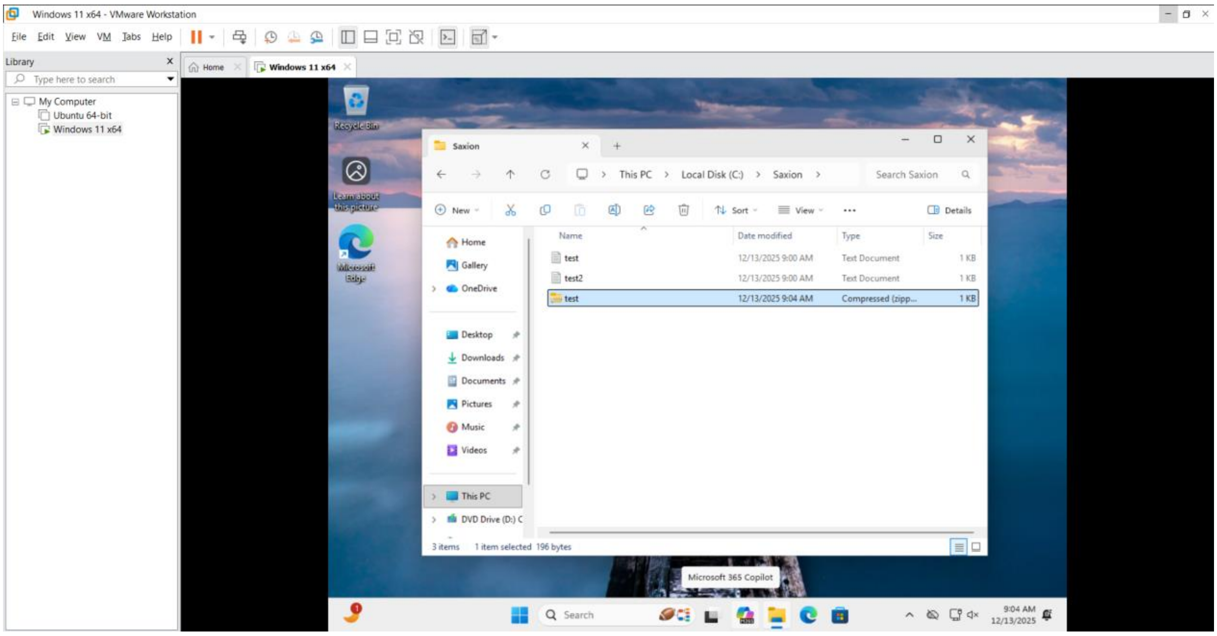
```
Microsoft Windows [Version 10.0.26200.6584]
(c) Microsoft Corporation. All rights reserved.

C:\Users\Leandro>cd \

C:\>mkdir Saxion

C:\>cd Saxion

C:\Saxion>echo Hello > test.txt

C:\Saxion>copy test.txt test2.txt
        1 file(s) copied.

C:\Saxion>
```

Relevant screenshots **tree** command:



```
C:\Users\Leandro>cd \

C:\>mkdir Saxion

C:\>cd Saxion

C:\Saxion>echo Hello > test.txt

C:\Saxion>copy test.txt test2.txt
        1 file(s) copied.

C:\Saxion>tree
Folder PATH listing
Volume serial number is 7225-7EB1
C:.
No subfolders exist


C:\Saxion>tree /f
Folder PATH listing
Volume serial number is 7225-7EB1
C:.
    test.txt
    test2.txt

No subfolders exist


C:\Saxion>
```

Relevant screenshots in the file explorer of the folder c:\Saxion + created zip file.

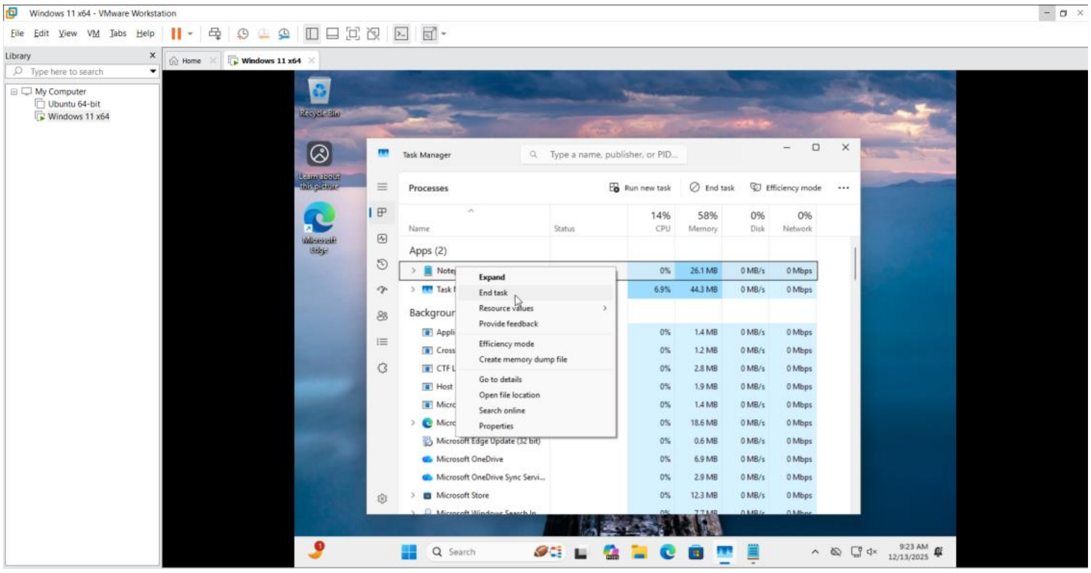


Name	Date modified	Type	Size
test	12/13/2025 9:00 AM	Text Document	1 KB
test2	12/13/2025 9:00 AM	Text Document	1 KB
test	12/13/2025 9:04 AM	Compressed (zipp...	1 KB

3 items 1 item selected 196 bytes

Terminating Processes

Relevant Screenshots Task Manager Window:

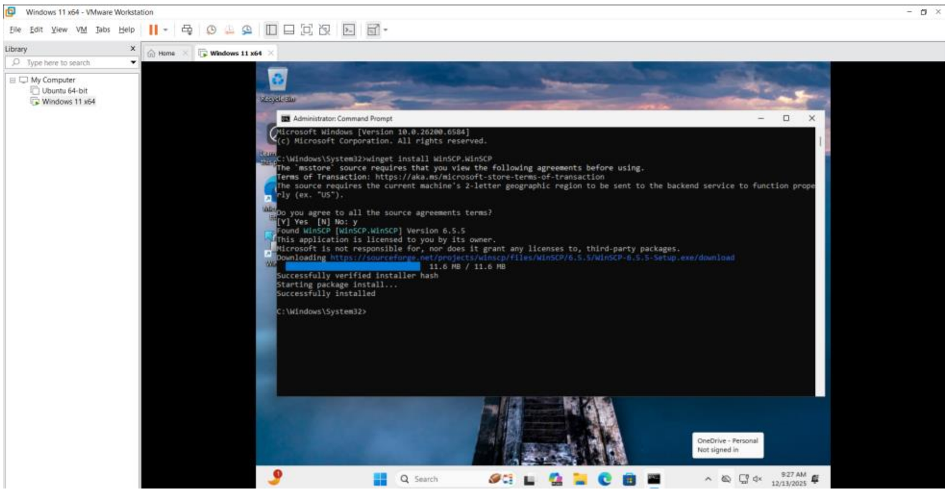


Name	Status	14% CPU	58% Memory	0% Disk	0% Network
Apps (2)					
Note		0%	26.1 MB	0 MB/s	0 Mbps
Task I		6.9%	44.3 MB	0 MB/s	0 Mbps
Backgrour					
Appli		0%	1.4 MB	0 MB/s	0 Mbps
Cross		0%	1.2 MB	0 MB/s	0 Mbps
CTF L		0%	2.8 MB	0 MB/s	0 Mbps
Host		0%	1.9 MB	0 MB/s	0 Mbps
Micro		0%	1.4 MB	0 MB/s	0 Mbps
Micro		0%	18.6 MB	0 MB/s	0 Mbps
Microsoft Edge Update (32 bit)		0%	0.6 MB	0 MB/s	0 Mbps
Microsoft OneDrive		0%	6.9 MB	0 MB/s	0 Mbps
Microsoft OneDrive Sync Servi...		0%	2.9 MB	0 MB/s	0 Mbps
Microsoft Store		0%	12.3 MB	0 MB/s	0 Mbps
Microsoft Windows Search In...		0%	7.7 MB	0 MB/s	0 Mbps

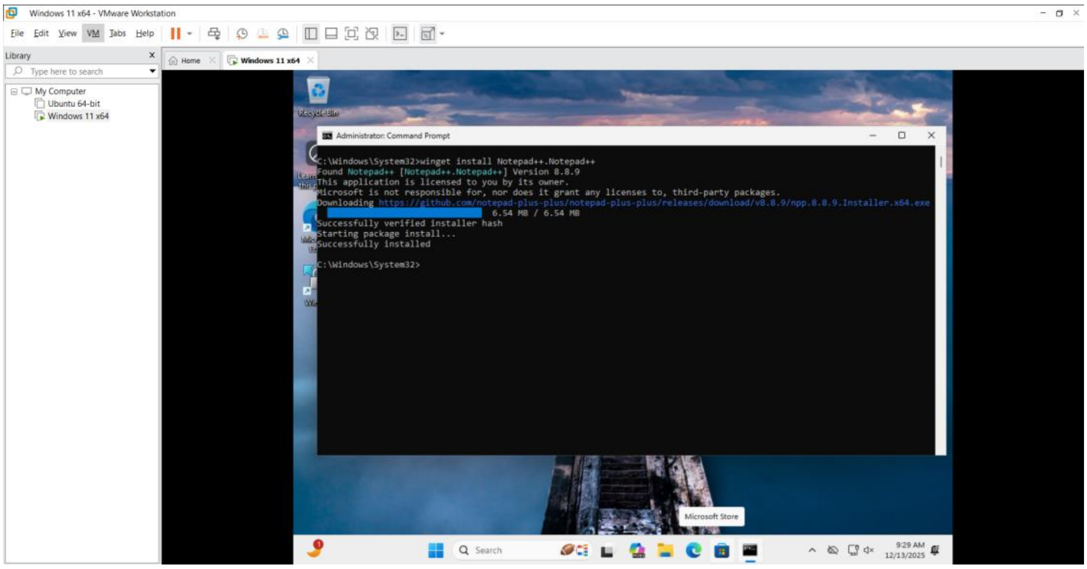
Install Software

Relevant screenshots that the following software is installed with winget:

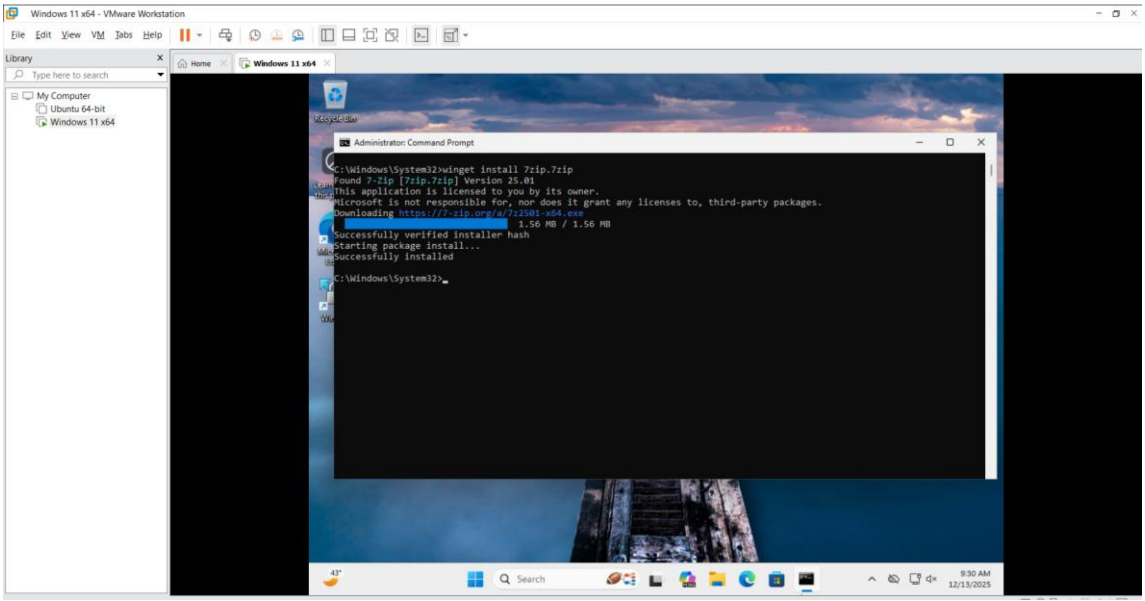
- WinSCP
- Notepad++
- 7zip



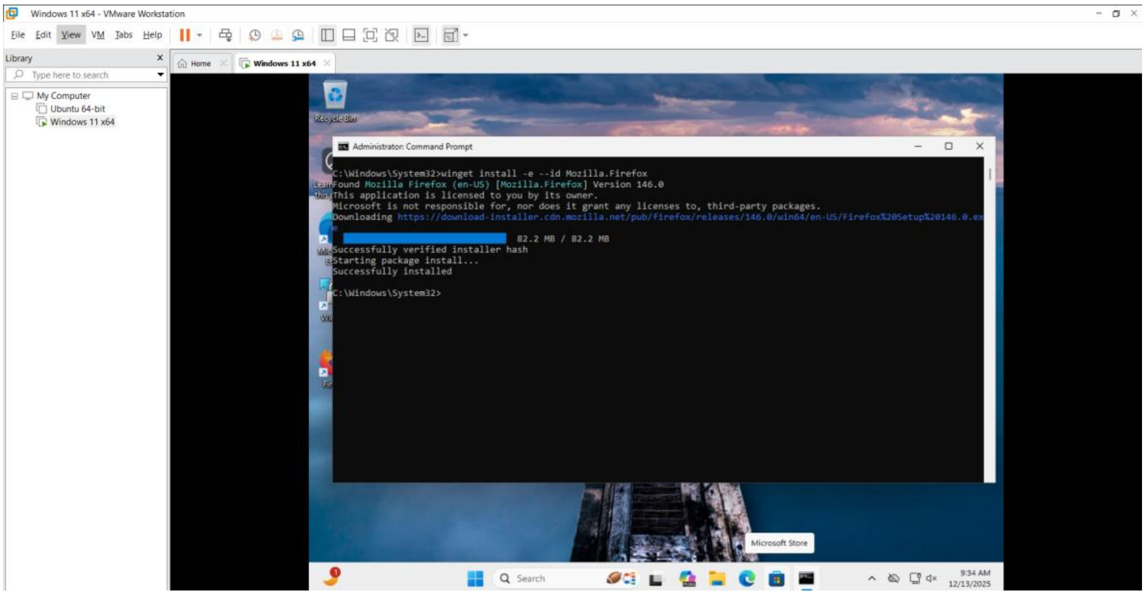
```
Microsoft Windows [Version 10.0.26200.6584]
(c) Microsoft Corporation. All rights reserved.

C:\Windows\System32>winget install WinSCP.WinSCP
The `msstore` source requires that you view the following agreements before using.
Terms of Transaction: https://aka.ms/microsoft-store-terms-of-transaction
The source requires the current machine's 2-letter geographic region to be sent to the backend service to function prope
rly (ex. "US").

Do you agree to all the source agreements terms?
[Y] Yes  [N] No: y
Found WinSCP [WinSCP.WinSCP] Version 6.5.5
This application is licensed to you by its owner.
Microsoft is not responsible for, nor does it grant any licenses to, third-party packages.
Downloading https://sourceforge.net/projects/winscp/files/WinSCP/6.5.5/WinSCP-6.5.5-Setup.exe/download
  ██████████████████████████████  11.6 MB / 11.6 MB
Successfully verified installer hash
Starting package install...
Successfully installed

C:\Windows\System32>
```



```
C:\Windows\System32>winget install Notepad++.Notepad++
Found Notepad++ [Notepad++.Notepad++] Version 8.8.9
This application is licensed to you by its owner.
Microsoft is not responsible for, nor does it grant any licenses to, third-party packages.
Downloading https://github.com/notepad-plus-plus/notepad-plus-plus/releases/download/v8.8.9/npp.8.8.9.Installer.x64.exe
                                6.54 MB / 6.54 MB
Successfully verified installer hash
Starting package install...
Successfully installed

C:\Windows\System32>
```



```
C:\Windows\System32>winget install 7zip.7zip
Found 7-Zip [7zip.7zip] Version 25.01
This application is licensed to you by its owner.
Microsoft is not responsible for, nor does it grant any licenses to, third-party packages.
Downloading https://7-zip.org/a/7z2501-x64.exe
                                1.56 MB / 1.56 MB
Successfully verified installer hash
Starting package install...
Successfully installed

C:\Windows\System32>
```

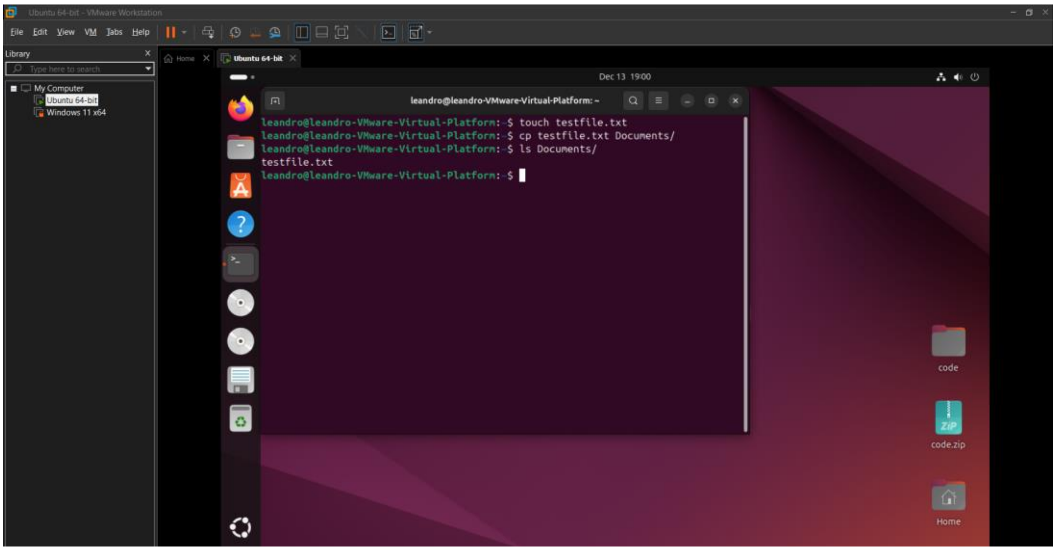


```
C:\Windows\System32>winget install -e --id Mozilla.Firefox
Found Mozilla Firefox (en-US) [Mozilla.Firefox] Version 146.0
This application is licensed to you by its owner.
Microsoft is not responsible for, nor does it grant any licenses to, third-party packages.
Downloading https://download-installer.cdn.mozilla.net/pub/firefox/releases/146.0/win64/en-US/Firefox%20Setup%20146.0.ex
e
                                82.2 MB / 82.2 MB
Successfully verified installer hash
Starting package install...
Successfully installed

C:\Windows\System32>
```

Assignment 5.4: Working with Linux

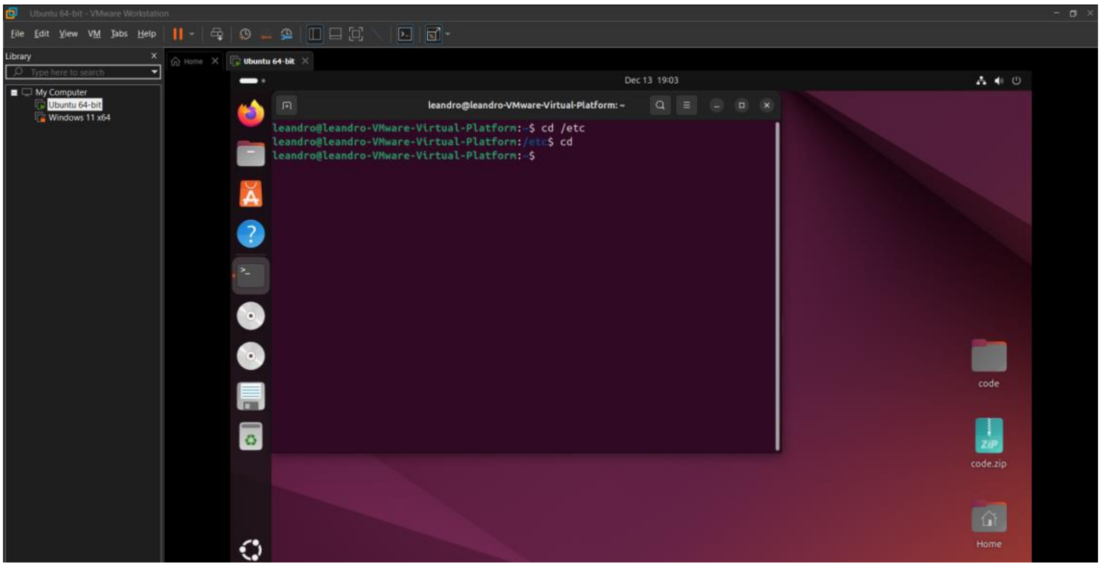
Relevant screenshots + motivation

1. Copying Files



```
leandro@leandro-VMware-Virtual-Platform:~$ touch testfile.txt
leandro@leandro-VMware-Virtual-Platform:~$ cp testfile.txt Documents/
leandro@leandro-VMware-Virtual-Platform:~$ ls Documents/
testfile.txt
leandro@leandro-VMware-Virtual-Platform:~$ 
```

2. Navigating the File Structure

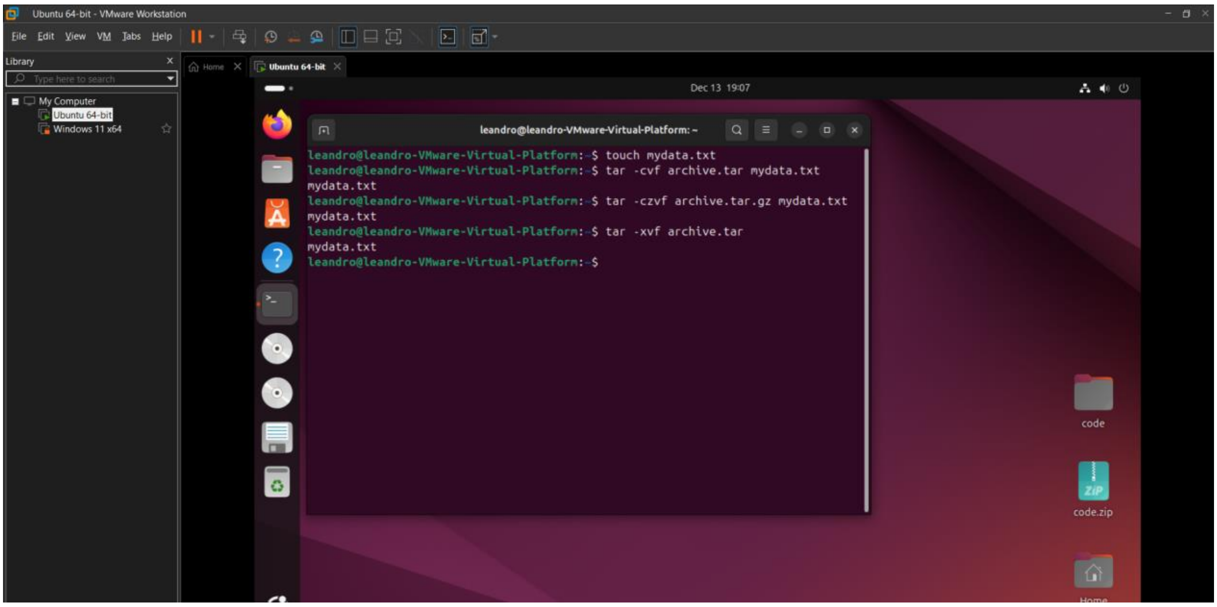


```
leandro@leandro-VMware-Virtual-Platform:~$ cd /etc
leandro@leandro-VMware-Virtual-Platform:/etc$ cd
leandro@leandro-VMware-Virtual-Platform:~$
```

Motivation:

- **How to navigate to your home directory**: you can issue the cd ~ or simply cd then enter commands in terminal. the tilde(~) represents the users home directory.
- **Key differences with windows**: linux has one hierarchical directory structure that begins at "root", which is /, while windows uses the drive letter paradigm (i.e., c:, d:) to separate different disk partitions. additionally, linux uses the forward slash (/) as path separators, while windows uses the backward slash (\).
- **What does /etc contain**: /etc is where all of the configuration files and startup/shutdown shell scripts that are system wide are located.

3. Compress Files

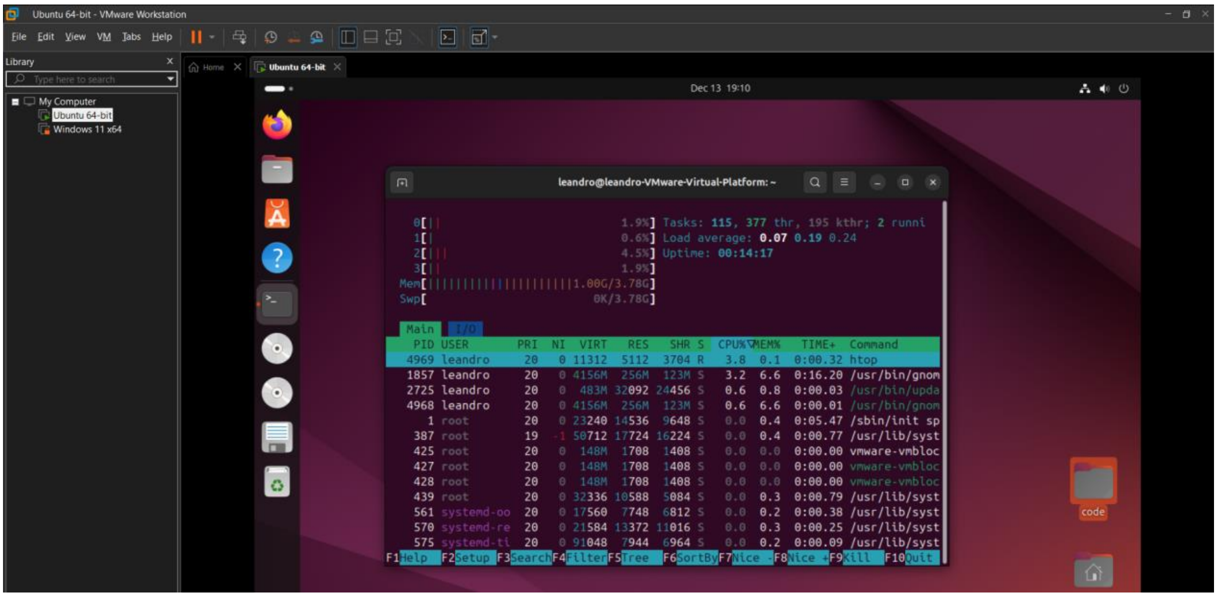


```
leandro@leandro-VMware-Virtual-Platform:~$ touch mydata.txt
leandro@leandro-VMware-Virtual-Platform:~$ tar -cvf archive.tar mydata.txt
mydata.txt
leandro@leandro-VMware-Virtual-Platform:~$ tar -czvf archive.tar.gz mydata.txt
mydata.txt
leandro@leandro-VMware-Virtual-Platform:~$ tar -xvf archive.tar
mydata.txt
leandro@leandro-VMware-Virtual-Platform:~$
```

Motivation:

- **Command to compress to tar**: tar -cvf archive_name.tar file_to_compress
- **Command to extract**: tar -xvf archive_name.tar
- **Gzip explanation**: To compress a file into a tar archive and use gzip compression simultaneously, we use the -z flag. The command is tar -czvf archive.tar.gz filename.

4. View Processes (htop)



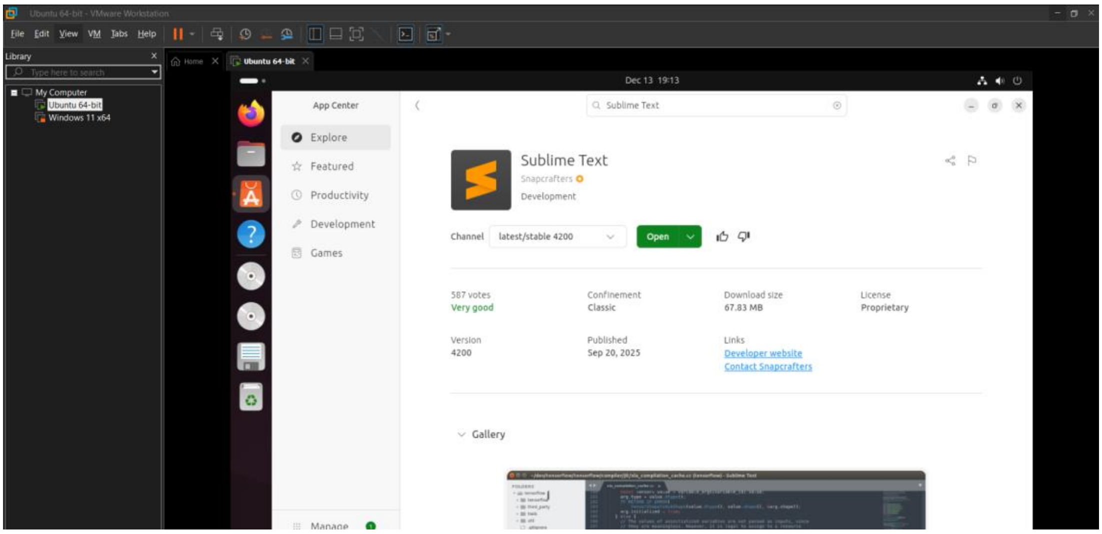
Ubuntu 64-bit - VMware Workstation
File Edit View VM Tabs Help
Library
Type here to search
My Computer
Ubuntu 64-bit
Windows 11 x64
Home
Ubuntu 64-bit
Dec 13 19:10
leandro@leandro-VMware-Virtual-Platform: ~
code

```
    0[||                       1.9%] Tasks: 115, 377 thr, 195 kthr; 2 runni
    1[|                        0.6%] Load average: 0.07 0.19 0.24
    2[|||                      4.5%] Uptime: 00:14:17
    3[||                       1.9%]
  Mem[||||||||||||||||||||1.00G/3.78G]
  Swp[                      0K/3.78G]

  Main  I/O
    PID USER       PRI  NI  VIRT   RES   SHR S  CPU%▽MEM%   TIME+  Command
   4969 leandro     20   0 11312  5112  3704 R   3.8  0.1  0:00.32 htop
   1857 leandro     20   0 4156M  256M  123M S   3.2  6.6  0:16.20 /usr/bin/gnom
   2725 leandro     20   0  483M 32092 24456 S   0.6  0.8  0:00.03 /usr/bin/upda
   4968 leandro     20   0 4156M  256M  123M S   0.6  6.6  0:00.01 /usr/bin/gnom
      1 root        20   0 23240 14536  9648 S   0.0  0.4  0:05.47 /sbin/init sp
    387 root        19  -1 50712 17724 16224 S   0.0  0.4  0:00.77 /usr/lib/syst
    425 root        20   0  148M  1708  1408 S   0.0  0.0  0:00.00 vmware-vmbloc
    427 root        20   0  148M  1708  1408 S   0.0  0.0  0:00.00 vmware-vmbloc
    428 root        20   0  148M  1708  1408 S   0.0  0.0  0:00.00 vmware-vmbloc
    439 root        20   0 32336 10588  5084 S   0.0  0.3  0:00.79 /usr/lib/syst
    561 systemd-oo  20   0 17560  7748  6812 S   0.0  0.2  0:00.38 /usr/lib/syst
    570 systemd-re  20   0 21584 13372 11016 S   0.0  0.3  0:00.25 /usr/lib/syst
    575 systemd-ti  20   0 91048  7944  6964 S   0.0  0.2  0:00.09 /usr/lib/syst
F1Help  F2Setup F3SearchF4FilterF5Tree  F6SortByF7Nice -F8Nice +F9Kill  F10Quit
```

Motivation:

- htop is an interactive tool that monitors your computer's operating system and also shows what programs are currently running on your system (and their resource usage). It provides information about how much of each of the following are being used by the system; CPU load, RAM usage and swap memory usage. When viewing the list of active programs, you can scroll up or down in the list and, when needed, terminate any of these programs.

5. Install Software



Sublime Text

Sublime Text
Snapcrafters
Development

Channel latest/stable 4200 Open

587 votes
Very good

Confinement
Classic

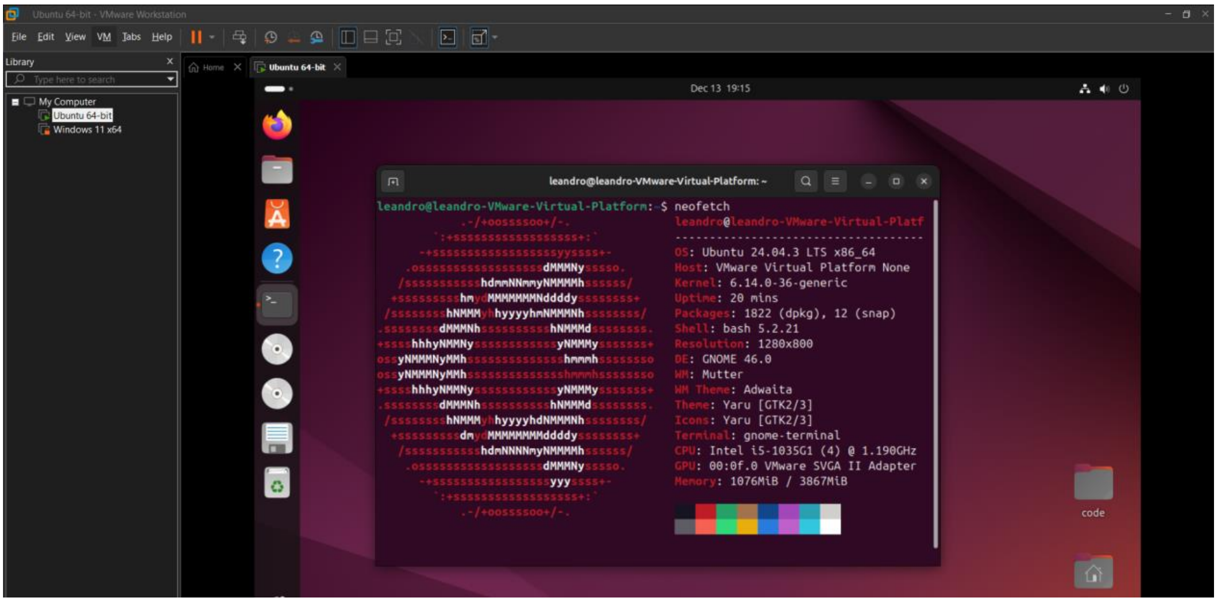
Download size
67.83 MB

License
Proprietary

Version
4200

Published
Sep 20, 2025

Links
Developer website
Contact Snapcrafters



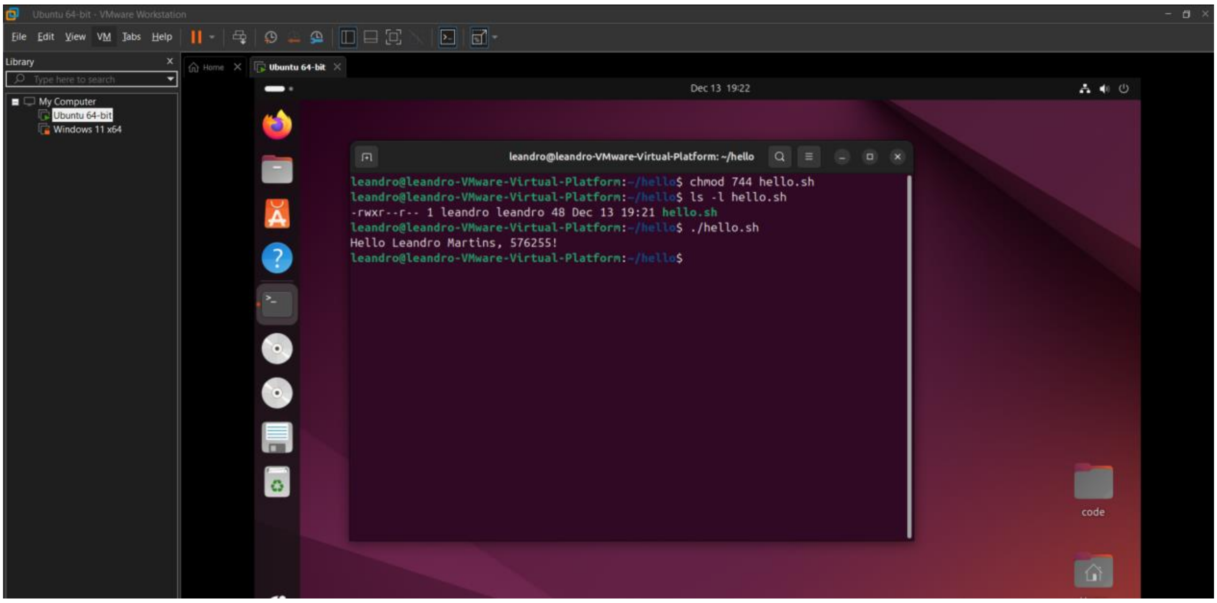
```
leandro@leandro-VMware-Virtual-Platform: ~
leandro@leandro-VMware-Virtual-Platform:~$ neofetch
    leandro@leandro-VMware-Virtual-Platf
    ------------------------------------
    OS: Ubuntu 24.04.3 LTS x86_64
    Host: VMware Virtual Platform None
    Kernel: 6.14.0-36-generic
    Uptime: 20 mins
    Packages: 1822 (dpkg), 12 (snap)
    Shell: bash 5.2.21
    Resolution: 1280x800
    DE: GNOME 46.0
    WM: Mutter
    WM Theme: Adwaita
    Theme: Yaru [GTK2/3]
    Icons: Yaru [GTK2/3]
    Terminal: gnome-terminal
    CPU: Intel i5-1035G1 (4) @ 1.190GHz
    GPU: 00:0f.0 VMware SVGA II Adapter
    Memory: 1076MiB / 3867MiB
```

Motivation:

- Neofetch is a tool that will show you all of the command line system info for your operating system when you run it. It will show the ASCII art logo of your operating system on the left side, and then to the right of this logo will be all of the details about your hardware and your software (like the OS version, the kernel version, uptime, CPU model, memory usage).

Assignment 5.5: Users and permissions on Linux

Relevant screenshots + motivation



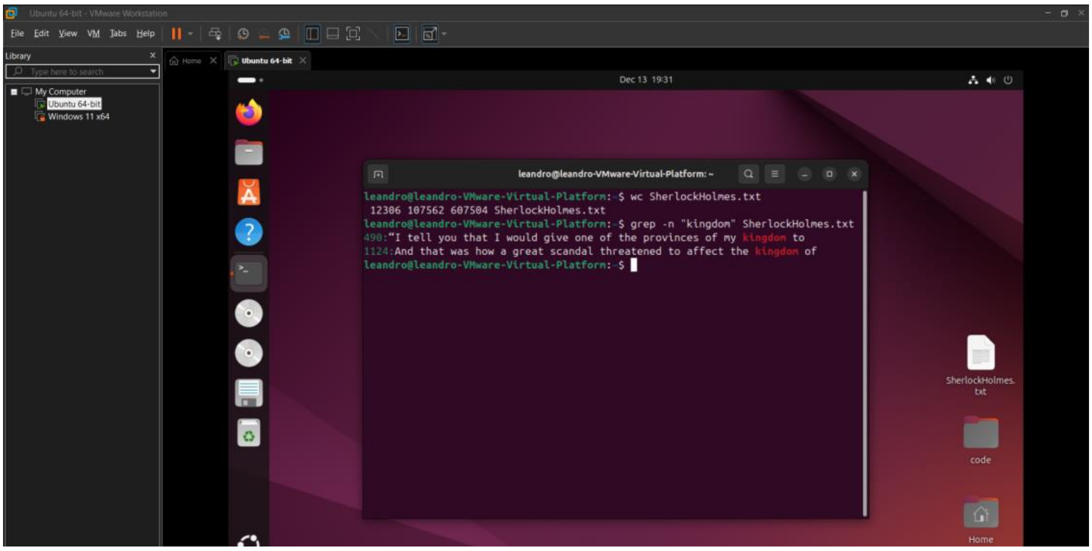
```
leandro@leandro-VMware-Virtual-Platform:~/hello$ chmod 744 hello.sh
leandro@leandro-VMware-Virtual-Platform:~/hello$ ls -l hello.sh
-rwxr--r-- 1 leandro leandro 48 Dec 13 19:21 hello.sh
leandro@leandro-VMware-Virtual-Platform:~/hello$ ./hello.sh
Hello Leandro Martins, 576255!
leandro@leandro-VMware-Virtual-Platform:~/hello$
```

Motivation:

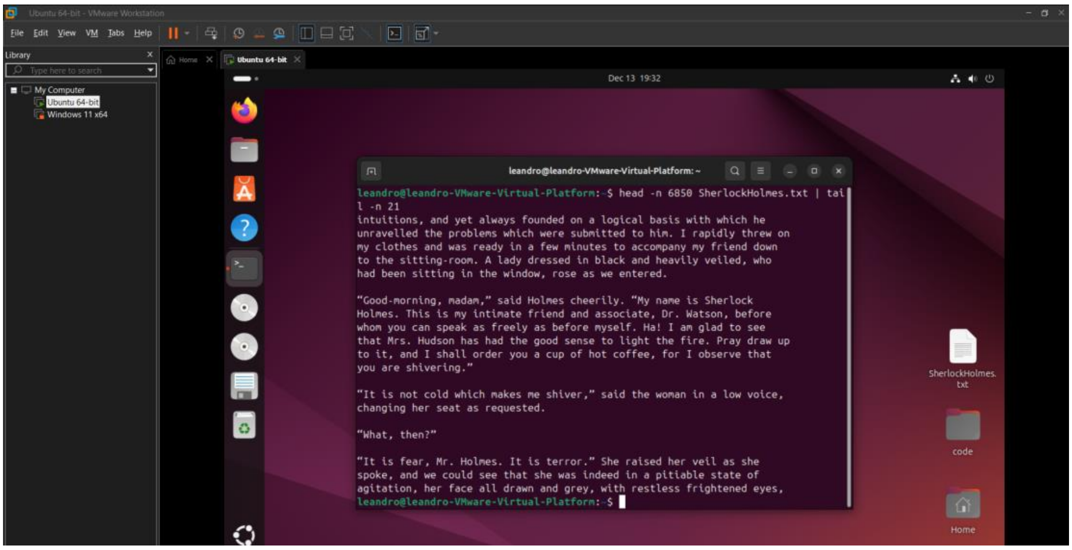
- First Line of Code / Shebang: The first line #!/bin/bash is a shebang, which means this bash shell file will run with the bash shell when you call the file.
- **Numeric Permission Values / Calculations**: The permission values for owner, group and other are determined as follows:
  - **Owner/ User**: The numeric value for read (4), write (2), and execute (1) permissions are added together. In my case, I had 7. As the owner/user, I have both read and write access, and can also run the file/script.
  - **Group**: The numeric value for read only (4) is assigned, because group members do not have write or execute privileges.
  - **Other/ Others**: Same as group members, the numeric value for read only (4) is assigned to others.
  - These three permission values add up to give a permission string of -rwxr--r--.

Assignment 5.6: View the contents of files

Relevant screenshots + motivation



```
leandro@leandro-VMware-Virtual-Platform:~$ wc SherlockHolmes.txt
 12306 107562 607504 SherlockHolmes.txt
leandro@leandro-VMware-Virtual-Platform:~$ grep -n "kingdom" SherlockHolmes.txt
490:“I tell you that I would give one of the provinces of my kingdom to
1124:And that was how a great scandal threatened to affect the kingdom of
leandro@leandro-VMware-Virtual-Platform:~$
```



```
leandro@leandro-VMware-Virtual-Platform:~$ head -n 6850 SherlockHolmes.txt | tai
l -n 21
intuitions, and yet always founded on a logical basis with which he
unravelled the problems which were submitted to him. I rapidly threw on
my clothes and was ready in a few minutes to accompany my friend down
to the sitting-room. A lady dressed in black and heavily veiled, who
had been sitting in the window, rose as we entered.

“Good-morning, madam,” said Holmes cheerily. “My name is Sherlock
Holmes. This is my intimate friend and associate, Dr. Watson, before
whom you can speak as freely as before myself. Ha! I am glad to see
that Mrs. Hudson has had the good sense to light the fire. Pray draw up
to it, and I shall order you a cup of hot coffee, for I observe that
you are shivering.”

“It is not cold which makes me shiver,” said the woman in a low voice,
changing her seat as requested.

“What, then?”

“It is fear, Mr. Holmes. It is terror.” She raised her veil as she
spoke, and we could see that she was indeed in a pitiable state of
agitation, her face all drawn and grey, with restless frightened eyes,
leandro@leandro-VMware-Virtual-Platform:~$
```

Motivation:

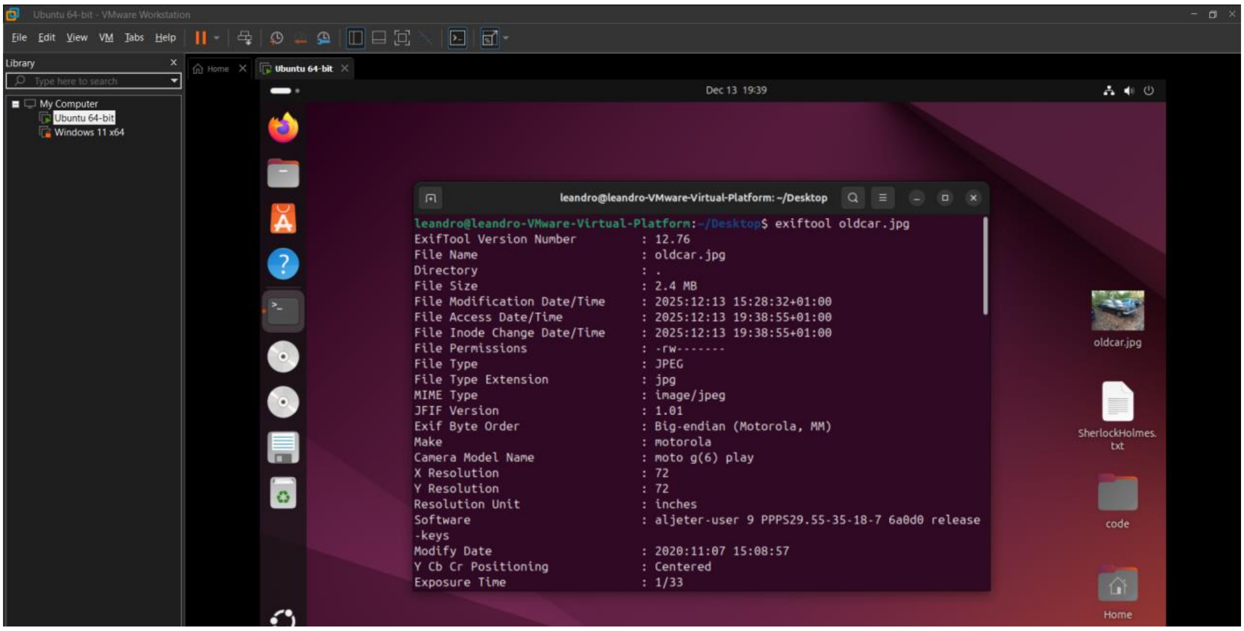
- **Definitions of Commands Used:**
  - **cat**: Command that allows you to see all the data contained in a file when run from the command-line (i.e., concatenates)
  - **wc**: (Word Count) Command that provides information about a file including the number of newlines, words, and bytes in the file
  - **less**: A command that will allow you to look through the data in a file by displaying it one page at a time (i.e., scrollable)
  - **tail**: Command that will display the last portion (by default 10 lines) of a file
  - **head**: Command that will display the top portion (by default 10 lines) of a file
  - **grep**: Command that will search for a specific character string or pattern in a file and print the lines with the specified match(s)

- **Statistics of File (wc output):** When I ran wc SherlockHolmes.txt, I was able to obtain an approximate count of around 12,300+ lines, 104,000+ words and 580,000+ characters in the file; exact number depends on which version of the file you are working with.
- **Locating "kingdom":** I located the "kingdom" text in the file using grep -n "kingdom" SherlockHolmes.txt. The -n flag was necessary as this allowed me to see the line numbers of each match, thus allowing me to determine the location of the text in the file.
- **Looking at Surrounding Data (Head and Tail):** In order to meet the requirement of looking at the first 10 lines of the file above the target line and the last 10 lines of the file below the target line, I used both the head and tail commands along with a pipe (|). First, I ran head in order to isolate the first portion of the file up to and including the target line plus 10 lines. I then took the output of the head command and piped it into tail -n 21 so that I could limit the output to include only the last 21 lines of the file (the first 10 lines above the target line + the target line + the next 10 lines below the target line). This resulted in isolating the specific paragraph that contained the "kingdom" text.

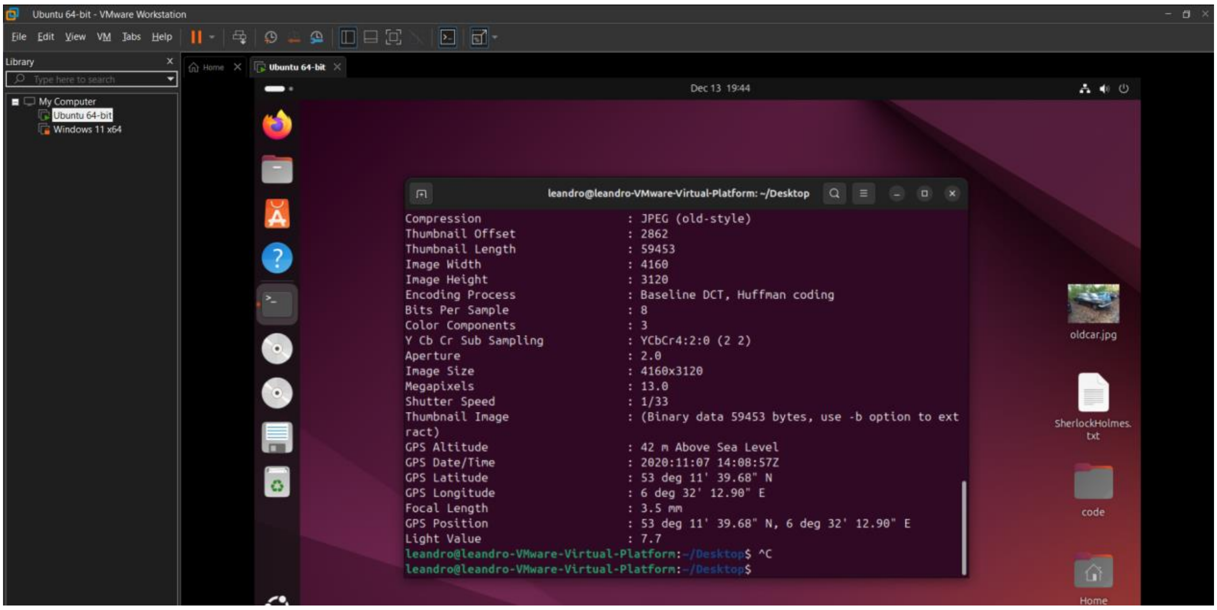
Assignment 5.7: Digital forensics

Relevant screenshots + motivation

1. Part 1: EXIF Data Analysis



```
leandro@leandro-VMware-Virtual-Platform:~/Desktop$ exiftool oldcar.jpg
ExifTool Version Number         : 12.76
File Name                       : oldcar.jpg
Directory                       : .
File Size                       : 2.4 MB
File Modification Date/Time     : 2025:12:13 15:28:32+01:00
File Access Date/Time           : 2025:12:13 19:38:55+01:00
File Inode Change Date/Time     : 2025:12:13 19:38:55+01:00
File Permissions                : -rw-------
File Type                       : JPEG
File Type Extension             : jpg
MIME Type                       : image/jpeg
JFIF Version                    : 1.01
Exif Byte Order                 : Big-endian (Motorola, MM)
Make                            : motorola
Camera Model Name               : moto g(6) play
X Resolution                    : 72
Y Resolution                    : 72
Resolution Unit                 : inches
Software                        : aljeter-user 9 PPPS29.55-35-18-7 6a0d0 release
-keys
Modify Date                     : 2020:11:07 15:08:57
Y Cb Cr Positioning             : Centered
Exposure Time                   : 1/33
```

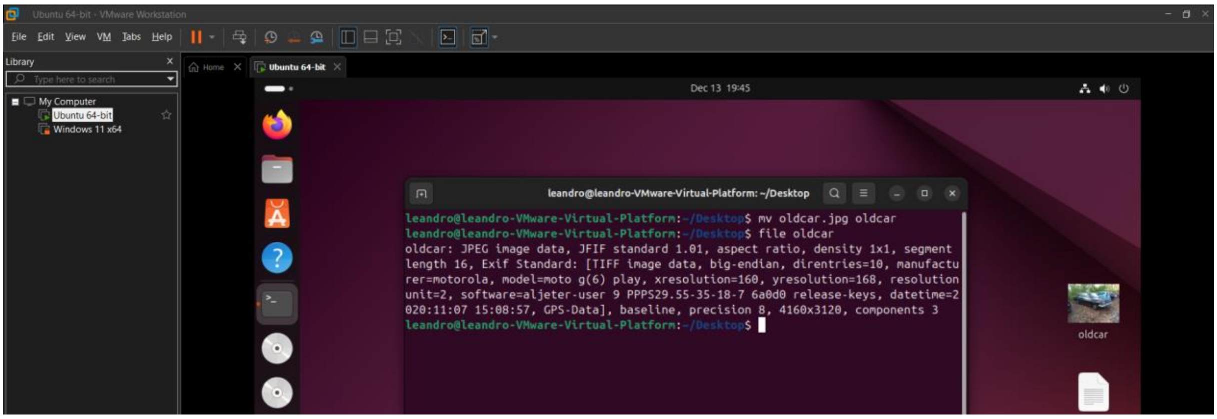


```
Compression                     : JPEG (old-style)
Thumbnail Offset                : 2862
Thumbnail Length                : 59453
Image Width                     : 4160
Image Height                    : 3120
Encoding Process                : Baseline DCT, Huffman coding
Bits Per Sample                 : 8
Color Components                : 3
Y Cb Cr Sub Sampling            : YCbCr4:2:0 (2 2)
Aperture                        : 2.0
Image Size                      : 4160x3120
Megapixels                      : 13.0
Shutter Speed                   : 1/33
Thumbnail Image                 : (Binary data 59453 bytes, use -b option to ext
ract)
GPS Altitude                    : 42 m Above Sea Level
GPS Date/Time                   : 2020:11:07 14:08:57Z
GPS Latitude                    : 53 deg 11' 39.68" N
GPS Longitude                   : 6 deg 32' 12.90" E
Focal Length                    : 3.5 mm
GPS Position                    : 53 deg 11' 39.68" N, 6 deg 32' 12.90" E
Light Value                     : 7.7
leandro@leandro-VMware-Virtual-Platform:~/Desktop$ ^C
leandro@leandro-VMware-Virtual-Platform:~/Desktop$
```

Motivation:

- Phone Brand/Type: According to the EXIF data, the photo was taken with an Motorola, model moto g(6) play
- GPS Coordinates: Yes, the coordinates are present in the metadata **(Groningen)**

2. Part 2: Filename Extensions



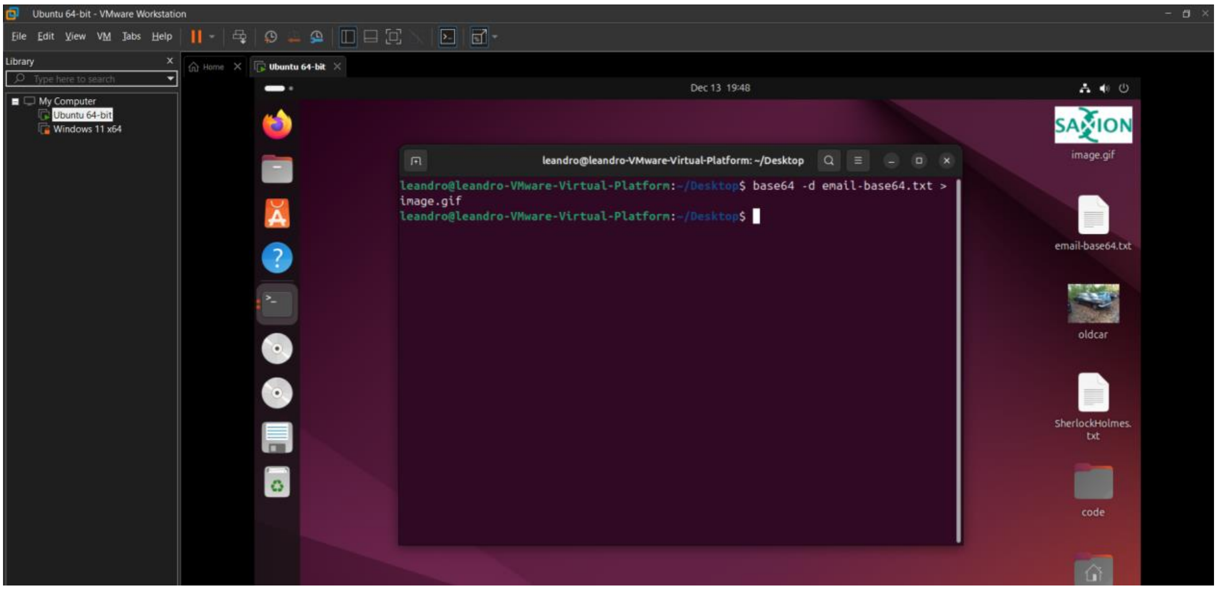
```
leandro@leandro-VMware-Virtual-Platform:~/Desktop$ mv oldcar.jpg oldcar
leandro@leandro-VMware-Virtual-Platform:~/Desktop$ file oldcar
oldcar: JPEG image data, JFIF standard 1.01, aspect ratio, density 1x1, segment
length 16, Exif Standard: [TIFF image data, big-endian, direntries=10, manufactu
rer=motorola, model=moto g(6) play, xresolution=160, yresolution=168, resolution
unit=2, software=aljeter-user 9 PPPS29.55-35-18-7 6a0d0 release-keys, datetime=2
020:11:07 15:08:57, GPS-Data], baseline, precision 8, 4160x3120, components 3
leandro@leandro-VMware-Virtual-Platform:~/Desktop$
```

Ubuntu 64-bit - VMware Workstation
File Edit View VM Tabs Help
Library
Type here to search
My Computer
Ubuntu 64-bit
Windows 11 x64
Home
Ubuntu 64-bit
Dec 13 19:45
leandro@leandro-VMware-Virtual-Platform: ~/Desktop
oldcar

Motivation:

- **Explanation**: While in linux you don't have to use a file extension for the os to identify what type of file you have, ubuntu was able to identify that oldcar.jpg had been renamed to oldcar and still told me that it was jpeg image data with the file command. The reason ubuntu was able to do this is because linux identifies the "magic number" or file header inside your file content instead of trusting that the file name is correct.

3. Part 3: BASE64 Decoding



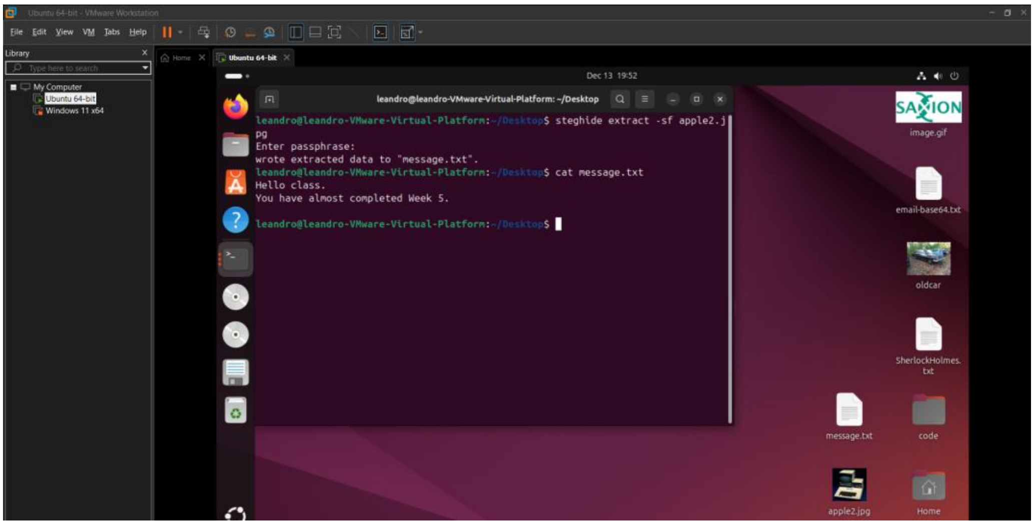
```
leandro@leandro-VMware-Virtual-Platform:~/Desktop$ base64 -d email-base64.txt >
image.gif
leandro@leandro-VMware-Virtual-Platform:~/Desktop$ 
```

Motivation:

- **Decoding Command:** I used the command base64 -d email-base64.txt > image.gif
  - The -d flag tells the tool to **decode** the data
  - The > symbol redirects the output (which would normally just print messy text to the screen) into a new file called image.gif
- **Result:** After decoding, the text file was successfully converted back into a binary image file

Assignment 5.8: Steganography

Relevant screenshots + motivation



```
leandro@leandro-VMware-Virtual-Platform:~/Desktop$ steghide extract -sf apple2.j
pg
Enter passphrase:
wrote extracted data to "message.txt".
leandro@leandro-VMware-Virtual-Platform:~/Desktop$ cat message.txt
Hello class.
You have almost completed Week 5.

leandro@leandro-VMware-Virtual-Platform:~/Desktop$ 
```

Motivation:

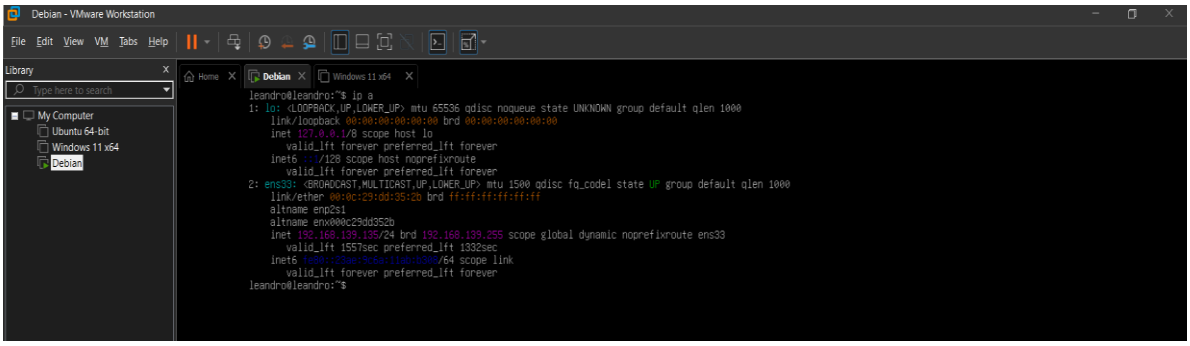
- Steganography Definition: The purpose of Steganography is to conceal a message or an image or file or video into a file (such as an image). When done correctly, no one will be able to determine that a file has been concealed with the new file. In contrast, encryption conceals the content, whereas Steganography conceals the fact that there is data at all
- How LSB Works: Most tools use manipulation of the least significant bits (the last digit or number) of each pixel to hide data. For example, if we are looking at an image with the red color values 01101010 and the green color values 01111011, we could change the first value to 01101000 and the second value to 01111001. In doing so, we would create an imperceptible difference between what was once visible to the naked eye and now visible to the machine (to read the bits)
- The Process:
  - I downloaded the Steghide tool onto my computer via Terminal
  - I attempted to decode the apple2.jpg using the command steghide extract -sf apple2.jpg
  - I then entered the password "apple2" to verify myself and retrieve the file containing the text that had been embedded
  - Lastly, I checked the content of the text file using the "cat" command to see the message that was hidden in the image

Assignment 5.9: Capture disk images

Make relevant screenshots + motivation:

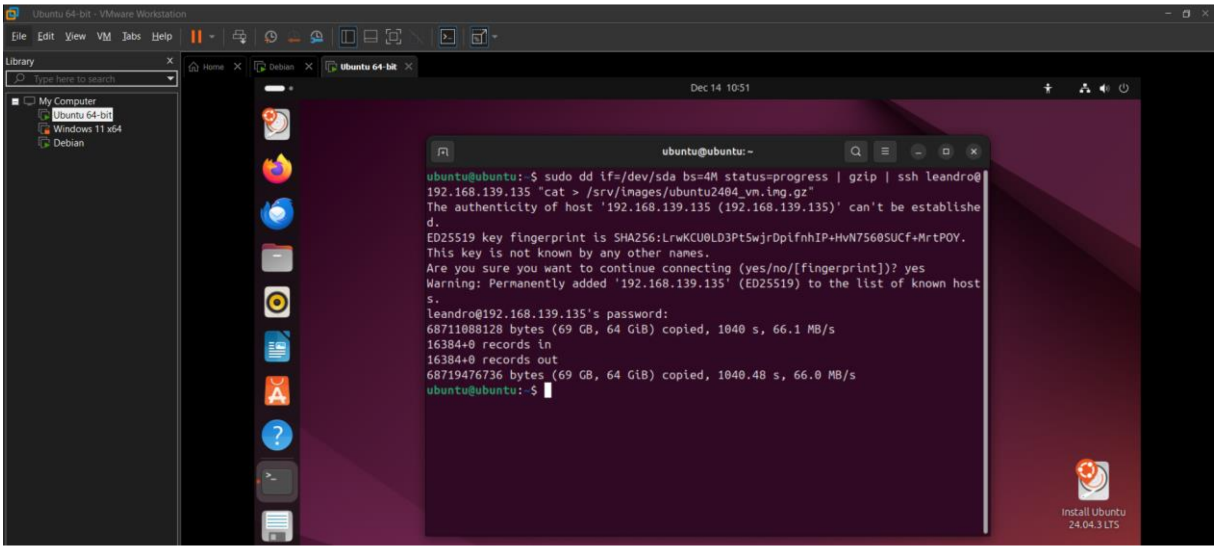
- Proof that the Debian 13 server stored a back-up image of the Ubuntu 24.04 Desktop VM.
- Proof that you can restore the back-up image into an empty VM.

1. Prepare the Debian Server



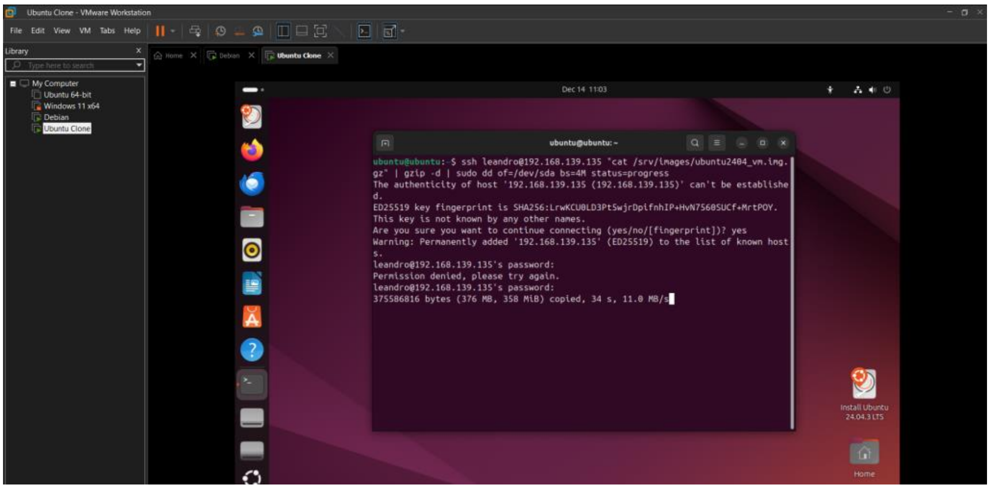
```
leandro@leandro:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host noprefixroute
       valid_lft forever preferred_lft forever
2: ens33: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 00:0c:29:dd:35:2b brd ff:ff:ff:ff:ff:ff
    altname enp2s1
    altname enx000c29dd352b
    inet 192.168.139.135/24 brd 192.168.139.255 scope global dynamic noprefixroute ens33
       valid_lft 1557sec preferred_lft 1332sec
    inet6 fe80::23ae:9c6a:11ab:b308/64 scope link
       valid_lft forever preferred_lft forever
leandro@leandro:~$
```

2. Capture the Image

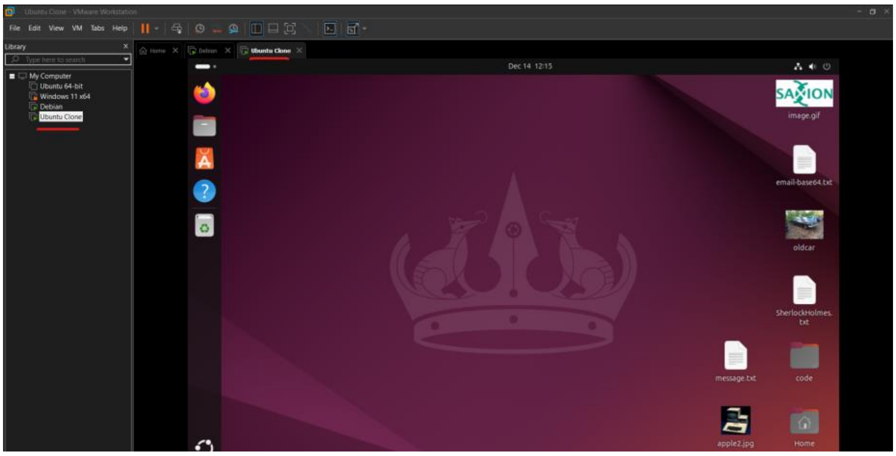


```
ubuntu@ubuntu:~$ sudo dd if=/dev/sda bs=4M status=progress | gzip | ssh leandro@
192.168.139.135 "cat > /srv/images/ubuntu2404_vm.img.gz"
The authenticity of host '192.168.139.135 (192.168.139.135)' can't be establishe
d.
ED25519 key fingerprint is SHA256:LrwKCU0LD3Pt5wjrDpifnhIP+HvN7560SUCf+MrtPOY.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '192.168.139.135' (ED25519) to the list of known host
s.
leandro@192.168.139.135's password:
68711088128 bytes (69 GB, 64 GiB) copied, 1040 s, 66.1 MB/s
16384+0 records in
16384+0 records out
68719476736 bytes (69 GB, 64 GiB) copied, 1040.48 s, 66.0 MB/s
ubuntu@ubuntu:~$
```

3. Restore the Image



```
ubuntu@ubuntu:~$ ssh leandro@192.168.139.135 "cat /srv/images/ubuntu2404_vm.img.
gz" | gzip -d | sudo dd of=/dev/sda bs=4M status=progress
The authenticity of host '192.168.139.135 (192.168.139.135)' can't be establishe
d.
ED25519 key fingerprint is SHA256:LrwKCU0LD3Pt5wjrDpifnhIP+HvN7560SUCf+MrtPOY.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '192.168.139.135' (ED25519) to the list of known host
s.
leandro@192.168.139.135's password:
Permission denied, please try again.
leandro@192.168.139.135's password:
375586816 bytes (376 MB, 358 MiB) copied, 34 s, 11.0 MB/s
```



Motivation:

1. Storage Verification

- **Process**: I established a Debian 13 server and installed an OpenSSH server on this server so that I can do remote file transfers securely. I created a folder in /srv/images to put the backups of images (images backups)
- **Command**: I utilized dd piped through gzip and then piped through ssh to send the disk image directly to the Debian server as opposed to sending it there from a local copy
    - dd if=/dev/sda : reads the raw disk blocks
    - gzip : compresses the data stream so I will use less space
    - ssh ... "cat > ..." : transmits the compressed data stream to the Debian server where it is written to a file

2. Restoration Verification

- **Process**: I created an exact replica of the hardware for a blank VM and booted to the same Ubuntu Live ISO as before without installing the OS
- **Command**: I ran the commands in reverse order:
  - ssh... "cat...": The ssh command reads the gzip compressed file from the remote server
  - gzip -d: gzip is used to decompress the stream in real time
  - sudo dd of=/dev/sda: sudo dd writes the recovered data blocks one at a time back to the newly made vm's empty disk

- **Result**: Once the transfer had completed, I removed the Live ISO, and booted the vm. The vm was able to boot into the original desktop version of ubuntu, which confirmed that the backup was a bit-for-bit copy of the original system