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CSC415 Operating Systems

Assignment 6 – Device-Driver

Description:
This assignment is to write a simple device driver skeleton and to write a user application that can test its functionality. This simple device driver is capable of recognizing palindrome numbers when the value is passed by a user as a string.

Approach / What I Did:

The whole program is basically divided into two parts: Kernel space and User space. These two interfaces interact through system call interface. Kernel space is where kernel is executed, and user space is where the user application is executed. In my driver file, all the kernels are executed. Major number is declared which is initialized automatically and store the device number. Char message will store the string passes from the user space and result will store the return value after the computing palindrome. Similarly, device-driver class struct pointer and device-driver driver are initialized to zero. Then we build the necessary prototype function like device open, read, release, IOCTL, palindrome and write. Since device are represented as a file structure in the kernel, we define a struct for file operations i.e., open, read, IOCTL, write, and release. We then initialize our driver, where crucial operation takes place like assigning magic numbers, registering device, and creating a device.

In my user application, program will prompt user to enter an integer which stored in char inputString , this value is send to kernel space using write where it will store the string . Then the user application receives the string from kernel space using read. Once, the string is received, it's converted into an integer and send back to kernel space using ioctl write call which will store integer then ioctl read is call which will process the stored integer in a method dev_palindrome which will return 1 if it's a palindrome or 0 if it's not. Then the received value is compared in user space and result is displayed to the user.

Issues and Resolutions:
The only issue I had was using different skeleton for the module which for some reason wasn't processing the integer and after read call will give me NULL , the received value from the kernel space was always NULL. After Trying different template for the module and editing it to meet my requirement I was able to resolve it.

Analysis:

1. Assigned Major number 240 to device

```
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770$ cd /dev
student@student-VirtualBox:/dev$ ls -l palindrome_dev*
crw------- 1 root root 240, 0 Aug  1 09:49 palindrome_dev
student@student-VirtualBox:/dev$
                                                    Ln 11, Col 37  Spaces: 3  UTF-8  LF  C
```

2. Loadable kernel module currently loaded

```
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770$ lsmod
Module                  Size  Used by
driver                 16384  0
```

3. Output from Kernel space

```
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770$ sudo tail -f /var/log/kern.log
[sudo] password for student:
Aug  1 09:49:56 student-VirtualBox kernel: [ 1691.813174] palindrome_dev_mod: Initializing the palindrome_dev_mod
 LKM
Aug  1 09:49:56 student-VirtualBox kernel: [ 1691.813178] palindrome_dev_mod: Registered correctly with major num
ber 240
Aug  1 09:49:56 student-VirtualBox kernel: [ 1691.813203] palindrome_dev_mod: Device class registered correctly
Aug  1 09:49:56 student-VirtualBox kernel: [ 1691.813247] palindrome_dev_mod: Device class created correctly
Aug  1 09:50:13 student-VirtualBox kernel: [ 1709.470135] palindrome_dev_mod: Device opened
Aug  1 09:50:21 student-VirtualBox kernel: [ 1717.231218] palindrome_dev_mod: Received 4 characters from the user
Aug  1 09:50:21 student-VirtualBox kernel: [ 1717.231222] palindrome_dev_mod: Sent 4 characters to the user
Aug  1 09:50:21 student-VirtualBox kernel: [ 1717.231236] palindrome_dev_mod: Received value 5225 from the user
Aug  1 09:50:21 student-VirtualBox kernel: [ 1717.231237] palindrome_dev_mod: Sent palindrome result 1 to the use
r
Aug  1 09:50:21 student-VirtualBox kernel: [ 1717.231251] palindrome_dev_mod: Device successfully closed
```

4. Insmod

```
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770$ cd module
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/module$ sudo insmod driver.ko
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/module$ tail -5 /var/log/syslog
Aug  4 02:14:13 student-VirtualBox code.desktop[3531]: #033[90m[main 2021-08-04T09:14:13.434Z]#033[0m update#setState available
for download
Aug  4 02:14:49 student-VirtualBox kernel: [ 2360.825485] palindrome_dev_mod: Initializing the palindrome_dev_mod LKM
Aug  4 02:14:49 student-VirtualBox kernel: [ 2360.825507] palindrome_dev_mod: Registered correctly with major number 240
Aug  4 02:14:49 student-VirtualBox kernel: [ 2360.825610] palindrome_dev_mod: Device class registered correctly
Aug  4 02:14:49 student-VirtualBox kernel: [ 2360.834261] palindrome_dev_mod: Device class created correctly
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/module$
```

5. mknod in /dev

```
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/test$ cd ..
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770$ sudo mknod --mode=666 /dev/palindrome c 415 0
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770$ tail-5 /var/log/syslog
tail-5: command not found
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770$ tail -5 /var/log/syslog
Aug  4 01:38:27 student-VirtualBox kernel: [  179.092456] palindrome_dev_mod: Received 4 characters from the user
Aug  4 01:38:27 student-VirtualBox kernel: [  179.092459] palindrome_dev_mod: Sent 4 characters to the user
Aug  4 01:38:27 student-VirtualBox kernel: [  179.092469] palindrome_dev_mod: Received value 1221 from the user
Aug  4 01:38:27 student-VirtualBox kernel: [  179.092470] palindrome_dev_mod: Sent palindrome result 1 to the user
Aug  4 01:38:27 student-VirtualBox kernel: [  179.092477] palindrome_dev_mod: Device successfully closed
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770$ cd /dev
student@student-VirtualBox:/dev$ ls -l
crw-------  1 root    root     10, 144 Aug  4 01:35 nvram
crw-rw-rw-  1 root    root    415,   0 Aug  4 01:43 palindrome
crw-------  1 root    root    240,   0 Aug  4 01:37 palindrome_dev
```

6. rm

```
student@student-VirtualBox:/dev$ sudo rm palindrome
student@student-VirtualBox:/dev$ ls -l
total 0
crw-r--r--  1 root    root     10, 235 Aug  4 01:35 autofs
drwxr-xr-x  2 root    root         540 Aug  4 01:35 block
drwxr-xr-x  2 root    root          80 Aug  4 01:35 bsg
crw-------  1 root    root     10, 234 Aug  4 01:35 btrfs-control
drwxr-xr-x  3 root    root          60 Aug  4 01:35 bus
lrwxrwxrwx  1 root    root           3 Aug  4 01:35 cdrom -> sr0
drwxr-xr-x  2 root    root        3680 Aug  4 01:37 char
crw-------  1 root    root      5,   1 Aug  4 01:35 console
```

Removed palindrome

```
crw-------  1 root    root     10, 144 Aug  4 01:35 nvram
crw-------  1 root    root    240,   0 Aug  4 01:37 palindrome_dev
crw-r-----  1 root    kmem      1,   4 Aug  4 01:35 port
crw-------  1 root    root    108,   0 Aug  4 01:35 ppp
```

7. **rmmod**

```
student@student-VirtualBox:/dev$ sudo rmmod driver.ko
student@student-VirtualBox:/dev$ tail -5 /var/log/syslog
Aug  4 01:56:24 student-VirtualBox dbus-daemon[545]: [system] Activating via systemd: service name='org.freedesktop.hostname1' u
nit='dbus-org.freedesktop.hostname1.service' requested by ':1.124' (uid=1000 pid=3118 comm="/usr/bin/gnome-screenshot --gapplica
tion-service " label="unconfined")
Aug  4 01:56:24 student-VirtualBox systemd[1]: Starting Hostname Service...
Aug  4 01:56:24 student-VirtualBox dbus-daemon[545]: [system] Successfully activated service 'org.freedesktop.hostname1'
Aug  4 01:56:24 student-VirtualBox systemd[1]: Started Hostname Service.
Aug  4 01:58:15 student-VirtualBox kernel: [ 1366.226144] palindrome_dev_mod: Goodbye from the LKM
student@student-VirtualBox:/dev$
```

Screen shot of compilation:

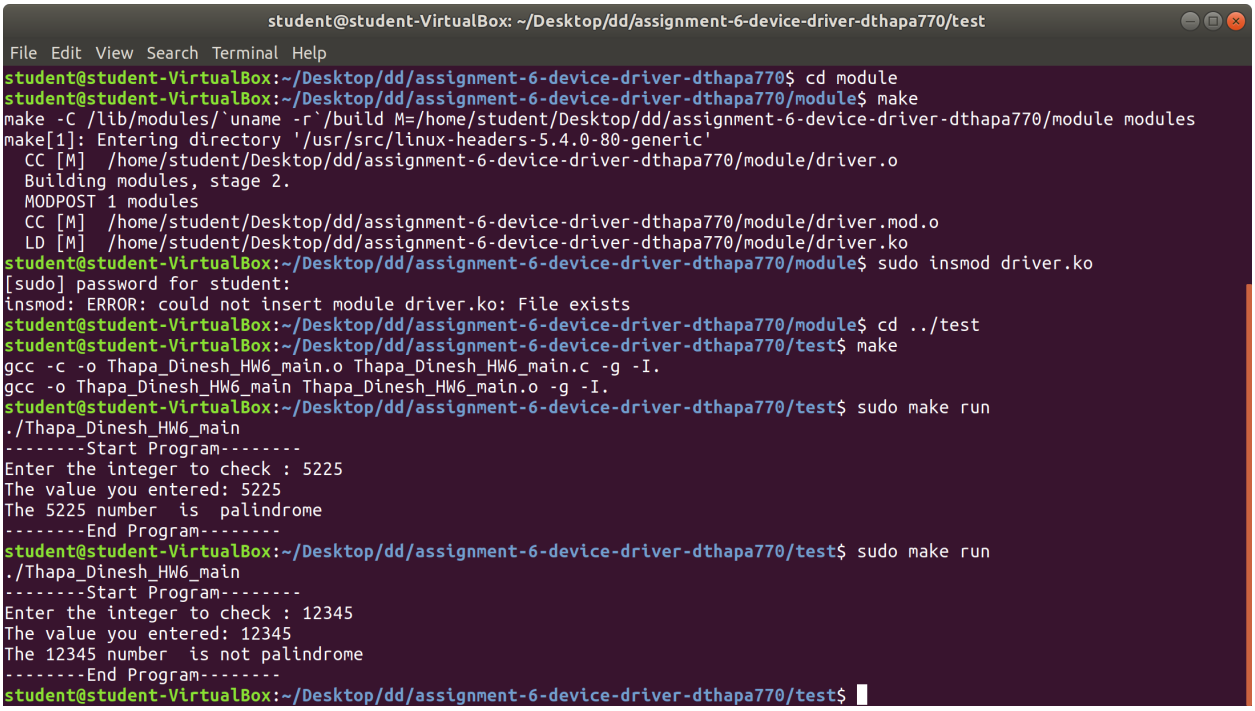
1.Make driver

```
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/module$ make
make -C /lib/modules/`uname -r`/build M=/home/student/Desktop/dd/assignment-6-device-driver-dthapa770/module modules
make[1]: Entering directory '/usr/src/linux-headers-5.4.0-80-generic'
  CC [M]  /home/student/Desktop/dd/assignment-6-device-driver-dthapa770/module/driver.o
  Building modules, stage 2.
  MODPOST 1 modules
  CC [M]  /home/student/Desktop/dd/assignment-6-device-driver-dthapa770/module/driver.mod.o
  LD [M]  /home/student/Desktop/dd/assignment-6-device-driver-dthapa770/module/driver.ko
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/module$
```

2. Make test program

```
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/module$ cd ../test
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/test$ make
gcc -c -o Thapa_Dinesh_HW6_main.o Thapa_Dinesh_HW6_main.c -g -I.
gcc -o Thapa_Dinesh_HW6_main Thapa_Dinesh_HW6_main.o -g -I.
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/test$
```

Screen shot(s) of the execution of the program:


student@student-VirtualBox: ~/Desktop/dd/assignment-6-device-driver-dthapa770/test
File Edit View Search Terminal Help
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770$ cd module
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/module$ make
make -C /lib/modules/`uname -r`/build M=/home/student/Desktop/dd/assignment-6-device-driver-dthapa770/module modules
make[1]: Entering directory '/usr/src/linux-headers-5.4.0-80-generic'
CC [M] /home/student/Desktop/dd/assignment-6-device-driver-dthapa770/module/driver.o
Building modules, stage 2.
MODPOST 1 modules
CC [M] /home/student/Desktop/dd/assignment-6-device-driver-dthapa770/module/driver.mod.o
LD [M] /home/student/Desktop/dd/assignment-6-device-driver-dthapa770/module/driver.ko
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/module$ sudo insmod driver.ko
[sudo] password for student:
insmod: ERROR: could not insert module driver.ko: File exists
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/module$ cd ../test
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/test$ make
gcc -c -o Thapa_Dinesh_HW6_main.o Thapa_Dinesh_HW6_main.c -g -I.
gcc -o Thapa_Dinesh_HW6_main Thapa_Dinesh_HW6_main.o -g -I.
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/test$ sudo make run
./Thapa_Dinesh_HW6_main
--------Start Program--------
Enter the integer to check : 5225
The value you entered: 5225
The 5225 number is palindrome
--------End Program--------
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/test$ sudo make run
./Thapa_Dinesh_HW6_main
--------Start Program--------
Enter the integer to check : 12345
The value you entered: 12345
The 12345 number is not palindrome
--------End Program--------
student@student-VirtualBox:~/Desktop/dd/assignment-6-device-driver-dthapa770/test$