Lab 2

Members: Fangwen Liao (3439869) | Yijin Wang (3476217) | Moritz Pfeffer (3261671)

Exercise 1

(a) Use only the ps command to list all processes (including UID) with parent process ID (PPID) 1.
I consult the man page of ps and find the **--ppid** switch.

> --ppid pidlist
> Select by parent process ID. This selects the processes with a parent process ID in pidlist.

To include the UID I use the u option, and to print it numerically I use the n modifier. Both are documented in the man pages of ps.

> u Display user-oriented format.
> n Numeric output for WCHAN and USER (including all types of UID and GID).

```
moritzpfeffer@debian:~$ ps --ppid 1 nu
    USER   PID %CPU %MEM    VSZ    RSS TTY       STAT START    TIME COMMAND
       0   212  0.0  0.1  11776   6712 ?         Ss   14:45    0:01
/lib/systemd/systemd-journald
       0   241  0.0  0.0  21868   1528 ?         Ss   14:45    0:00 /sbin/lvmetad -f
       0   242  0.0  0.1  16240   4100 ?         Ss   14:45    0:00
/lib/systemd/systemd-udevd
     115   431  0.0  0.0   6252   3116 ?         Ss   14:45    0:00 avahi-daemon:
running [debian.local]
       0   432  0.0  0.0   6612   1940 ?         Ss   14:45    0:00
/usr/sbin/irqbalance --foreground
       0   433  0.0  0.1   7456   4716 ?         Ss   14:45    0:00
/lib/systemd/systemd-logind
     108   436  0.0  0.1   7244   4648 ?         Ss   14:45    0:02 /usr/bin/dbus-
daemon --system --address=systemd: --nofork --nopidfile --systemd-activation
     113   461  0.0  0.0  24104   3044 ?         SNsl 14:45    0:00
/usr/lib/rtkit/rtkit-daemon
       0   462  0.0  0.4 101864  15860 ?         Ssl  14:45    0:00
/usr/sbin/NetworkManager --no-daemon
       0   465  0.0  0.1  39360   6424 ?         Ssl  14:45    0:00
/usr/lib/accountsservice/accounts-daemon
       0   466  0.0  0.0  23528   2996 ?         Ssl  14:45    0:00
/usr/sbin/rsyslogd -n
       0   468  0.0  0.2  51904   8392 ?         Ssl  14:45    0:00
/usr/sbin/ModemManager
       0   486  0.0  0.2  39616   8200 ?         Ssl  14:45    0:00
/usr/lib/policykit-1/polkitd --no-debug
       0   539  0.0  0.1  10496   5160 ?         Ss   14:45    0:00 /usr/sbin/sshd -D
       0   710  0.0  0.2  49556   7568 ?         Ssl  14:45    0:00 /usr/sbin/gdm3
       0   717  0.0  0.0  31868   2988 ?         Sl   14:45    0:03
/usr/sbin/VBoxService --pidfile /var/run/vboxadd-service.sh
     118   733  0.0  0.1   9552   6092 ?         Ss   14:45    0:00
```

```
        /lib/systemd/systemd --user
        0   741  0.0  0.0   2100    52 ?         Ss   14:45   0:00
/usr/sbin/minissdpd -i 0.0.0.0
        0  1003  0.0  0.2  51332  7736 ?         Ssl  14:45   0:00
/usr/lib/upower/upowerd
      105  1014  0.0  0.0  11572  3244 ?         Ss   14:45   0:00 /usr/sbin/exim4 -
bd -q30m
        0  1051  0.0  0.1  10796  4472 ?         Ss   14:45   0:00
/sbin/wpa_supplicant -u -s -O /run/wpa_supplicant
        0  1052  0.0  0.3  64484 13244 ?         Ssl  14:45   0:00
/usr/lib/packagekit/packagekitd
      116  1075  0.0  0.3  46728 13368 ?         Ssl  14:45   0:00
/usr/lib/colord/colord
     1000  1095  0.0  0.1   9552  6152 ?         Ss   14:45   0:00
/lib/systemd/systemd --user
     1000  1102  0.0  0.1  39280  4848 ?         Sl   14:45   0:00 /usr/bin/gnome-
keyring-daemon --daemonize --login
     1000  1168  0.0  0.0  15808   308 ?         S    14:45   0:00
/usr/bin/VBoxClient --clipboard
     1000  1179  0.0  0.0  15808   308 ?         S    14:45   0:00
/usr/bin/VBoxClient --seamless
     1000  1186  0.0  0.0  15808   308 ?         S    14:45   0:00
/usr/bin/VBoxClient --draganddrop
     1000  1194  0.0  0.0  15808   308 ?         S    14:45   0:00
/usr/bin/VBoxClient --vmsvga
     1000  1257  0.5  0.3 888652 11828 ?         S<l  14:45   1:04
/usr/bin/pulseaudio --start --log-target=syslog
     1000  1368  0.0  0.2  71848 10472 tty2      Sl+  14:45   0:00 /usr/lib/gnome-
settings-daemon/gsd-printer
     1000  1378  0.0  0.0  15808  1368 ?         S    14:45   0:01
/usr/bin/VBoxClient --vmsvga
        0  6174  0.0  0.0   5256  2864 ?         Ss   15:38   0:00 /usr/sbin/cron -f
        0 11456  0.0  0.2  55620  7480 ?         Ssl  17:19   0:00
/usr/lib/udisks2/udisksd --no-debug
        0 11994  0.0  0.1  14656  7172 ?         Ss   17:24   0:00 /usr/sbin/cupsd -
l
```

*(b) Filter the list of processes using grep (or awk) such that only processes no kernel threads, e.g. [kworker]])
running as username root remain.*
I consult the man page of ps and find the **--user** switch.

> --user userlist
> Select by effective user ID (EUID) or name. Identical to -u and U.

Like in (a) I use **nu** and pipe the output into grep.
Here I filter out lines with closing brackets using the **-v** switch.
These correspond to kernel threads for the following reason:
A post on stackexchange tells me that ps prints the command in brackets when the process args are
unavailable. Another page indicates that "these will be kernel threads implementing helper functions, specific
subsystems, work queues, etc."

```
moritzpfeffer@debian:~$ ps --user root nu | grep -v ]
    USER   PID %CPU %MEM    VSZ    RSS TTY       STAT START   TIME COMMAND
       0     1  0.0  0.1  28308   6552 ?         Ss   14:45   0:01 /sbin/init
       0   212  0.0  0.1  11776   6712 ?         Ss   14:45   0:01
/lib/systemd/systemd-journald
       0   241  0.0  0.0  21868   1528 ?         Ss   14:45   0:00 /sbin/lvmetad -f
       0   242  0.0  0.1  16240   4100 ?         Ss   14:45   0:00
/lib/systemd/systemd-udevd
       0   432  0.0  0.0   6612   1940 ?         Ss   14:45   0:00
/usr/sbin/irqbalance --foreground
       0   433  0.0  0.1   7456   4716 ?         Ss   14:45   0:00
/lib/systemd/systemd-logind
       0   462  0.0  0.4 101864  15860 ?         Ssl  14:45   0:00
/usr/sbin/NetworkManager --no-daemon
       0   465  0.0  0.1  39360   6424 ?         Ssl  14:45   0:00
/usr/lib/accountsservice/accounts-daemon
       0   466  0.0  0.0  23528   2996 ?         Ssl  14:45   0:00
/usr/sbin/rsyslogd -n
       0   468  0.0  0.2  51904   8392 ?         Ssl  14:45   0:00
/usr/sbin/ModemManager
       0   486  0.0  0.2  39616   8200 ?         Ssl  14:45   0:00
/usr/lib/policykit-1/polkitd --no-debug
       0   539  0.0  0.1  10496   5160 ?         Ss   14:45   0:00 /usr/sbin/sshd -D
       0   710  0.0  0.2  49556   7568 ?         Ssl  14:45   0:00 /usr/sbin/gdm3
       0   717  0.0  0.0  31868   2988 ?         Sl   14:45   0:03
/usr/sbin/VBoxService --pidfile /var/run/vboxadd-service.sh
       0   741  0.0  0.0   2100     52 ?         Ss   14:45   0:00
/usr/sbin/minissdpd -i 0.0.0.0
       0  1003  0.0  0.2  51332   7736 ?         Ssl  14:45   0:00
/usr/lib/upower/upowerd
       0  1051  0.0  0.1  10796   4472 ?         Ss   14:45   0:00
/sbin/wpa_supplicant -u -s -O /run/wpa_supplicant
       0  1052  0.0  0.3  64484  13244 ?         Ssl  14:45   0:00
/usr/lib/packagekit/packagekitd
       0  6174  0.0  0.0   5256   2864 ?         Ss   15:38   0:00 /usr/sbin/cron -f
       0 10735  0.0  0.1   8124   3744 ?         S    17:19   0:00 /sbin/dhclient -d
-q -sf /usr/lib/NetworkManager/nm-dhcp-helper -pf /var/run/dhclient-enp0s3.pid -lf
/var/lib/NetworkManager/dhclient-2b5ae656-5993-4431-82a4-da96c10b4d7e-enp0s3.lease
-cf /var/lib/NetworkManager/dhclient-enp0s3.conf enp0s3
       0 11456  0.0  0.2  55620   7480 ?         Ssl  17:19   0:00
/usr/lib/udisks2/udisksd --no-debug
       0 11994  0.0  0.1  14656   7172 ?         Ss   17:24   0:00 /usr/sbin/cupsd -
l
```

Then i verify that this really yields the expected number of processes.

```
moritzpfeffer@debian:~$ ps --user root nu | grep -v ] | wc -l
23
```

23 - 1 (header line) = 22. This matches the number indicated in the exercise description of (c). Thus, my command appears to be correct.

(c) For each of the remaining (~22) processes, provide a 2-3 sentences describing the functionality of each process (Hint: use man / Arch)

Program Name	Description
/sbin/init	This is the first running process with PID 1. On our system it links to /lib/systemd/systemd. It is responsible for bringing up services, running init scripts, mounting filesystems. Systemd was created by Lennart Poettering and replaces the SystemV init as discussed in exercise 1. *(man + Arch)*
/lib/systemd/systemd-journald	systemd-journald is a part of systemd and a service that aggregates logging message from various sources e.g. kernel logs. Logging messages are classified by their source and priority. *(man + Arch)*
/sbin/lvmetad	lvmetad serves as cache for LVM metadata. LVM stands for logical volume manager and is a storage abstraction layer. *(man)*
/lib/systemd/systemd-udevd	Wikipedia says that udev stands for "userspace /dev" and that it is a device manager. The kernel emits a uevent for example when a usb device is plugged in. Systemd-udevd itself runs in userspace but listens to these events. Then it creates or removes corresponding entries in /dev [1]
/usr/sbin/irqbalance	irqbalance distributes "interrupts accross processors on a multiprocessor system". It allows the user to customize the handling of interrupts by providing a policy script targeted at a specific IRQ. *(man)*
/lib/systemd/systemd-logind	systemd-logind is a service that handles user authentication. According to man, this includes "keeping track of users and sessions", session management and "device access management for users".
/usr/sbin/NetworkManager	NetworkManger is a service with the goal of simplyfying networking. It can manage multiple connection e.g. (Wifi + 3G) at once. Also it has the default policy to connect to networks whenever available. *(man)*
/usr/lib/accountsservice/accounts-daemon	The accounts-daemon resides in the /usr/lib/accountsservice directory which shows that it is part of the AccountsService by freedesktop. It exposes a "D-Bus interface for querying and manipulating user account information" (*man*). This makes for a more convenient API as developers don't have to fork of programs such as adduser [2].
/usr/sbin/rsyslogd	It provides support for message logging while avoiding auto-backgrounding.

Program Name	Description
/usr/sbin/ModemManager	provides a unified high level API for communicating with mobile broadband modems, regardless of the protocol used to communicate with the actual device (Generic AT, vendor-specific AT, QCDM, QMI, MBIM...).
/usr/lib/policykit-1/polkitd	polkitd provides the org.freedesktop.PolicyKit1 D-Bus service on the system message bus. Users or administrators should never need to start this daemon as it will be automatically started by dbus-daemon(1) whenever an application calls into the service.
/usr/sbin/sshd	Provides secure encrypted communications between two untrusted hosts over an insecure network. When this option is specified, sshd will not detach and does not become a daemon. This allows easy monitoring of sshd.
/usr/sbin/gdm3	gdm3 reads /etc/gdm3/custom.conf for its configuration. For each local display, gdm starts an X server and runs a minimal GNOME session including a graphical greeter. If configured so, the main gdm process also listens for XDMCP requests from remote displays.
/usr/sbin/VBoxService	Enables interoperability between host and the VM such as copy paste, shared folders etc. Also writes the process ID of the service to a file in /var/run/vboxadd-service.sh.
/usr/sbin/minissdpd	It listens for SSDP traffic and keeps track of what are the UPnP devices up on the network while the name or IP address of the interface used to listen to SSDP packets coming on multicast address 0.0.0.0.
/usr/lib/upower/upowerd	
/sbin/wpa_supplicant	
/usr/lib/packagekit/packagekitd	
/usr/sbin/cron	
/sbin/dhclient	
/usr/lib/udisks2/udisksd	
/usr/sbin/cupsd	

```
/usr/sbin/rsyslogd -n
> It provides support for message logging while avoiding auto-backgrounding.
/usr/sbin/ModemManager
> provides a unified high level API for communicating with mobile broadband
modems, regardless of the protocol used to communicate with the actual device
(Generic AT, vendor-specific AT, QCDM, QMI, MBIM...).
/usr/lib/policykit-1/polkitd --no-debug
> polkitd provides the org.freedesktop.PolicyKit1 D-Bus service on the system
```

message bus. Users or administrators should never need to start this daemon as it
will be automatically started by dbus-daemon(1) whenever an application calls into
the service.
/usr/sbin/sshd -D
> provide secure encrypted communications between two untrusted hosts over an
insecure network. When this option is specified, sshd will not detach and does not
become a daemon. This allows easy monitoring of sshd.
/usr/sbin/gdm3
> gdm3 reads /etc/gdm3/custom.conf for its configuration. For each local display,
gdm starts an X server and runs a minimal GNOME session including a graphical
greeter. If configured so, the main gdm process also listens for XDMCP requests
from remote displays.
/usr/sbin/VBoxService --pidfile /var/run/vboxadd-service.sh
> Write the process ID to a file in /var/run/vboxadd-service.sh.
/usr/sbin/minissdpd -i 0.0.0.0
> It listens for SSDP traffic and keeps track of what are the UPnP devices up on
the network while the name or IP address of the interface used to listen to SSDP
packets coming on multicast address 0.0.0.0.

Exercise 2

(a) Run the binary and show the process tree using pstree and the parent PID. While the fork file is excuting,
switch to another tty:

```
fangwenliao@debian:~/Downloads/OS_Lab2/fork$ make
gcc -w -Werror -o fork fork.c
fangwenliao@debian:~/Downloads/OS_Lab2/fork$ ./fork
Main process PID: 1845
Child PID: 1848
Child PID: 1847
Child PID: 1846
Child PID: 1850
Child PID: 1849
Child PID: 1851
Child PID: 1852
Press ENTER key to Continue

Process 1847 ended

Process 1846 ended

Process 1848 ended

Process 1852 ended

Process 1850 ended

Process 1851 ended

Process 1849 ended
```

```
Process 1845 ended
```

Meanwhile switch to another TTY, and run:

```
fangwenliao@debian:~$ pstree -p 1845
fork(1845)─┬─fork(1846)─┬─fork(1849)───fork(1852)
           │            └─fork(1851)
           ├─fork(1847)───fork(1850)
           └─fork(1848)
```

(b) Explain the number of running processes based on the source code in fork.c.
According to the man page of fork, the fork() copies the calling process in a separate memory space and the child process has the same content. In the source code there are 3 fork() calls. When process 1845 fork for the first time, it creates 1846, at this point both 1845 and 1846 will run the second fork. In the second fork, 1845 and 1846 create correspondly 1849 and 1847, after that 1845, 1846, 1847 1849 are prepared for the third fork. Finally 1852, 1851, 1850 1848 are forked.

(c) Do these processes share memory or other resources? Why (not)?
According to man page of fork, they are in different memory space, however fork() in Linux uses copy-on-write technique, they actually share the same physical memory, because they didn't write anything.

Exercise 3

(a) Implement an application in C that uses (1) a clone() system call to create a process, (2) a clone() system call to create a thread, and (3) a fork() (in that specific order)

```c
#include <stdio.h>       // printf()
#include <unistd.h>      // sleep(), getpid(), getppid()
#include <signal.h>      // SIGCHLD flag
#include <linux/sched.h> // CLONE flags
#include <stdlib.h>      // malloc

void printids()
{
    printf("TGID: %d\n", getpid());   // Print the TGID of the current process
    printf("PPID: %d\n", getppid()); // Print the PPID of the current process
}

int main(void)
{
    printf("[Parent Process]\n");
    printids(); // IDs of the main process
    printf("[Clone Process]\n");
    void *child_stack;
    child_stack = (void *)malloc(8192);
    clone(&printids, child_stack + 8192, CLONE_CHILD_CLEARTID | CLONE_CHILD_SETTID
| SIGCHLD);
    wait();
    free(child_stack);
    printf("[Clone Thread]\n");
    void *child_stack2;
    child_stack2 = (void *)malloc(8192);
    clone(&printids, child_stack2 + 8192, CLONE_VM | CLONE_FS | CLONE_FILES |
CLONE_SIGHAND | CLONE_THREAD, 0);
    sleep(1);
    if (fork() == 0) {
        printf("[Fork Process]\n");
        printids();
    }
    wait();
    free(child_stack2);
}
```

(b) For each of the created processes and threads, print and clearly show the TGID and PPID.

```
moritzpfeffer@debian:~$ ./a.out
[Parent Process]
TGID: 16846
PPID: 16073
[Clone Process]
```

```
TGID: 16847
PPID: 16846
[Clone Thread]
TGID: 16846
PPID: 16073
[Fork Process]
TGID: 16850
PPID: 16846
```

(c) Explain why each of the TGIDs and PPIDs have the values as shown.

Lets look at all PPIDs first.

We have [Parent Process].PID = [Parent Process].TGID = [Clone Process].PPID = [Fork Process].PPID.

That is because [Parent Process] spawns the other two processes and is their parent.

In contrast, [Parent Process].PID != [Clone Thread].PPID.

But, [Parent Process].PPID == [Clone Thread].PPID because both have the same parent which is the shell.

Now lets look at TGIDs.

[Parent Process], [Clone Process] and [Fork Process] each have their own TGID which also serves as their PID because they are distinct processes.

Only [Parent Process].TGID = [Clone Thread].TGID because both threads run in the same process.

Exercise 4

(a) Implement the list_processes function such that it outputs (prints) a list of all processes including the executable name, process ID, and thread group ID.

```c
#include <linux/module.h>
#include <linux/kernel.h>
#include <linux/init.h>
#include <linux/sched.h>

#define M_AUTHOR "Moritz Pfeffer <st152880@stud.uni-stuttgart.de>"
#define M_DESC "Process Module"

void list_processes(struct task_struct *task) // task_struct is defined in
<linux/sched.h>
{
    printk(KERN_INFO "name\tpid\ttgid");
    for_each_process(task)
    { // for_each_process is a helper method defined in <linux/sched.h>
        // TODO Implement: for each task print the executable name, PID, and TGID
        printk(KERN_INFO "%s\t%d\t%d", task->comm, task->pid, task->tgid);
    }
}

int init(void)
{
    printk(KERN_INFO "pm: init(void)\n");

    printk(KERN_INFO "pm: Module author = %s\n", M_AUTHOR);
```

```c
    printk(KERN_INFO "pm: Module description = %s\n", M_DESC);

    list_processes(&init_task);

    return 0;
}

void exit(void)
{
    printk(KERN_INFO "pm: exit(void)\n");
}

module_init(init); // Define module entry point
module_exit(exit); // Define module exit point

MODULE_LICENSE("GPL");
MODULE_AUTHOR(M_AUTHOR);
MODULE_DESCRIPTION(M_DESC);
```

(b) Show the output of the kern.log related to your module.

```
Nov 16 21:35:59 debian kernel: [ 3282.503447] pm: init(void)
Nov 16 21:35:59 debian kernel: [ 3282.503448] pm: Module author = Moritz Pfeffer
<st152880@stud.uni-stuttgart.de>
Nov 16 21:35:59 debian kernel: [ 3282.503448] pm: Module description = Process
Module
Nov 16 21:35:59 debian kernel: [ 3282.503448] name   pid tgid
Nov 16 21:35:59 debian kernel: [ 3282.503449] systemd    1    1
Nov 16 21:35:59 debian kernel: [ 3282.503450] kthreadd   2    2
Nov 16 21:35:59 debian kernel: [ 3282.503450] ksoftirqd/0    3    3
Nov 16 21:35:59 debian kernel: [ 3282.503451] kworker/0:0H   5    5
Nov 16 21:35:59 debian kernel: [ 3282.503451] rcu_sched 7    7
Nov 16 21:35:59 debian kernel: [ 3282.503452] rcu_bh     8    8
Nov 16 21:35:59 debian kernel: [ 3282.503452] migration/0    9    9
Nov 16 21:35:59 debian kernel: [ 3282.503453] lru-add-drain 10    10
Nov 16 21:35:59 debian kernel: [ 3282.503453] watchdog/0     11   11
Nov 16 21:35:59 debian kernel: [ 3282.503454] cpuhp/0    12   12
Nov 16 21:35:59 debian kernel: [ 3282.503454] cpuhp/1    13   13
Nov 16 21:35:59 debian kernel: [ 3282.503455] watchdog/1     14   14
Nov 16 21:35:59 debian kernel: [ 3282.503455] migration/1    15   15
Nov 16 21:35:59 debian kernel: [ 3282.503456] ksoftirqd/1    16   16
Nov 16 21:35:59 debian kernel: [ 3282.503456] kworker/1:0H   18   18
Nov 16 21:35:59 debian kernel: [ 3282.503457] kdevtmpfs 19   19
Nov 16 21:35:59 debian kernel: [ 3282.503457] netns 20   20
Nov 16 21:35:59 debian kernel: [ 3282.503458] khungtaskd     21   21
Nov 16 21:35:59 debian kernel: [ 3282.503458] oom_reaper     22   22
Nov 16 21:35:59 debian kernel: [ 3282.503459] writeback 23   23
Nov 16 21:35:59 debian kernel: [ 3282.503459] kcompactd0     24   24
Nov 16 21:35:59 debian kernel: [ 3282.503460] ksmd   26   26
Nov 16 21:35:59 debian kernel: [ 3282.503461] khugepaged     27   27
Nov 16 21:35:59 debian kernel: [ 3282.503461] crypto     28   28
Nov 16 21:35:59 debian kernel: [ 3282.503462] kintegrityd    29   29
```

```
Nov 16 21:35:59 debian kernel: [ 3282.503462] bioset      30  30
Nov 16 21:35:59 debian kernel: [ 3282.503463] kblockd    31  31
Nov 16 21:35:59 debian kernel: [ 3282.503463] devfreq_wq      32  32
Nov 16 21:35:59 debian kernel: [ 3282.503464] watchdogd 33   33
Nov 16 21:35:59 debian kernel: [ 3282.503464] kswapd0    34  34
Nov 16 21:35:59 debian kernel: [ 3282.503465] vmstat      35  35
Nov 16 21:35:59 debian kernel: [ 3282.503466] kthrotld  47  47
Nov 16 21:35:59 debian kernel: [ 3282.503466] ipv6_addrconf 48   48
Nov 16 21:35:59 debian kernel: [ 3282.503466] ata_sff    85  85
Nov 16 21:35:59 debian kernel: [ 3282.503467] scsi_eh_0 87  87
Nov 16 21:35:59 debian kernel: [ 3282.503467] scsi_tmf_0     89  89
Nov 16 21:35:59 debian kernel: [ 3282.503468] scsi_eh_1 91  91
Nov 16 21:35:59 debian kernel: [ 3282.503468] scsi_tmf_1     92  92
Nov 16 21:35:59 debian kernel: [ 3282.503469] bioset     109 109
Nov 16 21:35:59 debian kernel: [ 3282.503469] kworker/1:1H   112 112
Nov 16 21:35:59 debian kernel: [ 3282.503504] scsi_eh_2 114 114
Nov 16 21:35:59 debian kernel: [ 3282.503505] scsi_tmf_2     115 115
Nov 16 21:35:59 debian kernel: [ 3282.503506] scsi_eh_3 116 116
Nov 16 21:35:59 debian kernel: [ 3282.503506] scsi_tmf_3     117 117
Nov 16 21:35:59 debian kernel: [ 3282.503506] scsi_eh_4 118 118
Nov 16 21:35:59 debian kernel: [ 3282.503507] scsi_tmf_4     119 119
Nov 16 21:35:59 debian kernel: [ 3282.503507] scsi_eh_5 120 120
Nov 16 21:35:59 debian kernel: [ 3282.503508] scsi_tmf_5     121 121
Nov 16 21:35:59 debian kernel: [ 3282.503508] scsi_eh_6 122 122
Nov 16 21:35:59 debian kernel: [ 3282.503508] scsi_tmf_6     123 123
Nov 16 21:35:59 debian kernel: [ 3282.503509] scsi_eh_7 124 124
Nov 16 21:35:59 debian kernel: [ 3282.503509] scsi_tmf_7     125 125
Nov 16 21:35:59 debian kernel: [ 3282.503510] scsi_eh_8 126 126
Nov 16 21:35:59 debian kernel: [ 3282.503510] scsi_tmf_8     127 127
Nov 16 21:35:59 debian kernel: [ 3282.503511] scsi_eh_9 128 128
Nov 16 21:35:59 debian kernel: [ 3282.503511] scsi_tmf_9     129 129
Nov 16 21:35:59 debian kernel: [ 3282.503511] scsi_eh_10     130 130
Nov 16 21:35:59 debian kernel: [ 3282.503512] scsi_tmf_10    131 131
Nov 16 21:35:59 debian kernel: [ 3282.503512] scsi_eh_11     132 132
Nov 16 21:35:59 debian kernel: [ 3282.503513] scsi_tmf_11    133 133
Nov 16 21:35:59 debian kernel: [ 3282.503513] scsi_eh_12     134 134
Nov 16 21:35:59 debian kernel: [ 3282.503514] scsi_tmf_12    135 135
Nov 16 21:35:59 debian kernel: [ 3282.503514] scsi_eh_13     136 136
Nov 16 21:35:59 debian kernel: [ 3282.503515] scsi_tmf_13    137 137
Nov 16 21:35:59 debian kernel: [ 3282.503515] scsi_eh_14     138 138
Nov 16 21:35:59 debian kernel: [ 3282.503515] scsi_tmf_14    139 139
Nov 16 21:35:59 debian kernel: [ 3282.503516] scsi_eh_15     140 140
Nov 16 21:35:59 debian kernel: [ 3282.503516] scsi_tmf_15    141 141
Nov 16 21:35:59 debian kernel: [ 3282.503517] scsi_eh_16     142 142
Nov 16 21:35:59 debian kernel: [ 3282.503517] scsi_tmf_16    143 143
Nov 16 21:35:59 debian kernel: [ 3282.503517] scsi_eh_17     144 144
Nov 16 21:35:59 debian kernel: [ 3282.503518] scsi_tmf_17    145 145
Nov 16 21:35:59 debian kernel: [ 3282.503518] scsi_eh_18     146 146
Nov 16 21:35:59 debian kernel: [ 3282.503519] scsi_tmf_18    147 147
Nov 16 21:35:59 debian kernel: [ 3282.503520] scsi_eh_19     148 148
Nov 16 21:35:59 debian kernel: [ 3282.503520] scsi_tmf_19    149 149
Nov 16 21:35:59 debian kernel: [ 3282.503520] scsi_eh_20     150 150
Nov 16 21:35:59 debian kernel: [ 3282.503521] scsi_tmf_20    151 151
Nov 16 21:35:59 debian kernel: [ 3282.503521] scsi_eh_21     152 152
```

```
Nov 16 21:35:59 debian kernel: [ 3282.503521] scsi_tmf_21    153 153
Nov 16 21:35:59 debian kernel: [ 3282.503522] scsi_eh_22     154 154
Nov 16 21:35:59 debian kernel: [ 3282.503522] scsi_tmf_22    155 155
Nov 16 21:35:59 debian kernel: [ 3282.503523] scsi_eh_23     156 156
Nov 16 21:35:59 debian kernel: [ 3282.503523] scsi_tmf_23    157 157
Nov 16 21:35:59 debian kernel: [ 3282.503524] scsi_eh_24     158 158
Nov 16 21:35:59 debian kernel: [ 3282.503524] scsi_tmf_24    159 159
Nov 16 21:35:59 debian kernel: [ 3282.503524] scsi_eh_25     160 160
Nov 16 21:35:59 debian kernel: [ 3282.503525] scsi_tmf_25    161 161
Nov 16 21:35:59 debian kernel: [ 3282.503525] scsi_eh_26     162 162
Nov 16 21:35:59 debian kernel: [ 3282.503526] scsi_tmf_26    163 163
Nov 16 21:35:59 debian kernel: [ 3282.503526] scsi_eh_27     164 164
Nov 16 21:35:59 debian kernel: [ 3282.503526] scsi_tmf_27    165 165
Nov 16 21:35:59 debian kernel: [ 3282.503527] scsi_eh_28     166 166
Nov 16 21:35:59 debian kernel: [ 3282.503527] scsi_tmf_28    167 167
Nov 16 21:35:59 debian kernel: [ 3282.503528] scsi_eh_29     168 168
Nov 16 21:35:59 debian kernel: [ 3282.503528] scsi_tmf_29    169 169
Nov 16 21:35:59 debian kernel: [ 3282.503529] scsi_eh_30     170 170
Nov 16 21:35:59 debian kernel: [ 3282.503529] scsi_tmf_30    171 171
Nov 16 21:35:59 debian kernel: [ 3282.503529] scsi_eh_31     172 172
Nov 16 21:35:59 debian kernel: [ 3282.503530] scsi_tmf_31    173 173
Nov 16 21:35:59 debian kernel: [ 3282.503530] bioset     201 201
Nov 16 21:35:59 debian kernel: [ 3282.503531] kworker/0:1H   203 203
Nov 16 21:35:59 debian kernel: [ 3282.503531] kdmflush   207 207
Nov 16 21:35:59 debian kernel: [ 3282.503531] bioset     208 208
Nov 16 21:35:59 debian kernel: [ 3282.503532] kdmflush   211 211
Nov 16 21:35:59 debian kernel: [ 3282.503532] bioset     213 213
Nov 16 21:35:59 debian kernel: [ 3282.503533] kdmflush   216 216
Nov 16 21:35:59 debian kernel: [ 3282.503533] bioset     217 217
Nov 16 21:35:59 debian kernel: [ 3282.503534] kdmflush   220 220
Nov 16 21:35:59 debian kernel: [ 3282.503534] bioset     221 221
Nov 16 21:35:59 debian kernel: [ 3282.503534] kdmflush   226 226
Nov 16 21:35:59 debian kernel: [ 3282.503535] bioset     228 228
Nov 16 21:35:59 debian kernel: [ 3282.503536] kworker/u5:0   262 262
Nov 16 21:35:59 debian kernel: [ 3282.503536] jbd2/dm-0-8    277 277
Nov 16 21:35:59 debian kernel: [ 3282.503536] ext4-rsv-conver    278 278
Nov 16 21:35:59 debian kernel: [ 3282.503537] systemd-journal    308 308
Nov 16 21:35:59 debian kernel: [ 3282.503537] kauditd    314 314
Nov 16 21:35:59 debian kernel: [ 3282.503538] lvmetad    336 336
Nov 16 21:35:59 debian kernel: [ 3282.503538] systemd-udevd 341 341
Nov 16 21:35:59 debian kernel: [ 3282.503538] vmware-vmblock-    347 347
Nov 16 21:35:59 debian kernel: [ 3282.503539] vmtoolsd   348 348
Nov 16 21:35:59 debian kernel: [ 3282.503539] ttm_swap   416 416
Nov 16 21:35:59 debian kernel: [ 3282.503540] jbd2/dm-3-8    522 522
Nov 16 21:35:59 debian kernel: [ 3282.503540] ext4-rsv-conver    523 523
Nov 16 21:35:59 debian kernel: [ 3282.503541] jbd2/dm-4-8    529 529
Nov 16 21:35:59 debian kernel: [ 3282.503541] ext4-rsv-conver    530 530
Nov 16 21:35:59 debian kernel: [ 3282.503541] jbd2/dm-1-8    532 532
Nov 16 21:35:59 debian kernel: [ 3282.503542] ext4-rsv-conver    533 533
Nov 16 21:35:59 debian kernel: [ 3282.503542] ext4-rsv-conver    542 542
Nov 16 21:35:59 debian kernel: [ 3282.503543] VGAuthService 563 563
Nov 16 21:35:59 debian kernel: [ 3282.503543] rsyslogd   564 564
Nov 16 21:35:59 debian kernel: [ 3282.503544] irqbalance     565 565
Nov 16 21:35:59 debian kernel: [ 3282.503544] cron   566 566
```

```
Nov 16 21:35:59 debian kernel: [ 3282.503545] accounts-daemon    570 570
Nov 16 21:35:59 debian kernel: [ 3282.503545] cupsd 572 572
Nov 16 21:35:59 debian kernel: [ 3282.503546] systemd-logind    573 573
Nov 16 21:35:59 debian kernel: [ 3282.503546] dbus-daemon    574 574
Nov 16 21:35:59 debian kernel: [ 3282.503546] NetworkManager    626 626
Nov 16 21:35:59 debian kernel: [ 3282.503547] ModemManager  627 627
Nov 16 21:35:59 debian kernel: [ 3282.503547] rtkit-daemon  633 633
Nov 16 21:35:59 debian kernel: [ 3282.503548] avahi-daemon  634 634
Nov 16 21:35:59 debian kernel: [ 3282.503548] polkitd    638 638
Nov 16 21:35:59 debian kernel: [ 3282.503548] avahi-daemon  641 641
Nov 16 21:35:59 debian kernel: [ 3282.503549] cups-browsed  657 657
Nov 16 21:35:59 debian kernel: [ 3282.503549] dbus   658 658
Nov 16 21:35:59 debian kernel: [ 3282.503550] sshd   689 689
Nov 16 21:35:59 debian kernel: [ 3282.503550] gdm3   888 888
Nov 16 21:35:59 debian kernel: [ 3282.503551] gdm-session-wor    893 893
Nov 16 21:35:59 debian kernel: [ 3282.503551] systemd    897 897
Nov 16 21:35:59 debian kernel: [ 3282.503552] (sd-pam)   898 898
Nov 16 21:35:59 debian kernel: [ 3282.503552] gdm-wayland-ses   902 902
Nov 16 21:35:59 debian kernel: [ 3282.503553] dbus-daemon    904 904
Nov 16 21:35:59 debian kernel: [ 3282.503553] gnome-session-b   906 906
Nov 16 21:35:59 debian kernel: [ 3282.503554] gnome-shell    914 914
Nov 16 21:35:59 debian kernel: [ 3282.503581] upowerd    918 918
Nov 16 21:35:59 debian kernel: [ 3282.503582] Xwayland   932 932
Nov 16 21:35:59 debian kernel: [ 3282.503583] at-spi-bus-laun    937 937
Nov 16 21:35:59 debian kernel: [ 3282.503583] dbus-daemon    942 942
Nov 16 21:35:59 debian kernel: [ 3282.503584] at-spi2-registr    944 944
Nov 16 21:35:59 debian kernel: [ 3282.503584] pulseaudio    947 947
Nov 16 21:35:59 debian kernel: [ 3282.503585] wpa_supplicant    960 960
Nov 16 21:35:59 debian kernel: [ 3282.503585] packagekitd   961 961
Nov 16 21:35:59 debian kernel: [ 3282.503586] gnome-settings-   962 962
Nov 16 21:35:59 debian kernel: [ 3282.503586] colord    987 987
Nov 16 21:35:59 debian kernel: [ 3282.503587] minissdpd 1004    1004
Nov 16 21:35:59 debian kernel: [ 3282.503587] exim4 1252    1252
Nov 16 21:35:59 debian kernel: [ 3282.503588] gdm-session-wor   1279    1279
Nov 16 21:35:59 debian kernel: [ 3282.503588] systemd   1282    1282
Nov 16 21:35:59 debian kernel: [ 3282.503589] (sd-pam)   1283    1283
Nov 16 21:35:59 debian kernel: [ 3282.503589] gnome-keyring-d   1289    1289
Nov 16 21:35:59 debian kernel: [ 3282.503589] gdm-x-session 1292    1292
Nov 16 21:35:59 debian kernel: [ 3282.503590] Xorg   1294    1294
Nov 16 21:35:59 debian kernel: [ 3282.503590] dbus-daemon   1301    1301
Nov 16 21:35:59 debian kernel: [ 3282.503591] gnome-session-b   1304    1304
Nov 16 21:35:59 debian kernel: [ 3282.503591] ssh-agent 1354    1354
Nov 16 21:35:59 debian kernel: [ 3282.503592] at-spi-bus-laun   1363    1363
Nov 16 21:35:59 debian kernel: [ 3282.503592] dbus-daemon   1368    1368
Nov 16 21:35:59 debian kernel: [ 3282.503593] at-spi2-registr   1371    1371
Nov 16 21:35:59 debian kernel: [ 3282.503593] gnome-shell   1389    1389
Nov 16 21:35:59 debian kernel: [ 3282.503593] gvfsd 1394    1394
Nov 16 21:35:59 debian kernel: [ 3282.503594] gvfsd-fuse    1399    1399
Nov 16 21:35:59 debian kernel: [ 3282.503594] pulseaudio   1412    1412
Nov 16 21:35:59 debian kernel: [ 3282.503595] gnome-shell-cal   1418    1418
Nov 16 21:35:59 debian kernel: [ 3282.503595] evolution-sourc   1422    1422
Nov 16 21:35:59 debian kernel: [ 3282.503596] goa-daemon    1432    1432
Nov 16 21:35:59 debian kernel: [ 3282.503596] mission-control   1443    1443
Nov 16 21:35:59 debian kernel: [ 3282.503597] goa-identity-se   1451    1451
```

```
Nov 16 21:35:59 debian kernel: [ 3282.503597] gvfs-udisks2-vo    1452    1452
Nov 16 21:35:59 debian kernel: [ 3282.503598] udisksd    1459    1459
Nov 16 21:35:59 debian kernel: [ 3282.503598] gvfs-goa-volume    1466    1466
Nov 16 21:35:59 debian kernel: [ 3282.503598] gvfs-gphoto2-vo    1470    1470
Nov 16 21:35:59 debian kernel: [ 3282.503599] gvfs-afc-volume    1474    1474
Nov 16 21:35:59 debian kernel: [ 3282.503599] gvfs-mtp-volume    1479    1479
Nov 16 21:35:59 debian kernel: [ 3282.503600] gnome-settings-    1485    1485
Nov 16 21:35:59 debian kernel: [ 3282.503600] evolution-calen    1500    1500
Nov 16 21:35:59 debian kernel: [ 3282.503601] gnome-software    1509    1509
Nov 16 21:35:59 debian kernel: [ 3282.503601] tracker-miner-f    1510    1510
Nov 16 21:35:59 debian kernel: [ 3282.503601] evolution-calen    1514    1514
Nov 16 21:35:59 debian kernel: [ 3282.503602] gsd-printer    1524    1524
Nov 16 21:35:59 debian kernel: [ 3282.503602] vmtoolsd    1531    1531
Nov 16 21:35:59 debian kernel: [ 3282.503603] evolution-alarm    1532    1532
Nov 16 21:35:59 debian kernel: [ 3282.503603] tracker-store    1533    1533
Nov 16 21:35:59 debian kernel: [ 3282.503604] tracker-extract    1534    1534
Nov 16 21:35:59 debian kernel: [ 3282.503604] tracker-miner-u    1541    1541
Nov 16 21:35:59 debian kernel: [ 3282.503605] tracker-miner-a    1547    1547
Nov 16 21:35:59 debian kernel: [ 3282.503605] dconf-service    1563    1563
Nov 16 21:35:59 debian kernel: [ 3282.503606] evolution-calen    1568    1568
Nov 16 21:35:59 debian kernel: [ 3282.503606] evolution-addre    1569    1569
Nov 16 21:35:59 debian kernel: [ 3282.503607] evolution-addre    1588    1588
Nov 16 21:35:59 debian kernel: [ 3282.503607] gvfsd-trash    1662    1662
Nov 16 21:35:59 debian kernel: [ 3282.503607] gvfsd-burn    1676    1676
Nov 16 21:35:59 debian kernel: [ 3282.503608] gnome-terminal-    1687    1687
Nov 16 21:35:59 debian kernel: [ 3282.503608] bash    1693    1693
Nov 16 21:35:59 debian kernel: [ 3282.503609] su    1714    1714
Nov 16 21:35:59 debian kernel: [ 3282.503609] systemd    1715    1715
Nov 16 21:35:59 debian kernel: [ 3282.503610] (sd-pam)    1716    1716
Nov 16 21:35:59 debian kernel: [ 3282.503610] bash    1720    1720
Nov 16 21:35:59 debian kernel: [ 3282.503610] vmhgfs-fuse    1726    1726
Nov 16 21:35:59 debian kernel: [ 3282.503611] bash    1760    1760
Nov 16 21:35:59 debian kernel: [ 3282.503611] bash    1793    1793
Nov 16 21:35:59 debian kernel: [ 3282.503612] systemd-network    1833    1833
Nov 16 21:35:59 debian kernel: [ 3282.503612] bash    2130    2130
Nov 16 21:35:59 debian kernel: [ 3282.503613] gvfsd-metadata    2137    2137
Nov 16 21:35:59 debian kernel: [ 3282.503613] kworker/u4:0    2237    2237
Nov 16 21:35:59 debian kernel: [ 3282.503614] kworker/0:2    3274    3274
Nov 16 21:35:59 debian kernel: [ 3282.503614] dhclient    3341    3341
Nov 16 21:35:59 debian kernel: [ 3282.503615] bash    3526    3526
Nov 16 21:35:59 debian kernel: [ 3282.503615] kworker/u4:1    3698    3698
Nov 16 21:35:59 debian kernel: [ 3282.503615] kworker/0:0    5970    5970
Nov 16 21:35:59 debian kernel: [ 3282.503616] firefox-esr    6588    6588
Nov 16 21:35:59 debian kernel: [ 3282.503616] Privileged Cont    6631    6631
Nov 16 21:35:59 debian kernel: [ 3282.503617] WebExtensions    6679    6679
Nov 16 21:35:59 debian kernel: [ 3282.503617] Web Content    6716    6716
Nov 16 21:35:59 debian kernel: [ 3282.503618] Web Content    6742    6742
Nov 16 21:35:59 debian kernel: [ 3282.503618] sd_generic    6772    6772
Nov 16 21:35:59 debian kernel: [ 3282.503618] sd_espeak-ng    6775    6775
Nov 16 21:35:59 debian kernel: [ 3282.503619] sd_dummy    6783    6783
Nov 16 21:35:59 debian kernel: [ 3282.503619] speech-dispatch    6786    6786
Nov 16 21:35:59 debian kernel: [ 3282.503620] kdeinit5    6952    6952
Nov 16 21:35:59 debian kernel: [ 3282.503620] klauncher    6953    6953
Nov 16 21:35:59 debian kernel: [ 3282.503621] kdevelop    7036    7036
```

```
Nov 16 21:35:59 debian kernel: [ 3282.503621] kworker/1:0    7122    7122
Nov 16 21:35:59 debian kernel: [ 3282.503622] Web Content    7146    7146
Nov 16 21:35:59 debian kernel: [ 3282.503622] kworker/1:1    7178    7178
Nov 16 21:35:59 debian kernel: [ 3282.503623] kworker/0:1    7220    7220
Nov 16 21:35:59 debian kernel: [ 3282.503623] file.so    7239    7239
Nov 16 21:35:59 debian kernel: [ 3282.503623] kworker/1:2    7240    7240
Nov 16 21:35:59 debian kernel: [ 3282.503624] bash   7259    7259
Nov 16 21:35:59 debian kernel: [ 3282.503624] kworker/u4:2   7784    7784
Nov 16 21:35:59 debian kernel: [ 3282.503624] sudo   8339    8339
Nov 16 21:35:59 debian kernel: [ 3282.503625] insmod    8340    8340
```

(c) Which parts of the kernel module execute in kernel space?

All parts of the kernel module execute in kernel space. This can be seen from the fact that the kernel function *printk* is available in all the procedures i.e. init, exit and list_processes.