

Project 1 Report: Process and Thread

CSE 3320:Operating Systems

GROUP 3

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1 Assignment 0: Build the Linux kernel

According to the specifications stated in assignment 0 for project 1, all steps were carried out successfully on a 64-bit personal computer using a ubuntu via virtual box. However, there are some technical issues that were encountered in step 3 and step 6. In step 3, there were some error printout during the command execution using "sudo make -j4", later during the installation the best corrective action to avoid the printout errors is to switch the kernel version from kernel 5.3.0 to 5.0.1. . In step 6, there are still persistent failed operations when going into reboot mode in which it never successfully reboot. The best corrective action to solve the software error in step 6 is to "sudo poweroff" and turn the Virtual Machine Environment on manually.Also to note that using command 'sudo' for each procedure are required but using 'sudo su -' and navigating to the LINUX SOURCE folder is also another solution to execute the step procedures. Refer to figure 1 for kernel version printout. Refer to the following attached kernel and user-level source codes.

2 Assignment 1: Add a new system call into Linux Kernel

According to the specifications stated in assignment 1, all steps were carried out successfully. In addition, a 64-bit Linux system call table were used for this particular assignment as required for the hardware that I have in possession. There are no errors that were encountered in the following steps procedures. Refer to figure 2 for "helloworld" printout using a system call.

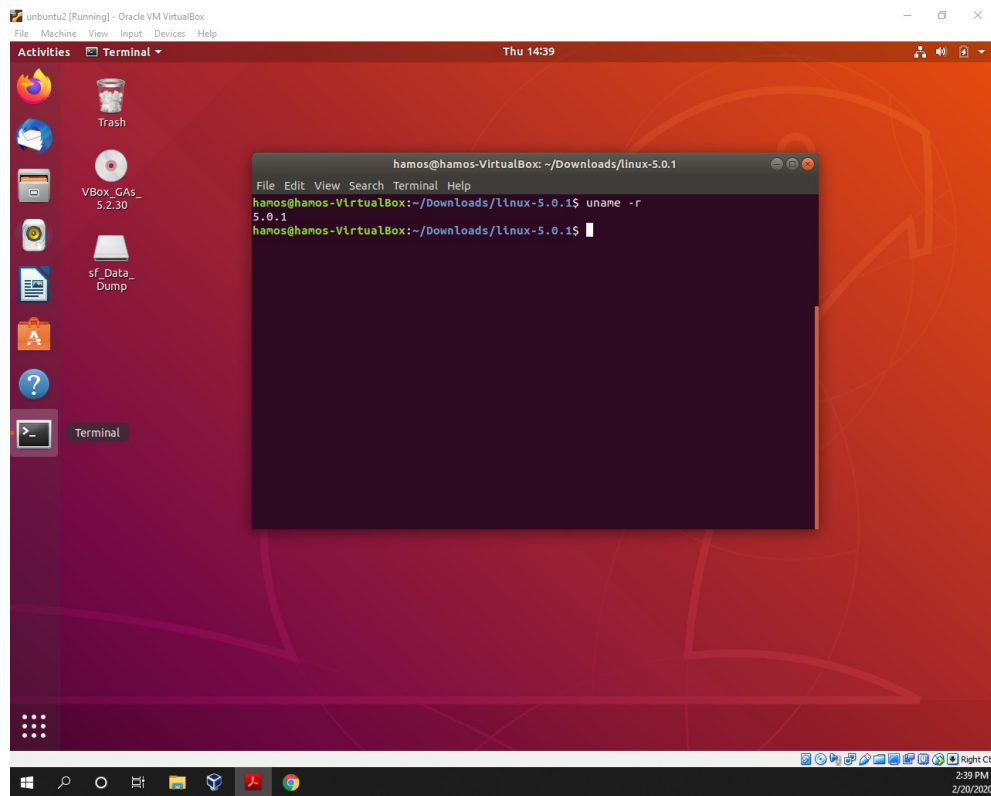
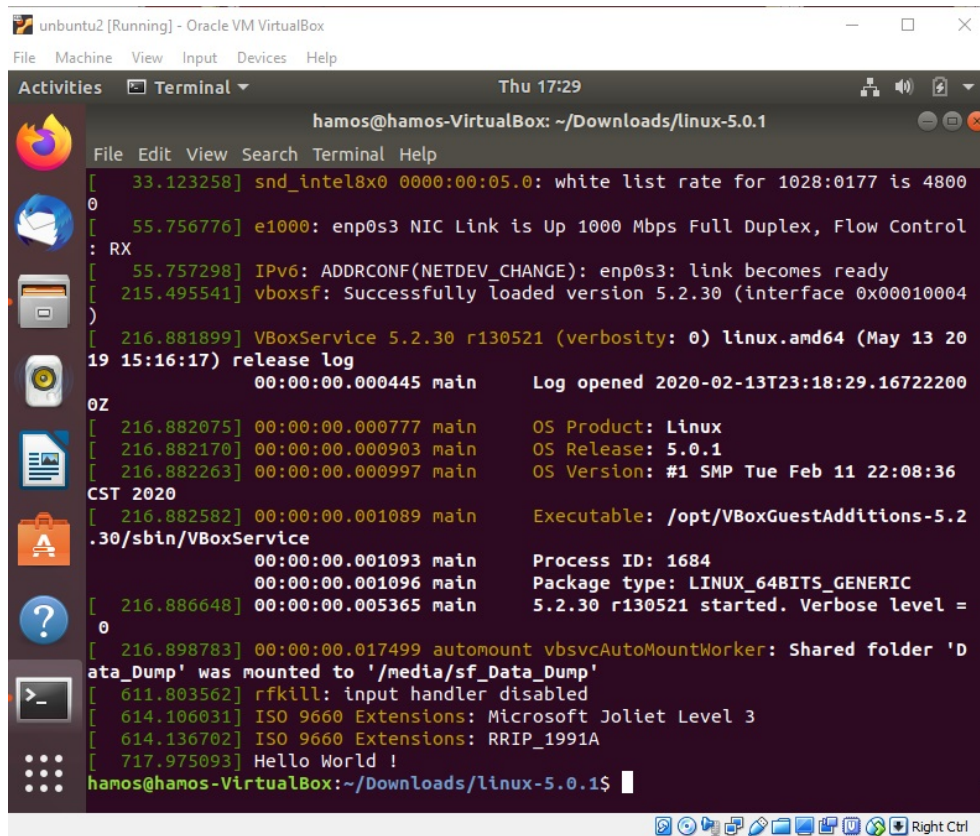


Figure 1: Assignment 0: step 6 printout of new kernel



```
unbuntu2 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal Thu 17:29
hamos@hamos-VirtualBox: ~/Downloads/linux-5.0.1
File Edit View Search Terminal Help
[ 33.123258] snd_intel8x0 0000:00:05.0: white list rate for 1028:0177 is 4800
0
[ 55.756776] e1000: enp0s3 NIC Link is Up 1000 Mbps Full Duplex, Flow Control
: RX
[ 55.757298] IPv6: ADDRCONF(NETDEV_CHANGE): enp0s3: link becomes ready
[ 215.495541] vboxsf: Successfully loaded version 5.2.30 (interface 0x00010004
)
[ 216.881899] VBoxService 5.2.30 r130521 (verbosity: 0) linux.amd64 (May 13 20
19 15:16:17) release log
00:00:00.000445 main Log opened 2020-02-13T23:18:29.16722200
0Z
[ 216.882075] 00:00:00.000777 main OS Product: Linux
[ 216.882170] 00:00:00.000903 main OS Release: 5.0.1
[ 216.882263] 00:00:00.000997 main OS Version: #1 SMP Tue Feb 11 22:08:36
CST 2020
[ 216.882582] 00:00:00.001089 main Executable: /opt/VBoxGuestAdditions-5.2
.30/sbin/VBoxService
00:00:00.001093 main Process ID: 1684
00:00:00.001096 main Package type: LINUX_64BITS_GENERIC
[ 216.886648] 00:00:00.005365 main 5.2.30 r130521 started. Verbose level =
0
[ 216.898783] 00:00:00.017499 automount vbsvcAutoMountWorker: Shared folder 'D
ata_Dump' was mounted to '/media/sf_Data_Dump'
[ 611.803562] rfkill: input handler disabled
[ 614.106031] ISO 9660 Extensions: Microsoft Joliet Level 3
[ 614.136702] ISO 9660 Extensions: RRIP_1991A
[ 717.975093] Hello World !
hamos@hamos-VirtualBox:~/Downloads/linux-5.0.1$
```

Figure 2: Assignment 1: "helloworld" system call printout using dmesg

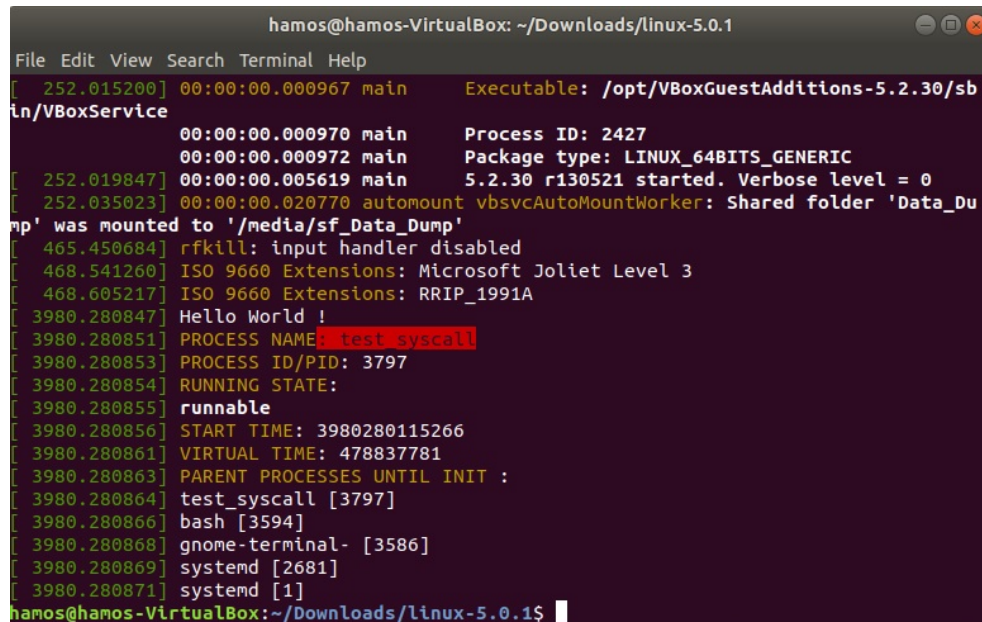
A screenshot of a terminal window titled 'hamos@hamos-VirtualBox: ~/Downloads/linux-5.0.1'. The terminal shows the boot process of a Linux system. It starts with '00:00:00.000967 main Executable: /opt/VBoxGuestAdditions-5.2.30/sbin/VBoxService'. Then, '00:00:00.000970 main Process ID: 2427' and '00:00:00.000972 main Package type: LINUX_64BITS_GENERIC' are shown. The system version '5.2.30 r130521 started. Verbose level = 0' is printed. A shared folder 'Data_Dump' is mounted to '/media/sf_Data_Dump'. The 'rfkill: input handler disabled' message appears. ISO 9660 extensions are listed: 'Microsoft Joliet Level 3' and 'RRIP_1991A'. The text 'Hello World !' is printed. The process 'test_syscall' is highlighted in red, with its details: 'PROCESS NAME: test_syscall', 'PROCESS ID/PID: 3797', 'RUNNING STATE: runnable', 'START TIME: 3980280115266', 'VIRTUAL TIME: 478837781', and 'PARENT PROCESSES UNTIL INIT : test_syscall [3797]'. Other processes shown include 'bash [3594]', 'gnome-terminal- [3586]', 'systemd [2681]', and 'systemd [1]'. The prompt 'hamos@hamos-VirtualBox:~/Downloads/linux-5.0.1\$' is at the bottom.

Figure 3: Assignment 2: information printout of a new system process from a system call print other

3 Assignment 2: Extend your new system call to print out the calling process information

According to the specifications stated in assignment 2, all steps were carried out successfully. A new system call, print self, was implemented in the kernel and user-level source code in which it print out various information of the process such as Process id(refer to as pid), running state, program name, start time, virtual time, and parent processes until init. The user-level code algorithms are implemented using a resource from a following website as stated in the step procedures. Refer to figure 3 for process information printout using a new system call. Refer to the following attached kernel and user-level source codes.

4 Assignment 3: Extend your new system call to print out the information of an arbitrary process identified by its PID

According to the specifications stated in assignment 3, the implementation of a new system call name print other was successful. The print other system call has successfully print the information for an arbitrary process. The mechanics of this system call functions when the client user code in the sys test call c file

```
hamos@hamos-VirtualBox: ~/Downloads/linux-5.0.1$ ps -A
PID TTY          TIME CMD
  1 ?        00:00:14 systemd
  2 ?        00:00:00 kthreadd
  3 ?        00:00:00 rcu_gp
  4 ?        00:00:00 rcu_par_gp
  6 ?        00:00:00 kworker/0:0H-kb
  8 ?        00:00:00 mm_percpu_wq
  9 ?        00:00:00 ksoftirqd/0
 10 ?       00:00:01 rcu_sched
 11 ?       00:00:00 migration/0
 12 ?       00:00:00 idle_inject/0
 13 ?       00:00:00 kworker/0:1-eve
 14 ?       00:00:00 cpuhp/0
 15 ?       00:00:00 cpuhp/1
 16 ?       00:00:00 idle_inject/1
 17 ?       00:00:00 migration/1
 18 ?       00:00:00 ksoftirqd/1
 20 ?       00:00:00 kworker/1:0H-kb
 21 ?       00:00:00 cpuhp/2
 22 ?       00:00:00 idle_inject/2
 23 ?       00:00:00 migration/2
 24 ?       00:00:00 ksoftirqd/2
 27 ?       00:00:00 kworker/2:0H-kb
 28 ?       00:00:00 kdevtmpfs
 29 ?       00:00:00 netns
 30 ?       00:00:00 rcu_tasks_kthre
 31 ?       00:00:00 kauditd
 32 ?       00:00:00 kworker/1:1-mm_
 33 ?       00:00:00 khungtaskd
 34 ?       00:00:00 oom_reaper
 35 ?       00:00:00 writeback
 36 ?       00:00:00 kcompactd0
 37 ?       00:00:00 ksm
 38 ?       00:00:00 khugepaged
 39 ?       00:00:00 crypto
 40 ?       00:00:00 kintegrityd
 41 ?       00:00:00 kblockd
 42 ?       00:00:00 tpm_dev_wq
 43 ?       00:00:00 ata_sff
 44 ?       00:00:00 md
 45 ?       00:00:00 edac-poller
 46 ?       00:00:00 devfreq_wq
 47 ?       00:00:00 watchdogd
 48 ?       00:00:00 kworker/u6:1-ev
 49 ?       00:00:00 kworker/2:1-eve
 50 ?       00:00:00 kworker/0:2H-kb
```

Figure 4: Assignment 3: pid hash table of current running system before compiling sys test call c file.

prompts the user to enter the Process Id (pid) number. Moreover, the user will enter the pid number and press enter, then the system will process, fetch, and print the process identified by the pid number of interest. The user can view all processes through the dmesg command through the Linux terminal. In addition, a new software application was installed for this particular assignment, the is application is name htop (using the command `sudo apt-get install htop` and `ps -A`). The htop software application accesses and create a table list of all run time pid numbers of the ubuntu operating system. From this software, determining the pid number of interest when using the client side prompt will help execute the arbitrary process of the pid number and print out its process in the dmesg. Refer to figure 4, figure 5, figure 6 figure 7 and figure 8 for the step procedural process of this assignment. Refer to the following attached kernel and user-level source codes that accompanies this report.

```
hamos@hamos-VirtualBox: ~/Downloads/linux-5.0.1
hamos@hamos-VirtualBox:~/Downloads/linux-5.0.1$ clear
hamos@hamos-VirtualBox:~/Downloads/linux-5.0.1$ gcc test_syscall.c -o test_syscall
hamos@hamos-VirtualBox:~/Downloads/linux-5.0.1$ ./test_syscall
ENTER PROCESS ID: 2676
Process Id 2676 is not executing
hamos@hamos-VirtualBox:~/Downloads/linux-5.0.1$ ./test_syscall
ENTER PROCESS ID: 2812
Process Id 2812 found, its executing, run command dmesg to viewhamos@hamos-VirtualBox:~/Downloads/linux-5.0.1$ ./test_syscall
ENTER PROCESS ID: 3388
Process Id 3388 found, its executing, run command dmesg to viewhamos@hamos-VirtualBox:~/Downloads/linux-5.0.1$ ./test_syscall
ENTER PROCESS ID: 3787
Process Id 3787 found, its executing, run command dmesg to viewhamos@hamos-VirtualBox:~/Downloads/linux-5.0.1$ ./test_syscall
ENTER PROCESS ID: 3908
Process Id 3908 found, its executing, run command dmesg to viewhamos@hamos-VirtualBox:~/Downloads/linux-5.0.1$ ./test_syscall
ENTER PROCESS ID: 3754
Process Id 3754 is not executing
hamos@hamos-VirtualBox:~/Downloads/linux-5.0.1$ ./test_syscall
ENTER PROCESS ID: 3707
hamos@hamos-VirtualBox:~/Downloads/linux-5.0.1$
```

Figure 5: Assignment 3: compiling and executing sys test call c file in order to use user prompt.

```

125.668758] audit: type=1400 audit(1582245143.488:62): apparmor="STATUS" operation="profile_replace" info="same as current profile
skipping" profile="unconfined" name="snap.gnome-system-monitor.gnome-system-monitor" pid=2470 comm="apparmor_parser"
125.670007] audit: type=1400 audit(1582245143.488:63): apparmor="STATUS" operation="profile_replace" info="same as current profile
skipping" profile="unconfined" name="snap.notepadqq.notepadqq" pid=2473 comm="apparmor_parser"
125.670162] audit: type=1400 audit(1582245143.488:64): apparmor="STATUS" operation="profile_replace" info="same as current profile
skipping" profile="unconfined" name="snap.update-ns.notepadqq" pid=2472 comm="apparmor_parser"
338.590796] VBoxService 5.2.30 r130521 (verbosity: 0) linux.amd64 (May 13 2019 15:16:17) release log
00:00:00.000357 main Log opened 2020-02-21T00:35:56.415753000Z
338.590892] 00:00:00.000541 main OS Product: Linux
338.591004] 00:00:00.000611 main OS Release: 5.0.1
338.591071] 00:00:00.000723 main OS Version: #1 SMP Mon Feb 17 13:50:55 CST 2020
338.591178] 00:00:00.000788 main Executable: /opt/VBoxGuestAdditions-5.2.30/sbin/VBoxService
00:00:00.000790 main Process ID: 2541
00:00:00.000792 main Package type: LINUX_64BITS_GENERIC
338.594504] 00:00:00.004128 main 5.2.30 r130521 started. Verbose level = 0
338.774536] vboxsf: Successfully loaded version 5.2.30 (interface 0x00010004)
338.775638] 00:00:00.185256 automount vbsvcAutoMountWorker: Shared folder 'Data_Dump' was mounted to '/media/sf_Data_Dump'
412.419793] rfkll: input handler disabled
415.848923] ISO 9660 Extensions: Microsoft Joliet Level 3
415.892483] ISO 9660 Extensions: RRIP_1991A
810.489289] Hello World !
810.489293] PROCESS NAME: test_syscall
810.489295] PROCESS ID/PID: 4041
810.489296] RUNNING STATE:
810.489297] runnable
810.489298] START TIME: 810489681926
810.489300] VIRTUAL TIME: 593705509
810.489301] PARENT PROCESSES UNTIL INIT :
810.489303] test_syscall [4041]
810.489304] bash [3917]
810.489306] gnome-terminal- [3908]
810.489308] systemd [2792]
810.489309] systemd [1]
848.240560] Hello World !
848.240571] PROCESS NAME: test_syscall
848.240572] PROCESS ID/PID: 4056
848.240574] RUNNING STATE:
848.240574] runnable
848.240576] START TIME: 848245912983
848.240577] VIRTUAL TIME: 589918719
848.240578] PARENT PROCESSES UNTIL INIT :
848.240580] test_syscall [4056]
848.240581] bash [3917]
848.240583] gnome-terminal- [3908]
848.240585] systemd [2792]
848.240587] systemd [1]
861.882296] PROCESS ID NOT FOUND FROM THE INPUT

```

Figure 6: Assignment 3: dmesg printout part 1 after execution of sys test call c file.


```
hamos@hamos-VirtualBox: ~/Downloads/linux-5.0.1
File Edit View Search Terminal Help
[ 861.882296] PROCESS ID NOT FOUND FROM THE INPUT
[ 912.137935] Hello World !
[ 912.137942] PROCESS NAME: test_syscall
[ 912.137944] PROCESS ID/PID: 4085
[ 912.137945] RUNNING STATE:
[ 912.137946] runnable
[ 912.137947] START TIME: 912137124206
[ 912.137949] VIRTUAL TIME: 600579175
[ 912.137950] PARENT PROCESSES UNTIL INIT :
[ 912.137952] test_syscall [4085]
[ 912.137954] bash [3917]
[ 912.137956] gnome-terminal- [3908]
[ 912.137958] systemd [2792]
[ 912.137960] systemd [1]
[ 947.301988] PROCESS ID NOT FOUND FROM THE INPUT
[ 969.158025] Hello World !
[ 969.158031] PROCESS NAME: test_syscall
[ 969.158033] PROCESS ID/PID: 4110
[ 969.158034] RUNNING STATE:
[ 969.158034] runnable
[ 969.158036] START TIME: 969157240055
[ 969.158038] VIRTUAL TIME: 513820726
[ 969.158040] PARENT PROCESSES UNTIL INIT :
[ 969.158042] test_syscall [4110]
[ 969.158043] bash [3917]
[ 969.158045] gnome-terminal- [3908]
[ 969.158047] systemd [2792]
[ 969.158049] systemd [1]
[ 972.937291] PROCESS ID NOT FOUND FROM THE INPUT
[ 976.954933] Hello World !
[ 976.954938] PROCESS NAME: test_syscall
[ 976.954940] PROCESS ID/PID: 4126
[ 976.954941] RUNNING STATE:
[ 976.954941] runnable
[ 976.954943] START TIME: 976954778003
[ 976.954944] VIRTUAL TIME: 521492691
[ 976.954946] PARENT PROCESSES UNTIL INIT :
[ 976.954947] test_syscall [4126]
[ 976.954949] bash [3917]
[ 976.954951] gnome-terminal- [3908]
[ 976.954952] systemd [2792]
[ 976.954954] systemd [1]
[ 984.129236] PROCESS ID NOT FOUND FROM THE INPUT
[ 991.162528] Hello World !
[ 991.162533] PROCESS NAME: test_syscall
[ 991.162535] PROCESS ID/PID: 4140
[ 991.162536] RUNNING STATE:
```

Figure 7: Assignment 3: dmesg printout part 2 after execution of sys test call c file.


```
Activities Terminal Thu 18:52
hamos@hamos-VirtualBox: ~/Downloads/linux-5.0.1

[ 969.158043] bash [3917]
[ 969.158045] gnome-terminal- [3908]
[ 969.158047] systemd [2792]
[ 969.158049] systemd [1]
[ 972.937291] PROCESS ID NOT FOUND FROM THE INPUT
[ 976.954933] Hello World !
[ 976.954938] PROCESS NAME: test_syscall
[ 976.954940] PROCESS ID/PID: 4126
[ 976.954941] RUNNING STATE:
[ 976.954941] runnable
[ 976.954943] START TIME: 976954778003
[ 976.954944] VIRTUAL TIME: 521492691
[ 976.954946] PARENT PROCESSES UNTIL INIT :
[ 976.954947] test_syscall [4126]
[ 976.954949] bash [3917]
[ 976.954951] gnome-terminal- [3908]
[ 976.954952] systemd [2792]
[ 976.954954] systemd [1]
[ 984.129236] PROCESS ID NOT FOUND FROM THE INPUT
[ 991.162528] Hello World !
[ 991.162533] PROCESS NAME: test_syscall
[ 991.162535] PROCESS ID/PID: 4140
[ 991.162536] RUNNING STATE:
[ 991.162536] runnable
[ 991.162538] START TIME: 991161863788
[ 991.162539] VIRTUAL TIME: 524945270
[ 991.162540] PARENT PROCESSES UNTIL INIT :
[ 991.162542] test_syscall [4140]
[ 991.162544] bash [3917]
[ 991.162545] gnome-terminal- [3908]
[ 991.162547] systemd [2792]
[ 991.162549] systemd [1]
[ 999.746809] Hello World !
[ 999.746814] PROCESS NAME: test_syscall
[ 999.746815] PROCESS ID/PID: 4154
[ 999.746816] RUNNING STATE:
[ 999.746817] runnable
[ 999.746819] START TIME: 999746199747
[ 999.746820] VIRTUAL TIME: 529471800
[ 999.746821] PARENT PROCESSES UNTIL INIT :
[ 999.746823] test_syscall [4154]
[ 999.746825] bash [3917]
[ 999.746826] gnome-terminal- [3908]
[ 999.746828] systemd [2792]
[ 999.746830] systemd [1]
hamos@hamos-VirtualBox:~/Downloads/linux-5.0.1$
```

Figure 8: Assignment 3: dmesg printout part 3 after execution of sys test call c file.