

Lab 2

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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/lvmtool -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 ?        SsSl 14:45   0:00
/usr/lib/rtkit/rtkit-daemon
    0   462  0.0  0.4 101864  15860 ?        SsSl 14:45   0:00
/usr/sbin/NetworkManager --no-daemon
    0   465  0.0  0.1  39360   6424 ?        SsSl 14:45   0:00
/usr/lib/accountsservice/accounts-daemon
    0   466  0.0  0.0  23528   2996 ?        SsSl 14:45   0:00
/usr/sbin/rsyslogd -n
    0   468  0.0  0.2  51904   8392 ?        SsSl 14:45   0:00
/usr/sbin/ModemManager
    0   486  0.0  0.2  39616   8200 ?        SsSl 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 ?        SsSl 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 -
1

```

(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/lvmtool -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 -
1

```

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. (<i>man</i> + <i>Arch</i>)
/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. (<i>man</i> + <i>Arch</i>)
/sbin/lvmtools	lvmtools serves as cache for LVM metadata. LVM stands for logical volume manager and is a storage abstraction layer. (<i>man</i>)
/lib/systemd/systemd-udev	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-udev 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. (<i>man</i>)
/lib/systemd/systemd-logind	systemd-logind is a service that handles user authentication. According to <i>man</i> , this includes "keeping track of users and sessions", session management and "device access management for users".
/usr/sbin/NetworkManager	NetworkManager is a service with the goal of simplifying networking. It can manage multiple connection e.g. (Wifi + 3G) at once. Also it has the default policy to connect to networks whenever available. (<i>man</i>)
/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" (<i>man</i>). 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	UPower gives an interface of power source energy management and upowerd provides this service on the system bus. it automatically starts.
/sbin/wpa_supplicant	it is a backend for wireless network interface configuration, it starts when the wireless interface is raised. How to use a WiFi interface
/usr/lib/packagekit/packagekitd	PackageKit makes common software task easier and smoother and is distribution neutral.
/usr/sbin/cron	it is responsible for the time based job scheduling in UNIX, it is a very old programm and receives little maintance by debian.
/sbin/dhclient	it is used go configure the DHCP client (Dynamic Host Configuration Protocol automatically sets up LAN) when setting up a LAN.
/usr/lib/udisks2/udisksd	udisks is used to operate disks or storage devices and udisksd is its daemon that starts automatically.
/usr/sbin/cupsd	CUPS prints from user applications, it converts informations for the printer to understand, and cupsd is its scheduler.

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)

For creating a process using `clone`, i straced a program that forks to learn the arguments to `clone`.

For creating a thread using `clone`, i consulted the man pages of `clone`.

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

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) {
    pid_t pid;
    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();
    } else {
        wait();
        free(child_stack2);
    }
    return 0;
}
```

(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.

```
#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);
    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] ksm      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]	bioaset	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]	bioaset	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]	VGAAuthService	563	563

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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] minissdpc 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

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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

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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*.