OS Project - Reader Writer Problem

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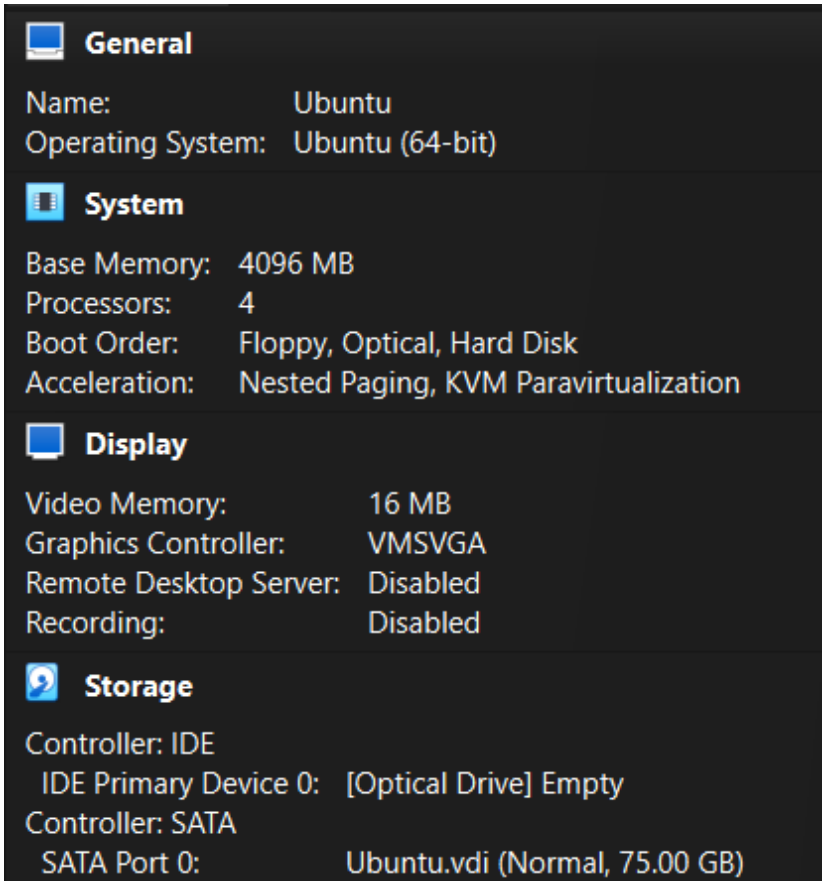
Introduction:

Reader-Writer Problem is a classic problem that occurs in Operating Systems. The problem occurs in a situation when multiple processes, threads or users want to access the same shared resource at the same time. The main idea is to apply a lock whenever a certain process or threads acquires the shared resource and release the lock when the desired operation is formed.

Setup:

Ubuntu is installed on our computers using a virtual machine named "Virtual Box" and a ISO file for Ubuntu. We allocated the following resources to the virtual machine:

i. 4 GB RAM
ii. 75 GB Storage Space on SSD
iii. 4 Cores of CPU
iv. 16 MB of Video Memory



Implementation:

After the installation of Ubuntu, we implmented our project with the following steps:

i. We prepared all the dependencies and installed them using the following commands:

```
sudo apt update

sudo apt install -y \
   build-essential \
   libncurses-dev \
   bison \
   flex \
   libssl-dev \
   libelf-dev \
   bc \
   fakeroot \
   dpkg-dev \
   libncurses5-dev \
   wget \
   git
```

ii. After installing all the dependencies, we cloned the latest version on Linux onto our virtual machine:

```
mkdir ~/kernel-build
cd ~/kernel-build

git clone https://git.kernel.org/pub/scm/linux/kernel/git/torvalds/linux.git linux
```

iii. After cloning the latest version of Linux, we prepared our kernel for configuration:

```
cd ~/kernel-build/linux
cp /boot/config-$(uname -r) .config
make olddefconfig
mkdir kernel/rw_sync
```

iv. Create the Kernel Source File using the command "nano kernel/rw_sync/rw_syscalls.c". The code for the file is given below:

```
#include <linux/kernel.h>
#include <linux/syscalls.h>
#include <linux/rwsem.h>
#include <linux/uaccess.h>

static DECLARE_RWSEM(rw_lock);

/* Acquire read lock */
SYSCALL_DEFINE0(rw_read_lock)
{
   down_read(&rw_lock);
   printk(KERN_INFO "Reader acquired lock\n");
   return 0;
}

/* Release read lock */
SYSCALL_DEFINE0(rw_read_unlock)
{
   up_read(&rw_lock);
   printk(KERN_INFO "Reader released lock\n");
   return 0;
}

/* Acquire write lock */
SYSCALL_DEFINE0(rw_write_lock)
{
   down_write(&rw_lock);
   printk(KERN_INFO "Writer acquired lock\n");
   return 0;
}

/* Release write lock */
SYSCALL_DEFINE0(rw_write_unlock)
{
   up_write(&rw_lock);
   printk(KERN_INFO "Writer released lock\n");
   return 0;
}
```

v. After this, we created a Makefile using the command "nano kernel/rw_sync/Makefile" with the following code:

```
obj-y := rw_syscalls.o
obj-y += kernel/rw_sync/
```

vi. We assigned the system calls numbers to the system calls we created in the **master lookup table.** We opened the syscalls_64.tbl using the command "nano arch/x86/entry/syscalls/syscall_64.tbl".

```
471     common  rw_read_lock            sys_rw_read_lock
472     common  rw_read_unlock          sys_rw_read_unlock
473     common  rw_write_lock           sys_rw_write_lock
474     common  rw_write_unlock         sys_rw_write_unlock
```

vii. We added the declarations in the syscalls.h header file after assigning the numbers to the system calls. First, we opened the syscall.h file using the command "nano include/linux/syscalls.h" and then added the declarations.

```
asmlinkage long sys_rw_read_lock(void);
asmlinkage long sys_rw_read_unlock(void);
asmlinkage long sys_rw_write_lock(void);
asmlinkage long sys_rw_write_unlock(void);
```

viii. After adding the declarations, we recompiled the kernel, updated the boot-loader and rebooted the system using the following commands.

```
make -j4
sudo make modules_install
sudo make install
sudo update-grub
sudo reboot
uname -r
```

ix. In the end, we tested our custom system calls using the following C program:

```
#include <stdio.h>
#include <unistd.h>
#include <sys/syscall.h>
#include <errno.h>
#include <string.h>
```

```
#define SYS_RW_READ_LOCK      471
#define SYS_RW_READ_UNLOCK    472
#define SYS_RW_WRITE_LOCK     473
#define SYS_RW_WRITE_UNLOCK   474

int main() {
    long ret;

    // Reader acquires lock
    printf("Reader trying to acquire lock\n");
    ret = syscall(SYS_RW_READ_LOCK);
    if (ret == -1) {
        printf("Error acquiring read lock: %s\n", strerror(errno));
        return 1;
    }
    printf("Reader acquired lock\n");

    sleep(2); // Simulate reading

    // Reader releases lock
    ret = syscall(SYS_RW_READ_UNLOCK);
    if (ret == -1) {
        printf("Error releasing read lock: %s\n", strerror(errno));
        return 1;
    }
    printf("Reader released lock\n");

    // Writer acquires lock
    printf("Writer trying to acquire lock\n");
    ret = syscall(SYS_RW_WRITE_LOCK);
    if (ret == -1) {
        printf("Error acquiring write lock: %s\n", strerror(errno));
        return 1;
    }
    printf("Writer acquired lock\n");

    sleep(2); // Simulate writing

    // Writer releases lock
    ret = syscall(SYS_RW_WRITE_UNLOCK);
    if (ret == -1) {
        printf("Error releasing write lock: %s\n", strerror(errno));
```

```
        return 1;
    }
    printf("Writer released lock\n");

    return 0;
}
```

Output: