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/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)

```
/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 man page of fork, the fork() copies the calling process in a seperate 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)? Arrording to man page of fork, they are in different memory space, however fork() in Linux use copy-to-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

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

```
  printf("\n\n");
  sleep(1);
}

int child(void *arg)
{
  printids();
}


int main(void)
{
  printf("This is the parent process.\n");
  printids(); // IDs of the main process
  getchar();

  printf("This is a child process created by clone().\n");
  void *child_stack;
  child_stack = (void*)malloc(1024);
  clone(&child, child_stack+1024, SIGCHLD, 0);
  getchar(); // Press a key to continue

  printf("This is a thread created by clone().\n");
  clone(&child, child_stack+2048, CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND, 0);
  getchar();

  printf("This is a fork().\n");
  fork();
  getchar();

  return 0;
}
```

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

```
fangwenliao@debian:~/Downloads/OS_Lab2/clone$ ./clone
This is the parent process.
TGID: 1739
PPID: 1676



This is a child process created by clone().
TGID: 1743
PPID: 1739



This is a thread created by clone().
TGID: 1744
PPID: 1739
```

```
This is a fork().
```

```
fangwenliao@debian:~/Downloads/OS_Lab2/clone$ pstree -pg 1739
clone(1739,1739)─┬─clone(1743,1739)
                 ├─clone(1744,1739)
                 └─clone(1745,1739)
```

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

The TGID of the first one is also used as process ID. The other three processes are all created by the first process, so they share the same PPID which is the PID of the first one. The three child processes fully copy the parent process, each process is guaranteed a unique TGID used to identify.

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);
    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
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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
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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
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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.