CS342

Operating Systems

Spring 2021

Homework #1

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Section: 1

1. Installation

In order to be able to continue using Windows operating system after installing Linux operating system, I first downloaded VirtualBox which is a virtual machine.

From the given link “https://ubuntu.com/download/desktop”, I have downloaded the desired version of Ubuntu -20.04. After I downloaded the .iso, I had to create a new operating system on the virtual machine. However, there was a difficulty while achieving this. When I clicked settings of Ubuntu in the virtual machine software, there was a warning at the bottom of the pop-up screen which says exactly the following,

“System acceleration Page: The hardware virtualization is enabled in the acceleration section of the system page although it is not supported by the host system. It should be disabled in order to start the virtual system.”

In order to solve this problem, I had to restart my desktop PC and enter the UEFI Firmware Settings. Since my motherboard is a product of ASUS brand, clicking F2 while opening the computer directs me to there. In the opening screen, click -> Advanced, click -> CPU configuration, Click -> SVM Mode, and click ‘enable’.

This solved my problem and I successfully installed a new operating system into my computer which is Linux.

10 Commands I have Learned

- **cd** -> Used to go to a directory
- **ls** -> Used to see what files are in the directory you are in
- **cp** -> Used to copy and paste files
- **touch** -> Used to create a file
- **mkdir** -> Used to create a folder or a directory
- **rm** -> Used to delete files and directories
- **man** -> Used to learn more about a command and how to used it
- **mv** -> Used to move files or rename a file
- **more** -> Used to view the content of a file
- **cat** -> Used to display the contents of a file

2. Location and Version

Location where the kernel executable resides:

/boot

Version, by running “uname -r” command

5.8.0-41-generic

3. Downloading Linux Kernel

I have downloaded the closest release of the Linux kernel which is 5.10.12.

The name of the downloaded file is, 'linux-5.10.12.tar.xz'.

Subdirectories:

arch, block, certs, crypto, Documentation, drivers, fs, include, init, ipc, kernel, lib, LICENCES, mm, net, samples, scripts, security, sound, tools, usr, virt

4. The system call table

There are two tables in the source code one is 32-bit system call table, the other is 64-bit system call table

The 32-bit system call table is found at the following path.

/arch/x86/entry/syscalls/syscall_32.tbl

The 64-bit system call table is found at the following path.

/arch/x86/entry/syscalls/syscall_64.tbl

System calls in the 32-bit system call table,

3: read

35: ftime

110: iopl

210: setresgid32

System calls in the 64-bit system call table

3: close

35: nanosleep

110: getppid

210: io_cancel

5. strace Command

In order to trace cp command, firstly, I have created a txt file in desktop by writing the following commands respectively.

cd Desktop

touch copyFile.txt

I wrote some dummy text in this txt file by double clicking it.

strace cp copyFile.txt pasteFile.txt

After running the command above, a txt file whose name is pasteFile.txt and content is the same as copyFile.txt has been created. The output of the command is given below:

execve("/usr/bin/cp", ["cp", "copyFile.txt", "pasteFile.txt"], 0x7ffce5de0f20 /* 61 vars */) = 0

brk(NULL) = 0x5591e389e000

arch_prctl(0x3001 /* ARCH_??? */, 0x7ffc4d04f960) = -1 EINVAL (Invalid argument)

access("/etc/ld.so.preload", R_OK) = -1 ENOENT (No such file or directory)

openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3

fstat(3, {st_mode=S_IFREG|0644, st_size=73485, ...}) = 0

mmap(NULL, 73485, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f979f67b000

close(3) = 0

openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libselinux.so.1", O_RDONLY|O_CLOEXEC) = 3

read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0@p\0\0\0\0\0\0"..., 832) = 832

fstat(3, {st_mode=S_IFREG|0644, st_size=163200, ...}) = 0

mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f979f679000

mmap(NULL, 174600, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f979f64e000

mprotect(0x7f979f654000, 135168, PROT_NONE) = 0

mmap(0x7f979f654000, 102400, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x6000) = 0x7f979f654000

mmap(0x7f979f66d000, 28672, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,
3, 0x1f000) = 0x7f979f66d000

mmap(0x7f979f675000, 8192, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x26000) = 0x7f979f675000

mmap(0x7f979f677000, 6664, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f979f677000

close(3) = 0

openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libacl.so.1", O_RDONLY|O_CLOEXEC) = 3

read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\360$\0\0\0\0\0\0"..., 832) =
832

fstat(3, {st_mode=S_IFREG|0644, st_size=39088, ...}) = 0

mmap(NULL, 41120, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f979f643000

mmap(0x7f979f645000, 20480, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x2000) = 0x7f979f645000

mmap(0x7f979f64a000, 8192, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,
3, 0x7000) = 0x7f979f64a000

mmap(0x7f979f64c000, 8192, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x8000) = 0x7f979f64c000

close(3) = 0

openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libattr.so.1", O_RDONLY|O_CLOEXEC) = 3

read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0 $\0\0\0\0\0\0"..., 832) = 832

fstat(3, {st_mode=S_IFREG|0644, st_size=26696, ...}) = 0

mmap(NULL, 28696, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f979f63b000

mmap(0x7f979f63d000, 12288, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x2000) = 0x7f979f63d000

mmap(0x7f979f640000, 4096, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,
3, 0x5000) = 0x7f979f640000

mmap(0x7f979f641000, 8192, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x5000) = 0x7f979f641000

close(3) = 0

openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3

read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\360q\2\0\0\0\0"..., 832) = 832

pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784

pread64(3, "\4\0\0\0\20\0\0\0\5\0\0\0GNU\0\2\0\0\300\4\0\0\0\3\0\0\0\0\0\0\0", 32, 848) = 32

pread64(3, "\4\0\0\0\24\0\0\0\3\0\0\0GNU\0\t\233\222%\274\260\320\31\331\326\10\204\276X>\263"..., 68, 880) = 68

fstat(3, {st_mode=S_IFREG|0755, st_size=2029224, ...}) = 0

pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784

pread64(3, "\4\0\0\0\20\0\0\0\5\0\0\0GNU\0\2\0\0\300\4\0\0\0\3\0\0\0\0\0\0\0", 32, 848) = 32

pread64(3, "\4\0\0\0\24\0\0\0\3\0\0\0GNU\0\t\233\222%\274\260\320\31\331\326\10\204\276X>\263"..., 68, 880) = 68

mmap(NULL, 2036952, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f979f449000

mprotect(0x7f979f46e000, 1847296, PROT_NONE) = 0

mmap(0x7f979f46e000, 1540096, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x25000) = 0x7f979f46e000

mmap(0x7f979f5e6000, 303104, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x19d000) = 0x7f979f5e6000

mmap(0x7f979f631000, 24576, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1e7000) = 0x7f979f631000

mmap(0x7f979f637000, 13528, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f979f637000

close(3)   = 0

openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libpcre2-8.so.0", O_RDONLY|O_CLOEXEC) = 3

read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\340\"\0\0\0\0\0\0"..., 832) = 832

fstat(3, {st_mode=S_IFREG|0644, st_size=584392, ...}) = 0

mmap(NULL, 586536, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f979f3b9000

mmap(0x7f979f3bb000, 409600, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x2000) = 0x7f979f3bb000

mmap(0x7f979f41f000, 163840, PROT_READ,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x66000) = 0x7f979f41f000

mmap(0x7f979f447000, 8192, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x8d000) = 0x7f979f447000

close(3) = 0

openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libdl.so.2", O_RDONLY|O_CLOEXEC) = 3

read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0 \22\0\0\0\0\0\0"..., 832) = 832

fstat(3, {st_mode=S_IFREG|0644, st_size=18816, ...}) = 0

mmap(NULL, 20752, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f979f3b3000

mmap(0x7f979f3b4000, 8192, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1000) = 0x7f979f3b4000

mmap(0x7f979f3b6000, 4096, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,
3, 0x3000) = 0x7f979f3b6000

mmap(0x7f979f3b7000, 8192, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x3000) = 0x7f979f3b7000

close(3) = 0

openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libpthread.so.0", O_RDONLY|O_CLOEXEC) = 3

read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\220\201\0\0\0\0\0\0"..., 832) =
832

pread64(3,
"\4\0\0\0\24\0\0\0\3\0\0\0GNU\0\345Ga\367\265T\320\374\301V)Yf]\223\337"..., 68,
824) = 68

fstat(3, {st_mode=S_IFREG|0755, st_size=157224, ...}) = 0

mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7f979f3b1000

pread64(3,
"\4\0\0\0\24\0\0\0\3\0\0\0GNU\0\345Ga\367\265T\320\374\301V)Yf]\223\337"..., 68,
824) = 68

mmap(NULL, 140408, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f979f38e000

mmap(0x7f979f395000, 69632, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x7000) = 0x7f979f395000

mmap(0x7f979f3a6000, 20480, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x18000) = 0x7f979f3a6000

mmap(0x7f979f3ab000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1c000) = 0x7f979f3ab000

mmap(0x7f979f3ad000, 13432, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f979f3ad000

close(3) = 0

mmap(NULL, 12288, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f979f38b000

arch_prctl(ARCH_SET_FS, 0x7f979f38b800) = 0

mprotect(0x7f979f631000, 12288, PROT_READ) = 0

mprotect(0x7f979f3ab000, 4096, PROT_READ) = 0

mprotect(0x7f979f3b7000, 4096, PROT_READ) = 0

mprotect(0x7f979f447000, 4096, PROT_READ) = 0

mprotect(0x7f979f641000, 4096, PROT_READ) = 0

mprotect(0x7f979f64c000, 4096, PROT_READ) = 0

mprotect(0x7f979f675000, 4096, PROT_READ) = 0

mprotect(0x5591e1c31000, 4096, PROT_READ) = 0

mprotect(0x7f979f6ba000, 4096, PROT_READ) = 0

munmap(0x7f979f67b000, 73485) = 0

set_tid_address(0x7f979f38bad0) = 2267

set_robust_list(0x7f979f38bae0, 24) = 0

rt_sigaction(SIGRTMIN, {sa_handler=0x7f979f395bf0, sa_mask=[], sa_flags=SA_RESTORER|SA_SIGINFO, sa_restorer=0x7f979f3a33c0}, NULL, 8) = 0

rt_sigaction(SIGRT_1, {sa_handler=0x7f979f395c90, sa_mask=[], sa_flags=SA_RESTORER|SA_RESTART|SA_SIGINFO, sa_restorer=0x7f979f3a33c0}, NULL, 8) = 0

rt_sigprocmask(SIG_UNBLOCK, [RTMIN RT_1], NULL, 8) = 0

prlimit64(0, RLIMIT_STACK, NULL, {rlim_cur=8192*1024, rlim_max=RLIM64_INFINITY}) = 0

statfs("/sys/fs/selinux", 0x7ffc4d04f8b0) = -1 ENOENT (No such file or directory)

statfs("/selinux", 0x7ffc4d04f8b0) = -1 ENOENT (No such file or directory)

brk(NULL) = 0x5591e389e000

```
brk(0x5591e38bf000)                 = 0x5591e38bf000
openat(AT_FDCWD, "/proc/filesystems", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0444, st_size=0, ...}) = 0
read(3, "nodev\tsysfs\nnodev\ttmpfs\nnodev\tbd"..., 1024) = 369
read(3, "", 1024)                   = 0
close(3)                            = 0
access("/etc/selinux/config", F_OK)     = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/lib/locale/locale-archive", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=8500896, ...}) = 0
mmap(NULL, 8500896, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f979eb6f000
close(3)                            = 0
geteuid()                           = 1000
stat("pasteFile.txt", 0x7ffc4d04f710)   = -1 ENOENT (No such file or directory)
stat("copyFile.txt", {st_mode=S_IFREG|0664, st_size=23, ...}) = 0
newfstatat(AT_FDCWD, "pasteFile.txt", 0x7ffc4d04f4a0, 0) = -1 ENOENT (No such file or
directory)
openat(AT_FDCWD, "copyFile.txt", O_RDONLY) = 3
fstat(3, {st_mode=S_IFREG|0664, st_size=23, ...}) = 0
openat(AT_FDCWD, "pasteFile.txt", O_WRONLY|O_CREAT|O_EXCL, 0664) = 4
fstat(4, {st_mode=S_IFREG|0664, st_size=0, ...}) = 0
fadvise64(3, 0, 0, POSIX_FADV_SEQUENTIAL) = 0
mmap(NULL, 139264, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0)
= 0x7f979eb4d000
read(3, "MUstafa Ya\305\237ar\n\nCs342\n\n", 131072) = 23
write(4, "MUstafa Ya\305\237ar\n\nCs342\n\n", 23) = 23
read(3, "", 131072)                   = 0
close(4)                            = 0
close(3)                            = 0
munmap(0x7f979eb4d000, 139264)          = 0
lseek(0, 0, SEEK_CUR)                   = -1 ESPIPE (Illegal seek)
```

close(0) = 0

close(1) = 0

close(2) = 0

exit_group(0) = ?

+++ exited with 0 +++

Some syscalls after running strace cp copyFile.txt pasteFile.txt

read

fstat

access

openat

mmap

arch_prctl

close

pread64

mprotect

munmap

fadvise64

geteuid

Secondly, I traced the ls command by writing

strace ls

The output of the command is below:

execve("/usr/bin/ls", ["ls"], 0x7ffe7d2f6380 /* 61 vars */) = 0

brk(NULL) = 0x5610246bb000

arch_prctl(0x3001 /* ARCH_??? */, 0x7ffc7c30ed40) = -1 EINVAL (Invalid argument)

access("/etc/ld.so.preload", R_OK) = -1 ENOENT (No such file or directory)

openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3

fstat(3, {st_mode=S_IFREG|0644, st_size=73485, ...}) = 0

mmap(NULL, 73485, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f633da62000

close(3) = 0

openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libselinux.so.1", O_RDONLY|O_CLOEXEC) = 3

read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0@p\0\0\0\0\0\0"..., 832) = 832

fstat(3, {st_mode=S_IFREG|0644, st_size=163200, ...}) = 0

mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f633da60000

mmap(NULL, 174600, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f633da35000

mprotect(0x7f633da3b000, 135168, PROT_NONE) = 0

mmap(0x7f633da3b000, 102400, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x6000) = 0x7f633da3b000

mmap(0x7f633da54000, 28672, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1f000) = 0x7f633da54000

mmap(0x7f633da5c000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x26000) = 0x7f633da5c000

mmap(0x7f633da5e000, 6664, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f633da5e000

close(3) = 0

openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3

read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\360q\2\0\0\0\0\0"..., 832) = 832

pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784

pread64(3, "\4\0\0\0\20\0\0\0\5\0\0\0GNU\0\2\0\0\300\4\0\0\0\3\0\0\0\0\0\0\0", 32, 848) = 32

pread64(3, "\4\0\0\0\24\0\0\0\3\0\0\0GNU\0\t\233\222%\274\260\320\31\331\326\10\204\276X>\263"..., 68, 880) = 68

fstat(3, {st_mode=S_IFREG|0755, st_size=2029224, ...}) = 0

pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784

pread64(3, "\4\0\0\0\20\0\0\0\5\0\0\0GNU\0\2\0\0\300\4\0\0\0\3\0\0\0\0\0\0\0", 32, 848) = 32

pread64(3, "\4\0\0\0\24\0\0\0\3\0\0\0GNU\0\t\233\222%\274\260\320\31\331\326\10\204\276X>\263"..., 68, 880) = 68

mmap(NULL, 2036952, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f633d843000

mprotect(0x7f633d868000, 1847296, PROT_NONE) = 0

mmap(0x7f633d868000, 1540096, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x25000) = 0x7f633d868000

mmap(0x7f633d9e0000, 303104, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x19d000) = 0x7f633d9e0000

mmap(0x7f633da2b000, 24576, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1e7000) = 0x7f633da2b000

mmap(0x7f633da31000, 13528, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f633da31000

close(3) = 0

openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libpcre2-8.so.0", O_RDONLY|O_CLOEXEC) = 3

read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\340\"\0\0\0\0\0\0"..., 832) = 832

fstat(3, {st_mode=S_IFREG|0644, st_size=584392, ...}) = 0

mmap(NULL, 586536, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f633d7b3000

mmap(0x7f633d7b5000, 409600, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x2000) = 0x7f633d7b5000

mmap(0x7f633d819000, 163840, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x66000) = 0x7f633d819000

mmap(0x7f633d841000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x8d000) = 0x7f633d841000

close(3) = 0

openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libdl.so.2", O_RDONLY|O_CLOEXEC) = 3

read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0 \22\0\0\0\0\0\0"..., 832) = 832

fstat(3, {st_mode=S_IFREG|0644, st_size=18816, ...}) = 0

mmap(NULL, 20752, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f633d7ad000

mmap(0x7f633d7ae000, 8192, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1000) = 0x7f633d7ae000

mmap(0x7f633d7b0000, 4096, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x3000) = 0x7f633d7b0000

mmap(0x7f633d7b1000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x3000) = 0x7f633d7b1000

close(3) = 0

openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libpthread.so.0", O_RDONLY|O_CLOEXEC) = 3

read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\220\201\0\0\0\0\0\0"..., 832) = 832

pread64(3, "\4\0\0\0\24\0\0\0\3\0\0\0GNU\0\345Ga\367\265T\320\374\301V)Yf]\223\337"..., 68, 824) = 68

fstat(3, {st_mode=S_IFREG|0755, st_size=157224, ...}) = 0

pread64(3, "\4\0\0\0\24\0\0\0\3\0\0\0GNU\0\345Ga\367\265T\320\374\301V)Yf]\223\337"..., 68, 824) = 68

mmap(NULL, 140408, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f633d78a000

mmap(0x7f633d791000, 69632, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x7000) = 0x7f633d791000

mmap(0x7f633d7a2000, 20480, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x18000) = 0x7f633d7a2000

mmap(0x7f633d7a7000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1c000) = 0x7f633d7a7000

mmap(0x7f633d7a9000, 13432, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f633d7a9000

close(3) = 0

mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f633d788000

arch_prctl(ARCH_SET_FS, 0x7f633d789400) = 0

mprotect(0x7f633da2b000, 12288, PROT_READ) = 0

mprotect(0x7f633d7a7000, 4096, PROT_READ) = 0

mprotect(0x7f633d7b1000, 4096, PROT_READ) = 0

mprotect(0x7f633d841000, 4096, PROT_READ) = 0

mprotect(0x7f633da5c000, 4096, PROT_READ) = 0

```
mprotect(0x561022df3000, 4096, PROT_READ) = 0
mprotect(0x7f633daa1000, 4096, PROT_READ) = 0
munmap(0x7f633da62000, 73485)          = 0
set_tid_address(0x7f633d7896d0)        = 2539
set_robust_list(0x7f633d7896e0, 24)     = 0
rt_sigaction(SIGRTMIN, {sa_handler=0x7f633d791bf0, sa_mask=[],
sa_flags=SA_RESTORER|SA_SIGINFO, sa_restorer=0x7f633d79f3c0}, NULL, 8) = 0
rt_sigaction(SIGRT_1, {sa_handler=0x7f633d791c90, sa_mask=[],
sa_flags=SA_RESTORER|SA_RESTART|SA_SIGINFO, sa_restorer=0x7f633d79f3c0}, NULL, 8) =
0
rt_sigprocmask(SIG_UNBLOCK, [RTMIN RT_1], NULL, 8) = 0
prlimit64(0, RLIMIT_STACK, NULL, {rlim_cur=8192*1024, rlim_max=RLIM64_INFINITY}) = 0
statfs("/sys/fs/selinux", 0x7ffc7c30ec90) = -1 ENOENT (No such file or directory)
statfs("/selinux", 0x7ffc7c30ec90)      = -1 ENOENT (No such file or directory)
brk(NULL)                              = 0x5610246bb000
brk(0x5610246dc000)                    = 0x5610246dc000
openat(AT_FDCWD, "/proc/filesystems", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0444, st_size=0, ...}) = 0
read(3, "nodev\tsysfs\nnodev\ttmpfs\nnodev\tbd"..., 1024) = 369
read(3, "", 1024)                      = 0
close(3)                               = 0
access("/etc/selinux/config", F_OK)     = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/lib/locale/locale-archive", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=8500896, ...}) = 0
mmap(NULL, 8500896, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f633cf6c000
close(3)                               = 0
ioctl(1, TCGETS, {B38400 opost isig icanon echo ...}) = 0
ioctl(1, TIOCGWINSZ, {ws_row=49, ws_col=100, ws_xpixel=0, ws_ypixel=0}) = 0
openat(AT_FDCWD, ".", O_RDONLY|O_NONBLOCK|O_CLOEXEC|O_DIRECTORY) = 3
fstat(3, {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
```

getdents64(3, /* 6 entries */, 32768)   = 224

getdents64(3, /* 0 entries */, 32768)   = 0

close(3)   = 0

fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0), ...}) = 0

write(1, "copyFile.txt Mustafa_Yasar_CS34"..., 58copyFile.txt
Mustafa_Yasar_CS342_HW1.docx pasteFile.txt

) = 58

close(1)   = 0

close(2)   = 0

exit_group(0)   = ?

+++ exited with 0 +++

Syscalls made while running ls command

brk

arch_prctl

access

openat

fstat

mmap

close

read

pread64

mprotect

munmap

set_tid_address

set_robust_list

rt_sigaction

prlimit64

...

Exited with 0 means the operation was successful. I accidentally wrote strace lp which is used to print files “line printer” and expects a destination. The strace log was considerably longer and the exit status was 1 which means there has been an error. Therefore, I understood that the exit status is really important.

6. time Command

time command with ls command.

time ls

Output:

copyFile.txt Mustafa_Yasar_CS342_HW1.docx pasteFile.txt

real 0m0,001s

user 0m0,001s

sys 0m0,000s

time command with cp command

time cp copyFile.txt pasteFile2.txt

Output:

real 0m0,002s

user 0m0,001s

sys 0m0,000s

real is the real time that elapses like the elapsed time at the wall clock. The time written at the real part is the time elapsing from start to finish of the command.

user is the CPU time that elapses in user-mode code within the process. User-mode code means the processes are outside the kernel.

sys is on the other hand the time elapsed in the kernel within the process.

7. C Program for LinkedList Insertion

```
#include <time.h>
#include <sys/time.h>
#include <stdio.h>
#include <stdlib.h>



struct Node {
	int data;
	struct Node* next;
};
struct Node *head = NULL;
struct Node *current = NULL;
void insert(int data) {
	struct Node *newNode = (struct Node*) malloc(sizeof(struct Node));
	newNode -> data = data;
	newNode -> next = head;
	head = newNode;
}

void printLinkedList() {
	struct Node* pointer = head;
	printf("\n");
	while ( pointer != NULL ) {
		printf("%d ", pointer -> data);
		pointer = pointer -> next;
	}
}
int main(void) {
```

```
	struct timeval start, end;
	int limit = 10000;
	srand( time(NULL) );
	gettimeofday(&start, NULL);
	for (int i = 0; i < limit; i++) {
		int randomNumber = rand();
		insert(randomNumber);
	}
	gettimeofday(&end, NULL);
	// printLinkedList(); // To check if the program is working correctly

	printf("The program took %ld ms\n", ((end.tv_sec * 1000000 + end.tv_usec)
		- (start.tv_sec * 1000000 + start.tv_usec)));
}
```