

El338 Lab Report Chapter2

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1 Environment

- VirtualBox 5.2.18
- Ubuntu 14.04 (64 bit) running on the virtual machine

2 Assignment

1. Design a kernel module that creates a `/proc` file named `/proc/jiffies` that reports the current value of `jiffies` when the `proc/jiffies` file is read, such as the command

```
cat /proc/jiffies
```

Be sure to remove `/proc/jiffies` when the module is removed.

2. Design a kernel module that creates a `proc` file named `/proc/seconds` that reports the number of elapsed seconds since the kernel module was loaded. This will involve using the value of `jiffies` as well as the HZ rate. When a user enters the command

```
cat /proc/seconds
```

your kernel module will report the number of seconds that elapsed since the kernel module was first loaded. Be sure to remove the `/proc/seconds` when the module is removed.

3 Decomposition and Analysis

Here, we try to decompose the original tasks into smaller parts, and solve the sub problems one by one.

1. Obtain the value of HZ and `jiffies` from certain module.

Solution. *As noted in the textbook, the tick rate is the value HZ defined in `<asm/param.h>`. Also, the number of timer interrupts that have occurred since the system was booted is stored as the global variable `jiffies` in `linux/jiffies.h`. Thus, we only need to import the two files, and make use of HZ and `jiffies` inside them.*

2. Consider the fact the variable `jiffies` changes its value every time we call it, we need to store its value when the module is first loaded.

Solution. *we can store the original value of `jiffies` in a global variable. That is, it is at the same level as `main`. In this way, we can require it from any part of the code.*

3. Figure out the relationship between elapsed time, frequency, and the number of timer interrupt.

Solution. *Here, frequency means "ticks per second". We can represent the relationship among them with an equation:*

$$\begin{aligned} t &= \frac{\Delta \text{interrupt}}{\text{tick_per_second}} \\ &= \frac{jiffies_2 - jiffirs_1}{HZ} \end{aligned}$$

4. Find a way to pass certain information from kernel to user.

Solution. *The example file, `hello.c` may give us some hint on the topic. As is shown in the textbook, a buffer is used to store the message, and an extra integer variable contains the length of the string.*

5. Use terminal in Linux to check our solution.

Solution. *We just need to compile the file, add it to the kernel, then interact with the command line.*

4 Details

In this part, some codes are shown for better illustration. We mainly show the difference between our file and the example file, `hello.c`

- Two files that we include to deal with assignment1.

```
/* jiffies.c */
#include <asm/uaccess.h>
#include <linux/jiffies.h>

/* in function proc_read */
rv = sprintf(buffer,
"The_current_value_of_jiffies_is_:%lu\n", jiffies);

/* the length, together with the length,
is passed to the user */
copy_to_user(usr_buf, buffer, rv);
```

- We made some further modification to the original file to satisfy assignment2.

```
/*seconds.c */

/* the global variable is defined in the beginning.
*/

unsigned long old_jiffies;

/* in function proc_init,
we output some basic information in the kernel */

old_jiffies = jiffies;

printk(KERN_INFO "frequency_of_the_time_interrupt:%d\n", HZ);

printk(KERN_INFO "jiffies_when_the_module_is_loaded:%lu\n",
old_jiffies);

/* the buffer, together with the length,
is passed to the user */

copy_to_user(usr_buf, buffer, rv);
```

```

/* in function proc_read */

int time_elapsed = (jiffies - old_jiffies) / HZ;

/* in the kernel */

printk(KERN_INFO " Jiffies when the function is called: %lu\n", jiffies);

printk(KERN_INFO "Time elapsed: %d\n", time_elapsed);

/* to the user */

rv = sprintf(buffer, "Time elapsed: %d\n", time_elapsed);
copy_to_user(usr_buf, buffer, rv);

```

5 Result

Here are the results of our experiment:

```

baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ make
make -C /lib/modules/4.4.0-142-generic/build M=/home/baoxiaoyi/Desktop/kernels/ch2 modules
make[1]: Entering directory '/usr/src/linux-headers-4.4.0-142-generic'
  Building modules, stage 2.
  MODPOST 1 modules
make[1]: Leaving directory '/usr/src/linux-headers-4.4.0-142-generic'
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ sudo insmod jiffies.ko
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ dmesg
[19600.158131] /proc/jiffies created
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ cat /proc/jiffies
The current value of jiffies is : 4299796896
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ cat /proc/jiffies
The current value of jiffies is : 4299798936
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ cat /proc/jiffies
The current value of jiffies is : 4299823230
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ sudo rmmod jiffies
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ dmesg
[19600.158131] /proc/jiffies created
[19741.985664] /proc/jiffies removed
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ █

```

Figure 1: Result for assignment 1

```

baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ make
make -C /lib/modules/4.4.0-142-generic/build M=/home/baoxiaoyi/Desktop/kernels/ch2 modules
make[1]: Entering directory `/usr/src/linux-headers-4.4.0-142-generic'
  Building modules, stage 2.
  MODPOST 1 modules
make[1]: Leaving directory `/usr/src/linux-headers-4.4.0-142-generic'
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ sudo insmod seconds.ko
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ dmesg
[19985.943709] Loading Module
[19985.943717] frequency of the time interrupt: 250
[19985.943721] jiffies when the module is loaded: 4299889300
[19985.943724] /proc/seconds created
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ cat /proc/seconds
Time elapsed : 19
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ cat /proc/seconds
Time elapsed : 24
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ cat /proc/seconds
Time elapsed : 33
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ sudo rmmod seconds
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ dmesg
[19985.943709] Loading Module
[19985.943717] frequency of the time interrupt: 250
[19985.943721] jiffies when the module is loaded: 4299889300
[19985.943724] /proc/seconds created
[20005.607324] Jiffies when the function is called: 4299894216
[20005.607333] Time elapsed : 19
[20005.607333]
[20010.141826] Jiffies when the function is called: 4299895349
[20010.141838] Time elapsed : 24
[20010.141838]
[20019.043557] Jiffies when the function is called: 4299897575
[20019.043565] Time elapsed : 33
[20019.043565]
[20032.807852] /proc/seconds removed
baoxiaoyi@baoxiaoyi-VirtualBox:~/Desktop/kernels/ch2$ █

```

Figure 2: Result for assignment 2

6 Future work

It is just the start of our exploration into operating system, and of course there are a lot more to be done. To be more specific, there are two points that we may improve in the future:

- Elapsed time as a floating number. Thereby, the description of elapsed time can be more precise to users.
- A pointer for passing the value of jiffies when the module is loaded.