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Github: gamersekofy CSC415 Operating Systems

Assignment 6 – Device Driver

Description:
This assignment implements a very complex device driver that tells the user their CPU's temperature and a simple tester that demonstrate the following:

- Reading data from the driver
- Writing data to the driver in the form of a configuration option
- `ioctl` command usage

Both the kernel module and the user application are written in C.

The kernel module attempts to read CPU temperature data from `/sys/class/thermal/thermal_zone0/temp`. In the event that it's not available (for example when using a virtual machine), a simulated temperature will be displayed. In either case, to demonstrate reading and writing to/from the driver, the user application asks the user for their preferred temperature unit. When a unit is provided, the user application will then request the driver to perform unit conversion and report the final temperature value.

Approach:
0. IMPORTANT: I read and understood every single line of the README.md file provided in the assignment repository.
1. I contemplated what sort of application would be the best to display my mastery and understanding of developing drivers.
2. After deciding on developing a temperature monitor, I researched for the simplest way to read temperature data of components.
3. After developing my module, I decided to create a simple script called `helper.sh` that runs commands such as `make` and `insmod` to facilitate deployment of the kernel module

As the description and my approach steps state, this is a complex kernel module which monitors the temperature of your CPU. The included user application consumes the module's output and reports it to the user. If the CPU's temperature isn't available (for example, when the user is on a virtual machine), a flag named `is_simulated` is set and a fake but believable temperature is returned. In either case, the user application asks the user for their preferred temperature unit, then requests that the kernel module perform conversion into that unit before reporting data.

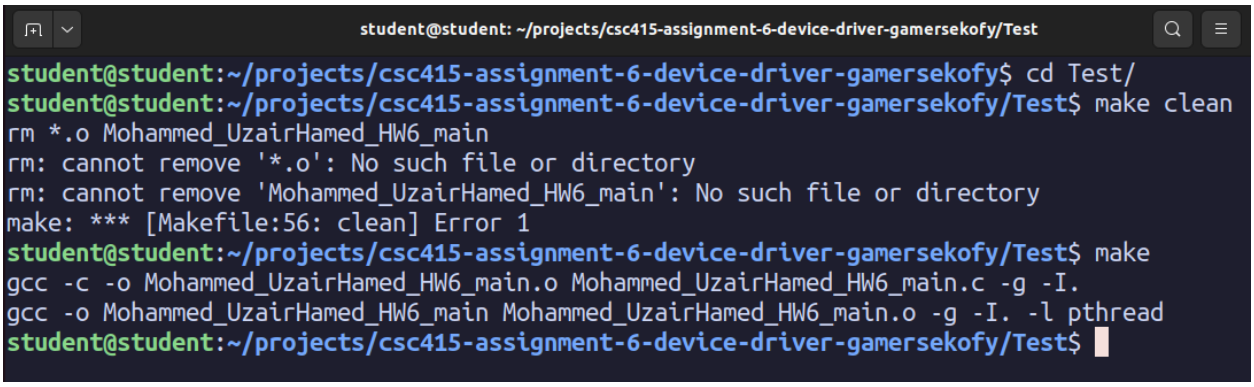
I tested my module on both real and simulated hardware and found that it works correctly and reports the accurate temperature if it's available.

Issues and Resolutions:

Due to the complex nature of this assignment, I encountered a few small issues that weren't impossible to fix. My biggest issue arose when trying to implement functionality that returns a simulated temperature when actual temperature isn't available. Initially, both the real and simulated temperatures were being returned when the user application was run, even when the actual temperature was available. This caused both values to be printed, which was not the desired behavior. I was able to fix this issue by introducing an `is_simulated` flag to track whether the temperature being read was simulated or real. This flag gets set to true when `/sys/class/thermal/thermal_zone0/temp` doesn't exist. With the flag set to true, the kernel module generates a random temperature value and returns it.

Analysis: N/A

Screen shot of compilation:
Tester:



Module:

```
student@student:~/projects/csc415-assignment-6-device-driver-gamersekofy/Module$ make clean
make -C /lib/modules/`uname -r`/build M=/home/student/projects/csc415-assignment-6-device-driver-ga
mersekofy/Module clean
make[1]: Entering directory '/usr/src/linux-headers-6.8.0-49-generic'
make[1]: Leaving directory '/usr/src/linux-headers-6.8.0-49-generic'
student@student:~/projects/csc415-assignment-6-device-driver-gamersekofy/Module$ make
make -C /lib/modules/`uname -r`/build M=/home/student/projects/csc415-assignment-6-device-driver-ga
mersekofy/Module modules
make[1]: Entering directory '/usr/src/linux-headers-6.8.0-49-generic'
warning: the compiler differs from the one used to build the kernel
  The kernel was built by: x86_64-linux-gnu-gcc-12 (Ubuntu 12.3.0-1ubuntu1~22.04) 12.3.0
  You are using:           gcc-12 (Ubuntu 12.3.0-1ubuntu1~22.04) 12.3.0
  CC [M]  /home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Module/tempMonitor.o
  MODPOST /home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Module/Module.symver
s
  CC [M]  /home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Module/tempMonitor.m
od.o
  LD [M]  /home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Module/tempMonitor.k
o
  BTF [M] /home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Module/tempMonitor.k
o
Skipping BTF generation for /home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Mo
dule/tempMonitor.ko due to unavailability of vmlinux
make[1]: Leaving directory '/usr/src/linux-headers-6.8.0-49-generic'
```

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

PREREQUISITE: Installation of the module via the helper script:

```
student@student:~/projects/csc415-assignment-6-device-driver-gamersekofy/Module$ ./helper.sh
What would you like to do?
1. Install
2. Uninstall
Enter option [1 or 2]: 1
Installing the kernel module...
make -C /lib/modules/`uname -r`/build M=/home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Module clean
make[1]: Entering directory '/usr/src/linux-headers-6.8.0-49-generic'
  CLEAN   /home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Module/Module.symvers
make[1]: Leaving directory '/usr/src/linux-headers-6.8.0-49-generic'
make -C /lib/modules/`uname -r`/build M=/home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Module modules
make[1]: Entering directory '/usr/src/linux-headers-6.8.0-49-generic'
warning: the compiler differs from the one used to build the kernel
  The kernel was built by: x86_64-linux-gnu-gcc-12 (Ubuntu 12.3.0-1ubuntu1~22.04) 12.3.0
  You are using:           gcc-12 (Ubuntu 12.3.0-1ubuntu1~22.04) 12.3.0
  CC [M]  /home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Module/tempMonitor.o
  MODPOST /home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Module/Module.symvers
  CC [M]  /home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Module/tempMonitor.mod.o
  LD [M]  /home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Module/tempMonitor.ko
  BTF [M] /home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Module/tempMonitor.ko
Skipping BTF generation for /home/student/projects/csc415-assignment-6-device-driver-gamersekofy/Module/tempMonitor.ko due to unavailabi
lity of vmlinux
make[1]: Leaving directory '/usr/src/linux-headers-6.8.0-49-generic'
[sudo] password for student:
mknod: /dev/temp_monitor: File exists
Module installed and device file created successfully.
student@student:~/projects/csc415-assignment-6-device-driver-gamersekofy/Module$
```

EXECUTION OF THE USER PROGRAM:

```
student@student:~/projects/csc415-assignment-6-device-driver-gamersekofy/Test$ make run
gcc -c -o Mohammed_UzairHamed_HW6_main.o Mohammed_UzairHamed_HW6_main.c -g -I.
gcc -o Mohammed_UzairHamed_HW6_main Mohammed_UzairHamed_HW6_main.o -g -I. -l pthread
./Mohammed_UzairHamed_HW6_main
Choose temperature unit (C/F):
```

```
student@student:~/projects/csc415-assignment-6-device-driver-gamersekofy/Test$ make run
gcc -c -o Mohammed_UzairHamed_HW6_main.o Mohammed_UzairHamed_HW6_main.c -g -I.
gcc -o Mohammed_UzairHamed_HW6_main Mohammed_UzairHamed_HW6_main.o -g -I. -l pthread
./Mohammed_UzairHamed_HW6_main
Choose temperature unit (C/F): C
CPU Temperature
--- -----------
21 C (simulated temperature)

student@student:~/projects/csc415-assignment-6-device-driver-gamersekofy/Test$
```

Figure 1: Executing the program on a virtual machine

```
uzair@uzair-Macmini: ~/temp
uzair@uzair-Macmini:~/temp/csc415-assignment-6-device-driver-gamersekofy/Test$ make run
./Mohammed_UzairHamed_HW6_main
Choose temperature unit (C/F): c
CPU Temperature
--- -----------
58 C

uzair@uzair-Macmini:~/temp/csc415-assignment-6-device-driver-gamersekofy/Test$
```

Figure 2: Executing the program on real hardware