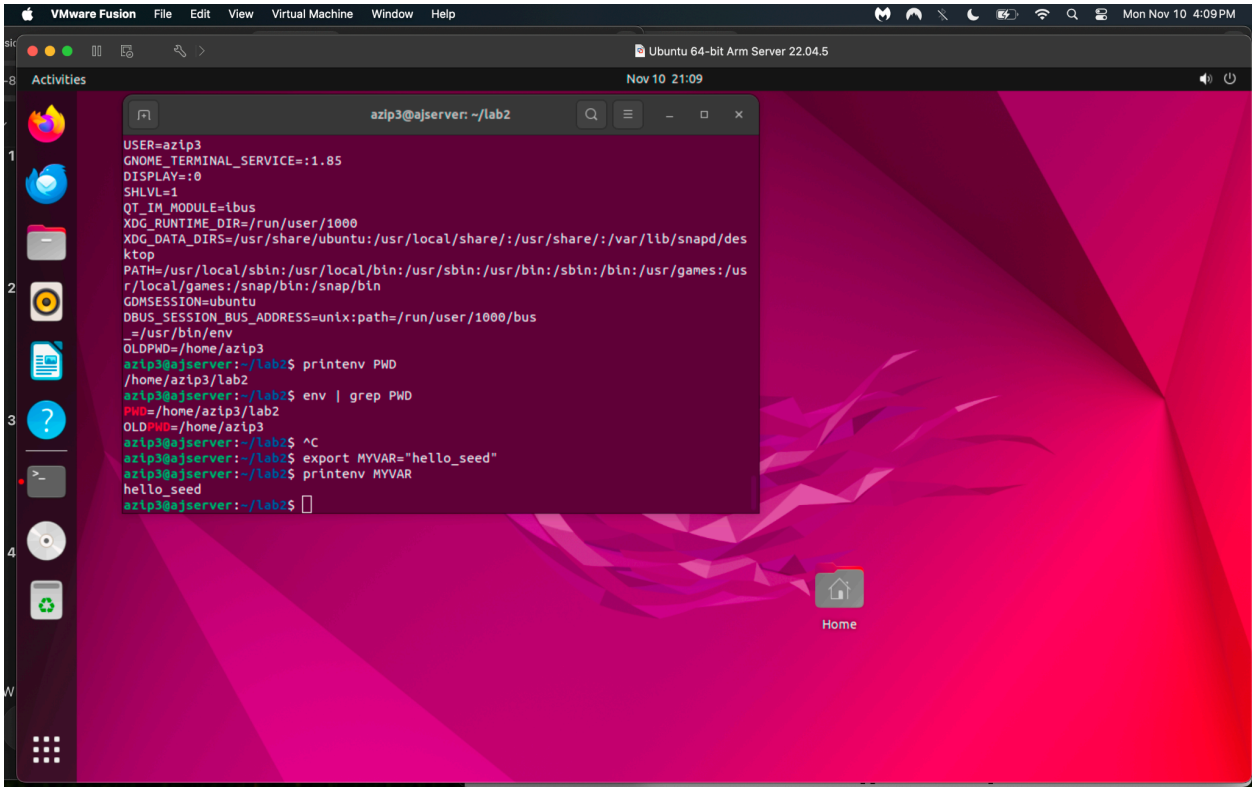
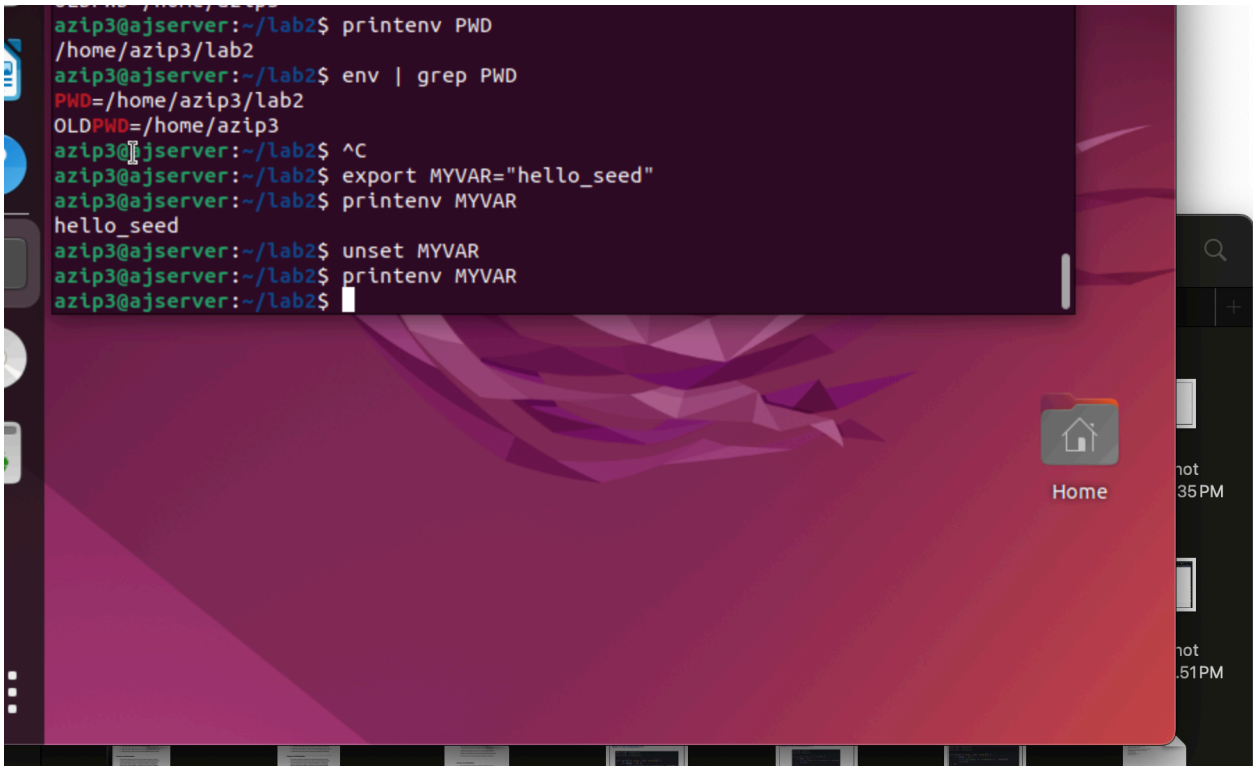
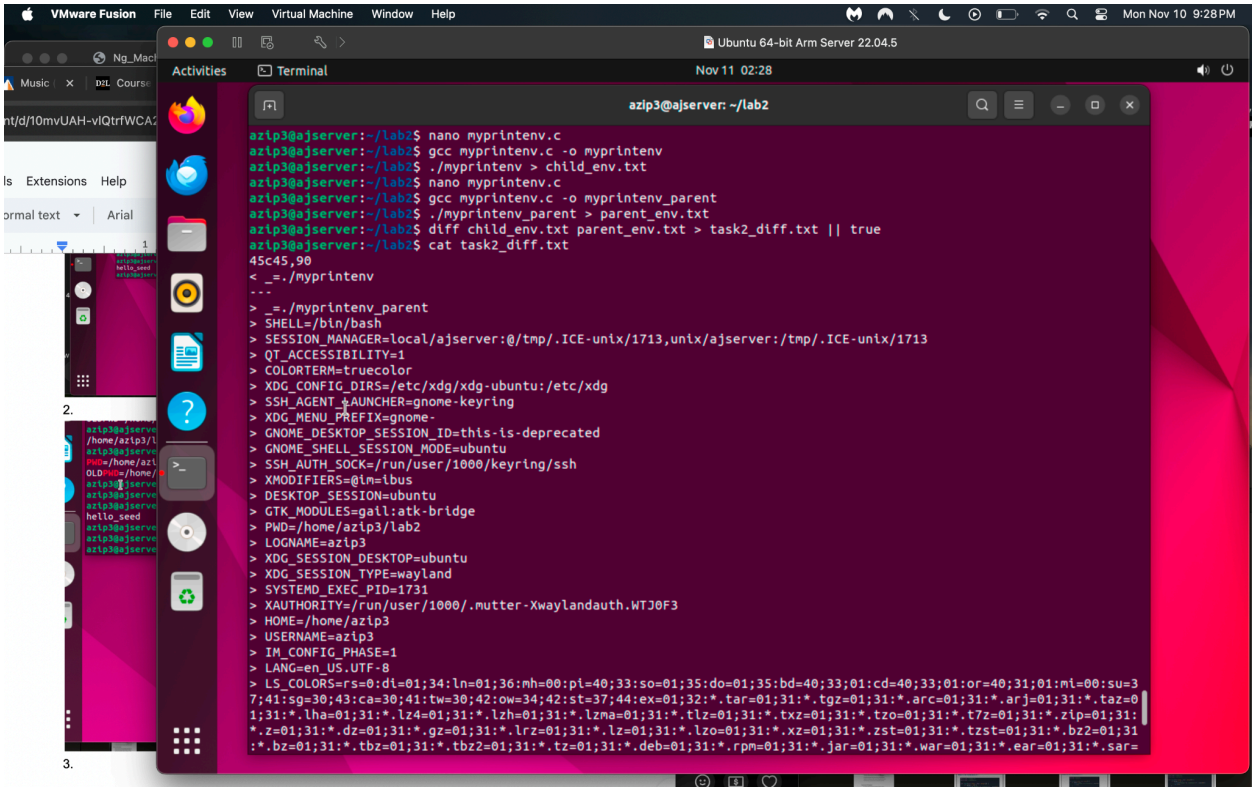
Task 1. In this task it shows how you can manipulate environment variables in a Bash Shell. Using export and unset show that they are shell builtins that modify the shell environment. Exported variables can be inherited by child processes



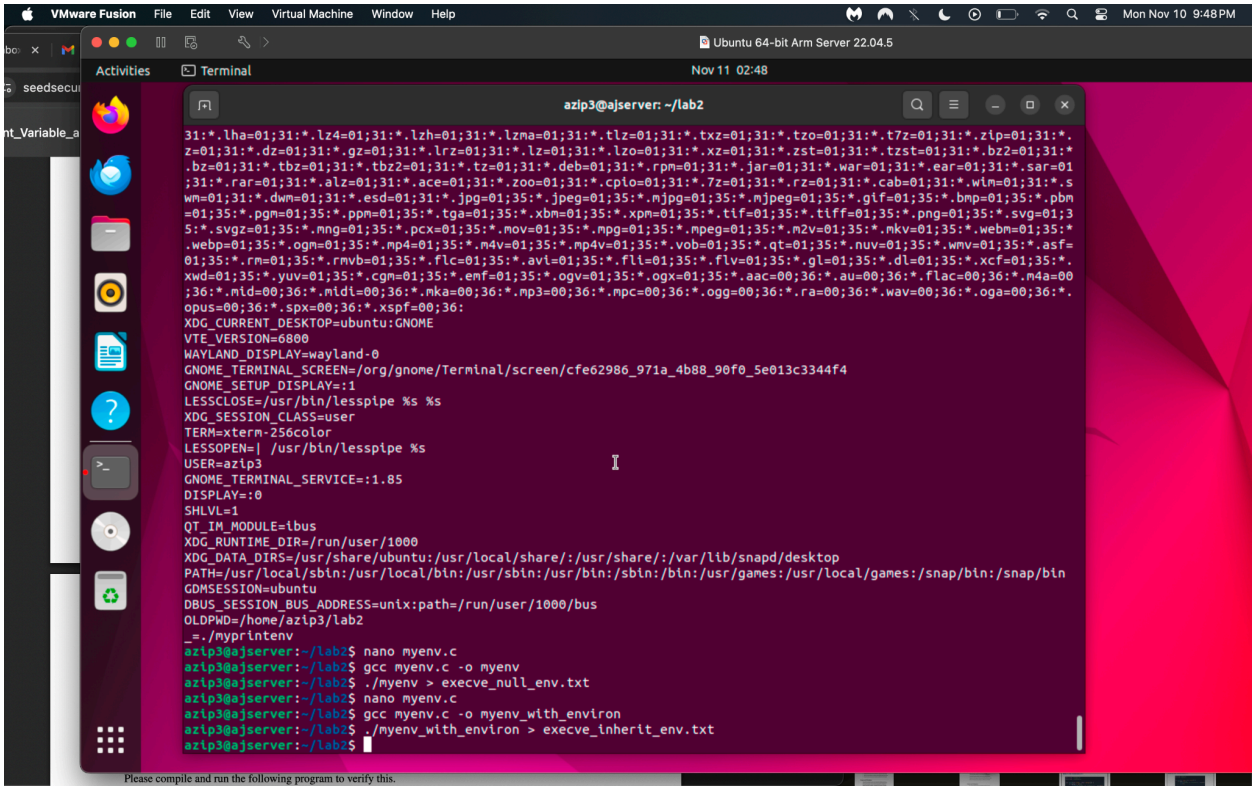


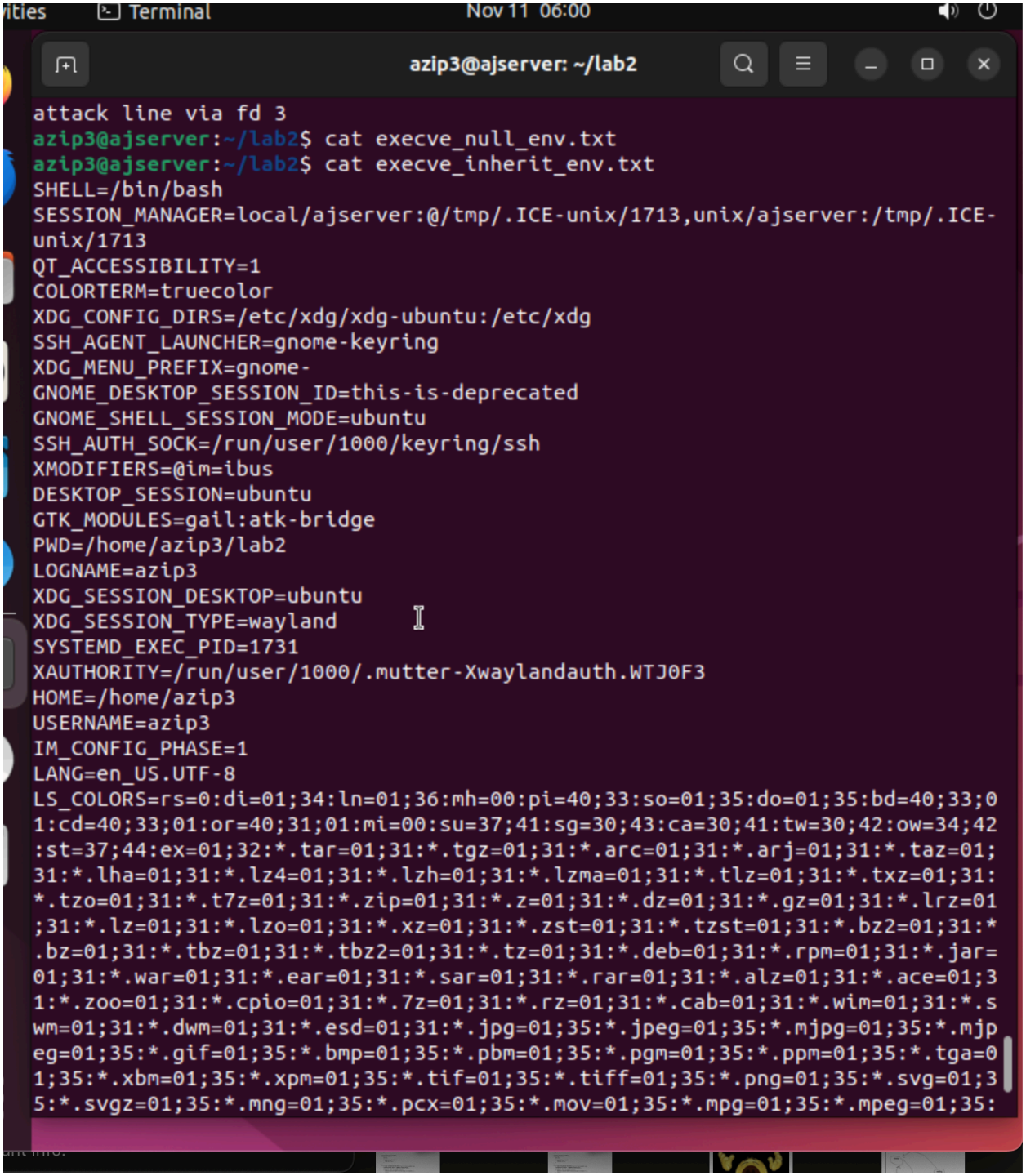
Task 2. We ran myprintenv.c with two configurations. The Difference File seemed to be the same which shows that child processes that are made inherit the parents environment variables.



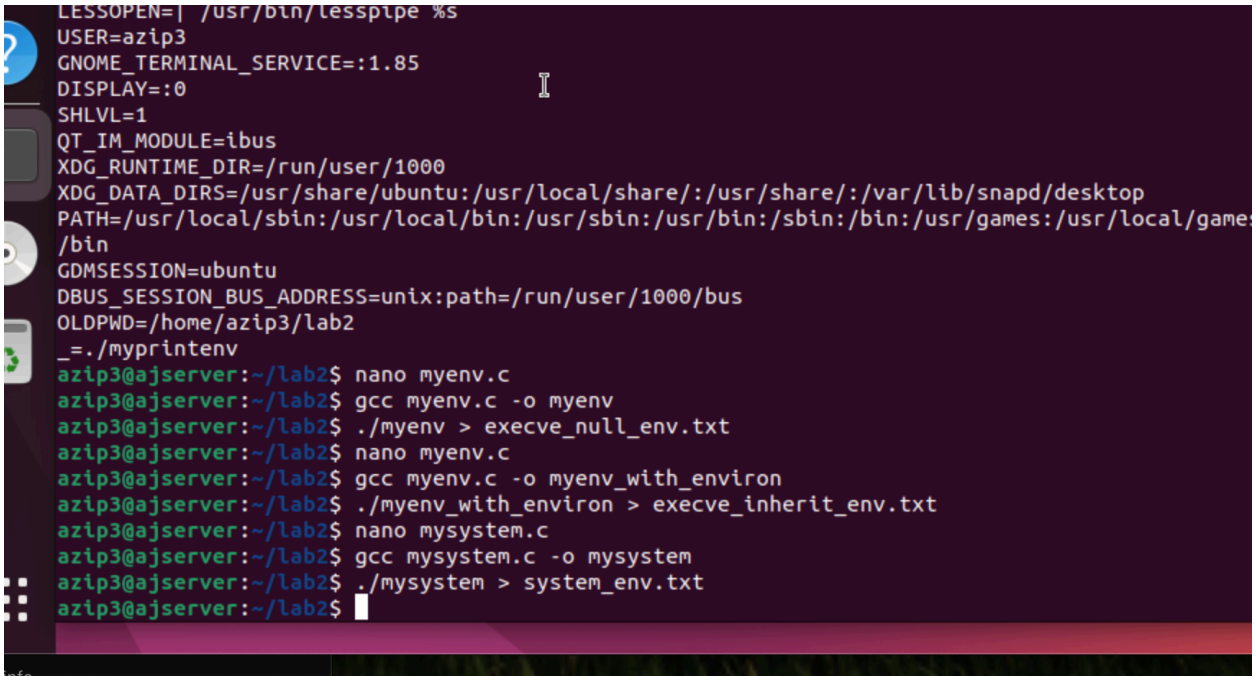
Task 3.

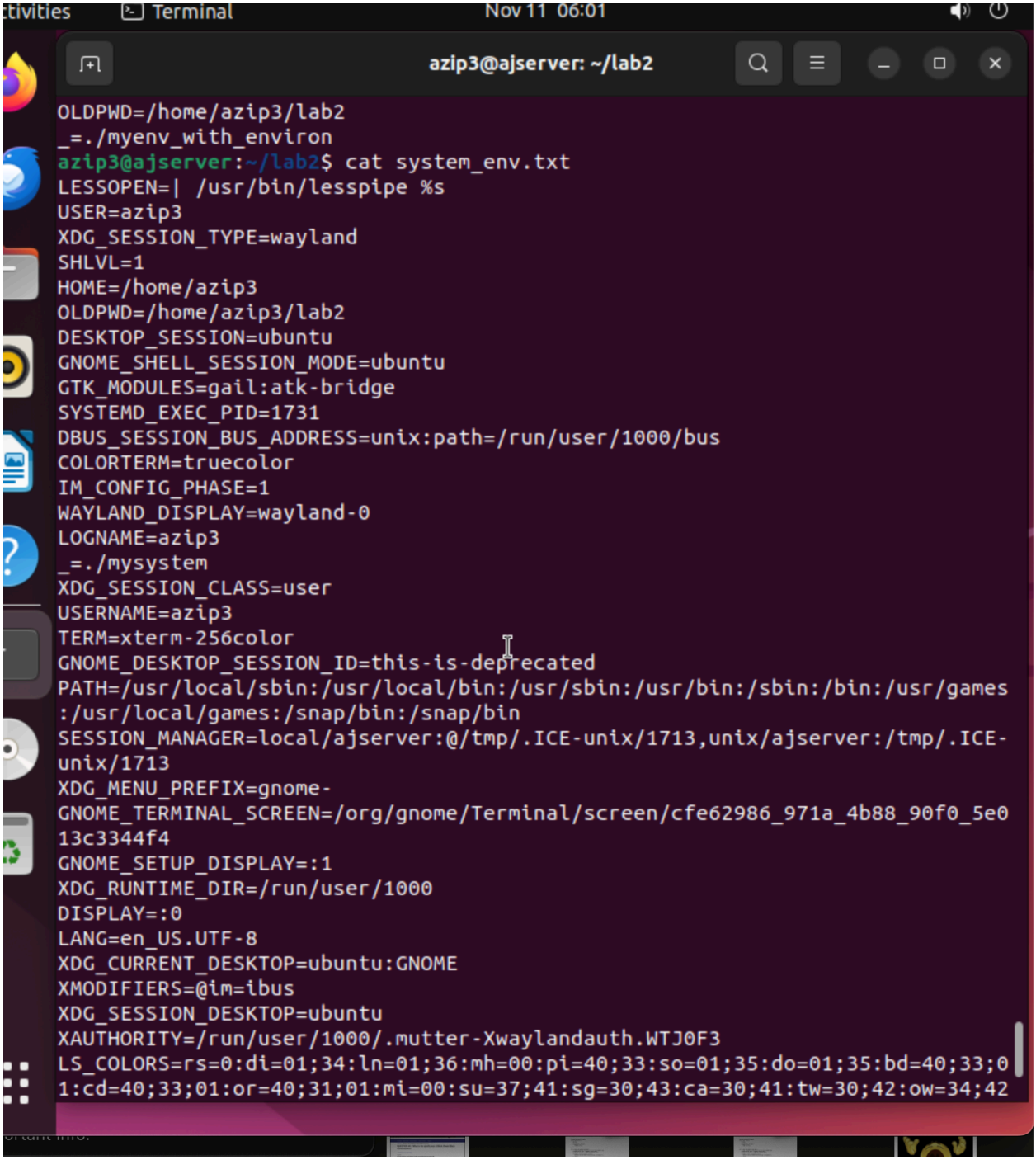
I learned that the “execve()” accepts an explicit envp pointer. If you pass environ then the environment array is available to the executed program. When I pass NULL that means no environment is provided. If you want inheritance you need the environment array if you want to use the “execve()”. When we have execve(...,NULL) the environment is empty, but if it’s execve(...,environ) it prints the full environment inherited from the calling process.


VMware Fusion File Edit View Virtual Machine Window Help
Mon Nov 10 9:48 PM
Ubuntu 64-bit Arm Server 22.04.5
Activities
Terminal
Nov 11 02:48
azip3@ajserver: ~/lab2
31:*.lha=01;31:*.lz4=01;31:*.lzh=01;31:*.lzma=01;31:*.tlz=01;31:*.txz=01;31:*.tzo=01;31:*.t7z=01;31:*.zip=01;31:*.z=01;31:*.dz=01;31:*.gz=01;31:*.lrz=01;31:*.lz=01;31:*.lzo=01;31:*.xz=01;31:*.zst=01;31:*.tzst=01;31:*.bz2=01;31:*.bz=01;31:*.tbz=01;31:*.tbz2=01;31:*.tz=01;31:*.deb=01;31:*.rpm=01;31:*.jar=01;31:*.war=01;31:*.ear=01;31:*.sar=01;31:*.rar=01;31:*.alz=01;31:*.ace=01;31:*.zoo=01;31:*.cpio=01;31:*.7z=01;31:*.rz=01;31:*.cab=01;31:*.wim=01;31:*.swm=01;31:*.dwm=01;31:*.esd=01;31:*.jpg=01;35:*.jpeg=01;35:*.mjpg=01;35:*.mjpeg=01;35:*.gif=01;35:*.bmp=01;35:*.pbm=01;35:*.pgm=01;35:*.ppm=01;35:*.tga=01;35:*.xbm=01;35:*.xpm=01;35:*.tif=01;35:*.tiff=01;35:*.png=01;35:*.svg=01;35:*.svgz=01;35:*.mng=01;35:*.pcx=01;35:*.mov=01;35:*.mpg=01;35:*.mpeg=01;35:*.m2v=01;35:*.mkv=01;35:*.webm=01;35:*.webp=01;35:*.ogm=01;35:*.mp4=01;35:*.m4v=01;35:*.mp4v=01;35:*.vob=01;35:*.qt=01;35:*.nuv=01;35:*.wmv=01;35:*.asf=01;35:*.rm=01;35:*.rmvb=01;35:*.flc=01;35:*.avi=01;35:*.fli=01;35:*.flv=01;35:*.gl=01;35:*.dl=01;35:*.xcf=01;35:*.xwd=01;35:*.yuv=01;35:*.cgm=01;35:*.emf=01;35:*.ogv=01;35:*.ogx=01;35:*.aac=00;36:*.au=00;36:*.flac=00;36:*.m4a=00;36:*.mid=00;36:*.midi=00;36:*.mka=00;36:*.mp3=00;36:*.mpc=00;36:*.ogg=00;36:*.ra=00;36:*.wav=00;36:*.oga=00;36:*.opus=00;36:*.spx=00;36:*.xspf=00;36:
XDG_CURRENT_DESKTOP=ubuntu:GNOME
VTE_VERSION=6800
WAYLAND_DISPLAY=wayland-0
GNOME_TERMINAL_SCREEN=/org/gnome/Terminal/screen/cfe62986_971a_4b88_90f0_5e013c3344f4
GNOME_SETUP_DISPLAY=:1
LESSCLOSE=/usr/bin/lesspipe %s %s
XDG_SESSION_CLASS=user
TERM=xterm-256color
LESSOPEN=| /usr/bin/lesspipe %s
USER=azip3
GNOME_TERMINAL_SERVICE=:1.85
DISPLAY=:0
SHLVL=1
QT_IM_MODULE=ibus
XDG_RUNTIME_DIR=/run/user/1000
XDG_DATA_DIRS=/usr/share/ubuntu:/usr/local/share/:/usr/share/:/var/lib/snapd/desktop
PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:/usr/games:/usr/local/games:/snap/bin:/snap/bin
GDMSESSION=ubuntu
DBUS_SESSION_BUS_ADDRESS=unix:path=/run/user/1000/bus
OLDPWD=/home/azip3/lab2
_=./myprintenv
azip3@ajserver:~/lab2$ nano myenv.c
azip3@ajserver:~/lab2$ gcc myenv.c -o myenv
azip3@ajserver:~/lab2$ ./myenv > execve_null_env.txt
azip3@ajserver:~/lab2$ nano myenv.c
azip3@ajserver:~/lab2$ gcc myenv.c -o myenv_with_environ
azip3@ajserver:~/lab2$ ./myenv_with_environ > execve_inherit_env.txt
azip3@ajserver:~/lab2$
Please compile and run the following program to verify this.

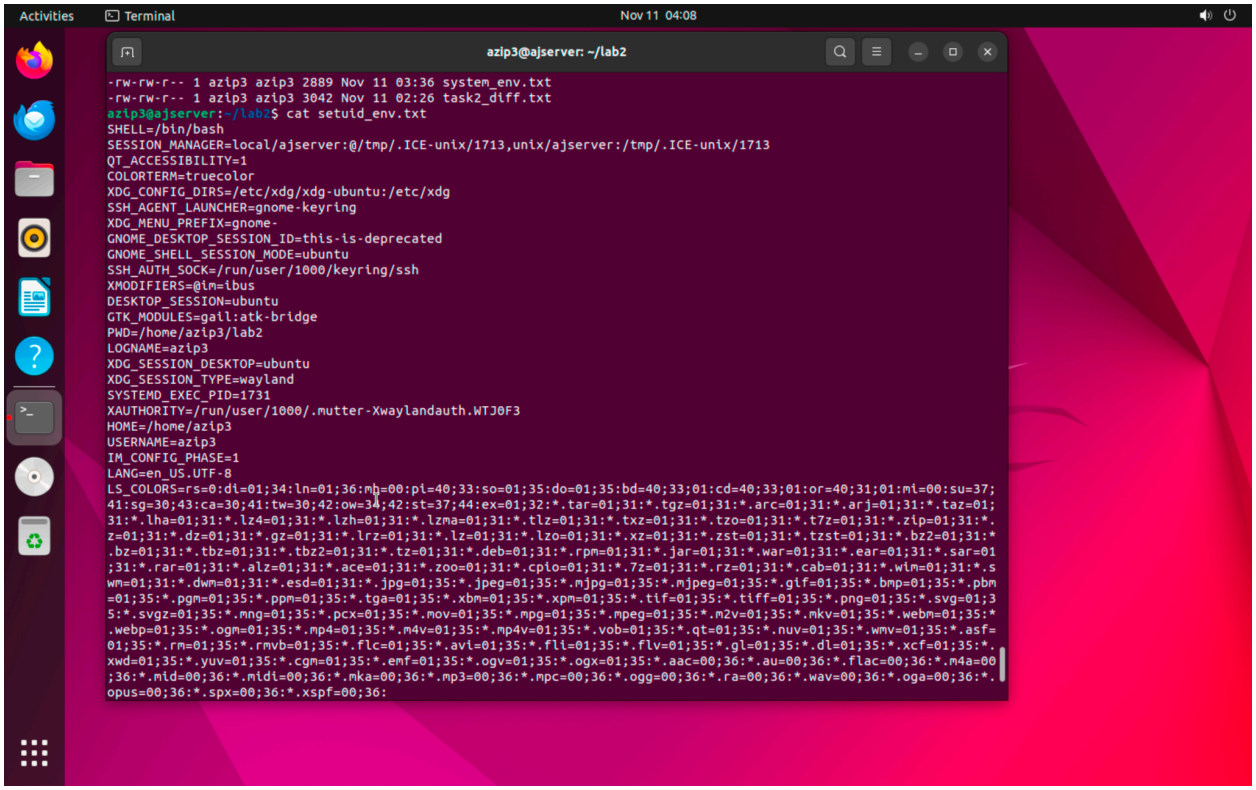


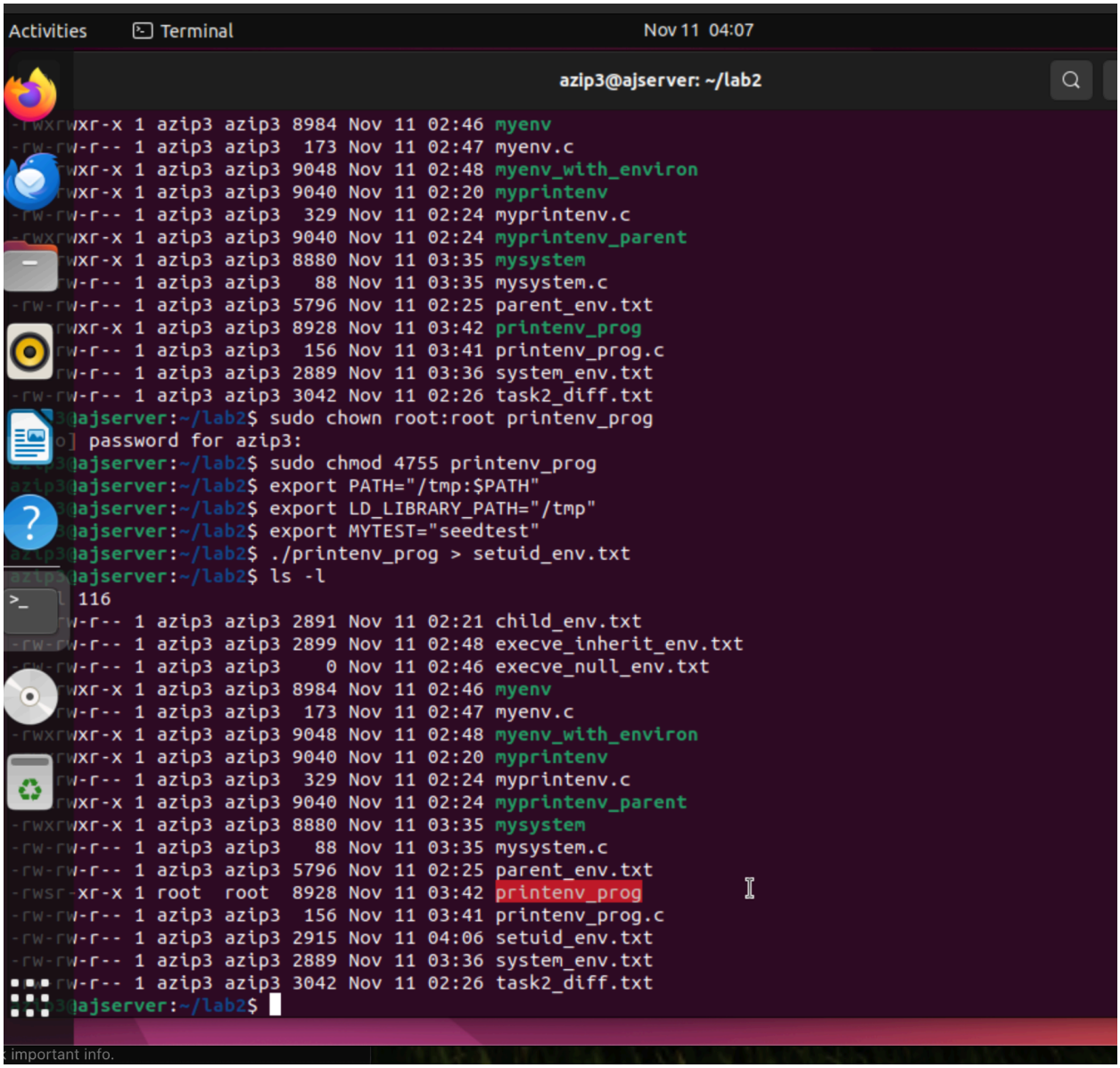
Task 4.
This task confirmed that “system()” passes the caller environment to /bin/sh which will execute the requested command. This shows why using system() in privileged programs is dangerous because a attacker controlled environment can be used to influence shell behavior.


LESSOPEN=| /usr/bin/lesspipe %s
USER=azip3
GNOME_TERMINAL_SERVICE=:1.85
DISPLAY=:0
SHLVL=1
QT_IM_MODULE=ibus
XDG_RUNTIME_DIR=/run/user/1000
XDG_DATA_DIRS=/usr/share/ubuntu:/usr/local/share/:/usr/share/:/var/lib/snapd/desktop
PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:/usr/games:/usr/local/game
/bin
GDMSESSION=ubuntu
DBUS_SESSION_BUS_ADDRESS=unix:path=/run/user/1000/bus
OLDPWD=/home/azip3/lab2
_=./myprintenv
azip3@ajserver:~/lab2$ nano myenv.c
azip3@ajserver:~/lab2$ gcc myenv.c -o myenv
azip3@ajserver:~/lab2$ ./myenv > execve_null_env.txt
azip3@ajserver:~/lab2$ nano myenv.c
azip3@ajserver:~/lab2$ gcc myenv.c -o myenv_with_environ
azip3@ajserver:~/lab2$ ./myenv_with_environ > execve_inherit_env.txt
azip3@ajserver:~/lab2$ nano mysystem.c
azip3@ajserver:~/lab2$ gcc mysystem.c -o mysystem
azip3@ajserver:~/lab2$ ./mysystem > system_env.txt
azip3@ajserver:~/lab2$



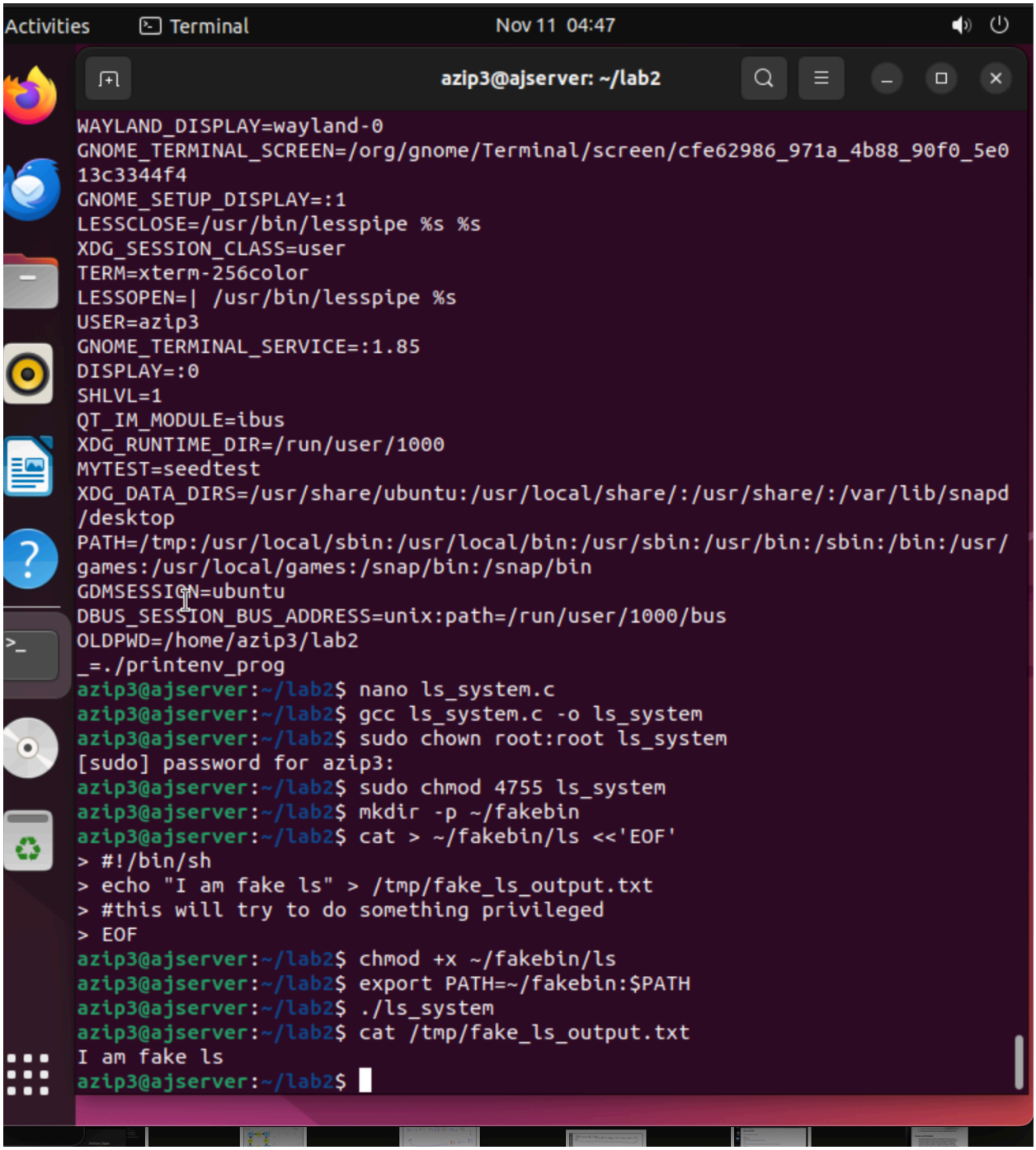
Task 5. In this task I learned about SET-UID programs. After exporting PATH,LD_LIBRSRY_PATH, etc, I executed root owned SET-UID program that prints environ. The output shows that loader related variables are not honored for SETUID root binaries (LD_PRELOAD,LD_LIBRARY_PATH) while some variables like (LANG and HOME) can still be visible sometimes. This demonstrates operating system and loader level protections are intended to prevent privilege escalation by environment manipulation but also highlighted that SET-UID programs must be written defensively.


Activities
Terminal
Nov 11 04:08
azip3@ajserver: ~/lab2
-rw-rw-r-- 1 azip3 azip3 2889 Nov 11 03:36 system_env.txt
-rw-rw-r-- 1 azip3 azip3 3042 Nov 11 02:26 task2_diff.txt
azip3@ajserver:~/lab2$ cat setuid_env.txt
SHELL=/bin/bash
SESSION_MANAGER=local/ajserver:@/tmp/.ICE-unix/1713,unix/ajserver:/tmp/.ICE-unix/1713
QT_ACCESSIBILITY=1
COLORTERM=truecolor
XDG_CONFIG_DIRS=/etc/xdg/xdg-ubuntu:/etc/xdg
SSH_AGENT_LAUNCHER=gnome-keyring
XDG_MENU_PREFIX=gnome-
GNOME_DESKTOP_SESSION_ID=this-is-deprecated
GNOME_SHELL_SESSION_MODE=ubuntu
SSH_AUTH_SOCK=/run/user/1000/keyring/ssh
XMODIFIERS=@im=ibus
DESKTOP_SESSION=ubuntu
GTK_MODULES=gail:atk-bridge
PWD=/home/azip3/lab2
LOGNAME=azip3
XDG_SESSION_DESKTOP=ubuntu
XDG_SESSION_TYPE=wayland
SYSTEMD_EXEC_PID=1731
XAUTHORITY=/run/user/1000/.mutter-Xwaylandauth.WTJ0F3
HOME=/home/azip3
USERNAME=azip3
IM_CONFIG_PHASE=1
LANG=en_US.UTF-8
LS_COLORS=rs=0:di=01;34:ln=01;36:mh=00:pi=40;33:so=01;35:do=01;35:bd=40;33;01:cd=40;33;01:or=40;31;01:mi=00:su=37;41:sg=30;43:ca=30;41:tw=30;42:ow=34;42:st=37;44:ex=01;32:*.tar=01;31:*.tgz=01;31:*.arc=01;31:*.arj=01;31:*.taz=01;31:*.lha=01;31:*.lz4=01;31:*.lzh=01;31:*.lzma=01;31:*.tlz=01;31:*.txz=01;31:*.tzo=01;31:*.t7z=01;31:*.zip=01;31:*.z=01;31:*.dz=01;31:*.gz=01;31:*.lrz=01;31:*.lz=01;31:*.lzo=01;31:*.xz=01;31:*.zst=01;31:*.tzst=01;31:*.bz2=01;31:*.bz=01;31:*.tbz=01;31:*.tbz2=01;31:*.tz=01;31:*.deb=01;31:*.rpm=01;31:*.jar=01;31:*.war=01;31:*.ear=01;31:*.sar=01;31:*.rar=01;31:*.alz=01;31:*.ace=01;31:*.zoo=01;31:*.cpio=01;31:*.7z=01;31:*.rz=01;31:*.cab=01;31:*.wim=01;31:*.swm=01;31:*.dwm=01;31:*.esd=01;31:*.jpg=01;35:*.jpeg=01;35:*.mjpg=01;35:*.mjpeg=01;35:*.gif=01;35:*.bmp=01;35:*.pbm=01;35:*.pgm=01;35:*.ppm=01;35:*.tga=01;35:*.xbm=01;35:*.xpm=01;35:*.tif=01;35:*.tiff=01;35:*.png=01;35:*.svg=01;35:*.svgz=01;35:*.mng=01;35:*.pcx=01;35:*.mov=01;35:*.mpg=01;35:*.mpeg=01;35:*.m2v=01;35:*.mkv=01;35:*.webm=01;35:*.webp=01;35:*.ogm=01;35:*.mp4=01;35:*.m4v=01;35:*.mp4v=01;35:*.vob=01;35:*.qt=01;35:*.nuv=01;35:*.wmv=01;35:*.asf=01;35:*.rm=01;35:*.rmvb=01;35:*.flc=01;35:*.avi=01;35:*.fli=01;35:*.flv=01;35:*.gl=01;35:*.dl=01;35:*.xcf=01;35:*.xwd=01;35:*.yuv=01;35:*.cgm=01;35:*.emf=01;35:*.ogv=01;35:*.ogx=01;35:*.aac=00;36:*.au=00;36:*.flac=00;36:*.m4a=00;36:*.mid=00;36:*.midi=00;36:*.mka=00;36:*.mp3=00;36:*.mpc=00;36:*.ogg=00;36:*.ra=00;36:*.wav=00;36:*.oga=00;36:*.opus=00;36:*.spx=00;36:*.xspf=00;36:



Task 6.

This task showed why/how using system() in Set-UID programs is risky. The vulnerable program called “system(“ls”)” which causes /bin/sh to resolve ls via PATH. By adding a directory containing a malicious ls earlier in PATH an attacker may cause the SET-UID program to execute unintended code. Many shells when they detect they are running in a set-uid context they drop privileges and refuse risky behavior. This prevents the attack in the system using shells. But if it lacks protection then the attack work.I learned to avoid “system()” and use “execve()” instead with an absolute path to the intended executable.



Task 7.

This task investigated LD_PRELOAD and dynamic linking. A custom library that overrides sleep() successfully changed behavior of a normal program when LD_PRELOAD pointed to it. But when it was made SET-uid root, LD_PRELOAD was ignored and the override wouldn't run. This shows loaders safety feature as it does not honor LD_… environment variables for privileged executables in order to prevent untrusted user libraries from being loaded into high-privilege processes.

```
azip3@ajserver:~/lab2$ cat /tmp/fake_ls_output.txt
I am fake ls
azip3@ajserver:~/lab2$ nano mylib.c
azip3@ajserver:~/lab2$ gcc -fPIC -g -c mylib.c
azip3@ajserver:~/lab2$ gcc -shared -o libmylib.so.1.0.1 mylib.o -lc
azip3@ajserver:~/lab2$ nano myprog.c
azip3@ajserver:~/lab2$ gcc myprog.c -o myprog
azip3@ajserver:~/lab2$ export LD_PRELOAD=./libmylib.so.1.0.1
azip3@ajserver:~/lab2$ ./myprog
I am not sleeping!
azip3@ajserver:~/lab2$ sudo chown root:root myprog
azip3@ajserver:~/lab2$ sudo chmod 4755 myprog
azip3@ajserver:~/lab2$ export LD_PRELOAD=./libmylib.so.1.0.1
azip3@ajserver:~/lab2$ ./myprog > setuid_mylib_result.txt 2>&1 || true
azip3@ajserver:~/lab2$
```

Task 8.

This task compared system() and execve() in set-uid context using catall for the example. Using system() is unsafe as it involves a shell that interprets the command and the resulting behavior can be influenced by PATH and other environment variables, opening avenues for injection privilege misuse. In contrast, execve() executes the intended binary directly and avoids shell parsing so it makes it safer for privileged programs. Provided the program uses absolute paths and carefully controls arguments and environment.

```
  27 | }
     | ~
azip3@ajserver:~/lab2$ nano catall.c
azip3@ajserver:~/lab2$ nano catall.c
azip3@ajserver:~/lab2$ gcc catall.c -o catall
azip3@ajserver:~/lab2$ sudo chown root:root catall
[sudo] password for azip3:
azip3@ajserver:~/lab2$ sudo chmod 4755 catall
azip3@ajserver:~/lab2$ ./catall /etc/passwd
root:x:0:0:root:/root:/bin/bash
```

```
azip3@ajserver:~/lab2$ ./catall "/etc/passwd; touch /tmp/hacked"
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/usr/sbin/nologin
```

```
azip3@ajserver:~/lab2$ ./catall "/etc/passwd; touch /tmp/hacked"
/bin/cat: '/etc/passwd; touch /tmp/hacked': No such file or directory
azip3@ajserver:~/lab2$
```

Task 9.

Setuid() changed the process's user IDs but doesn't removes resources that were obtained when it was privileged. The principle of least privilege would require closing and revoking privileges resources before dropping privileges. Task 9 shows capability leaking. The set-UID program opened /etc/zzz while running with elevated privilege and then called (setuid(getuid()) to drop root privileges before spawning a shell. Although UID was changed resources acquired while privileged stayed and could still be used by process of inherited spawned shell. This

shows surprisingly that dropping UID alone isn't enough. To avoid capability leaking a program must explicitly close/revoke privileges.