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CPTS 360 – Lab 3 Report

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When the kernel module is loaded, it contains a proc file, a linked list for CPU information of processes to be registered, a timer, and a work queue. When a process is registered, the kernel module adds that process to a linked list containing the pid (process id) and CPU runtime value of that process which will be updated until it terminates. This registration process is handled through a procfile write, and the procfile write callback simply adds the node of a new process to the list. The kernel module is initialized with a timer and work queue which schedules a work handler at the start. In the work handler, a spinlock occurs for updating the CPU values of the processes in the linked list. The spinlock ensures that race conditions do not occur when the list is being updated and another process is trying to be registered. If a process has terminated, then it is removed from the list. Otherwise, it remains in the list and its CPU value is updated. The timer wakes every five seconds via the timer callback, and since it is responsible for scheduling the work that is done in the work handler, it allows the updates of the processes to occur every five seconds. If a process initiates a procfile read at any point, the kernel module will clear the internal procfs buffer, and then store the information of each process in the list into a temporary buffer. When a process is stored in the temporary buffer, the information in the temporary buffer is concatenated to the internal procfs buffer. Once all processes have been added to the internal procfs buffer, then the proc file read callback simply returns the procfs buffer which contains information on all the processes and their corresponding CPU times at the time. Finally, when the kernel module is unloaded, it will remove the procfile (and parent proc directory), and delete the list, timer, and work queue.

One Process:

```
chandyego@Ubuntu:~/assignment-3-chandyego84$ ./userapp 15 &
[1] 55023
chandyego@Ubuntu:~/assignment-3-chandyego84$ cat /proc/kmlab/status
PID 55023: CPU Time 2200000000
cat: /proc/kmlab/status: Device or resource busy
chandyego@Ubuntu:~/assignment-3-chandyego84$ cat /proc/kmlab/status
cat: /proc/kmlab/status: Device or resource busy
[1]+  Done                    ./userapp 15
```

Two Processes:

```
chandyego@Ubuntu:~/assignment-3-chandyego84$ /bin/sh /home/chandyego/assignment-3-chandyego84/kmlab_test.sh
[sudo] password for chandyego:
rm -f userapp *~ *.ko *.o *.mod.c Module.symvers modules.order
make -C /lib/modules/6.5.0-26-generic/build M=/home/chandyego/assignment-3-chandyego84 modules
make[1]: Entering directory '/usr/src/linux-headers-6.5.0-26-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/chandyego/assignment-3-chandyego84/kmlab.o
  MODPOST /home/chandyego/assignment-3-chandyego84/Module.symvers
  CC [M]  /home/chandyego/assignment-3-chandyego84/kmlab.mod.o
  LD [M]  /home/chandyego/assignment-3-chandyego84/kmlab.ko
  BTF [M] /home/chandyego/assignment-3-chandyego84/kmlab.ko
Skipping BTF generation for /home/chandyego/assignment-3-chandyego84/kmlab.ko due to unavailability of vmlinux
make[1]: Leaving directory '/usr/src/linux-headers-6.5.0-26-generic'
gcc -o userapp userapp.c
PID 57972: CPU Time 5040000000
PID 57973: CPU Time 4960000000
```

Example of dmesg logs (when running two processes):

```
[29233.098470] KMLAB MODULE LOADING
[29233.098481] /proc/kmlab created
[29233.098483] /proc/kmlab/status created
[29233.098493] KMLAB MODULE LOADED
[29233.103320] Added process for PID 57972 to the list
[29233.103377] Added process for PID 57973 to the list
[29238.274414] This line is printed every 5000 ms
[29238.274426] KM_WQ work handler function
[29238.274427] locked spinlock - updating the CPU times of processes
[29238.274430] unlocked spinlock
[29239.106905] procfile read /proc/kmlab/status:
               PID 57972: CPU Time 5040000000
               PID 57973: CPU Time 4960000000
[29243.389729] This line is printed every 5000 ms
[29243.391371] KM_WQ work handler function
[29243.391373] locked spinlock - updating the CPU times of processes
[29243.391376] unlocked spinlock
[29248.510078] This line is printed every 5000 ms
[29248.510327] KM_WQ work handler function
[29248.510329] locked spinlock - updating the CPU times of processes
[29248.510330] Process 57972 has terminated and removed from list
[29248.510332] unlocked spinlock
[29253.634563] This line is printed every 5000 ms
[29253.634837] KM_WQ work handler function
```