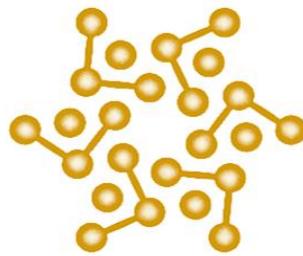




Operating Systems



Lab #01

Title: Read System Call

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1.1 Objectives

1. To understand what a system call is and how user programs interact with the operating system
2. To learn how the read(), open(), write(), and close() system calls work in Linux
3. To observe how file descriptors are created and used by the OS
4. To practice using the nano editor and basic terminal commands
5. To analyze the system call flow using a simple C program

1.2 Concept

A **system call** is an interface that allows a user program to request a service from the operating system.

User programs cannot directly access hardware or kernel memory, so they use system calls to perform tasks

such as file handling, process creation, memory allocation, and input/output operations.

The **read()** system call is used to transfer data from a file into a buffer in memory.

To read a file, it must first be opened using **open()**, which returns a file descriptor.

The **write()** system call sends data to an output stream (e.g. screen or file).

The **close()** system call is used to release the file descriptor after operations are completed. This lab introduces how low-level file operations work behind high-level functions.

1: READ SYSTEM CALL

```
alinagame@DESKTOP-4TJUFLT: ~
alinagame@DESKTOP-4TJUFLT:~$ mkdir -p ~/os_lab
alinagame@DESKTOP-4TJUFLT:~$ ls
game_project os_lab projects
Repos    buildLogs  os_lab  buildLogs
```

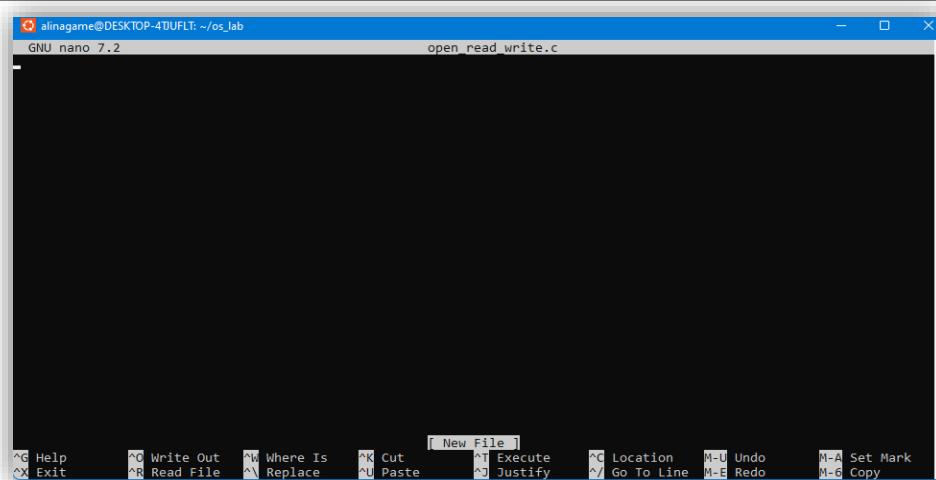
Explanation:

1. mkdir = make directory
2. -p = makes sure error would not occur even if directory already exists
3. ~/ = home folder
4. os_lab = folder name

```
alinagame@DESKTOP-4TJUFLT:~$ cd ~/os_lab
alinagame@DESKTOP-4TJUFLT:~/os_lab$ -
alinagame@DESKTOP-4TJUFLT:~/os_lab$ nano open_read_write.c
alinagame@DESKTOP-4TJUFLT:~/os_lab$
```

Opens nano , terminal text editor where we can read/write/copy/paste the programs.

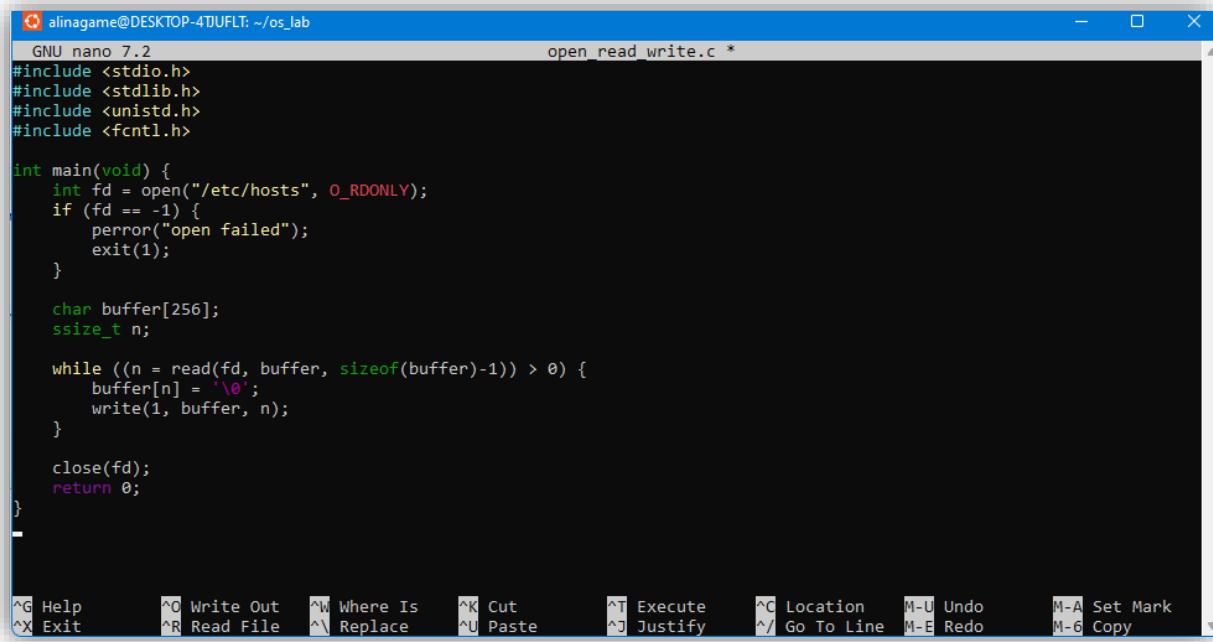
After running above command following interface opens



Nano Shortcuts:

Key	Meaning
Ctrl + O	save (Write Out)
Enter	confirm file name
Ctrl + X	exit

Copy/Paste Code



```
GNU nano 7.2                                     open read_write.c *
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <fcntl.h>

int main(void) {
    int fd = open("/etc/hosts", O_RDONLY);
    if (fd == -1) {
        perror("open failed");
        exit(1);
    }

    char buffer[256];
    ssize_t n;

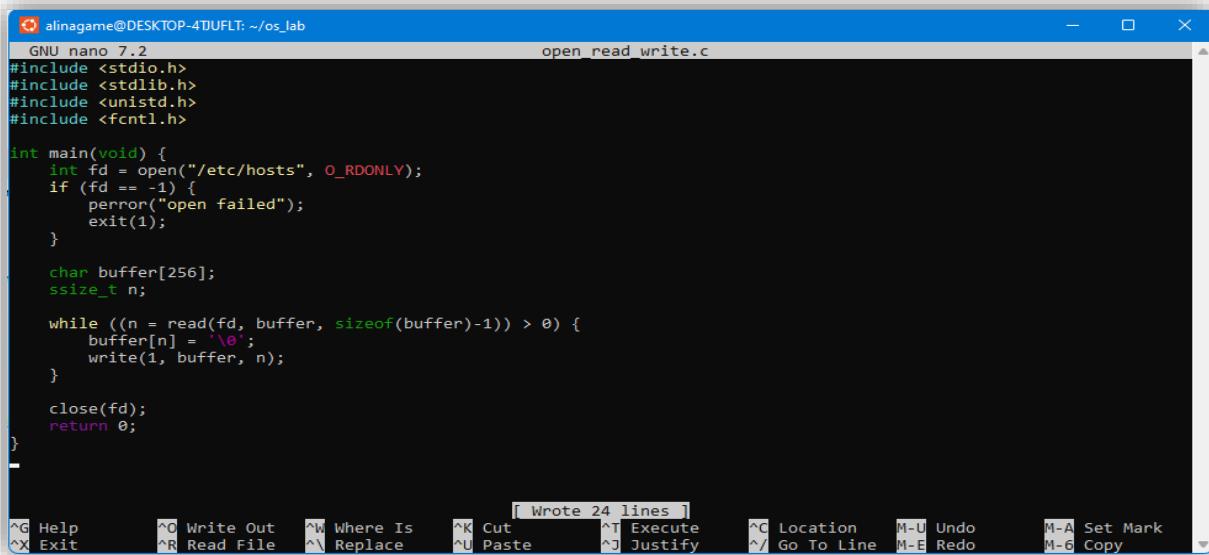
    while ((n = read(fd, buffer, sizeof(buffer)-1)) > 0) {
        buffer[n] = '\0';
        write(1, buffer, n);
    }

    close(fd);
    return 0;
}
```

^G Help ^O Write Out ^W Where Is ^K Cut ^T Execute ^C Location M-U Undo ^X Exit ^R Read File ^\ Replace ^U Paste ^J Justify ^/ Go To Line M-E Redo M-A Set Mark M-6 Copy

Ctrl + O → Enter

Exit: **Ctrl + X**



```
GNU nano 7.2                                     open_read_write.c
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <fcntl.h>

int main(void) {
    int fd = open("/etc/hosts", O_RDONLY);
    if (fd == -1) {
        perror("open failed");
        exit(1);
    }

    char buffer[256];
    ssize_t n;

    while ((n = read(fd, buffer, sizeof(buffer)-1)) > 0) {
        buffer[n] = '\0';
        write(1, buffer, n);
    }

    close(fd);
    return 0;
}
```

[Wrote 24 lines]

^G Help ^O Write Out ^W Where Is ^K Cut ^T Execute ^C Location M-U Undo ^X Exit ^R Read File ^\ Replace ^U Paste ^J Justify ^/ Go To Line M-E Redo M-A Set Mark M-6 Copy

Line	Meaning
open("/etc/hosts", O_RDONLY)	OS request: file open
fd	file descriptor: OS Number which represents file
read()	OS request: bring file data to buffer

write(1, ...)	1 means screen
close()	file close

```
alinagame@DESKTOP-4TJUFLT:~/os_lab$ gcc open_read_write.c -o read_prog
```

We use gcc (GNU C compiler)

There was no error it means code is error free

Run Program:

```
alinagame@DESKTOP-4TJUFLT:~/os_lab$ ./read_prog
# This file was automatically generated by WSL. To stop automatic generation of this file, add the following entry to /etc/wsl.conf:
# [network]
# generateHosts = false
127.0.0.1      localhost
127.0.1.1      DESKTOP-4TJUFLT.localdomain    DESKTOP-4TJUFLT
192.168.43.247 host.docker.internal
192.168.43.247 gateway.docker.internal
127.0.0.1      kubernetes.docker.internal

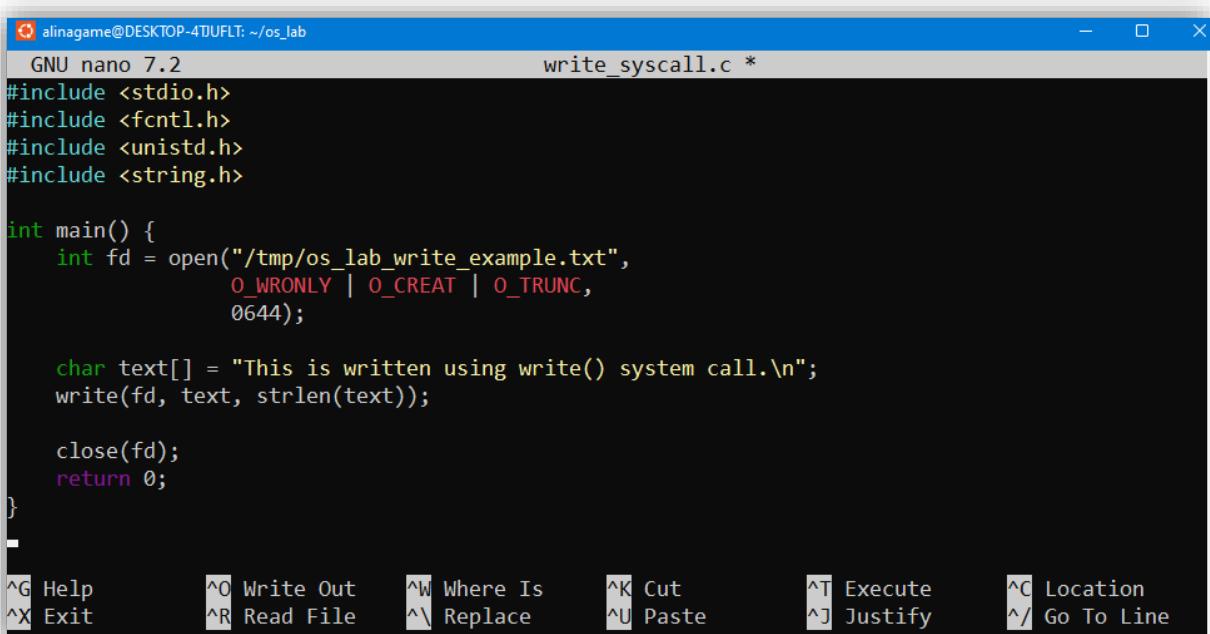
# The following lines are desirable for IPv6 capable hosts
::1      ip6-localhost ip6-loopback
fe00::0  ip6-localnet
ff00::0  ip6-mcastprefix
ff02::1  ip6-allnodes
ff02::2  ip6-allrouters
```

2: WRITE SYSTEM CALL

Open nano:

```
alinagame@DESKTOP-4TJUFLT:~/os_lab$ nano write_syscall.c
```

Paste Code



```
alinagame@DESKTOP-4TJUFLT: ~/os_lab
GNU nano 7.2                               write_syscall.c *

#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>
#include <string.h>

int main() {
    int fd = open("/tmp/os_lab_write_example.txt",
                  O_WRONLY | O_CREAT | O_TRUNC,
                  0644);

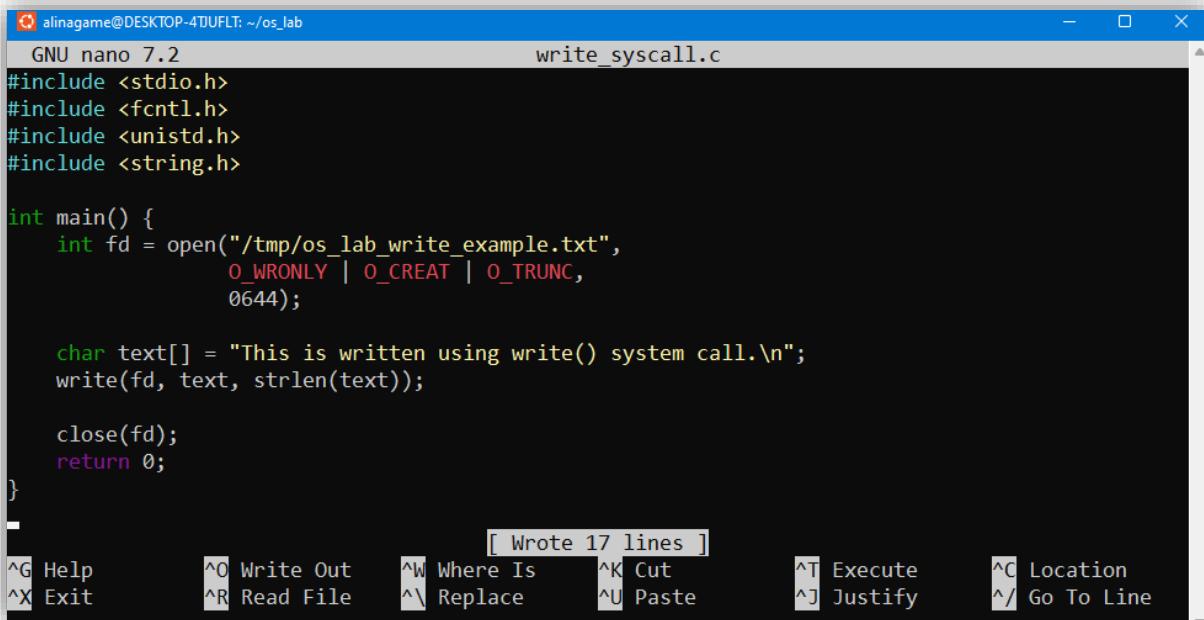
    char text[] = "This is written using write() system call.\n";
    write(fd, text, strlen(text));

    close(fd);
    return 0;
}

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

Save + Exit

Ctrl+O → Enter → Ctrl+X



```
alinagame@DESKTOP-4TJUFLT:~/os_lab
GNU nano 7.2                               write_syscall.c
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>
#include <string.h>

int main() {
    int fd = open("/tmp/os_lab_write_example.txt",
                  O_WRONLY | O_CREAT | O_TRUNC,
                  0644);

    char text[] = "This is written using write() system call.\n";
    write(fd, text, strlen(text));

    close(fd);
    return 0;
}

[ Wrote 17 lines ]
```

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

Compile & Run:

```
alinagame@DESKTOP-4TJUFLT:~/os_lab$ gcc write_syscall.c -o write_prog
```

Verify file was created:

```
alinagame@DESKTOP-4TJUFLT:~/os_lab$ cat /tmp/os_lab_write_example.txt
This is written using write() system call.
alinagame@DESKTOP-4TJUFLT:~/os_lab$
```

3: Fork + Exec

```
alinagame@DESKTOP-4TJUFLT:~/os_lab$ nano fork_exec.c
```

Paste Code

The screenshot shows a terminal window titled "GNU nano 7.2" with the file name "fork_exec.c" at the top right. The code inside the editor is:

```
GNU nano 7.2                      fork_exec.c *
#include <stdio.h>
#include <unistd.h>
#include <sys/wait.h>

int main() {
    pid_t pid = fork();

    if(pid == 0)
        execlp("ls", "ls", "-l", NULL);

    else
        wait(NULL);

    return 0;
}
```

At the bottom of the editor window, there is a menu bar with the following options:

- Help
- Write Out
- Where Is
- Cut
- Execute
- Location

Below the menu bar, there are keyboard shortcuts:

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

Save & Exit the code

The screenshot shows the same terminal window as before, but now it displays a message at the bottom indicating the file has been saved:

[Wrote 17 lines]

The rest of the screen content and the menu bar are identical to the previous screenshot.

Compile & Run

```
alinagame@DESKTOP-4TJUFLT:~/os_lab$ ./fork_exec_prog
total 60
-rw-r--r-- 1 alinagame alinagame 207 Nov 17 20:00 fork_exec.c
-rwxr-xr-x 1 alinagame alinagame 16048 Nov 17 20:00 fork_exec_prog
-rw-r--r-- 1 alinagame alinagame 405 Nov 17 19:44 open_read_write.c
-rwxr-xr-x 1 alinagame alinagame 16232 Nov 17 19:46 read_prog
-rwxr-xr-x 1 alinagame alinagame 16144 Nov 17 19:54 write_prog
-rw-r--r-- 1 alinagame alinagame 351 Nov 17 19:50 write_syscall.c
```

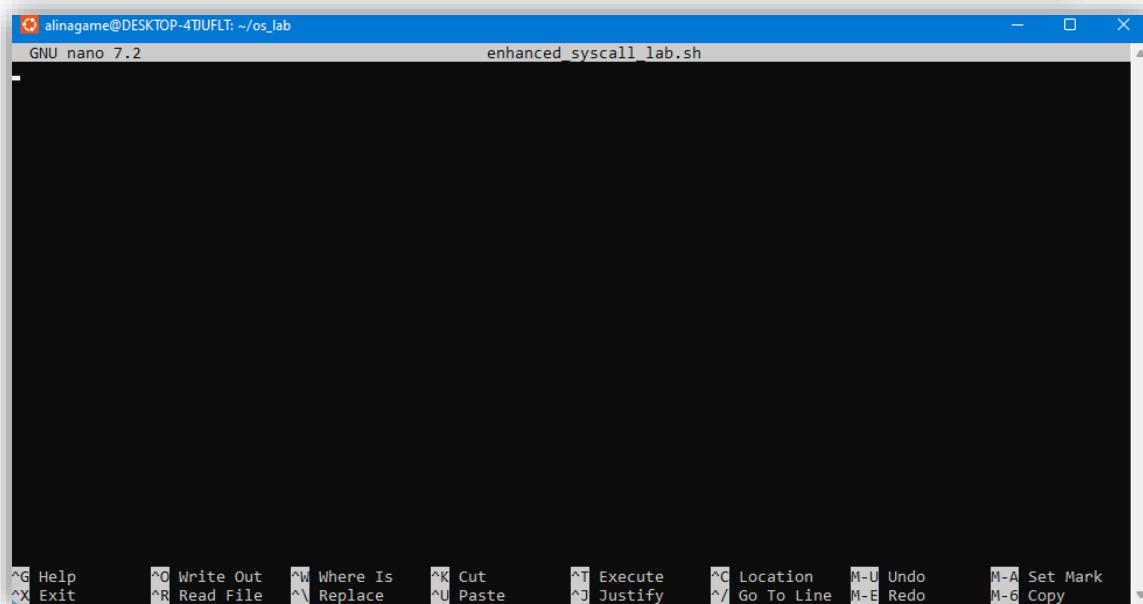
Strace traces system level calls

```
alinagame@DESKTOP-4TJUFLT:~/os_lab$ strace -c ./read_prog
# This file was automatically generated by WSL. To stop automatic generation of this file, add the following entry to /etc/wsl.conf:
# [network]
# generateHosts = false
127.0.0.1      localhost
127.0.1.1      DESKTOP-4TJUFLT.localdomain    DESKTOP-4TJUFLT
192.168.43.247 host.docker.internal
192.168.43.247 gateway.docker.internal
127.0.0.1      kubernetes.docker.internal

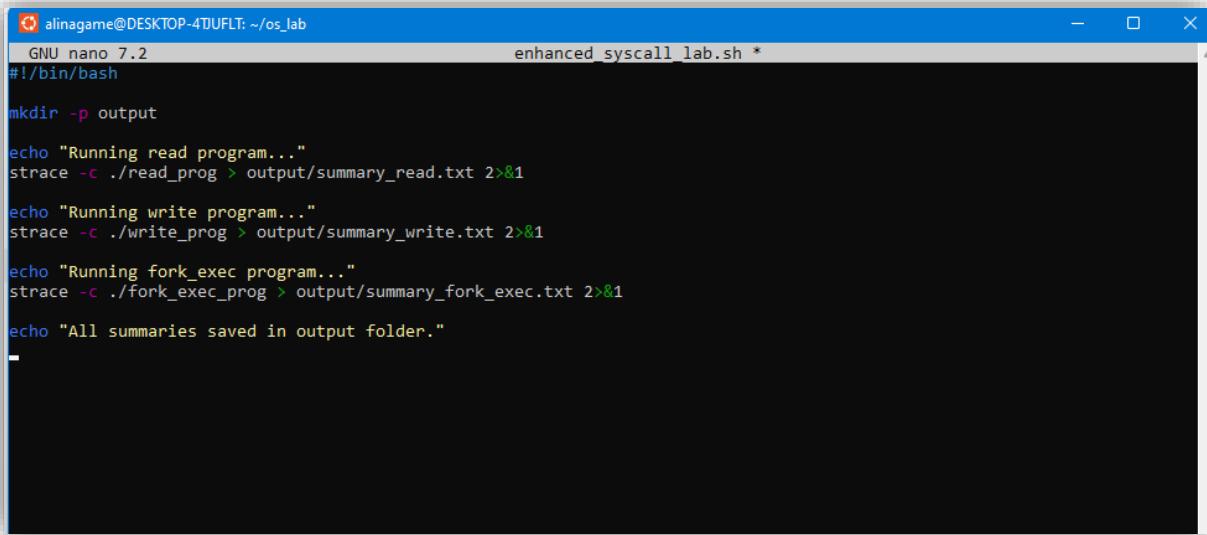
# The following lines are desirable for IPv6 capable hosts
::1      ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters
% time      seconds   usecs/call   calls   errors syscall
----- -----
24.27    0.000952     119       8        mmap
13.49    0.000529     176       3        openat
 8.98    0.000352     117       3        write
 8.77    0.000344      68       5        read
 7.78    0.000305     152       2        fstat
```

Open nano

```
alinagame@DESKTOP-4TJUFLT:~/os_lab$ nano enhanced_syscall_lab.sh
```



Create Script



```
alinagame@DESKTOP-4TUFLT: ~/os_lab
GNU nano 7.2                                         enhanced_syscall_lab.sh *
#!/bin/bash

mkdir -p output

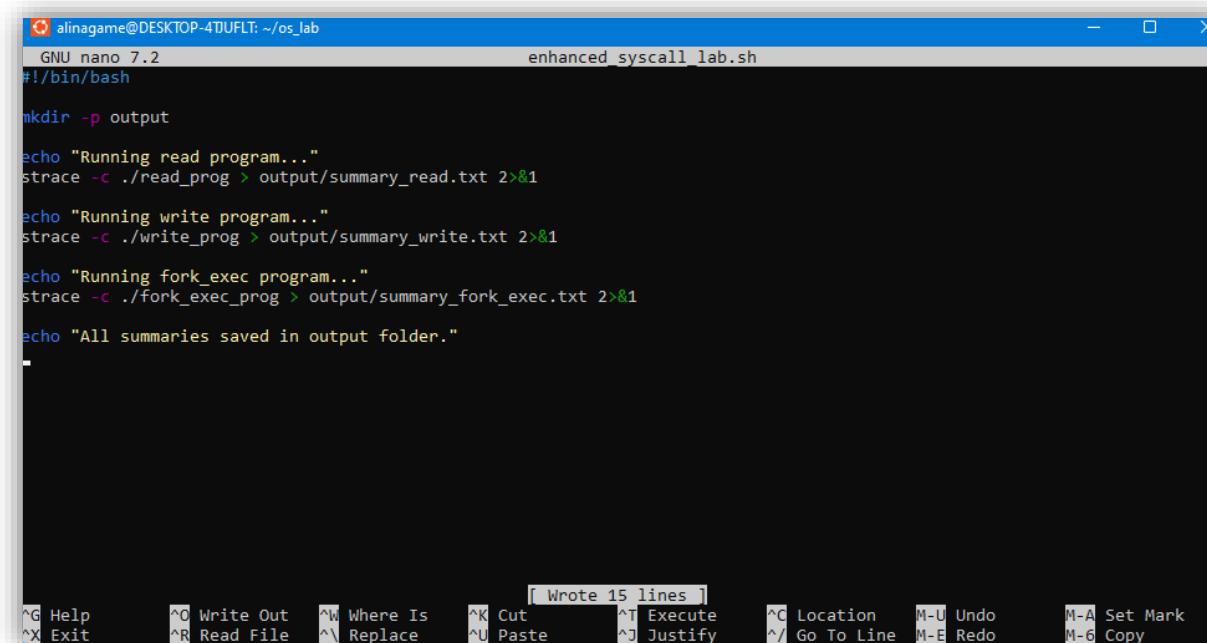
echo "Running read program..."
strace -c ./read_prog > output/summary_read.txt 2>&1

echo "Running write program..."
strace -c ./write_prog > output/summary_write.txt 2>&1

echo "Running fork_exec program..."
strace -c ./fork_exec_prog > output/summary_fork_exec.txt 2>&1

echo "All summaries saved in output folder."
```

Pasting the commands



```
alinagame@DESKTOP-4TUFLT: ~/os_lab
GNU nano 7.2                                         enhanced_syscall_lab.sh
#!/bin/bash

mkdir -p output

echo "Running read program..."
strace -c ./read_prog > output/summary_read.txt 2>&1

echo "Running write program..."
strace -c ./write_prog > output/summary_write.txt 2>&1

echo "Running fork_exec program..."
strace -c ./fork_exec_prog > output/summary_fork_exec.txt 2>&1

echo "All summaries saved in output folder."
```

Wrote 15 lines

^G Help ^O Write Out ^W Where Is ^K Cut ^T Execute ^C Location M-U Undo M-A Set Mark
^X Exit ^R Read File ^\ Replace ^U Paste ^] Justify ^/ Go To Line M-E Redo M-G Copy

```
alinagame@DESKTOP-4TUFLT:~/os_lab$ gcc fork_exec.c -o fork_exec_prog
```

Making it executable

```
alinagame@DESKTOP-4TJUFLT:~/os_lab$ chmod +x enhanced_syscall_lab.sh
```

Run

```
alinagame@DESKTOP-4TJUFLT:~/os_lab$ ./enhanced_syscall_lab.sh
Running read program...
Running write program...
Running fork_exec program...
All summaries saved in output folder.
```

CONCLUSION:

In this lab, I've learned how the write() system call works and how files are created and modified at the kernel level. I observed how system calls differ from normal library functions and understood how Linux handles low-level file output.

