

Template Week 5 – Operating Systems

Student number: 580606

Assignment 5.1: Unix-like

- a) Find out what the difference is between UNIX and unix-like operating systems?
Unix is a computer operating system developed in 1969. Today the term Unix is used to describe any operating system that conforms to Unix standards, meaning the core operating system operates the same as the original Unix operating system. A Unix-like operating system is one that behaves in a manner similar to a Unix system, while not fully conforming to or being certified to any version of the Single UNIX Specification.
- 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 is an American computer scientist who worked at a research company Bell Labs. He is one of the creators of UNIX OS and won the 1983 Turing Award for it. He also developed the B programming language which was the foundation of C. While working at Bell Labs Thompson took part in the creation of the Plan B and Inferno operating systems. After retiring from the company he went on to work on the Go programming language at Google.

Dennis Ritchie was an American computer scientist at Bell Labs who created the UNIX operated system and won the 1983 Turing Award for it. He began his research career working on the Multics OS, but moved on to join Ken Thompson in developing a flexible operating system. He improved on Thompson's B programming language and created the C programming language. Later on he lead the development of the Plan B and Inferno operating systems at Bell Labs.

Bill Joy is an American software developer and the cofounder of the computer manufacturer Sun Microsystems. He is known for creating a version of the UNIX OS called Berkley UNIX which was initially used at educational institutions. It used the new TCP/IP networking technology to accommodate the growth of the Internet. He was a contributor to the Java programming language and the Jini networking system, which helped connect household appliances to the Internet.

Richard Stallman is an American computer programmer, free-software advocate and the founder of the Free Software Foundation. His career began with the development of the Emacs text editor in C at MIT. During his free time Stallman worked in the GNU Project which is a free version of the UNIX OS. He campaigns against software patents and licenses.

Linus Torvalds is a Finnish computer scientist most known for creating the Linux OS. He based it off the UNIX OS and made it open-source after attending a Richard Stallman speech. Torvalds has also developed the distributed version control system Git.

- c) What is the philosophy of the GNU movement?
The GNU movement believes that users should have freedom in their computing. It distinguishes 4 essential freedoms: to run the program, to study and change the program in source code, to redistribute exact copies and to distribute modified versions. The GNU movement believes that most non-free programs are malware, because they mistreat the users due to the developer's

corruption by power. On the other hand, with free software users control the program on both personal and collective levels.

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

No, I believe Ubuntu does not fully comply with the philosophy of the GNU movement. Firstly, some of the software recommended by Ubuntu is nonfree. Secondly, Richard Stallman published an article detailing how in a newer version Ubuntu implemented user data collection into the Ubuntu desktop. Thus, he advises against recommending Ubuntu as free software.

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

Windows Subsystem for Linux is an open source tool developed by Microsoft which allows users to use a Linux environment inside Windows without installing a virtual machine or dual booting.

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

Android, iOS and ChromeOS belong to the Unix-like operating-system family. Android and ChromeOS are in the Linux branch and iOS is in the Darwin/BSD branch

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 mainly used in scientific research to perform complex simulations. They are widespread in space research, astrophysics, weather and ocean flow studies. Supercomputers can be used in the military. For instance, the ASCI Red helped maintain the US nuclear arsenal by computing complex simulations of the weapons in action without real-world testing. Additionally, chess supercomputers have been created and tested against world's most renowned players.

- 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?

PlayStation 3 cluster is a distributes system control computer constructed primarily from PlayStation 3 video game consoles. It has been used in medical research by Stanford University. PS3 owners could contribute to the study of improper protein folding. PS3 clusters are also used by the University of Rhode Island in a Gravity Grid which performs calculations for gravitational waves researchers. Another supercomputer comprised of PS3 consoles was built by the US Air Force Research laboratory to analyze high definition satellite images.

- 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?

Oracle Linux for ARM is running on this Raspberry Pi cluster

- 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/>

No, it does not. The 500th supercomputer has 48128 total cores. One Raspberry Pi has from 1 to 4 cores, so the maximum number of cores in a the 1050 Raspberry Pi supercomputer is 4200, which is far less any supercomputer in thee list.

- e) What CPU architecture is used for the PlayStation 5 and Xbox Series X? PlayStation 5 and Xbox Series X both use AMD Zen 2-based x86-64 CPU
What operating systems run on these consoles? PlayStation 5 uses a custom Orbis OS which is based on FreeBSD and Xbox Series X runs Xbox System Software based on Windows.
What conclusion can you draw from the answer to the previous question? The consoles use the same ISA, which makes cross-platform development easier. Both consoles use a PC-like OS system, which bridges the gap between game development and general software development.

Assignment 5.3: Working with Windows

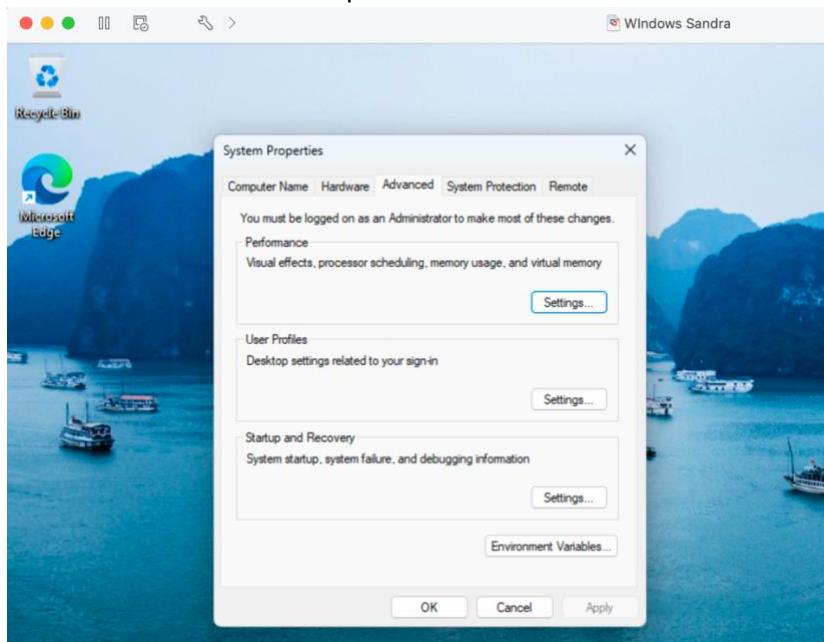
Take relevant screenshots of the assignments below

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

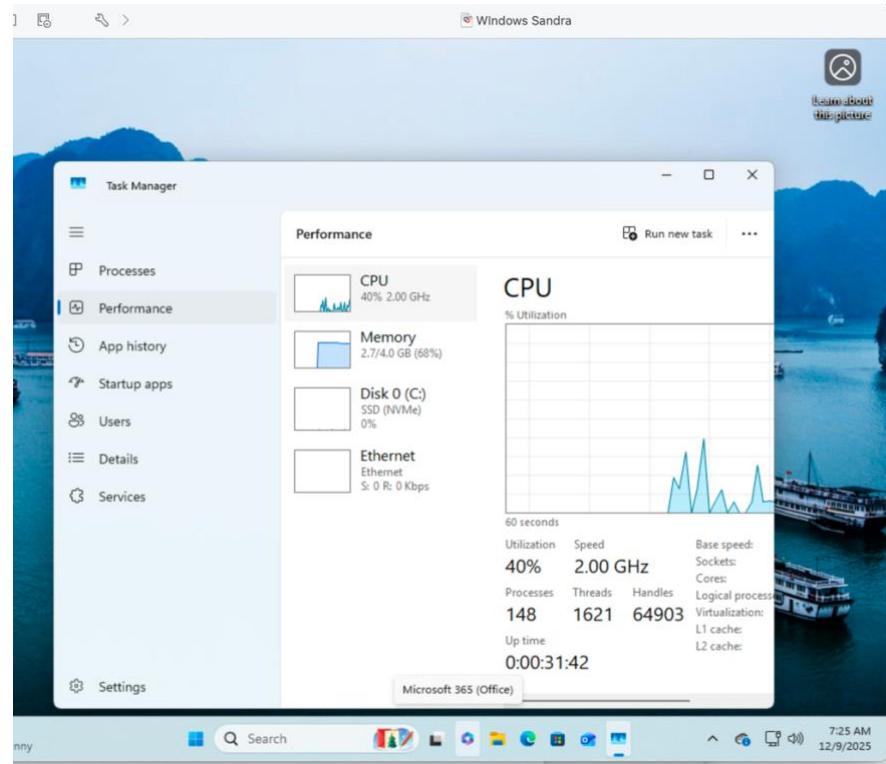
- b) The file explorer can be opened with **Windows** + E, Which key combination could you also use?

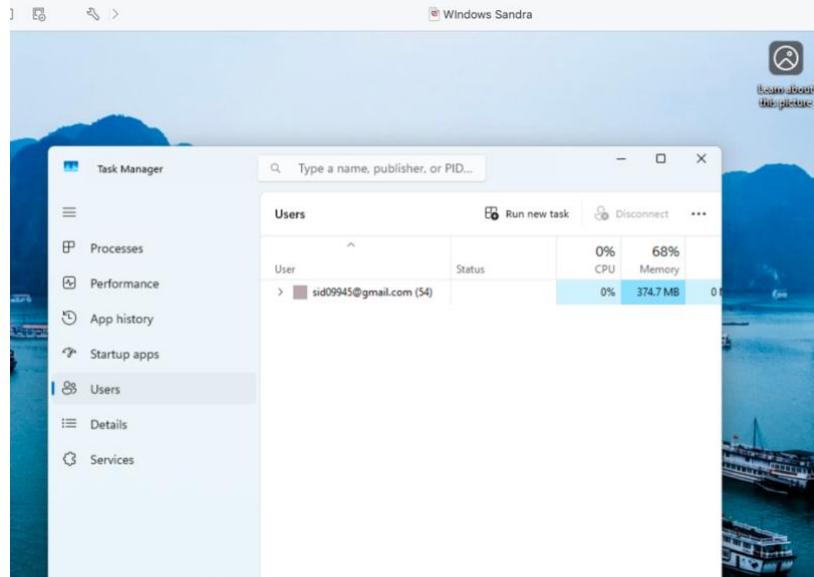
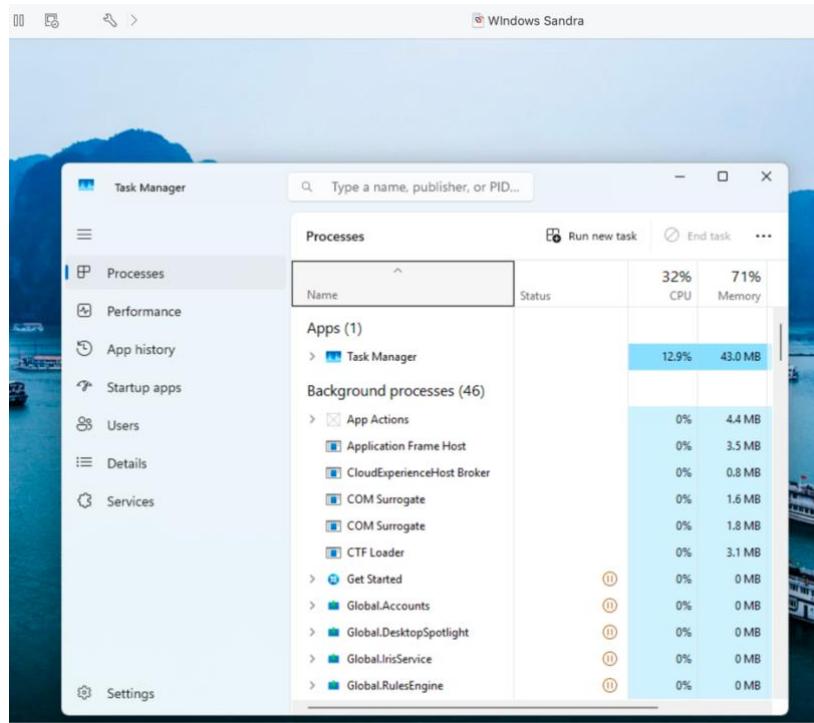
I have to use Command+E.

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



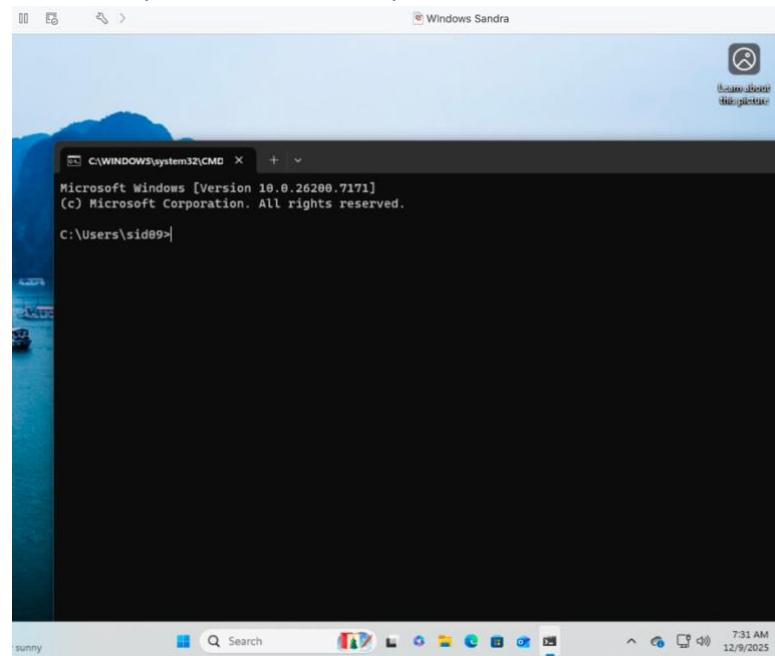
- d) Open task manager with a key combination. Take screenshots of the tabs: processes (shows active processes), performance, and users. Place these three screenshots in this template.





- 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?
You should use **Windows + Shift + left/right arrow** to move apps between screens.
- 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?
You should use **Windows + 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.



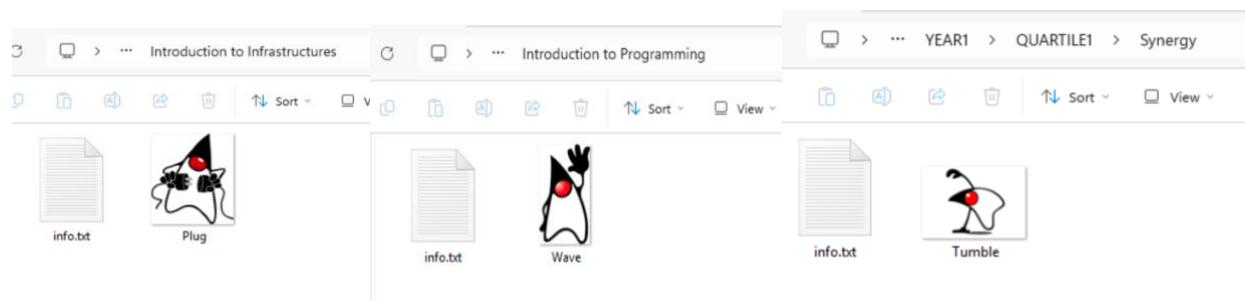
Working in the File Explorer

Relevant screenshots **copy** command:

```
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

Install the latest PowerShell for new features and improvements! https://aka.ms/PSWindows

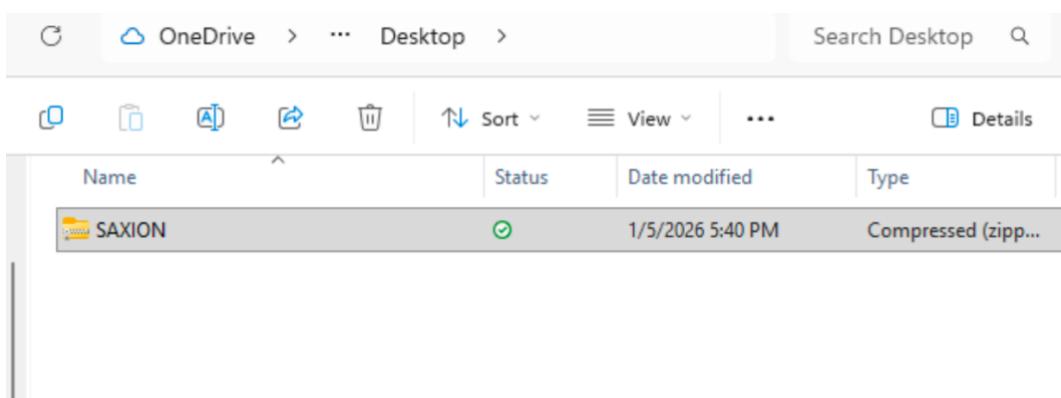
PS C:\SAXION> copy Wave.png "HBOICT\YEAR1\QUARTILE1\Introduction to Programming"
PS C:\SAXION> copy Plug.png "HBOICT\YEAR1\QUARTILE1\Introduction to Infrastructures"
PS C:\SAXION> copy Tumble.png "HBOICT\YEAR1\QUARTILE1\Synergy"
PS C:\SAXION>
```

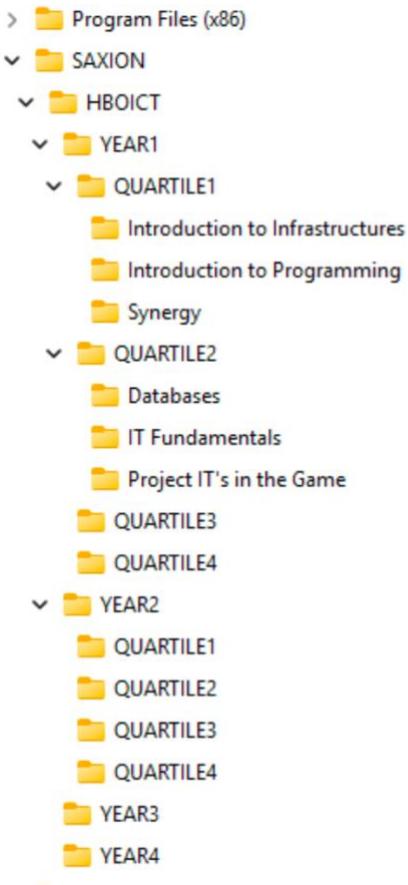


Relevant screenshots **tree** command:

```
PS C:\SAXION> tree
Folder PATH listing
Volume serial number is 0000022D E87A:C8E6
C:.
    HBOICT
        YEAR1
            QUARTILE1
                Introduction to Infrastructures
                Introduction to Programming
                Synergy
            QUARTILE2
                Databases
                IT Fundamentals
                Project IT's in the Game
            QUARTILE3
            QUARTILE4
        YEAR2
            QUARTILE1
            QUARTILE2
            QUARTILE3
            QUARTILE4
        YEAR3
        YEAR4
PS C:\SAXION> echo sandra
sandra
PS C:\SAXION> |
```

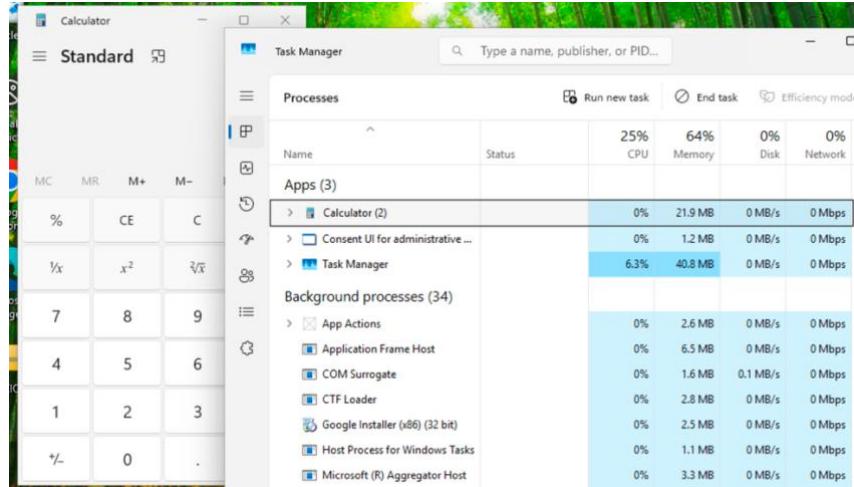
Relevant screenshots in the file explorer of the folder c:\Saxion + created zip file.





Terminating Processes

Relevant Screenshots Task Manager Window:



Install Software

Relevant screenshots that the following software is installed with winget:

- WinSCP

```
The following packages were found among the working sources.
Please specify one of them using the --source option to proceed.
Name      Id           Source
-----
WinSCP   WinSCP.WinSCP winget
PS C:\Users\sid09> winget install -e --id WinSCP.WinSCP --source winget
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...
The installer will request to run as administrator, expect a prompt.
Successfully installed
PS C:\Users\sid09>
```

Activate Windows
Go to Settings to activate Wind

- Notepad++

```
The following packages were found among the working sources.
Please specify one of them using the --source option to proceed.
Name      Id           Source
-----
Notepad++ Notepad++.Notepad++ winget
PS C:\Users\sid09> winget install -e --id Notepad++.Notepad++ --source winget
Found Notepad++ [Notepad++.Notepad++] Version 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/releases/download/v8.9/npp.8.9.Installer.m64.exe
[██████████] 6.25 MB / 6.25 MB
Successfully verified installer hash
Starting package install...
The installer will request to run as administrator, expect a prompt.
Successfully installed
PS C:\Users\sid09> |
```

Activate Windows
Go to Settings to activate Window

- 7zip

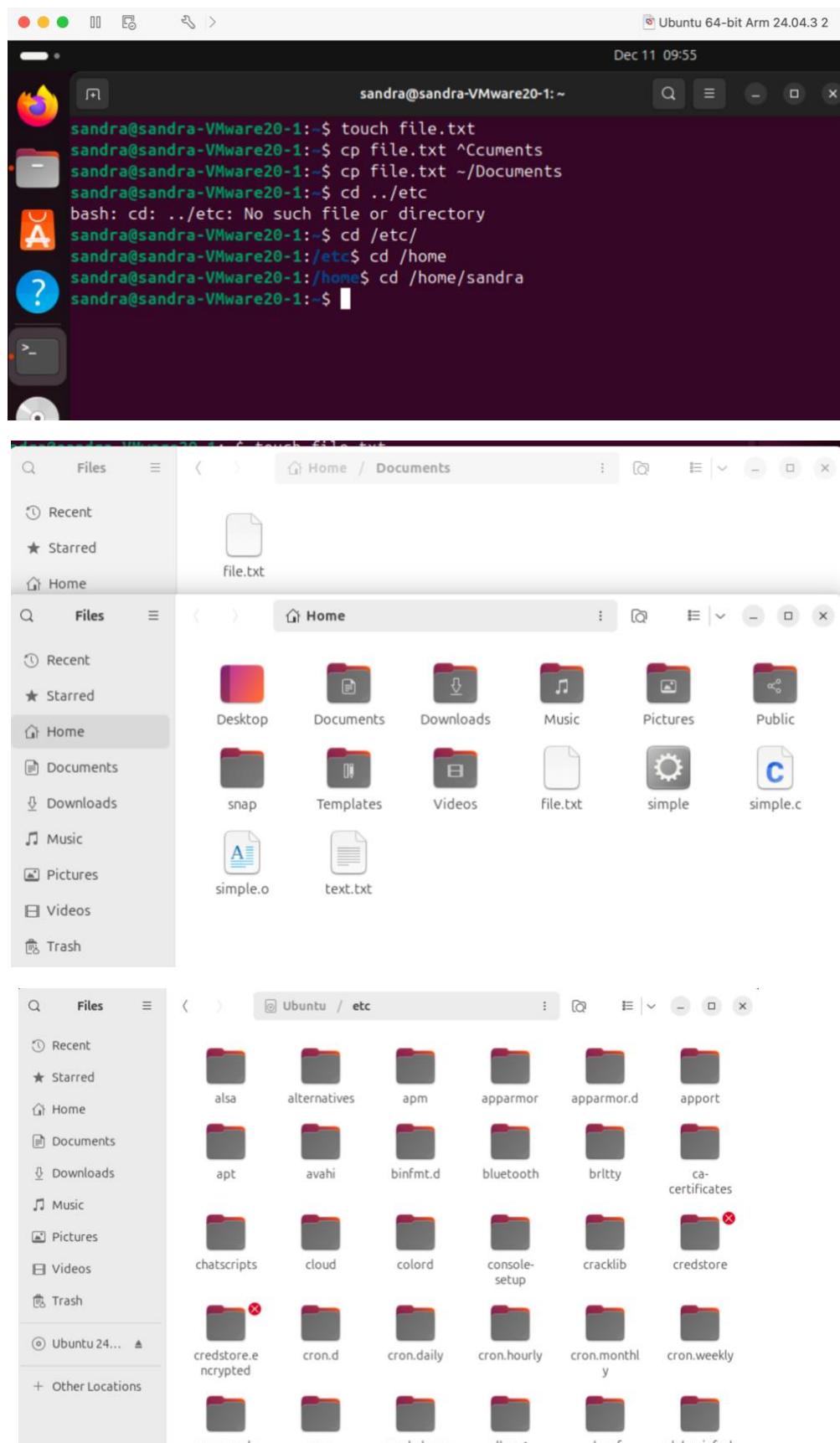
```
More help can be found at: https://aka.ms/winget-command-help
PS C:\Users\sid09> winget install -e --id 7zip.7zip --source winget
Found 7-Zip [7zip.7zip] Version 25.01
This application is licensed to you by its owner.
Microsoft is not responsible for, nor does it grant any licenses to, third-party packages.
Downloading https://7-zip.org/a/7z2501-arm64.exe
[██████████] 1.51 MB / 1.51 MB
Successfully verified installer hash
Starting package install...
The installer will request to run as administrator, expect a prompt.
Successfully installed
PS C:\Users\sid09>
PS C:\Users\sid09> |
```

Activate W
Go to Settings

The winget install command installs the specified application. The -e option ensures that the command will install the application which matches exactly with the specified name. The -id option is used to point winget to the application user wants to install

Assignment 5.4: Working with Linux

Relevant screenshots + motivation



Linux file structure operates from one root directory /. While Windows uses separate hierarchies distinguished by drive letters (C:\, D:\)

The /etc directory stores essential system configuration files.

I would use the tar command to compress a text file and extract an archive.

The top terminal window shows a user named 'sandra' at 'sandra-VMware20-1'. It runs several commands related to file compression:

```
sandra@sandra-VMware20-1: ~$ ^[[200-echo A file to archive > myfile.txt
echo: command not found
sandra@sandra-VMware20-1: ~$ echo A file to archive > myfile.txt
sandra@sandra-VMware20-1: ~$ tar -cvf archive.tar myfile.txt
myfile.txt
sandra@sandra-VMware20-1: ~$ tar -cvfz archive2.tar.gz myfile.txt
tar: archive2.tar.gz: Cannot stat: No such file or directory
myfile.txt
tar: Exiting with failure status due to previous errors
sandra@sandra-VMware20-1: ~$ tar -cvzf archive2.tar.gz myfile.txt
myfile.txt
sandra@sandra-VMware20-1: ~$
```

The bottom terminal window shows the 'htop' process monitor. It displays system load, memory usage, and a detailed list of running processes. The processes listed include system daemons like 'htop', 'libexec', 'init', 'systemd', 'avahi', 'messagebus', 'gnome-remo', 'polkitd', and various root and user processes.

Main	I/O										
PID	USER	PRI	NI	VIRT	RES	SHR	S	CPU%	MEM%	TIME+	Command
4171	sandra	20	0	11040	4388	3112	R	2.0	0.1	0:00.26	htop
4102	sandra	20	0	550M	53540	42036	S	0.7	1.3	0:00.47	/usr/libexec/
1	root	20	0	22952	13324	8700	S	0.0	0.3	0:00.64	/sbin/init sp
365	root	19	-1	67076	17628	16080	S	0.0	0.4	0:00.16	/usr/lib/syst
436	root	20	0	30984	8632	4488	S	0.0	0.2	0:00.07	/usr/lib/syst
747	systemd-oo	20	0	17232	6936	6068	S	0.0	0.2	0:00.44	/usr/lib/syst
753	systemd-re	20	0	21492	12596	10292	S	0.0	0.3	0:00.06	/usr/lib/syst
758	systemd-ti	20	0	90896	7076	6136	S	0.0	0.2	0:00.02	/usr/lib/syst
812	systemd-ti	20	0	90896	7076	6136	S	0.0	0.2	0:00.00	/usr/lib/syst
864	avahi	20	0	8704	3812	3356	S	0.0	0.1	0:00.03	avahi-daemon:
865	messagebus	20	0	12256	6536	3880	S	0.0	0.2	0:00.23	@dbus-daemon
868	gnome-remo	20	0	504M	15140	12676	S	0.0	0.4	0:00.00	/usr/libexec/
871	polkitd	20	0	382M	11584	7532	S	0.0	0.3	0:00.14	/usr/lib/polk
872	root	20	0	306M	6840	6112	S	0.0	0.2	0:00.00	/usr/libexec/
876	root	20	0	1804M	38356	24352	S	0.0	1.0	0:00.61	/usr/lib/snap

The htop application shows the processes running for a Unix system. At the top there is a representation of the load of different cores with different colors standing for different type of processes. Below you can see the memory and swap rows. Each line below contains information about a running process.

The screenshot shows a terminal window titled "sandra@sandra-VMware20-1:~". The window title bar includes icons for minimize, maximize, and close, along with the terminal name and the date/time "Dec 11 10:26". The terminal itself displays the output of the "neofetch" command. On the left, there is a large, artistic ASCII art logo consisting of various symbols like dots, plus signs, and slashes. On the right, the "neofetch" output provides detailed information about the system, including:

- OS:** Ubuntu 24.04.3 LTS aarch64
- Host:** VMware20.1 1
- Kernel:** 6.14.0-36-generic
- Uptime:** 20 mins
- Packages:** 1635 (dpkg), 11 (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:** (2)
- GPU:** 00:0f.0 VMware Device 0406
- Memory:** 2091MiB / 3899MiB

Assignment 5.5: Users and permissions on Linux

Relevant screenshots + motivation

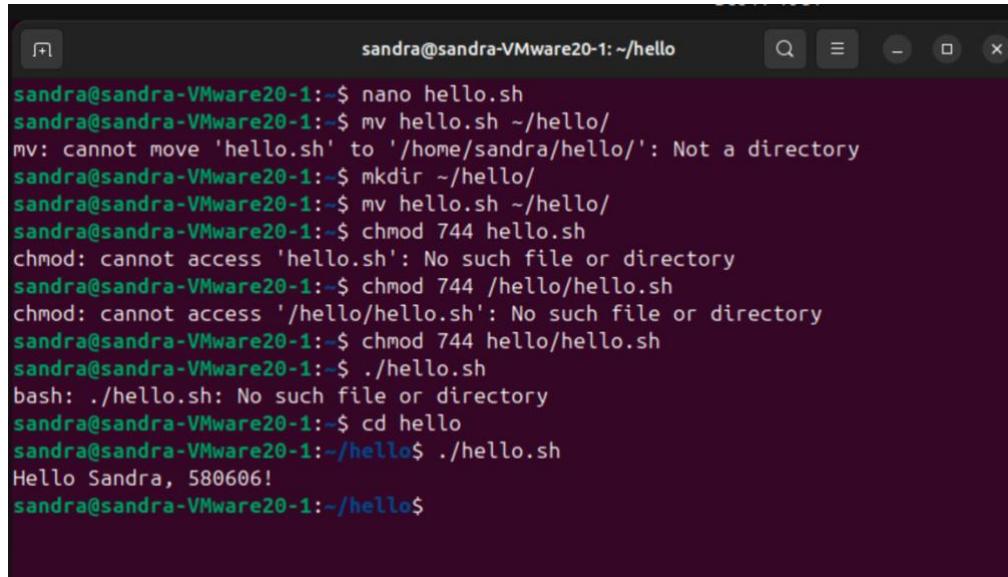
The screenshot shows a terminal window titled "sandra@sandra-VMware20-1:~". The window title bar includes icons for minimize, maximize, and close, along with the terminal name and the date/time "Dec 11 10:26". The terminal displays the following command being run:

```
GNU nano 7.2          hello.sh *
```

```
#!/bin/bash
echo Hello Sandra, 580606!
```

At the bottom of the terminal, a menu of keyboard shortcuts is visible:

$\wedge G$	Help	$\wedge O$	Write Out	$\wedge W$	Where Is	$\wedge K$	Cut	$\wedge T$	Execute	$\wedge C$	Location
$\wedge X$	Exit	$\wedge R$	Read File	$\wedge \backslash$	Replace	$\wedge U$	Paste	$\wedge J$	Justify	$\wedge /$	Go To Line



```
sandra@sandra-VMware20-1:~$ nano hello.sh
sandra@sandra-VMware20-1:~$ mv hello.sh ~/hello/
mv: cannot move 'hello.sh' to '/home/sandra/hello/': Not a directory
sandra@sandra-VMware20-1:~$ mkdir ~/hello/
sandra@sandra-VMware20-1:~$ mv hello.sh ~/hello/
sandra@sandra-VMware20-1:~$ chmod 744 hello.sh
chmod: cannot access 'hello.sh': No such file or directory
sandra@sandra-VMware20-1:~$ chmod 744 /hello/hello.sh
chmod: cannot access '/hello/hello.sh': No such file or directory
sandra@sandra-VMware20-1:~$ chmod 744 hello/hello.sh
sandra@sandra-VMware20-1:~$ ./hello.sh
bash: ./hello.sh: No such file or directory
sandra@sandra-VMware20-1:~$ cd hello
sandra@sandra-VMware20-1:~/hello$ ./hello.sh
Hello Sandra, 580606!
sandra@sandra-VMware20-1:~/hello$
```

Assignment 5.6: View the contents of files

Relevant screenshots + motivation

cat – show the contents of a file

wc – counts lines, words, characters and bytes in a file

less – displays the contents of a file one page at a time

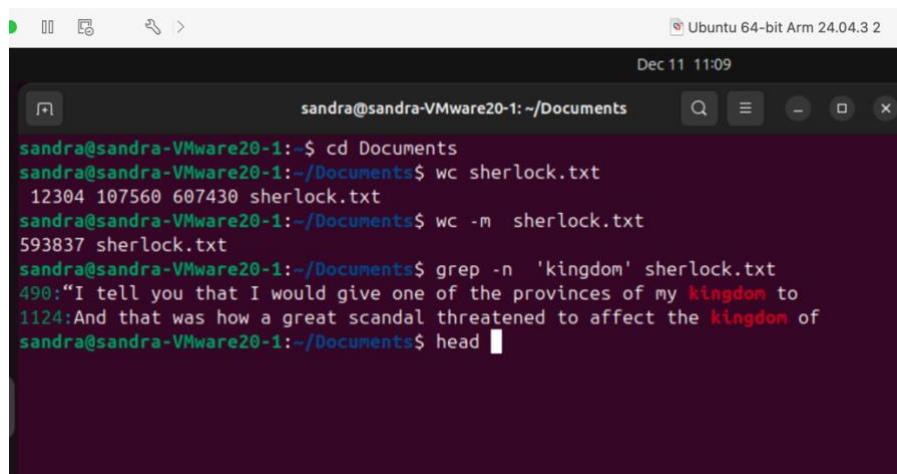
tail – return a number of lines from the bottom of a file

head – return a number of lines from the top of a file

grep – search for a string in a file

The file has 12304 lines, 107560 words, 593837 characters

The word ‘kingdom’ appears on line 490 and 1124.



```
Ubuntu 64-bit Arm 24.04.3 2
Dec 11 11:09

sandra@sandra-VMware20-1:~$ cd Documents
sandra@sandra-VMware20-1:~/Documents$ wc sherlock.txt
12304 107560 607430 sherlock.txt
sandra@sandra-VMware20-1:~/Documents$ wc -m sherlock.txt
593837 sherlock.txt
sandra@sandra-VMware20-1:~/Documents$ grep -n 'kingdom' sherlock.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
sandra@sandra-VMware20-1:~/Documents$ head
```

```
sandra@sandra-VMware20-1:~/Documents$ cd Documents
sandra@sandra-VMware20-1:~/Documents$ head -500 sherlock.txt | tail -21
"Then I shall drop you a line to let you know how we progress."
"Pray do so. I shall be all anxiety."
"Then, as to money?"
"You have carte blanche."
"Absolutely?"
"I tell you that I would give one of the provinces of my kingdom to
have that photograph."
"And for present expenses?"
The King took a heavy chamois leather bag from under his cloak and laid
it on the table.
"There are three hundred pounds in gold and seven hundred in notes," he
said.
sandra@sandra-VMware20-1:~/Documents$
```

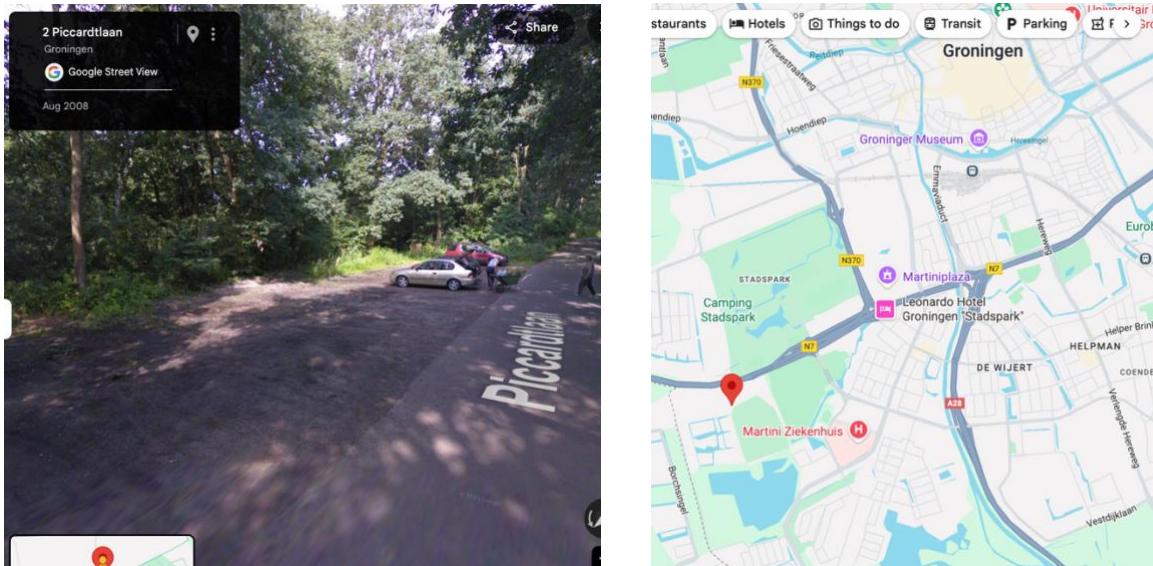
```
sandra@sandra-VMware20-1:~/Documents$ head -1134 sherlock.txt | tail -21
The King stared at him in amazement.
"Irene's photograph!" he cried. "Certainly, if you wish it."
"I thank your Majesty. Then there is no more to be done in the matter.
I have the honour to wish you a very good morning." He bowed, and,
turning away without observing the hand which the King had stretched
out to him, he set off in my company for his chambers.
And that was how a great scandal threatened to affect the kingdom of
Bohemia, and how the best plans of Mr. Sherlock Holmes were beaten by a
woman's wit. He used to make merry over the cleverness of women, but I
have not heard him do it of late. And when he speaks of Irene Adler, or
when he refers to her photograph, it is always under the honourable
title of the woman.

II. THE RED-HEADED LEAGUE
sandra@sandra-VMware20-1:~/Documents$
```

Assignment 5.7: Digital forensics

Relevant screenshots + motivation

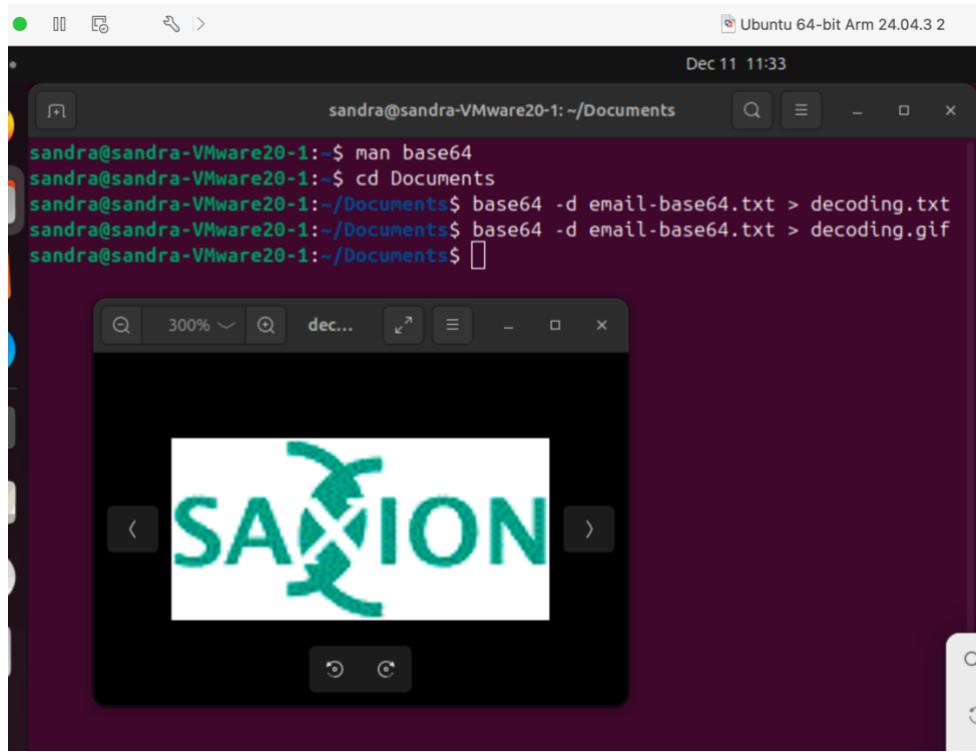
The photo was taken on a Motorola phone. The GPS coordinates are 53°11'39.6794"N 6°32'12.9018"E, which is a location in Groningen.



```
sandra@sandra-VMware20-1:~/Documents$ exif oldcar.jpg
EXIF tags in 'oldcar.jpg' ('Motorola' byte order):
-----
Tag |Value
+-
Manufacturer |motorola
Model |moto g(6) play
X-Resolution |72
Y-Resolution |72
Resolution Unit |Inch
Software |aljeter-user 9 PPPS29.55-35-18-7 6a0d0 release-keys
Date and Time |2020:11:07 15:08:57
YCbCr Positioning |Centered
Compression |JPEG compression
X-Resolution |72
Y-Resolution |72
Resolution Unit |Inch
Exposure Time |1/33 sec.
F-Number |f/2.0
Exposure Program |Normal program
ISO Speed Ratings |64
```

```
sandra@sandra-VMware20-1:~/Documents$ mv oldcar.jpg oldcar
sandra@sandra-VMware20-1:~/Documents$ 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
sandra@sandra-VMware20-1:~/Documents$
```

Yes, Ubuntu still recognizes oldcar as a jpg image.



Assignment 5.8: Steganography

Relevant screenshots + motivation

A screenshot of a terminal window titled "message.txt *". The content of the file is displayed as:

```
GNU nano 7.2
SECRET, HIDING DATA IN PLAIN VIEW !!!
```

The terminal window has a dark background and standard nano editor interface elements.A screenshot of a terminal window showing the usage of the steghide command. It displays options for embedding and extracting data from files, including parameters for verbosity, extraction, and passphrase. At the bottom, it shows a command to embed a file into a JPEG and a prompt for a passphrase, followed by a confirmation message about overwriting an existing file.

```
-v, --verbose           display detailed information

extracting options:
-sf, --stegofile        select stego file
-sf <filename>          extract data from <filename>
-p, --passphrase         specify passphrase
-p <passphrase>          use <passphrase> to extract data
-xf, --extractfile      select file name for extracted data
-xf <filename>          write the extracted data to <filename>
-f, --force              overwrite existing files
-q, --quiet              suppress information messages
-v, --verbose            display detailed information

options for the info command:
-p, --passphrase         specify passphrase
-p <passphrase>          use <passphrase> to get info about embedded data

To embed emb.txt in cvr.jpg: steghide embed -cf cvr.jpg -ef emb.txt
To extract embedded data from stg.jpg: steghide extract -sf stg.jpg
sandra@sandra-VMware20-1:~/Documents$ steghide extract -sf apple2.jpg
Enter passphrase:
the file "message.txt" does already exist. overwrite ? (y/n) y
wrote extracted data to "message.txt".
sandra@sandra-VMware20-1:~/Documents$
```

The screenshot shows a terminal window with the title bar "message.txt" and the path "~/Documents". The window contains the following text:

```
Hello class.  
You have almost completed Week 5.
```

Assignment 5.9: Capture disk images

Make relevant screenshots + motivation:

```
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
sandra@debian:~$ sudo apt update
[sudo] password for Sandra:
Hit:1 http://security.debian.org/debian-security trixie-security InRelease
Hit:2 http://deb.debian.org/debian trixie InRelease
Hit:3 http://deb.debian.org/debian trixie-updates InRelease
All packages are up to date.
sandra@debian:~$ sudo apt install openssh-server -y
openssh-server is already the newest version (1:10.0p1-7).
openssh-server set to manually installed.
Summary:
  Upgrading: 0, Installing: 0, Removing: 0, Not Upgrading: 0
sandra@debian:~$ sudo systemctl enable --now ssh
Synchronizing state of ssh.service with SysV service script with /usr/lib/systemd/systemd-sysv-install.
Executing: /usr/lib/systemd/systemd-sysv-install enable ssh
sandra@debian:~$ sudo mkdir -p /srv/images
sandra@debian:~$ sudo chown $USER:$USER /srv/images
sandra@debian:~$ 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: ens160: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 00:0c:29:49:1f:99 brd ff:ff:ff:ff:ff:ff
        altname enp2s0
        altname enx000c29491f99
        inet 192.168.139.136/24 brd 192.168.139.255 scope global dynamic noprefixroute ens160
            valid_lft 1670sec preferred_lft 1445sec
        inet6 fe80::bcda:4881:2704:88df/64 scope link
            valid_lft forever preferred_lft forever
sandra@debian:~$ _
```

- Proof that the Debian 13 server stored a back-up image of the Ubuntu 24.04 Desktop VM.

```
sandra@192.168.139.136's password:  
Sorry, try again.  
[sudo] password for sandra:  
Permission denied, please try again.  
sandra@192.168.139.136's password:  
sudo: 3 incorrect password attempts  
  
sandra@192.168.139.136: Permission denied (publickey,password).  
sandra@sandra-VMware20-1:~$  
sandra@sandra-VMware20-1:~$ sudo dd if=/dev/nvme0n1 bs=4M status=progress | gzip  
| ssh sandra@192.168.139.136 "cat > /srv/images/ubuntu24043_vm.img.gz"  
sandra@192.168.139.136's password:  
Sorry, try again.  
[sudo] password for sandra:  
  
Permission denied, please try again.  
sandra@192.168.139.136's password:  
21411921920 bytes (21 GB, 20 GiB) copied, 308 s, 69.5 MB/s  
5120+0 records in  
5120+0 records out  
21474836480 bytes (21 GB, 20 GiB) copied, 308.27 s, 69.7 MB/s  
sandra@sandra-VMware20-1:~$
```

- Proof that you can restore the back-up image into an empty VM.

```
ubuntu@ubuntu:~$ ssh sandra@192.168.139.136 "cat /srv/images/ubuntu24043_vm.img.  
gz" | gzip -d | sudo dd of=/dev/nvme0n1 bs=4M status=progress  
ssh: connect to host 192.168.139.136 port 22: Network is unreachable  
  
gzip: stdin: unexpected end of file  
0+0 records in  
0+0 records out  
0 bytes copied, 0.0085515 s, 0.0 kB/s  
ubuntu@ubuntu:~$ ssh sandra@192.168.139.136 "cat /srv/images/ubuntu24043_vm.img.  
gz" | gzip -d | sudo dd of=/dev/nvme0n1 bs=4M status=progress  
The authenticity of host '192.168.139.136 (192.168.139.136)' can't be established.  
ED25519 key fingerprint is SHA256:NxWZx8myBjvUkRIUH3vR7bIaDTM2wBEexDwHPnkxOZM.  
This key is not known by any other names.  
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes  
Warning: Permanently added '192.168.139.136' (ED25519) to the list of known host  
s.  
sandra@192.168.139.136's password:  
21359591424 bytes (21 GB, 20 GiB) copied, 127 s, 168 MB/s  
0+645575 records in  
0+645575 records out  
21474836480 bytes (21 GB, 20 GiB) copied, 127.76 s, 168 MB/s  
ubuntu@ubuntu:~$
```

