

OPERATING SYSTEMS PROJECT

Submitted by: Mahika Gupta

SRN: PES1UG20CS243

DATE: 18/04/2022

Developing a kernel module to list all the current tasks in a linux system including the init task, in a tree structure.

1. CODE:

a. C file:

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

struct task_struct *task;
struct task_struct *task_child;
struct list_head *list;

int tasks_lister_linear_init(void)
{
    printk(KERN_INFO "Loading module...\n");

    for_each_process(task)
    {
        // printk("\t-");
        printk(KERN_INFO "pid: %d | pname: %s | state: %ld\n", task->pid,
task->comm, task->state);
        list_for_each(list,&task->children)
        {
            task_child = list_entry(list,struct task_struct, sibling);
            // printk("\t\t--");
        }
    }
}
```

```

        printk(KERN_INFO "\t--CHILD_pid: %d | CHILD_pname: %s |
CHILD_state: %ld\n", task_child->pid, task_child->comm,
task_child->state);

    }

}

printk(KERN_INFO "Module loaded.\n");
return 0;
}

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

module_init(tasks_lister_linear_init);
module_exit(tasks_lister_linear_exit);

MODULE_LICENSE("GPL");

```

b. Makefile:

```

obj-m += PES1UG20CS243.o

KERNELDIR ?= /lib/modules/$(shell uname -r)/build
PWD := $(shell pwd)

all:
    $(MAKE) -C $(KERNELDIR) M=$(PWD) modules
clean:
    $(MAKE) -C $(KERNELDIR) M=$(PWD) clean

```

2. SCREENSHOTS OF OUTPUT:

- Execute the Makefile
- Load the module and display.

Activities Visual Studio Code Apr 18 07:48 Makefile - src - Visual Studio Code

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EXPLORER

- SRC
 - > dfs
 - > linear
 - .Module.symvers.cmd
 - .modules.order.cmd
 - PES1UG20CS243.ko.cmd
 - PES1UG20CS243.mod.cmd
 - PES1UG20CS243.mod.o.cmd
 - PES1UG20CS243.o.cmd
 - tasks_lister_linear.ko.cmd
 - tasks_lister_linear.mod.cmd
 - tasks_lister_linear.mod.o.cmd
 - tasks_lister_linear.o.cmd
 - Makefile

C PES1UG20CS243.c z, u M Makefile M x

```
linear > M Makefile
1 obj-m += PES1UG20CS243.o
2
3 KERNELDIR ?= /lib/modules/$(shell uname -r)/build
PWD := $(shell pwd)
5
6 all:
7     $(MAKE) -C $(KERNELDIR) M=$(PWD) modules
8 clean:
```

PROBLEMS 2 OUTPUT DEBUG CONSOLE TERMINAL

mahika@ubuntu:~/tasks-lister/src/linear\$ make
make -C /lib/modules/5.13.0-39-generic/build M=/home/mahika/tasks-lister/src/linear modules
make[1]: Entering directory '/usr/src/linux-headers-5.13.0-39-generic'
make[1]: Leaving directory '/usr/src/linux-headers-5.13.0-39-generic'
mahika@ubuntu:~/tasks-lister/src/linear\$ sudo insmod PES1UG20CS243.ko
[sudo] password for mahika:
insmod: ERROR: could not insert module PES1UG20CS243.ko: File exists
mahika@ubuntu:~/tasks-lister/src/linear\$ sudo dmesg

Ln 5, Col 1 Tab Size: 4 UTF-8 LF Makefile R Q

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EXPLORER

- SRC
 - > dfs
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 - .Module.symvers.cmd
 - .modules.order.cmd
 - PES1UG20CS243.ko.cmd
 - PES1UG20CS243.mod.cmd
 - PES1UG20CS243.mod.o.cmd
 - PES1UG20CS243.o.cmd
 - tasks_lister_linear.ko.cmd
 - tasks_lister_linear.mod.cmd
 - tasks_lister_linear.mod.o.cmd
 - tasks_lister_linear.o.cmd
 - Makefile

C PES1UG20CS243.c z, u M Makefile M x

```
linear > M Makefile
1 obj-m += PES1UG20CS243.o
2
3 KERNELDIR ?= /lib/modules/$(shell uname -r)/build
PWD := $(shell pwd)
5
6 all:
7     $(MAKE) -C $(KERNELDIR) M=$(PWD) modules
8 clean:
```

PROBLEMS 2 OUTPUT DEBUG CONSOLE TERMINAL

[294.789143] pid: 2197 | pname: kworker/5:3 | state: 1026
[294.789143] pid: 2287 | pname: kworker//:3 | state: 1026
[294.789144] pid: 2446 | pname: kworker/u16:6 | state: 1026
[294.789145] pid: 2441 | pname: kworker/u16:7 | state: 1026
[294.789145] pid: 2442 | pname: kworker/u16:8 | state: 1026
[294.789146] pid: 2443 | pname: kworker/u16:9 | state: 1026
[294.789146] Module loaded.
[7555.668020] [11092.863044] hrtimer: interrupt took 16445869 ns
[7555.668020] Loading module...
[11092.863044] [11092.863074] p[2197] | pname: systemd | state: 1
[11092.863076] CHILD pid: 459 | CHILD pname: systemd-journal | CHILD state: 1
[11092.863078] CHILD pid: 496 | CHILD pname: systemd-udevd | CHILD state: 1
[11092.863080] CHILD pid: 674 | CHILD pname: multipathd | CHILD state: 1
[11092.863082] CHILD pid: 733 | CHILD pname: systemd-timesync | CHILD state: 1
[11092.863083] CHILD pid: 782 | CHILD pname: systemd-network | CHILD state: 1
[11092.863084] CHILD pid: 784 | CHILD pname: systemd-resolve | CHILD state: 1
[11092.863085] CHILD pid: 808 | CHILD pname: anacron | CHILD state: 1
[11092.863086] CHILD pid: 809 | CHILD pname: arcani_daemon | CHILD state: 1
[11092.863087] CHILD pid: 810 | CHILD pname: dbus-daemon | CHILD state: 1
[11092.863088] CHILD pid: 811 | CHILD pname: NetworkManager | CHILD state: 1
[11092.863089] CHILD pid: 816 | CHILD pname: udevd | CHILD state: 1
[11092.863090] CHILD pid: 817 | CHILD pname: networkd-dispatcher | CHILD state: 1
[11092.863091] CHILD pid: 818 | CHILD pname: polkitd | CHILD state: 1
[11092.863092] CHILD pid: 820 | CHILD pname: power-profiles- | CHILD state: 1
[11092.863093] CHILD pid: 821 | CHILD pname: rsyslogd | CHILD state: 1
[11092.863094] CHILD pid: 822 | CHILD pname: snapd | CHILD state: 1
[11092.863095] CHILD pid: 828 | CHILD pname: accounts-daemon | CHILD state: 1
[11092.863097] CHILD pid: 829 | CHILD pname: switcheroo-cont | CHILD state: 1
[11092.863098] CHILD pid: 830 | CHILD pname: systemd-logind | CHILD state: 1
[11092.863099] CHILD pid: 833 | CHILD pname: udisks2 | CHILD state: 1
[11092.863100] CHILD pid: 834 | CHILD pname: wpa_supplicant | CHILD state: 1
[11092.863101] CHILD pid: 889 | CHILD pname: ModemManager | CHILD state: 1
[11092.863108] CHILD pid: 898 | CHILD pname: cupsd | CHILD state: 1
[11092.863111] CHILD pid: 914 | CHILD pname: unattended-upgr | CHILD state: 1

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EXPLORER SRC linear

C PES1UG20CS243.c z,u M Makefile M x

```
linear > M Makefile
1 obj-m += PES1UG20CS243.o
2
3 KERNELDIR ?= /lib/modules/$(shell uname -r)/build
PWD := $(shell pwd)
5
6 all:
7     $(MAKE) -C $(KERNELDIR) M=$(PWD) modules
8 clean:
```

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL

bash · linear + - ^ x

[12940_396033] pid: 840 | pname: avahi-daemon | state: 1
[12940_396034] pid: 889 | pname: ModemManager | state: 1
[12940_396034] pid: 914 | pname: unattended-upgr | state: 1
[12940_396035] pid: 945 | pname: cron | state: 1
[12940_396035] pid: 956 | pname: whoopsie | state: 1
[12940_396036] pid: 963 | pname: kerneloops | state: 1
[12940_396037] pid: 968 | pname: agetty | state: 1
[12940_396037] pid: 969 | pname: kerneloops | state: 1
[12940_396038] pid: 971 | pname: sshd | state: 1
[12940_396038] pid: 976 | pname: gdm3 | state: 1
[12940_396039] --CHILD pid: 1538 | CHILD_pname: gdm-session-wor | CHILD_state: 1
[12940_396040] pid: 1098 | pname: rtkit-daemon | state: 1
[12940_396041] pid: 1119 | pname: upowerd | state: 1
[12940_396041] pid: 1299 | pname: packagekitd | state: 1
[12940_396042] pid: 1476 | pname: colord | state: 1
[12940_396042] pid: 1586 | pname: spice-vdagentd | state: 1
[12940_396043] pid: 1538 | pname: gdm-session-wor | state: 1
[12940_396044] pid: 1579 | CHILD_pname: gdm-wayland-ses | CHILD_state: 1
[12940_396044] pid: 1545 | pname: systemd | state: 1
[12940_396045] --CHILD pid: 1546 | CHILD_pname: (sd-pam) | CHILD_state: 1
[12940_396046] --CHILD pid: 1552 | CHILD_pname: pipewire | CHILD_state: 1
[12940_396046] --CHILD pid: 1553 | CHILD_pname: pipewire-media- | CHILD_state: 1
[12940_396047] --CHILD pid: 1554 | CHILD_pname: pulseaudio | CHILD_state: 1
[12940_396048] --CHILD pid: 1558 | CHILD_pname: dbus-daemon | CHILD_state: 1
[12940_396049] --CHILD pid: 1563 | CHILD_pname: gvfsd | CHILD_state: 1
[12940_396049] --CHILD pid: 1578 | CHILD_pname: gvfsd-fuse | CHILD_state: 1
[12940_396050] --CHILD pid: 1605 | CHILD_pname: tracker-miner-f | CHILD_state: 1
[12940_396051] --CHILD pid: 1638 | CHILD_pname: gnome-session-c | CHILD_state: 1
[12940_396052] --CHILD pid: 1648 | CHILD_pname: gnome-session-b | CHILD_state: 1
[12940_396052] --CHILD pid: 1648 | CHILD_pname: gvfs-udisks2-vn | CHILD_state: 1
[12940_396053] --CHILD pid: 1664 | CHILD_pname: gnome-shell | CHILD_state: 1
[12940_396054] --CHILD pid: 1674 | CHILD_pname: gvfs-afc-volume | CHILD_state: 1
[12940_396055] --CHILD pid: 1688 | CHILD_pname: gvfs-qphotov2-vo | CHILD_state: 1
[12940_396055] --CHILD pid: 1687 | CHILD_pname: gvfs-ftp-volume | CHILD_state: 1

Ln 5, Col 1 Tab Size: 4 UTF-8 LF Makefile R Q

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File Edit Selection View Go Run Terminal Help

EXPLORER SRC linear

C PES1UG20CS243.c z,u M Makefile M x

```
linear > M Makefile
1 obj-m += PES1UG20CS243.o
2
3 KERNELDIR ?= /lib/modules/$(shell uname -r)/build
PWD := $(shell pwd)
5
6 all:
7     $(MAKE) -C $(KERNELDIR) M=$(PWD) modules
8 clean:
```

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL

bash · linear + - ^ x

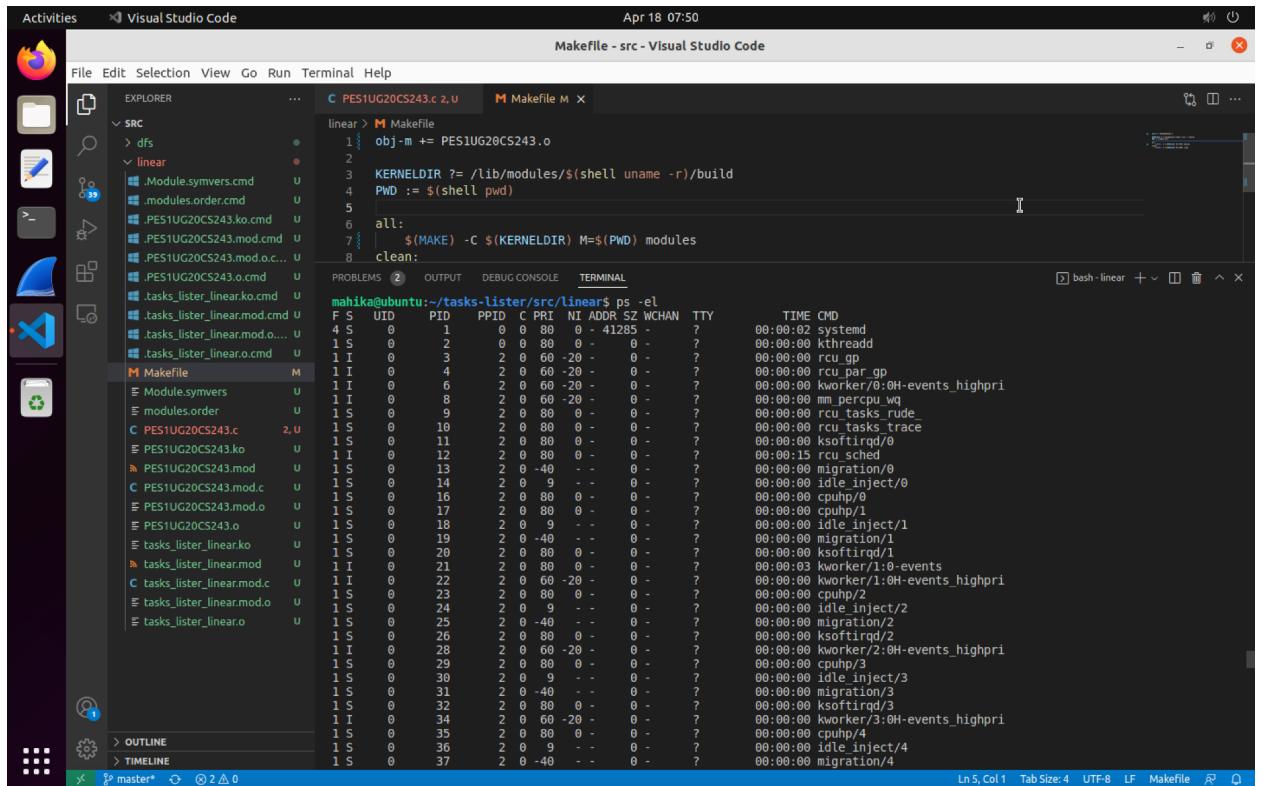
[12940_396147] pid: 2682 | pname: update-notifier | state: 1
[12940_396147] pid: 4339 | pname: kworker/3:0 | state: 1026
[12940_396148] pid: 7646 | pname: kworker/5:2 | state: 1026
[12940_396148] pid: 8783 | pname: kworker/u16:0 | state: 1026
[12940_396149] pid: 8822 | pname: kworker/6:1 | state: 1026
[12940_396149] pid: 9247 | pname: kworker/0:1 | state: 1026
[12940_396150] pid: 9254 | pname: kworker/1:2 | state: 1026
[12940_396151] pid: 12218 | pname: kworker/3:1 | state: 1026
[12940_396151] pid: 12465 | pname: kworker/4:2 | state: 1026
[12940_396152] pid: 12945 | pname: kworker/2:3 | state: 1026
[12940_396152] pid: 13603 | pname: gjs | state: 1
[12940_396154] pid: 13677 | pname: kworker/7:0 | state: 1026
[12940_396156] pid: 13078 | pname: kworker/0:3 | state: 1026
[12940_396157] pid: 13191 | pname: kworker/16:2 | state: 1026
[12940_396158] pid: 13194 | pname: kworker/6:2 | state: 1026
[12940_396159] pid: 13197 | pname: cupsd | state: 1
[12940_396159] pid: 13198 | pname: kworker/5:1 | state: 1026
[12940_396159] pid: 13199 | pname: cups-browsed | state: 1
[12940_396159] pid: 13206 | pname: kworker/2:2 | state: 1026
[12940_396159] pid: 13219 | pname: kworker/16:3 | state: 1026
[12940_396159] pid: 13291 | pname: kworker/3:2 | state: 1026
[12940_396159] pid: 13330 | pname: cgroups-srv | state: 1
[12940_396160] pid: 14062 | pname: tools-srv | state: 1
[12940_396161] pid: 14082 | pname: sh | state: 1
[12940_396161] --CHILD pid: 14083 | CHILD_pname: cpuUsage.sh | CHILD_state: 1
[12940_396162] pid: 14083 | pname: cpulUsage.sh | state: 1
[12940_396163] --CHILD pid: 14086 | CHILD_pname: sleep | CHILD_state: 1
[12940_396168] pid: 14086 | pname: sleep | state: 1
[12940_396168] pid: 14087 | pname: sudo | state: 1
[12940_396169] --CHILD pid: 14088 | CHILD_pname: insmod | CHILD_state: 0
[12940_396169] pid: 14088 | pname: insmod | state: 0
[12940_396170] Module loaded.

mahika@ubuntu:/tasks-lister/src/linear\$

Ln 5, Col 1 Tab Size: 4 UTF-8 LF Makefile R Q

3. TEST CASE OUTPUT:

- To test the module, run the command ps -el
- Comparing the pid, we can see that the module and this command give the same output.



The screenshot shows a Visual Studio Code interface with a terminal window open. The terminal window title is "Makefile - src - Visual Studio Code". The terminal content shows the output of the "ps -el" command, which lists processes on the system. The output includes columns for F S, UID, PID, PPID, C, PRI, NI, ADDR, SZ, WCHAN, TTY, TIME, and CMD. The terminal window also displays the Makefile code for "PES1UG20CS243.c". The status bar at the bottom of the terminal window shows "Ln 5, Col 1" and other terminal settings.

```
linear > M Makefile
1 obj-m += PES1UG20CS243.o
2
3 KERNELDIR ?= /lib/modules/$(shell uname -r)/build
4 PWD := $(shell pwd)
5
6 all:
7 $(MAKE) -C $(KERNELDIR) M=$(PWD) modules
8 clean:
```

F S	UID	PID	PPID	C	PRI	NI	ADDR	SZ	WCHAN	TTY	TIME	CMD			
4	S	5	0	1	0	0	80	0	-	41285	?	00:00:02	systemd		
1	S	5	0	2	0	0	80	0	-	0	?	00:00:00	kthreadd		
1	I	0	3	2	0	60	-20	-	-	?	?	00:00:00	rcu_gp		
1	I	0	4	2	0	60	-20	-	-	?	?	00:00:00	rcu_par_gp		
1	I	0	6	2	0	60	-20	-	-	?	?	00:00:00	kworker/0:0H-events_highpri		
1	I	0	8	2	0	60	-20	-	-	?	?	00:00:00	mm_percpu_wq		
1	S	5	0	9	2	0	80	0	-	0	?	00:00:00	rcu_tasks_rude		
C	PES1UG20CS243.c	2	U	1	5	0	10	2	0	80	0	-	?	00:00:00	rcu_tasks_trace
E	PES1UG20CS243.ko	U	1	I	0	11	2	0	80	0	-	?	00:00:00	ksoftirqd/0	
E	PES1UG20CS243.mod	U	1	I	0	12	2	0	80	0	-	?	00:00:15	rcu_sched	
A	PES1UG20CS243.mod	U	1	I	0	13	2	0	-40	-	?	?	00:00:00	migration/0	
C	PES1UG20CS243.mod.c	U	1	I	0	14	2	0	9	-	?	?	00:00:00	idle_inject/0	
E	PES1UG20CS243.mod.o	U	1	I	0	15	2	0	80	0	-	?	00:00:00	cpuhp/0	
E	PES1UG20CS243.o	U	1	I	0	16	2	0	80	0	-	?	00:00:00	cpuhp/1	
E	tasks_listner_linear.ko	U	1	I	0	17	2	0	80	0	-	?	00:00:00	cpuhp/1	
E	tasks_listner_linear.mod	U	1	I	0	18	2	0	9	-	?	?	00:00:00	idle_inject/1	
E	tasks_listner_linear.mod	U	1	I	0	19	2	0	-40	-	?	?	00:00:00	migration/1	
E	tasks_listner_linear.mod	U	1	I	0	20	2	0	80	0	-	?	00:00:00	ksoftirqd/1	
A	tasks_listner_linear.mod	U	1	I	0	21	2	0	80	0	-	?	00:00:03	kworker/1:0H-events	
C	tasks_listner_linear.mod.c	U	1	I	0	22	2	0	60	-20	-	?	00:00:00	kworker/1:0H-events_highpri	
E	tasks_listner_linear.mod.o	U	1	I	0	23	2	0	80	0	-	?	00:00:00	cpuhp/2	
E	tasks_listner_linear.o	U	1	I	0	24	2	0	9	-	?	?	00:00:00	idle_inject/2	
E	tasks_listner_linear.o	U	1	I	0	25	2	0	-40	-	?	?	00:00:00	migration/2	
E	tasks_listner_linear.o	U	1	I	0	26	2	0	80	0	-	?	00:00:00	ksoftirqd/2	
I	0	28		I	0	29	2	0	60	-20	-	?	00:00:00	kworker/2:0H-events_highpri	
I	0	29		I	0	30	2	0	80	0	-	?	00:00:00	cpuhp/3	
I	0	30		I	0	31	2	0	-40	-	?	?	00:00:00	idle_inject/3	
I	0	31		I	0	32	2	0	80	0	-	?	00:00:00	migration/3	
I	0	32		I	0	33	2	0	60	-20	-	?	00:00:00	ksoftirqd/3	
I	0	33		I	0	34	2	0	80	0	-	?	00:00:00	kworker/3:0H-events_highpri	
I	0	34		I	0	35	2	0	80	0	-	?	00:00:00	cpuhp/4	
I	0	35		I	0	36	2	0	9	-	?	?	00:00:00	idle_inject/4	
I	0	36		I	0	37	2	0	-40	-	?	?	00:00:00	migration/4	

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EXPLORER SRC linear PES1UG20CS243.c z,u Makefile M

linear > Makefile

```
1 obj-m += PES1UG20CS243.o
2
3 KERNELDIR ?= /lib/modules/$(shell uname -r)/build
4 PWD := $(shell pwd)
5
6 all:
7     $(MAKE) -C $(KERNELDIR) M=$(PWD) modules
8 clean:
```

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL

bash - linear

1 S 1000 2418 2241 15 80 0 - 4291241 futex ? 00:49:21 code
0 S 1000 2453 2237 0 80 0 - 5311129 ep_pol ? 00:00:28 code
0 R 1000 2461 2237 0 80 0 - 7437642 - ? 00:00:43 code
0 R 1000 2485 2461 0 80 0 - 5311025 - ? 00:00:32 code
0 S 1000 2520 2461 0 80 0 - 5313146 ep_pol ? 00:00:04 code
0 S 1000 2539 2453 0 80 0 - 438207 unix_s ? 00:00:18 cpptrools
0 S 1000 2590 2453 0 80 0 - 5300122 ep_pol ? 00:00:01 code
0 S 1000 2659 2485 0 80 0 - 2035 do_wai pts/0 00:00:00 bash
0 S 1000 2682 1640 0 80 0 - 123290 do_pol ? 00:00:01 update-notifier
1 I 0 4339 2 0 80 0 - 0 - ? 00:00:01 kworker/3:0-events
1 I 0 7640 2 0 80 0 - 0 - ? 00:00:01 kworker/5:2-mm_percpu_wq
1 R 0 8783 2 0 80 0 - 0 - ? 00:00:01 kworker/u16:0-events_unbound
1 I 0 9247 2 0 80 0 - 0 - ? 00:00:00 kworker/0:1-events
1 I 0 9254 2 0 80 0 - 0 - ? 00:00:00 kworker/1:2-events
1 I 0 13077 2 0 80 0 - 0 - ? 00:00:00 kworker/7:0-events
1 I 0 13194 2 0 80 0 - 0 - ? 00:00:00 kworker/6:2-mm_percpu_wq
1 S 0 13197 1 0 80 0 - 180068 - ? 00:00:00 cupsd
1 S 0 13199 1 0 80 0 - 43237 - ? 00:00:00 cups-browsed
0 S 1000 14062 2539 0 80 0 - 1312738 futex ? 00:00:00 cpptrools-srv
0 S 1000 15423 2 0 80 0 - 0 - ? 00:00:00 kworker/2:0-events
0 S 1000 15433 1664 0 80 0 - 748156 do_pol ? 00:00:00 qis
1 I 0 15476 2 0 80 0 - 0 - ? 00:00:00 kworker/4:2
1 I 0 15477 2 0 80 0 - 0 - ? 00:00:00 kworker/7:1-events
1 I 0 15478 2 0 80 0 - 0 - ? 00:00:00 kworker/6:0-events
1 I 0 15479 2 0 80 0 - 0 - ? 00:00:00 kworker/2:1-events
1 I 0 15483 2 0 80 0 - 0 - ? 00:00:00 kworker/0:2-events
1 I 0 15484 2 0 80 0 - 0 - ? 00:00:00 kworker/5:1
1 I 0 15491 2 0 80 0 - 0 - ? 00:00:00 kworker/3:2-events
1 I 0 15542 2 0 80 0 - 0 - ? 00:00:00 kworker/u16:2-ext4-rsv-conversion
1 I 0 15603 2 0 80 0 - 0 - ? 00:00:00 kworker/0:0-events
1 I 0 16025 2 0 80 0 - 0 - ? 00:00:00 kworker/u16:3-events_unbound
4 R 1000 16027 2659 0 80 0 - 2321 - pts/0 00:00:00 ps

mahika@ubuntu:~/tasks-lister/src/linear\$

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