

Keerthana Shivakumar

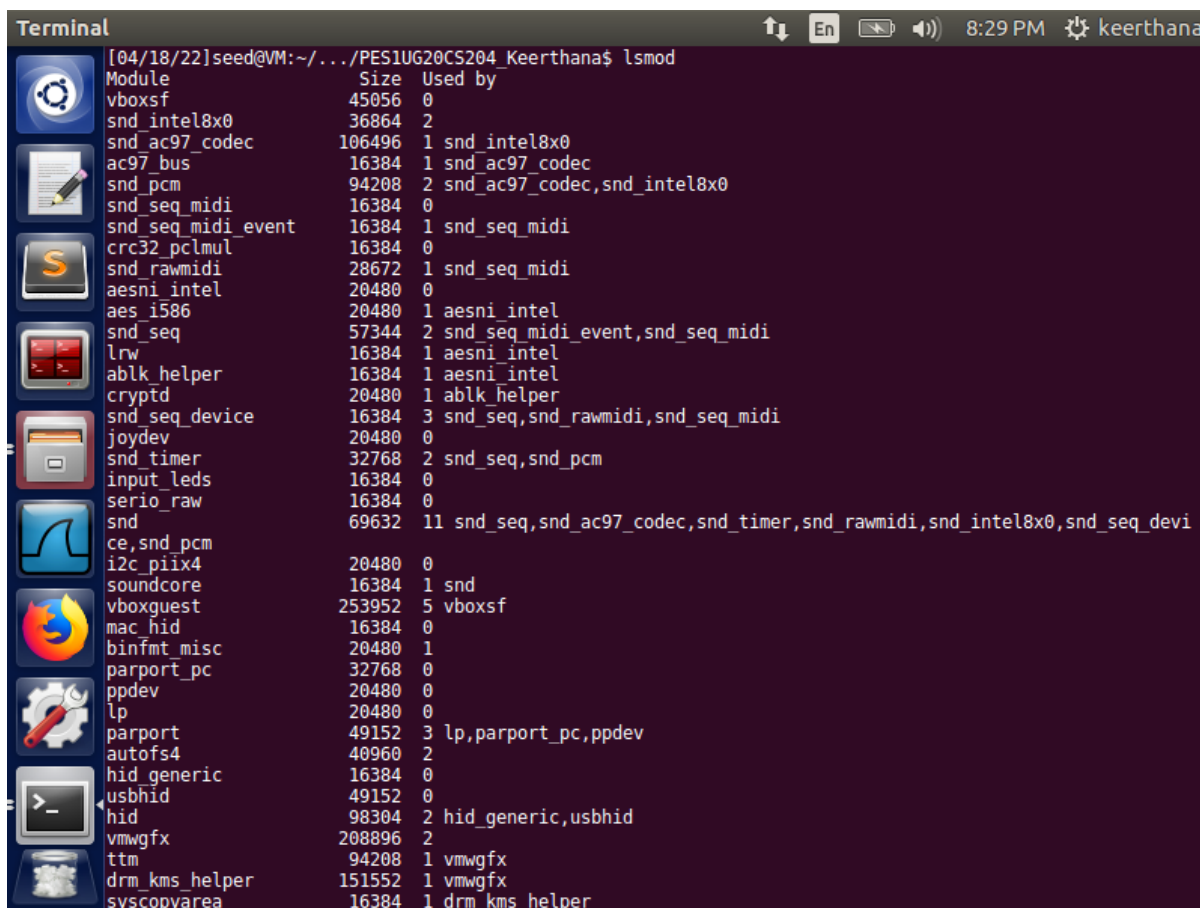
PES1UG20CS204

Operating Systems Project

Write a kernel module that lists all current tasks in a Linux system beginning from the `init` task. Refer to Chapter 2 in the text book for creating Linux kernel modules. Output the task name (known as executable name), state and process id of each task in a tree structure.

Step 1 – Creating Kernel Modules

Command `lsmod` can be used to list all the kernel modules that are currently loaded.



```
Terminal
[04/18/22]seed@VM:~/.../PES1UG20CS204_Keerthana$ lsmod
Module                  Size      Used by
vboxsf                  45056      0
snd_intel8x0            36864      2
snd_ac97_codec          106496     1 snd_intel8x0
ac97_bus                16384     1 snd_ac97_codec
snd_pcm                 94208     2 snd_ac97_codec,snd_intel8x0
snd_seq_midi            16384      0
snd_seq_midi_event      16384     1 snd_seq_midi
crc32_pclmul            16384      0
snd_rawmidi             28672     1 snd_seq_midi
aesni_intel            20480      0
aes_i586                20480     1 aesni_intel
snd_seq                 57344     2 snd_seq_midi_event,snd_seq_midi
lrw                     16384     1 aesni_intel
ablk_helper             16384     1 aesni_intel
cryptd                  20480     1 ablk_helper
snd_seq_device          16384     3 snd_seq,snd_rawmidi,snd_seq_midi
joydev                  20480      0
snd_timer               32768     2 snd_seq,snd_pcm
input_leds              16384      0
serio_raw               16384      0
snd                     69632    11 snd_seq,snd_ac97_codec,snd_timer,snd_rawmidi,snd_intel8x0,snd_seq_devi
ce,snd_pcm
i2c_piix4               20480      0
soundcore               16384     1 snd
vboxguest               253952     5 vboxsf
mac_hid                 16384      0
binfmt_misc             20480      1
parport_pc              32768      0
ppdev                   20480      0
lp                      20480      0
parport                 49152     3 lp,parport_pc,ppdev
autofs4                 40960      2
hid_generic             16384      0
usbhid                  49152      0
hid                     98304     2 hid_generic,usbhid
vmwgfx                  208896     2
ttm                     94208     1 vmwgfx
drm_kms_helper          151552     1 vmwgfx
syscopyarea             16384     1 drm_kms_helper
```

Program for kernel – project3.c

//Code includes test cases created

```
#include<linux/init.h>
```

```
#include<linux/kernel.h>
```

```

#include<linux/module.h>

#include<linux/printk.h>

#include<linux/sched.h>

void dfs(struct task_struct *task){
    struct task_struct *task_next;
    struct list_head *list;
    list_for_each(list, &task->children) {
        task_next = list_entry(list, struct task_struct, sibling);
        if(task->pid==0)//child process
            printk(KERN_INFO "\t\tChild:- pid: %d | pname: %s | state: %ld\n",
task_next->pid, task_next->comm, task_next->state);
        else if(task->pid>0)//parent process
            printk(KERN_INFO "Parent:- pid: %d | pname: %s | state: %ld\n",
task_next->pid, task_next->comm, task_next->state);
        dfs(task_next);
    }
}

int tasks_lister_dfs_init(void)
{
    printk(KERN_INFO "Loading module...\n");
    dfs(&init_task);
    printk(KERN_INFO "Module loaded.\n");
    return 0;
}

void tasks_lister_dfs_exit(void)
{

```

```

    printk(KERN_INFO "Module removed.\n");
}

module_init(tasks_lister_dfs_init);
module_exit(tasks_lister_dfs_exit);

```

About the code

- linux/init.h – header file includes all things related to _init part.
- linux/module.h – header file where module_init (tells the kernel what is the entry point to our program) and module_exit (tells the kernel what is the exit point to our program) are present.
- linux/kernel.h – header file where all the workload happening features are listed.
- linux/sched.h – header file that contains scheduling parameters required for implementation of each supported scheduling policy.
- task_struct – declared under linux/sched.h.
- list_for_each – used to iterate over a list.
- list_entry – gets the struct for this entry. Arguments are the struct head pointer, type of struct it is embedded in and name of the head pointer within the struct.
- task_next->pid is to display the process ID of the task.
- task_next->comm is the command that triggered that event.
- task_next->state is used to indicate the process state. (In this case, all events are interruptible, since their states are displayed as 1)
- #define TASK_RUNNING 0
- #define TASK_INTERRUPTIBLE 1
- #define TASK_UNINTERRUPTIBLE 2
- #define TASK_ZOMBIE 4
- #define TASK_STOPPED 8
- The function tasks_lister_dfs_init is used to load a module and traverse the tree in DFS (depth first search).
- The function tasks_lister_dfs_exit is to remove the module.

Makefile – used for compiling the kernel module

```
obj-m += project3.o
```

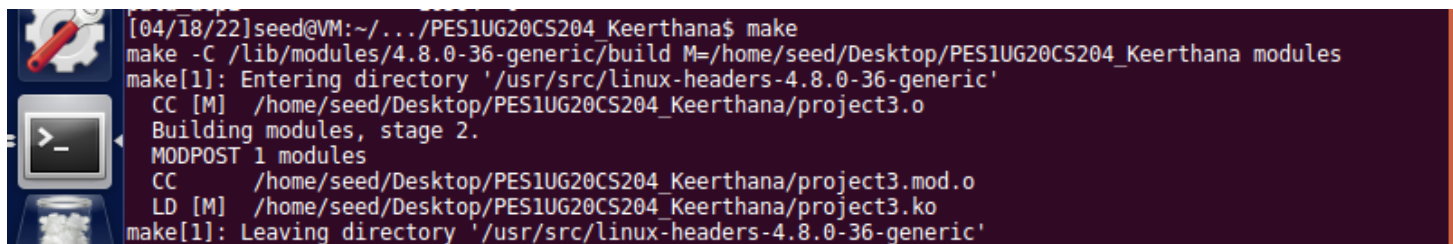
```
all:
```

```
make -C /lib/modules/$(shell uname -r)/build M=$(PWD) modules
```

clean:

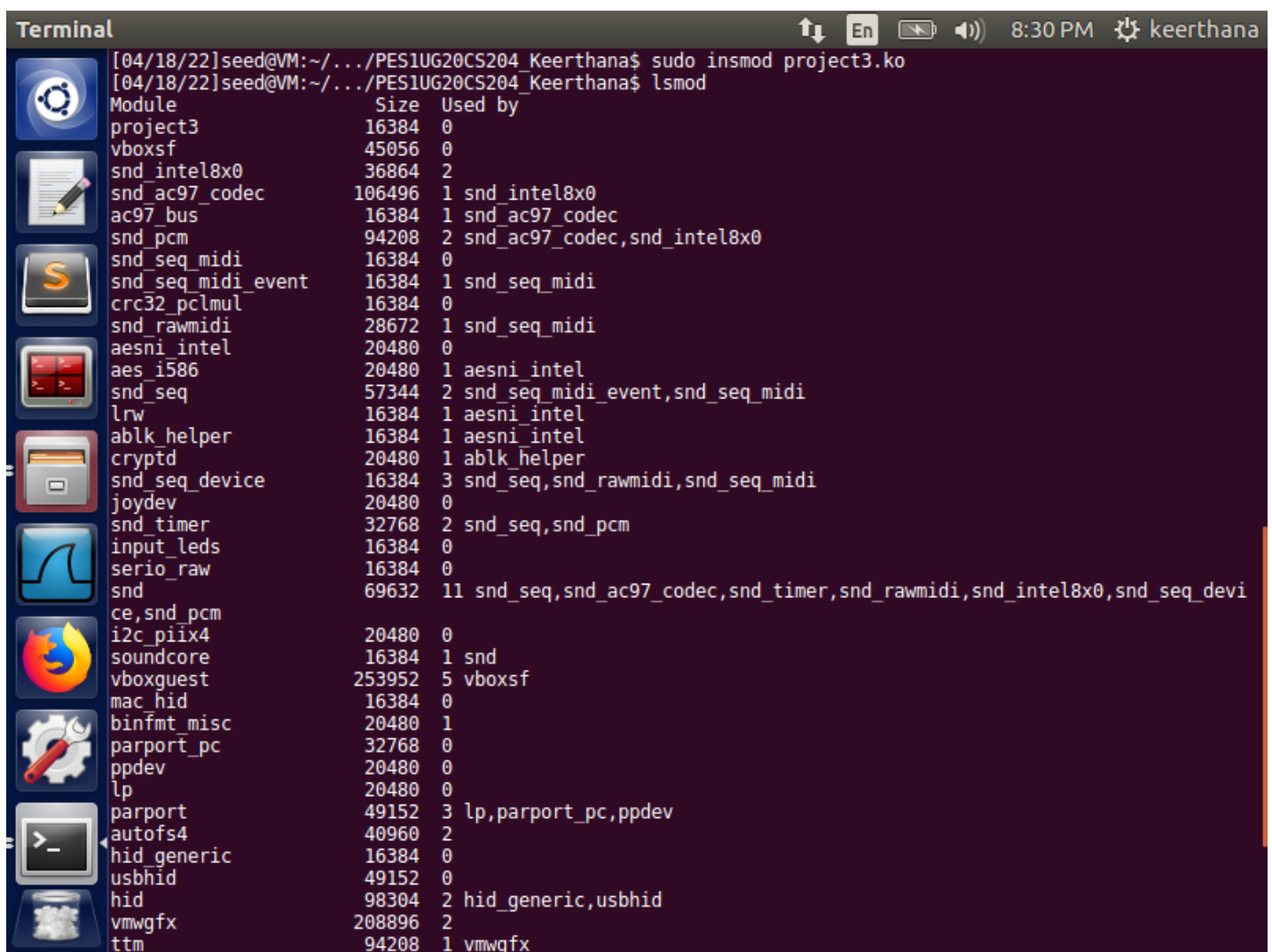
```
make -C /lib/modules/$(shell uname -r)/build M=$(PWD) clean
```

Step 2 - Compile the project3.c code using make command – files like project3.ko (compiled kernel module) , project3.mod.o (object file) and project3.o (object file) get created.



```
[04/18/22]seed@VM:~/.../PES1UG20CS204_Keerthana$ make
make -C /lib/modules/4.8.0-36-generic/build M=/home/seed/Desktop/PES1UG20CS204_Keerthana modules
make[1]: Entering directory '/usr/src/linux-headers-4.8.0-36-generic'
CC [M] /home/seed/Desktop/PES1UG20CS204_Keerthana/project3.o
Building modules, stage 2.
MODPOST 1 modules
CC /home/seed/Desktop/PES1UG20CS204_Keerthana/project3.mod.o
LD [M] /home/seed/Desktop/PES1UG20CS204_Keerthana/project3.ko
make[1]: Leaving directory '/usr/src/linux-headers-4.8.0-36-generic'
```

Step 3 - Load the kernel using the insmod command – sudo insmod project3.ko. It can be seen that the project3 module has been added.



```
Terminal
[04/18/22]seed@VM:~/.../PES1UG20CS204_Keerthana$ sudo insmod project3.ko
[04/18/22]seed@VM:~/.../PES1UG20CS204_Keerthana$ lsmod
Module              Size  Used by
project3            16384  0
vboxsf              45056  0
snd_intel8x0        36864  2
snd_ac97_codec     106496  1 snd_intel8x0
ac97_bus            16384  1 snd_ac97_codec
snd_pcm             94208  2 snd_ac97_codec,snd_intel8x0
snd_seq_midi        16384  0
snd_seq_midi_event  16384  1 snd_seq_midi
crc32_pclmul        16384  0
snd_rawmidi         28672  1 snd_seq_midi
aesni_intel         20480  0
aes_i586            20480  1 aesni_intel
snd_seq             57344  2 snd_seq_midi_event,snd_seq_midi
lrw                 16384  1 aesni_intel
ablk_helper         16384  1 aesni_intel
cryptd              20480  1 ablk_helper
snd_seq_device      16384  3 snd_seq,snd_rawmidi,snd_seq_midi
joydev              20480  0
snd_timer           32768  2 snd_seq,snd_pcm
input_leds          16384  0
serio_raw           16384  0
snd                 69632  11 snd_seq,snd_ac97_codec,snd_timer,snd_rawmidi,snd_intel8x0,snd_seq_devi
ce,snd_pcm
i2c_piix4           20480  0
soundcore           16384  1 snd
vboxguest           253952  5 vboxsf
mac_hid             16384  0
binfmt_misc         20480  1
parport_pc          32768  0
ppdev               20480  0
lp                  20480  0
parport             49152  3 lp,parport_pc,ppdev
autofs4             40960  2
hid_generic         16384  0
usbhid              49152  0
hid                 98304  2 hid_generic,usbhid
vmwgfx              208896  2
ttm                 94208  1 vmwgfx
```

Step 4 - To check the contents of the message in the kernel log buffer, command dmesg can be used. It will display all the contents of the module in the tree structure, traversed in the depth first search manner.

```
Terminal 9:51 PM keertana
[ 1554.944599] Loading module...
[ 1554.944601] Child:- pid: 1 | pname: systemd | state: 1
[ 1554.944602] Parent:- pid: 241 | pname: systemd-journal | state: 1
[ 1554.944603] Parent:- pid: 264 | pname: systemd-udev | state: 1
[ 1554.944604] Parent:- pid: 620 | pname: squid | state: 1
[ 1554.944604] Parent:- pid: 623 | pname: squid | state: 1
[ 1554.944605] Parent:- pid: 1103 | pname: log_file_daemon | state: 1
[ 1554.944606] Parent:- pid: 1104 | pname: pinger | state: 1
[ 1554.944607] Parent:- pid: 775 | pname: accounts-daemon | state: 1
[ 1554.944608] Parent:- pid: 776 | pname: avahi-daemon | state: 1
[ 1554.944608] Parent:- pid: 779 | pname: avahi-daemon | state: 1
[ 1554.944609] Parent:- pid: 777 | pname: systemd-logind | state: 1
[ 1554.944610] Parent:- pid: 778 | pname: ModemManager | state: 1
[ 1554.944611] Parent:- pid: 808 | pname: inetd | state: 1
[ 1554.944612] Parent:- pid: 820 | pname: dbus-daemon | state: 1
[ 1554.944612] Parent:- pid: 854 | pname: cups-browsed | state: 1
[ 1554.944613] Parent:- pid: 857 | pname: acpid | state: 1
[ 1554.944614] Parent:- pid: 858 | pname: rsyslogd | state: 1
[ 1554.944615] Parent:- pid: 859 | pname: NetworkManager | state: 1
[ 1554.944615] Parent:- pid: 1005 | pname: dhclient | state: 1
[ 1554.944616] Parent:- pid: 1018 | pname: dnsmasq | state: 1
[ 1554.944617] Parent:- pid: 868 | pname: cron | state: 1
[ 1554.944618] Parent:- pid: 878 | pname: snapd | state: 1
[ 1554.944618] Parent:- pid: 952 | pname: named | state: 1
[ 1554.944619] Parent:- pid: 955 | pname: sshd | state: 1
[ 1554.944620] Parent:- pid: 958 | pname: polkitd | state: 1
[ 1554.944621] Parent:- pid: 978 | pname: vsftpd | state: 1
[ 1554.944621] Parent:- pid: 981 | pname: lightdm | state: 1
[ 1554.944622] Parent:- pid: 1001 | pname: Xorg | state: 0
[ 1554.944623] Parent:- pid: 1101 | pname: lightdm | state: 1
[ 1554.944623] Parent:- pid: 1144 | pname: upstart | state: 1
[ 1554.944624] Parent:- pid: 1444 | pname: upstart-udev-br | state: 1
[ 1554.944625] Parent:- pid: 1456 | pname: dbus-daemon | state: 1
[ 1554.944625] Parent:- pid: 1468 | pname: window-stack-br | state: 1
[ 1554.944626] Parent:- pid: 1494 | pname: gnome-keyring-d | state: 1
```

```
Terminal 8:31 PM keertana
[ 1804.850839] Parent:- pid: 1937 | pname: apache2 | state: 1
[ 1804.850840] Parent:- pid: 1938 | pname: apache2 | state: 1
[ 1804.850841] Parent:- pid: 1939 | pname: apache2 | state: 1
[ 1804.850842] Parent:- pid: 1940 | pname: apache2 | state: 1
[ 1804.850843] Parent:- pid: 1941 | pname: apache2 | state: 1
[ 1804.850844] Parent:- pid: 1973 | pname: udiskd | state: 1
[ 1804.850845] Parent:- pid: 2002 | pname: fwupd | state: 1
[ 1804.850847] Child:- pid: 2 | pname: kthreadd | state: 1
[ 1804.850848] Parent:- pid: 3 | pname: ksoftirqd/0 | state: 1
[ 1804.850849] Parent:- pid: 5 | pname: kworker/0:0H | state: 1
[ 1804.850850] Parent:- pid: 7 | pname: rcu_sched | state: 1
[ 1804.850879] Parent:- pid: 8 | pname: rcu_bh | state: 1
[ 1804.850880] Parent:- pid: 9 | pname: migration/0 | state: 1
[ 1804.850881] Parent:- pid: 10 | pname: lru-add-drain | state: 1
[ 1804.850882] Parent:- pid: 11 | pname: watchdog/0 | state: 1
[ 1804.850883] Parent:- pid: 12 | pname: cpuhp/0 | state: 1
[ 1804.850884] Parent:- pid: 13 | pname: kdevtmpfs | state: 1
[ 1804.850885] Parent:- pid: 14 | pname: netns | state: 1
[ 1804.850887] Parent:- pid: 15 | pname: khungtaskd | state: 1
[ 1804.850888] Parent:- pid: 16 | pname: oom_reaper | state: 1
[ 1804.850889] Parent:- pid: 17 | pname: writeback | state: 1
[ 1804.850890] Parent:- pid: 18 | pname: kcompactd0 | state: 1
[ 1804.850891] Parent:- pid: 19 | pname: ksm | state: 1
[ 1804.850892] Parent:- pid: 20 | pname: khugepaged | state: 1
[ 1804.850893] Parent:- pid: 21 | pname: crypto | state: 1
[ 1804.850894] Parent:- pid: 22 | pname: kintegrityd | state: 1
[ 1804.850895] Parent:- pid: 23 | pname: bioset | state: 1
[ 1804.850896] Parent:- pid: 24 | pname: kblockd | state: 1
[ 1804.850897] Parent:- pid: 25 | pname: ata_sff | state: 1
[ 1804.850898] Parent:- pid: 26 | pname: md | state: 1
[ 1804.850899] Parent:- pid: 27 | pname: devfreq_wq | state: 1
[ 1804.850900] Parent:- pid: 28 | pname: watchdogd | state: 1
[ 1804.850901] Parent:- pid: 32 | pname: kswapd0 | state: 1
[ 1804.850902] Parent:- pid: 33 | pname: vmstat | state: 1
[ 1804.850903] Parent:- pid: 34 | pname: ecryptfs-kthrea | state: 1
[ 1804.850905] Parent:- pid: 73 | pname: kthrotld | state: 1
[ 1804.850906] Parent:- pid: 74 | pname: acpi_thermal_pm | state: 1
[ 1804.850907] Parent:- pid: 75 | pname: bioset | state: 1
[ 1804.850908] Parent:- pid: 76 | pname: bioset | state: 1
[ 1804.850909] Parent:- pid: 78 | pname: bioset | state: 1
[ 1804.850910] Parent:- pid: 79 | pname: bioset | state: 1
```