

Keerthana Shivakumar

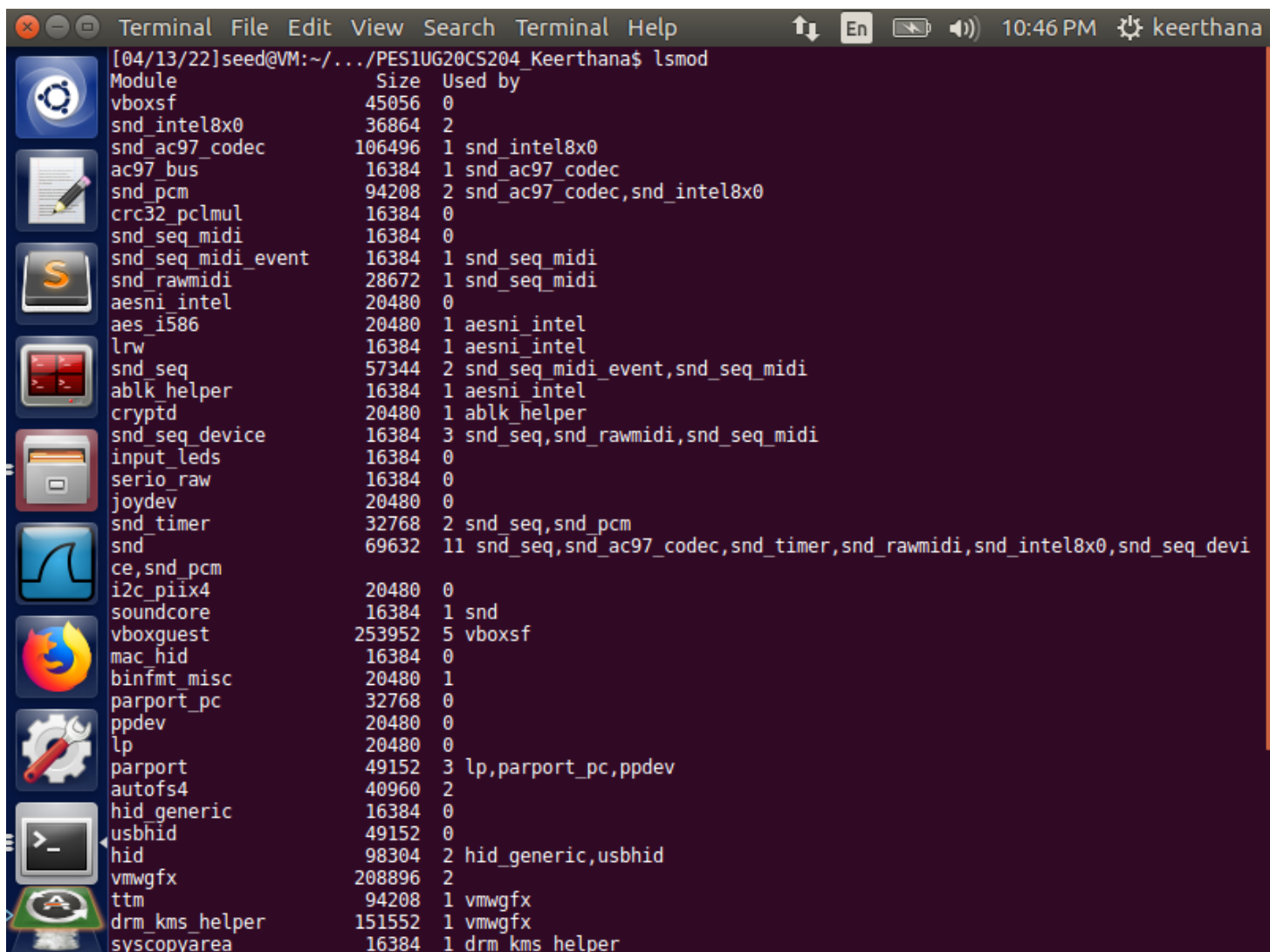
PES1UG20CS204

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.



```
[04/13/22]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
crc32_pclmul           16384      0
snd_seq_midi            16384      0
snd_seq_midi_event      16384      1 snd_seq_midi
snd_rawmidi             28672      1 snd_seq_midi
aesni_intel            20480      0
aes_i586                20480      1 aesni_intel
lrw                     16384      1 aesni_intel
snd_seq                 57344      2 snd_seq_midi_event,snd_seq_midi
ablkc_helper            16384      1 aesni_intel
cryptd                  20480      1 ablk_helper
snd_seq_device          16384      3 snd_seq,snd_rawmidi,snd_seq_midi
input_leds              16384      0
serio_raw               16384      0
joydev                  20480      0
snd_timer               32768      2 snd_seq,snd_pcm
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 – project.c

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

#include<linux/kernel.h>

#include<linux/module.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);

        printk(KERN_INFO "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");

}

/*Macros for registering module entry and exit points*/
```

```
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 += project.o
```

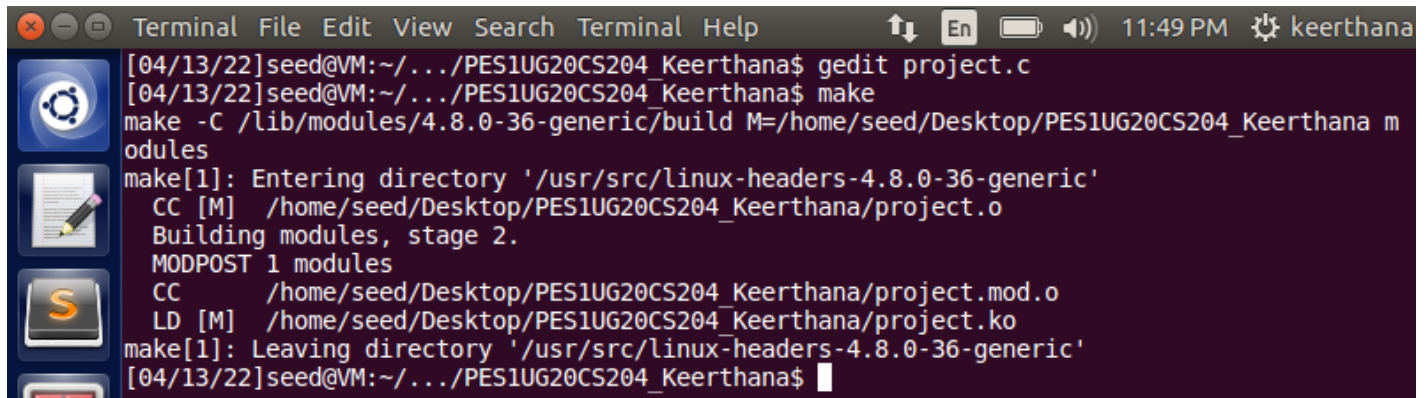
```
all:
```

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

clean:

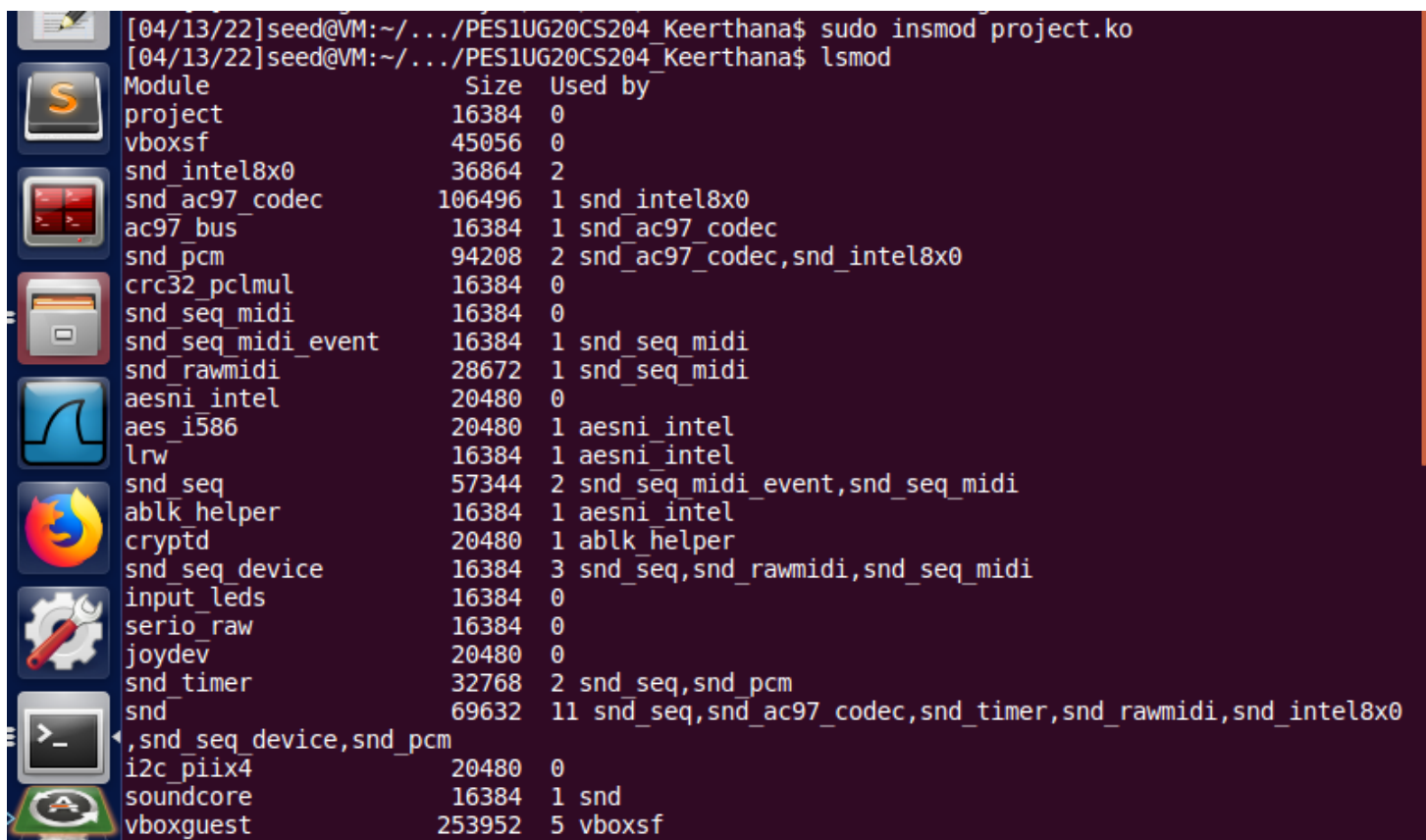
```
make -C /lib/modules/$(shell uname -r)/build M=$(PWD) clean
```

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



```
Terminal File Edit View Search Terminal Help 11:49 PM keertana
[04/13/22]seed@VM:~/.../PES1UG20CS204_Keertana$ gedit project.c
[04/13/22]seed@VM:~/.../PES1UG20CS204_Keertana$ make
make -C /lib/modules/4.8.0-36-generic/build M=/home/seed/Desktop/PES1UG20CS204_Keertana modules
make[1]: Entering directory '/usr/src/linux-headers-4.8.0-36-generic'
CC [M] /home/seed/Desktop/PES1UG20CS204_Keertana/project.o
Building modules, stage 2.
MODPOST 1 modules
CC /home/seed/Desktop/PES1UG20CS204_Keertana/project.mod.o
LD [M] /home/seed/Desktop/PES1UG20CS204_Keertana/project.ko
make[1]: Leaving directory '/usr/src/linux-headers-4.8.0-36-generic'
[04/13/22]seed@VM:~/.../PES1UG20CS204_Keertana$
```

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






















```
[04/13/22]seed@VM:~/.../PES1UG20CS204_Keertana$ sudo insmod project.ko
[04/13/22]seed@VM:~/.../PES1UG20CS204_Keertana$ lsmod
Module              Size  Used by
project              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
crc32_pclmul         16384  0
snd_seq_midi         16384  0
snd_seq_midi_event   16384  1 snd_seq_midi
snd_rawmidi          28672  1 snd_seq_midi
aesni_intel         20480  0
aes_i586             20480  1 aesni_intel
lrw                  16384  1 aesni_intel
snd_seq              57344  2 snd_seq_midi_event,snd_seq_midi
ablkc_helper         16384  1 aesni_intel
cryptd               20480  1 ablkc_helper
snd_seq_device       16384  3 snd_seq,snd_rawmidi,snd_seq_midi
input_leds           16384  0
serio_raw            16384  0
joydev               20480  0
snd_timer            32768  2 snd_seq,snd_pcm
snd                   69632  11 snd_seq,snd_ac97_codec,snd_timer,snd_rawmidi,snd_intel8x0
,snd_seq_device,snd_pcm
i2c_piix4            20480  0
soundcore            16384  1 snd
vboxguest            253952  5 vboxsf
```

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 File Edit View Search Terminal Help 12:01 AM keertana
[04/13/22]seed@VM:~/../PES1UG20CS204_Keertana$ dmesg
[ 6531.517841] project: module license 'unspecified' taints kernel.
[ 6531.517843] Disabling lock debugging due to kernel taint
[ 6531.523420] Loading module...
[ 6531.523422] pid: 1 | pname: systemd | state: 1
[ 6531.523423] pid: 244 | pname: systemd-journal | state: 1
[ 6531.523424] pid: 264 | pname: systemd-udev | state: 1
[ 6531.523425] pid: 620 | pname: squid | state: 1
[ 6531.523427] pid: 623 | pname: squid | state: 1
[ 6531.523428] pid: 1160 | pname: log_file_daemon | state: 1
[ 6531.523429] pid: 2916 | pname: pinger | state: 1
[ 6531.523430] pid: 758 | pname: ModemManager | state: 1
[ 6531.523431] pid: 763 | pname: systemd-logind | state: 1
[ 6531.523432] pid: 773 | pname: accounts-daemon | state: 1
[ 6531.523433] pid: 801 | pname: acpid | state: 1
[ 6531.523435] pid: 809 | pname: dbus-daemon | state: 1
[ 6531.523436] pid: 838 | pname: NetworkManager | state: 1
[ 6531.523437] pid: 1036 | pname: dhclient | state: 1
[ 6531.523438] pid: 1052 | pname: dnsmasq | state: 1
[ 6531.523439] pid: 839 | pname: avahi-daemon | state: 1
[ 6531.523440] pid: 845 | pname: avahi-daemon | state: 1
[ 6531.523441] pid: 844 | pname: rsyslogd | state: 1
[ 6531.523442] pid: 853 | pname: cron | state: 1
[ 6531.523443] pid: 858 | pname: inetd | state: 1
[ 6531.523445] pid: 870 | pname: snapd | state: 1
[ 6531.523446] pid: 954 | pname: named | state: 1
[ 6531.523447] pid: 971 | pname: sshd | state: 1
[ 6531.523448] pid: 976 | pname: polkitd | state: 1
[ 6531.523449] pid: 986 | pname: mysqld | state: 1
[ 6531.523450] pid: 989 | pname: vsftpd | state: 1
[ 6531.523451] pid: 994 | pname: lightdm | state: 1
[ 6531.523452] pid: 1028 | pname: Xorg | state: 1
[ 6531.523453] pid: 1113 | pname: lightdm | state: 1
[ 6531.523454] pid: 1195 | pname: upstart | state: 1
[ 6531.523455] pid: 1513 | pname: upstart-udev-br | state: 1
```

Terminal File Edit View Search Terminal Help 12:02 AM keertana



[6531.523456]	pid: 1526	pname: dbus-daemon state: 1
[6531.523457]	pid: 1538	pname: window-stack-br state: 1
[6531.523458]	pid: 1551	pname: gnome-keyring-d state: 1
[6531.523459]	pid: 1585	pname: bamfdaemon state: 1
[6531.523460]	pid: 1587	pname: upstart-dbus-br state: 1
[6531.523461]	pid: 1592	pname: gpg-agent state: 1
[6531.523462]	pid: 1595	pname: upstart-dbus-br state: 1
[6531.523463]	pid: 1597	pname: upstart-file-br state: 1
[6531.523464]	pid: 1599	pname: ibus-daemon state: 1
[6531.523465]	pid: 1615	pname: ibus-dconf state: 1
[6531.523466]	pid: 1625	pname: ibus-ui-gtk3 state: 1
[6531.523467]	pid: 1651	pname: ibus-engine-sim state: 1
[6531.523468]	pid: 1607	pname: gvfsd state: 1
[6531.523468]	pid: 1613	pname: gvfsd-fuse state: 1
[6531.523469]	pid: 1629	pname: ibus-x11 state: 1
[6531.523470]	pid: 1627	pname: at-spi-bus-laun state: 1
[6531.523471]	pid: 1635	pname: dbus-daemon state: 1
[6531.523472]	pid: 1641	pname: at-spi2-registr state: 1
[6531.523473]	pid: 1735	pname: hud-service state: 1
[6531.523474]	pid: 1737	pname: unity-settings- state: 1
[6531.523475]	pid: 1746	pname: gnome-session-b state: 1
[6531.523476]	pid: 1965	pname: unity-fallback- state: 1
[6531.523477]	pid: 1966	pname: gnome-software state: 1
[6531.523478]	pid: 1967	pname: nm-applet state: 1
[6531.523479]	pid: 1976	pname: nautilus state: 1
[6531.523481]	pid: 1977	pname: polkit-gnome-au state: 1
[6531.523482]	pid: 2171	pname: zeitgeist-datah state: 1
[6531.523483]	pid: 2326	pname: update-notifier state: 1
[6531.523484]	pid: 2604	pname: deja-dup-monito state: 1
[6531.523485]	pid: 1751	pname: unity-panel-ser state: 1
[6531.523485]	pid: 1779	pname: dconf-service state: 1
[6531.523486]	pid: 1794	pname: indicator-messa state: 1
[6531.523487]	pid: 1795	pname: indicator-bluet state: 1
[6531.523488]	pid: 1798	pname: indicator-power state: 1
[6531.523489]	pid: 1802	pname: indicator-datet state: 1


```
Terminal File Edit View Search Terminal Help 12:02 AM En keertana
[ 6531.523597] pid: 89 | pname: bioset | state: 1
[ 6531.523598] pid: 90 | pname: bioset | state: 1
[ 6531.523599] pid: 91 | pname: bioset | state: 1
[ 6531.523600] pid: 92 | pname: bioset | state: 1
[ 6531.523601] pid: 93 | pname: bioset | state: 1
[ 6531.523602] pid: 94 | pname: bioset | state: 1
[ 6531.523603] pid: 95 | pname: bioset | state: 1
[ 6531.523604] pid: 96 | pname: bioset | state: 1
[ 6531.523605] pid: 97 | pname: bioset | state: 1
[ 6531.523606] pid: 98 | pname: bioset | state: 1
[ 6531.523607] pid: 99 | pname: bioset | state: 1
[ 6531.523608] pid: 100 | pname: scsi_eh_0 | state: 1
[ 6531.523609] pid: 101 | pname: scsi_tm_f_0 | state: 1
[ 6531.523610] pid: 102 | pname: scsi_eh_1 | state: 1
[ 6531.523611] pid: 103 | pname: scsi_tm_f_1 | state: 1
[ 6531.523612] pid: 105 | pname: ipv6_addrconf | state: 1
[ 6531.523613] pid: 128 | pname: deferwq | state: 1
[ 6531.523614] pid: 129 | pname: charger manager | state: 1
[ 6531.523615] pid: 130 | pname: bioset | state: 1
[ 6531.523616] pid: 172 | pname: kpsmoused | state: 1
[ 6531.523617] pid: 180 | pname: kworker/0:1H | state: 1
[ 6531.523619] pid: 181 | pname: scsi_eh_2 | state: 1
[ 6531.523620] pid: 182 | pname: scsi_tm_f_2 | state: 1
[ 6531.523621] pid: 183 | pname: ttm_swap | state: 1
[ 6531.523622] pid: 184 | pname: bioset | state: 1
[ 6531.523623] pid: 208 | pname: jbd2/sda1-8 | state: 1
[ 6531.523624] pid: 209 | pname: ext4-rsv-conver | state: 1
[ 6531.523625] pid: 240 | pname: kauditd | state: 1
[ 6531.523626] pid: 527 | pname: iprt-VBoxWQueue | state: 1
[ 6531.523627] pid: 27024 | pname: kworker/0:0 | state: 1
[ 6531.523628] pid: 27036 | pname: kworker/u2:0 | state: 1
[ 6531.523629] pid: 27573 | pname: kworker/0:2 | state: 1
[ 6531.523630] pid: 27576 | pname: kworker/u2:2 | state: 1
[ 6531.523631] Module loaded.
[04/13/22]seed@VM:~/.../PES1UG20CS204_Keertana$
```