COMP 521/L—Advanced Operating Systems and Lab
Assignment #1—Introduction to Linux Kernel Modules

Objective:
> To learn how to create modules and load them into the Linux kernel under the /proc virtual file system.

Specification:
- The two modules for this assignment will be coded/tested within a Linux Virtual Machine (VirtualBox, Vmware, etc.) to prevent any potential permanent impact/changes to the testing computer's actual Operating System.
- The two modules will consist of the following:
    1. A module that reports the number of elapsed jiffies (1 jiffy = the time between two successive clock ticks), calculated from the instance when the module was loaded into the Linux kernel.
    2. A module that reports the number of elapsed seconds, calculated from the instance when the module was loaded into the Linux kernel.
- In order to test the two modules, you need to do the following:
    1. Create two kernel source code files in C, one named: `jiffies.c` and the other named: `seconds.c` which contain the following:
        - For `jiffies.c:`
            - Appropriate `#include` statements of header files: `linux/module.h`, `linux/kernel.h`, `linux/proc_fs.h`, `linux/jiffies.h`
            - The function `jiffies_read` for reading the `/proc/jiffies` kernel buffer. This will be called whenever `cat /proc/jiffies` is executed.
            - A file operations structure called `proc_fops` which maps the functions for reading and writing (only reading in this case) from the kernel buffer.
            - The `__init jiffies_init` function which calls `proc_create` to register the module and create the `/proc` file.
            - The `__exit jiffies_exit` function which calls `remove_proc_entry` to remove the module from the `/proc` file system.
        - For `seconds.c:`
            - Appropriate `#include` statements of header files: `linux/module.h`, `linux/kernel.h`, `linux/proc_fs.h`, `linux/time.h`
            - The function `seconds_read` for reading the `/proc/seconds` kernel buffer. This will be called whenever `cat /proc/seconds` is executed.
            - A file operations structure called `proc_fops` which maps the functions for reading and writing (only reading in this case) from the kernel buffer.
            - The `__init seconds_init` function which calls `proc_create` to register the module and create the `/proc` file.
            - The `__exit seconds_exit` function which calls `remove_proc_entry` to remove the module from the /proc file system.
    2. Compile both kernel source code using the provided make file `Makefile` and debug any errors, if necessary, with the command: `make`
    3. Load the kernel modules using the commands: `sudo insmod jiffies.ko` and `sudo insmod seconds.ko`
    To check whether the modules have loaded, use the `lsmod | head` command.
    4. Test the modules with the commands: `cat /proc/jiffies` and `cat /proc/seconds`
    5. Remove the kernel module using the command: `sudo rmmod jiffies` and `sudo rmmod seconds` {Note: the **.ko** suffix is unnecessary when removing a module}

Test Run Screenshots

Compiling using Makefile:

```
osc@ubuntu:~/comp521/asmt1$ ls
jiffies.c  Makefile  seconds.c
osc@ubuntu:~/comp521/asmt1$ make
make -C /lib/modules/4.15.0-213-generic/build M=/home/osc/comp521/asmt1 modules
make[1]: Entering directory '/usr/src/linux-headers-4.15.0-213-generic'
  CC [M]  /home/osc/comp521/asmt1/jiffies.o
  CC [M]  /home/osc/comp521/asmt1/seconds.o
  Building modules, stage 2.
  MODPOST 2 modules
  CC      /home/osc/comp521/asmt1/jiffies.mod.o
  LD [M]  /home/osc/comp521/asmt1/jiffies.ko
  CC      /home/osc/comp521/asmt1/seconds.mod.o
  LD [M]  /home/osc/comp521/asmt1/seconds.ko
make[1]: Leaving directory '/usr/src/linux-headers-4.15.0-213-generic'
osc@ubuntu:~/comp521/asmt1$ _
```

Inserting, Executing, and Removing the modules from the Kernel, and deleting the output (non-source) files:

```
osc@ubuntu:~/comp521/asmt1$ sudo insmod jiffies.ko
osc@ubuntu:~/comp521/asmt1$ sudo insmod seconds.ko
osc@ubuntu:~/comp521/asmt1$ lsmod | head
Module                  Size  Used by
seconds                16384  0
jiffies                16384  0
binfmt_misc            20480  1
joydev                 24576  0
snd_intel8x0           40960  0
snd_ac97_codec        131072  1 snd_intel8x0
ac97_bus               16384  1 snd_ac97_codec
snd_pcm               102400  2 snd_intel8x0,snd_ac97_codec
snd_timer              32768  1 snd_pcm
osc@ubuntu:~/comp521/asmt1$ cat /proc/jiffies
Elapsed jiffies: 4295013413
osc@ubuntu:~/comp521/asmt1$ cat /proc/seconds
Elapsed seconds: 19
osc@ubuntu:~/comp521/asmt1$ sudo rmmod jiffies
osc@ubuntu:~/comp521/asmt1$ sudo rmmod seconds
osc@ubuntu:~/comp521/asmt1$ make clean
make -C /lib/modules/4.15.0-213-generic/build M=/home/osc/comp521/asmt1 clean
make[1]: Entering directory '/usr/src/linux-headers-4.15.0-213-generic'
  CLEAN   /home/osc/comp521/asmt1/.tmp_versions
  CLEAN   /home/osc/comp521/asmt1/Module.symvers
make[1]: Leaving directory '/usr/src/linux-headers-4.15.0-213-generic'
osc@ubuntu:~/comp521/asmt1$ ls
jiffies.c  Makefile  seconds.c
osc@ubuntu:~/comp521/asmt1$ _
```