EXERCISE

3.2 Including the initial parent process, how many processes are created by the program shown in Figure 3.31?

```
#include <stdio.h>
#include <unistd.h>

int main()
{
    /* fork a child process */
    fork();

    /* fork another child process */
    fork();

    /* and fork another */
    fork();

    return 0;
}
```

Figure 3.31 How many processes are created?

2^3=8 processes are created.

3.14 Using the program in Figure 3.34, identify the values of pid at lines A, B, C, and D. (Assume that the actual pids of the parent and child are 2600 and 2603, respectively.)

```
#include <sys/types.h>
#include <stdio.h>
#include <unistd.h>

int main()
{
pid_t pid, pid1;

   /* fork a child process */
   pid = fork();

   if (pid < 0) { /* error occurred */
      fprintf(stderr, "Fork Failed");
      return 1;
   }
   else if (pid == 0) { /* child process */
      pid1 = getpid();
      printf("child: pid = %d",pid); /* A */
      printf("child: pid1 = %d",pid1); /* B */
   }
   else { /* parent process */
      pid1 = getpid();
      printf("parent: pid = %d",pid); /* C */
      printf("parent: pid1 = %d",pid1); /* D */
      wait(NULL);
   }

   return 0;
}
```

Figure 3.34 What are the pid values?

A: 0; B: 2603; C: 2603; D:2600

3.17 Using the program shown in Figure 3.35, explain what the output will be at lines X and Y.

```
#include <sys/types.h>
#include <stdio.h>
#include <unistd.h>

#define SIZE 5

int nums[SIZE] = {0,1,2,3,4};

int main()
{
int i;
pid_t pid;

   pid = fork();

   if (pid == 0) {
      for (i = 0; i < SIZE; i++) {
         nums[i] *= -i;
         printf("CHILD: %d ",nums[i]); /* LINE X */
      }
   }
   else if (pid > 0) {
      wait(NULL);
      for (i = 0; i < SIZE; i++)
         printf("PARENT: %d ",nums[i]); /* LINE Y */
   }

   return 0;
}
```

Figure 3.35 What output will be at Line X and Line Y?

Line X:

CHILD: 0 CHILD: -1 CHILD: -4 CHILD: -9 CHILD: -16

Line Y:

PARENT: 0 PARENT: 1 PARENT: 2 PARENT: 3 PARENT: 4

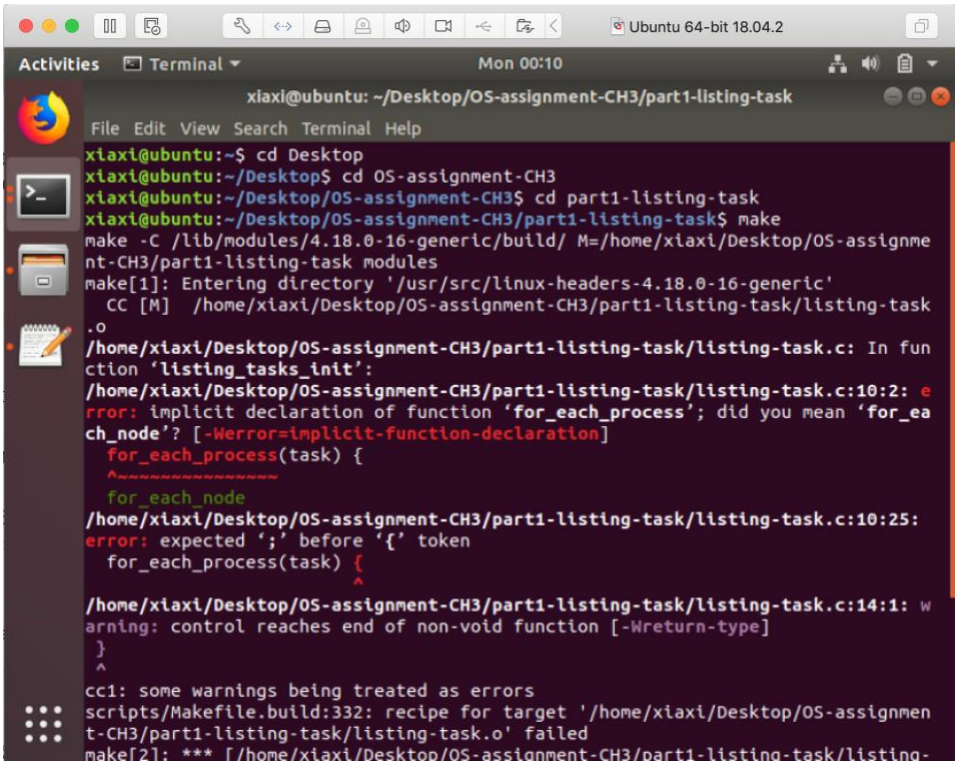
Operating System
Xi XIA
BUPT Number 2016213482
Class Number 2016215117

Programming Project

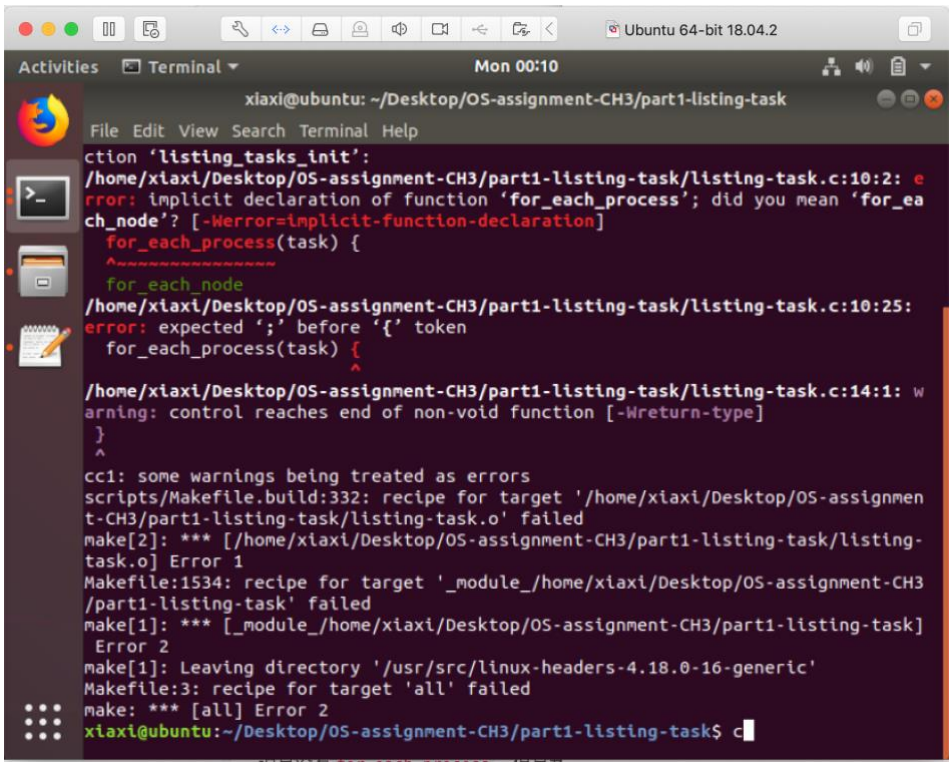
Project 2—Linux Kernel Module for Listing Tasks

Part I—Iterating over Tasks Linearly

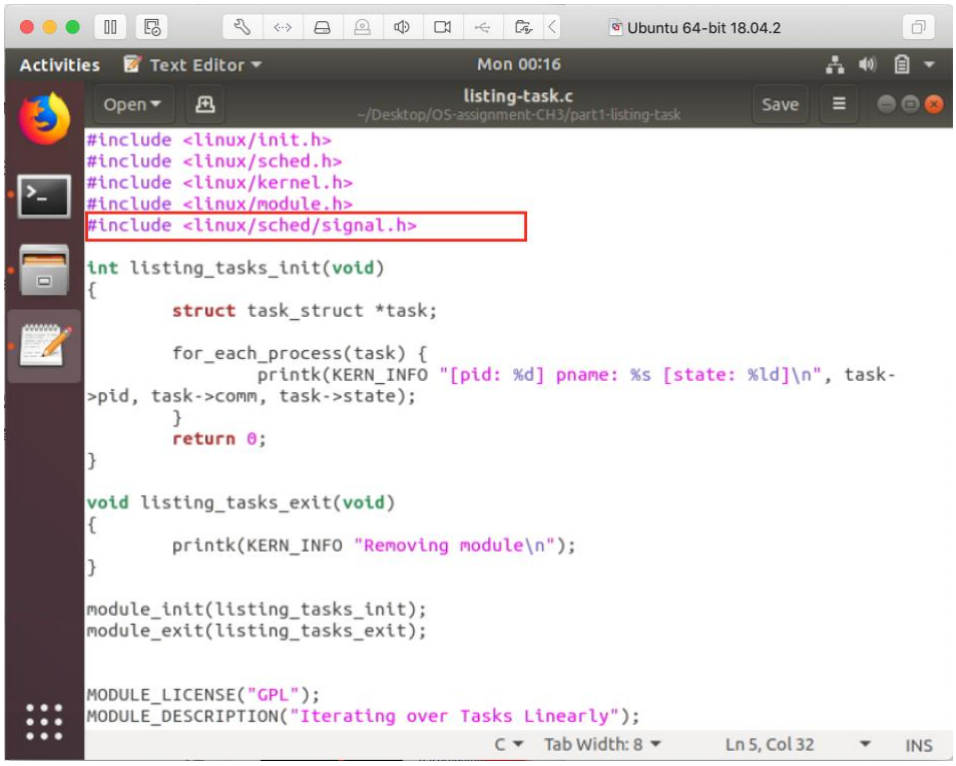
1. 到目标文件夹，make 编译



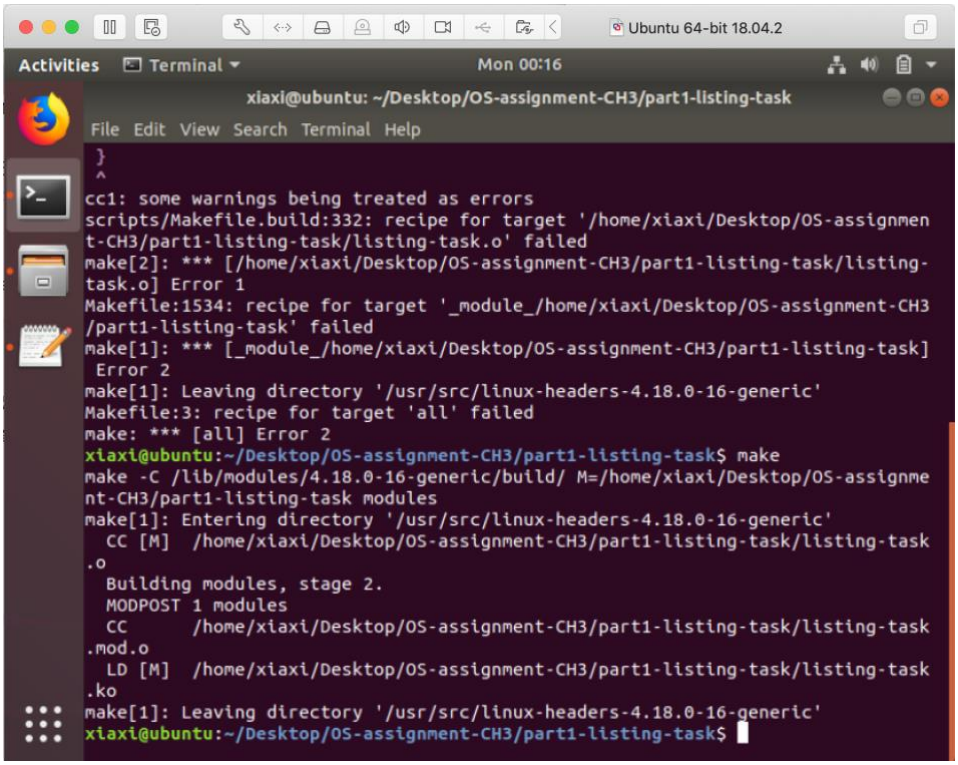
2. 发现报错



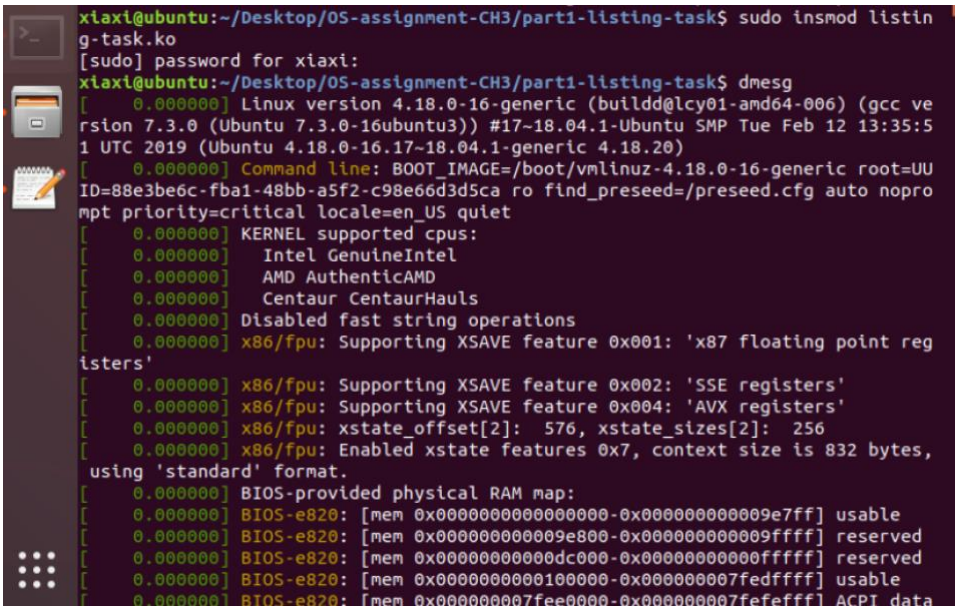
3. debug
   此处报错是因为 for_each_process 的方法定义在 include/linux/sched.h 文件下，应该添加头文件的引用。



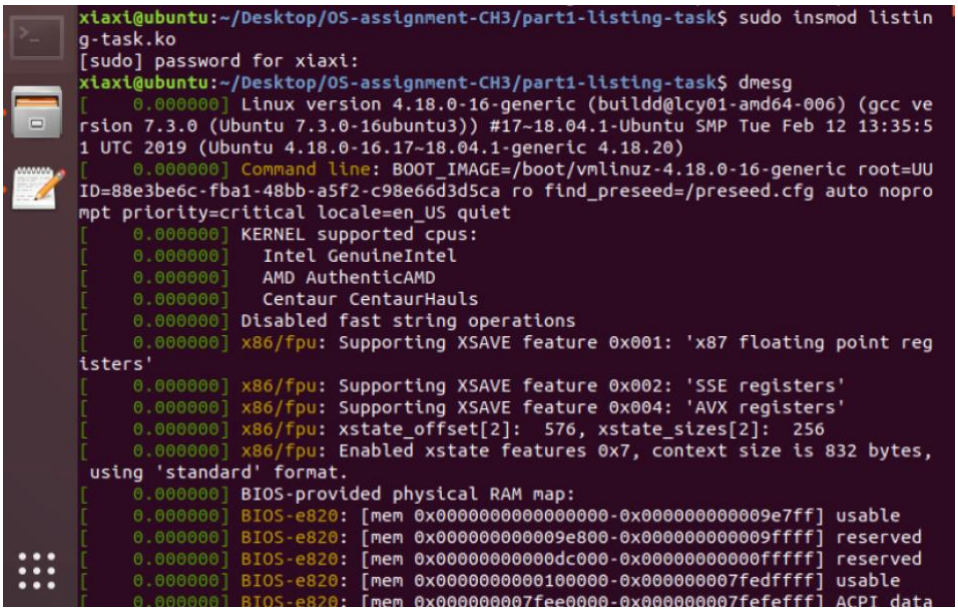
4. 重新 make 编译



5. 插入模块



6. dmsg 检查



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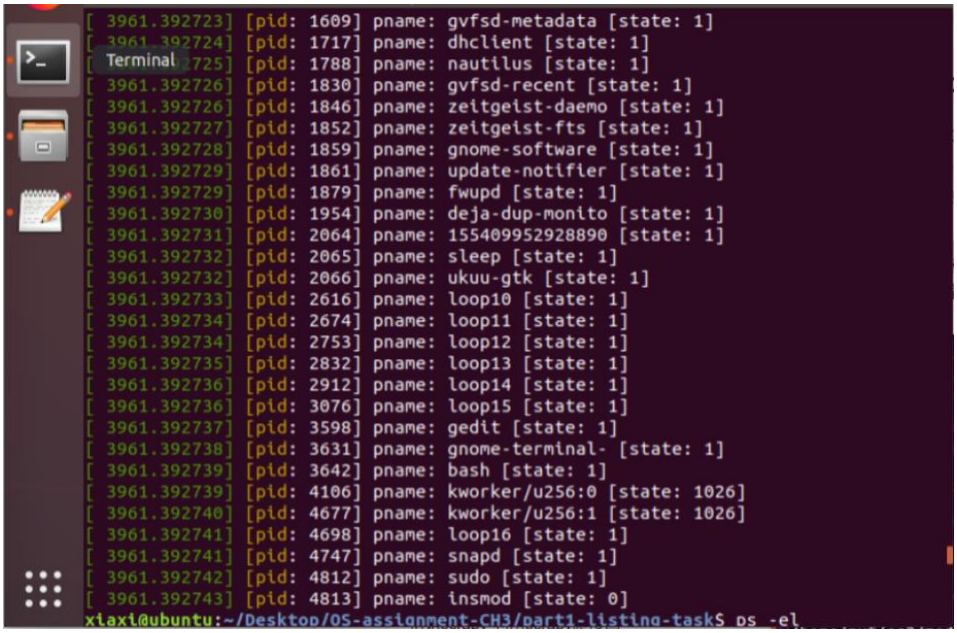
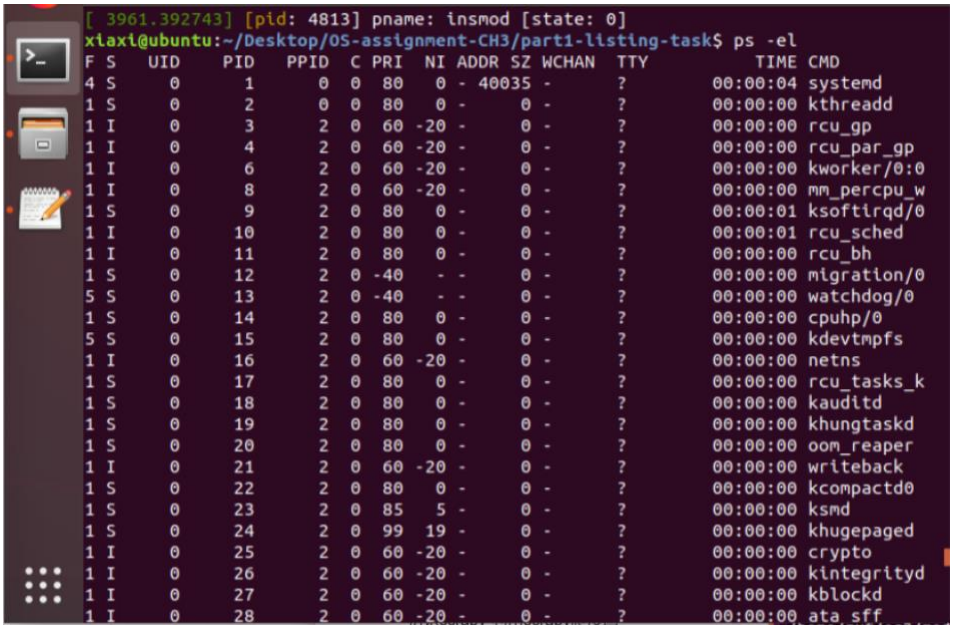


7. 对比 ps -el 显示的信息



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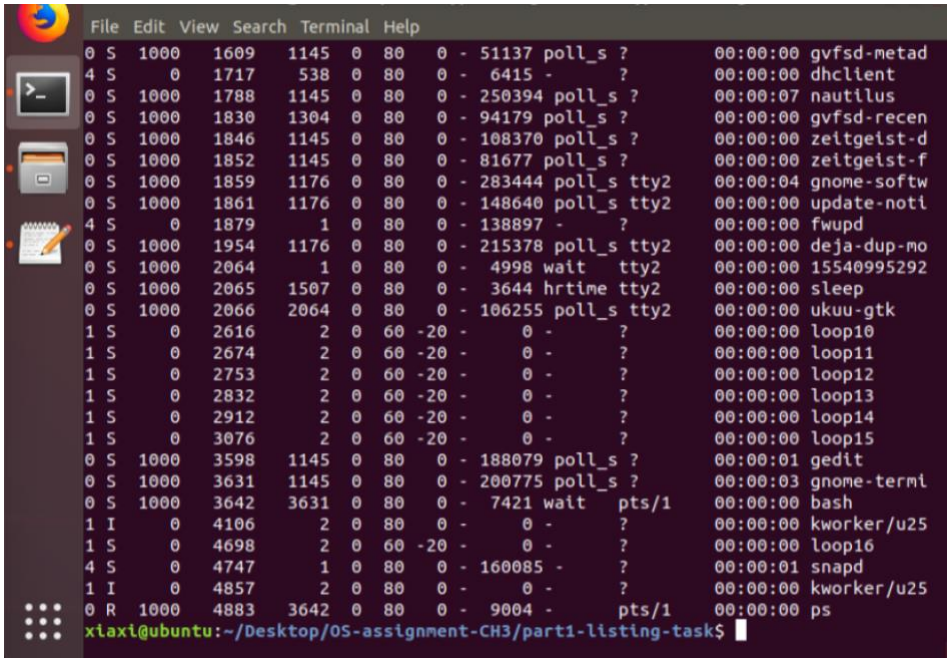

可以看到两种方式列出的 task 差不多，比如 loop10，loop11，loop12，loop13 …这些。

Part II—Iterating over Tasks with a Depth-First Search Tree

1. cd 到文件夹，make 编译

```
xiaxi@ubuntu:~/Desktop/OS-assignment-CH3/part2-dfs-tree-tasks$ make
make -C /lib/modules/4.18.0-16-generic/build/ M=/home/xiaxi/Desktop/OS-assignme
nt-CH3/part2-dfs-tree-tasks modules
make[1]: Entering directory '/usr/src/linux-headers-4.18.0-16-generic'
  CC [M]  /home/xiaxi/Desktop/OS-assignment-CH3/part2-dfs-tree-tasks/dfs-tree-t
asks.o
  Building modules, stage 2.
  MODPOST 1 modules
  CC      /home/xiaxi/Desktop/OS-assignment-CH3/part2-dfs-tree-tasks/dfs-tree-t
asks.mod.o
  LD [M]  /home/xiaxi/Desktop/OS-assignment-CH3/part2-dfs-tree-tasks/dfs-tree-t
asks.ko
make[1]: Leaving directory '/usr/src/linux-headers-4.18.0-16-generic'
```

注：从 Linux 内核 4.11 开始，变量 init_task 在 linux/sched/task.h 被声明，而不是在 linux/sched.h

dfs-tree-tasks.c
~/Desktop/OS-assignment-CH3/part2-dfs-tree-tasks

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

void dfs(struct task_struct *task)
{
        struct task_struct *next_task;
        struct list_head *list;
        list_for_each(list, &task->children) {
                next_task = list_entry(list, struct task_struct, sibling);
                printk(KERN_INFO "[pid: %d] pname: %s [state: %ld]\n",next_task->pid, next_task->comm, next_task->state);
                dfs(next_task);
        }
}
int dfs_tree_tasks_init(void)
{
        printk(KERN_INFO "Loading module\n");
        dfs(&init_task);
        return 0;
}

void dfs_tree_tasks_exit(void)
{
        printk(KERN_INFO "Removing module\n");
}
```

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2. 插入模块

```
xiaxi@ubuntu:~/Desktop/OS-assignment-CH3/part2-dfs-tree-tasks$ sudo insmod dfs-tree-tasks.ko
```

3. dmesg 检查

```
xiaxi@ubuntu:~/Desktop/OS-assignment-CH3/part2-dfs-tree-tasks$ dmesg
[    0.000000] Linux version 4.18.0-16-generic (buildd@lcy01-amd64-006) (gcc version 7.3.0 (Ubuntu 7.3.0-16ubuntu3)) #17~18.04.1-Ubuntu SMP Tue Feb 12 13:35:51 UTC 2019 (Ubuntu 4.18.0-16.17~18.04.1-generic 4.18.20)
[    0.000000] Command line: BOOT_IMAGE=/boot/vmlinuz-4.18.0-16-generic root=UUID=88e3be6c-fba1-48bb-a5f2-c98e66d3d5ca ro find_preseed=/preseed.cfg auto noprompt priority=critical locale=en_US quiet
[    0.000000] KERNEL supported cpus:
[    0.000000]   Intel GenuineIntel
[    0.000000]   AMD AuthenticAMD
[    0.000000]   Centaur CentaurHauls
[    0.000000] Disabled fast string operations
[    0.000000] x86/fpu: Supporting XSAVE feature 0x001: 'x87 floating point registers'
[    0.000000] x86/fpu: Supporting XSAVE feature 0x002: 'SSE registers'
[    0.000000] x86/fpu: Supporting XSAVE feature 0x004: 'AVX registers'
[    0.000000] x86/fpu: xstate_offset[2]:  576, xstate_sizes[2]:  256
[    0.000000] x86/fpu: Enabled xstate features 0x7, context size is 832 bytes, using 'standard' format.
[    0.000000] BIOS-provided physical RAM map:
[    0.000000] BIOS-e820: [mem 0x0000000000000000-0x000000000009e7ff] usable
[    0.000000] BIOS-e820: [mem 0x000000000009e800-0x000000000009ffff] reserved
[    0.000000] BIOS-e820: [mem 0x00000000000dc000-0x00000000000fffff] reserved
[    0.000000] BIOS-e820: [mem 0x0000000000100000-0x000000007fedffff] usable
[    0.000000] BIOS-e820: [mem 0x000000007fee0000-0x000000007fefefff] ACPI data
[    0.000000] BIOS-e820: [mem 0x000000007feff000-0x000000007fefffff] ACPI NVS
```

...

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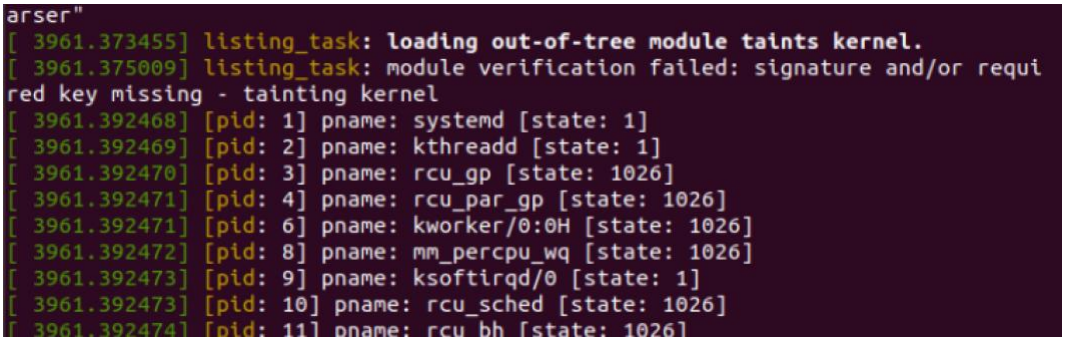

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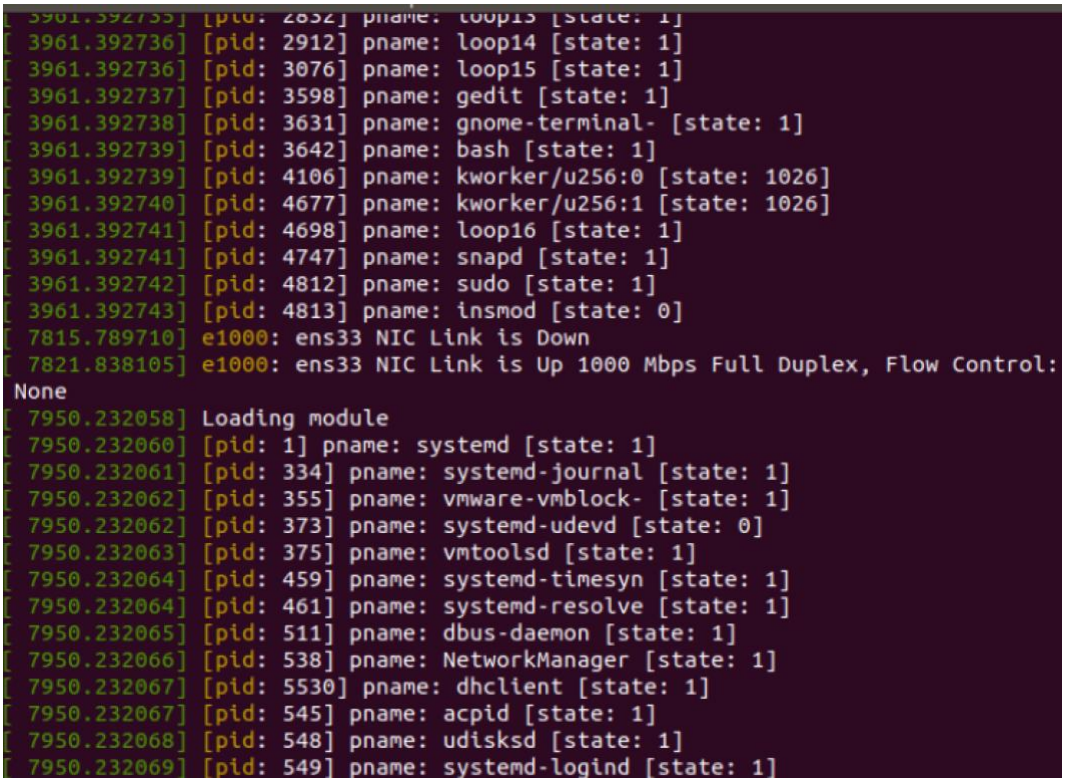

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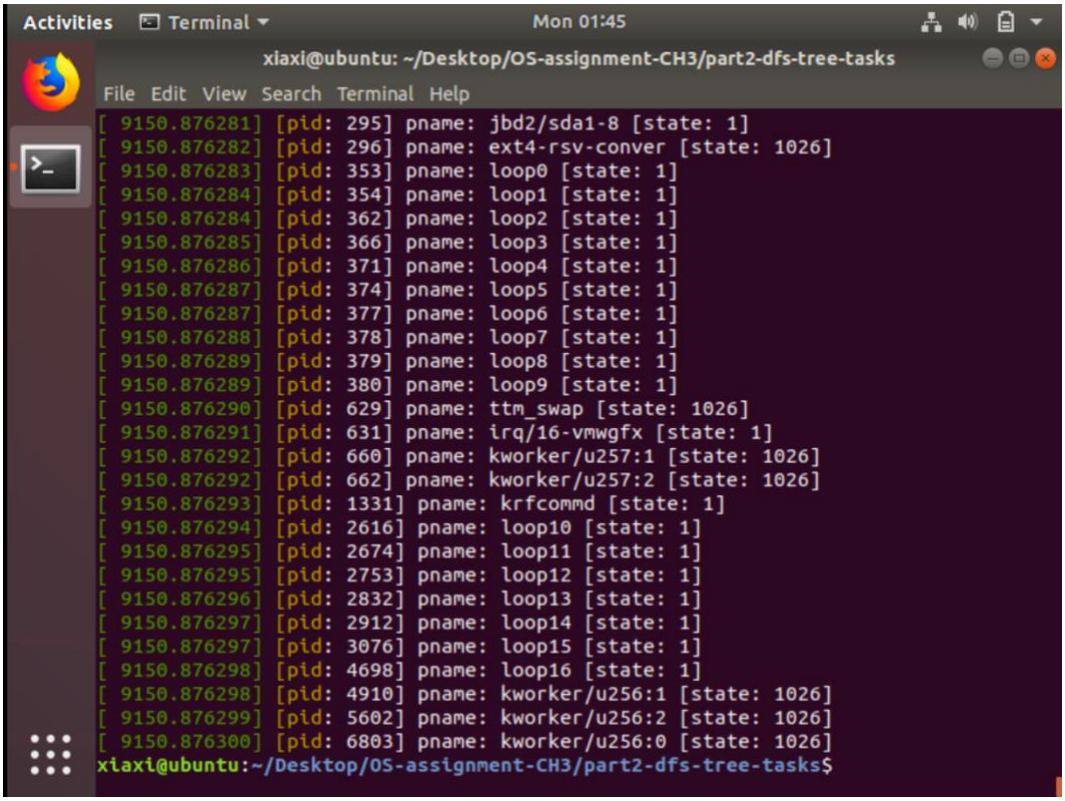

4. ps-eLf 检查

```
xiaxi@ubuntu:~/Desktop/OS-assignment-CH3/part2-dfs-tree-tasks$ ps -eLf
UID          PID    PPID     LWP  C NLWP STIME TTY          TIME CMD
root           1       0       1  0    1 Mar31 ?        00:00:05 /sbin/init auto n
root           2       0       2  0    1 Mar31 ?        00:00:00 [kthreadd]
root           3       2       3  0    1 Mar31 ?        00:00:00 [rcu_gp]
root           4       2       4  0    1 Mar31 ?        00:00:00 [rcu_par_gp]
root           6       2       6  0    1 Mar31 ?        00:00:00 [kworker/0:0H-kb]
root           8       2       8  0    1 Mar31 ?        00:00:00 [mm_percpu_wq]
root           9       2       9  0    1 Mar31 ?        00:00:01 [ksoftirqd/0]
root          10       2      10  0    1 Mar31 ?        00:00:01 [rcu_sched]
root          11       2      11  0    1 Mar31 ?        00:00:00 [rcu_bh]
root          12       2      12  0    1 Mar31 ?        00:00:00 [migration/0]
root          13       2      13  0    1 Mar31 ?        00:00:00 [watchdog/0]
root          14       2      14  0    1 Mar31 ?        00:00:00 [cpuhp/0]
root          15       2      15  0    1 Mar31 ?        00:00:00 [kdevtmpfs]
root          16       2      16  0    1 Mar31 ?        00:00:00 [netns]
root          17       2      17  0    1 Mar31 ?        00:00:00 [rcu_tasks_kthre]
root          18       2      18  0    1 Mar31 ?        00:00:00 [kauditd]
root          19       2      19  0    1 Mar31 ?        00:00:00 [khungtaskd]
root          20       2      20  0    1 Mar31 ?        00:00:00 [oom_reaper]
root          21       2      21  0    1 Mar31 ?        00:00:00 [writeback]
root          22       2      22  0    1 Mar31 ?        00:00:00 [kcompactd0]
root          23       2      23  0    1 Mar31 ?        00:00:00 [ksmd]
root          24       2      24  0    1 Mar31 ?        00:00:00 [khugepaged]
root          25       2      25  0    1 Mar31 ?        00:00:00 [crypto]
root          26       2      26  0    1 Mar31 ?        00:00:00 [kintegrityd]
root          27       2      27  0    1 Mar31 ?        00:00:00 [kblockd]
root          28       2      28  0    1 Mar31 ?        00:00:00 [ata_sff]
```

…

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(中间还有很多)

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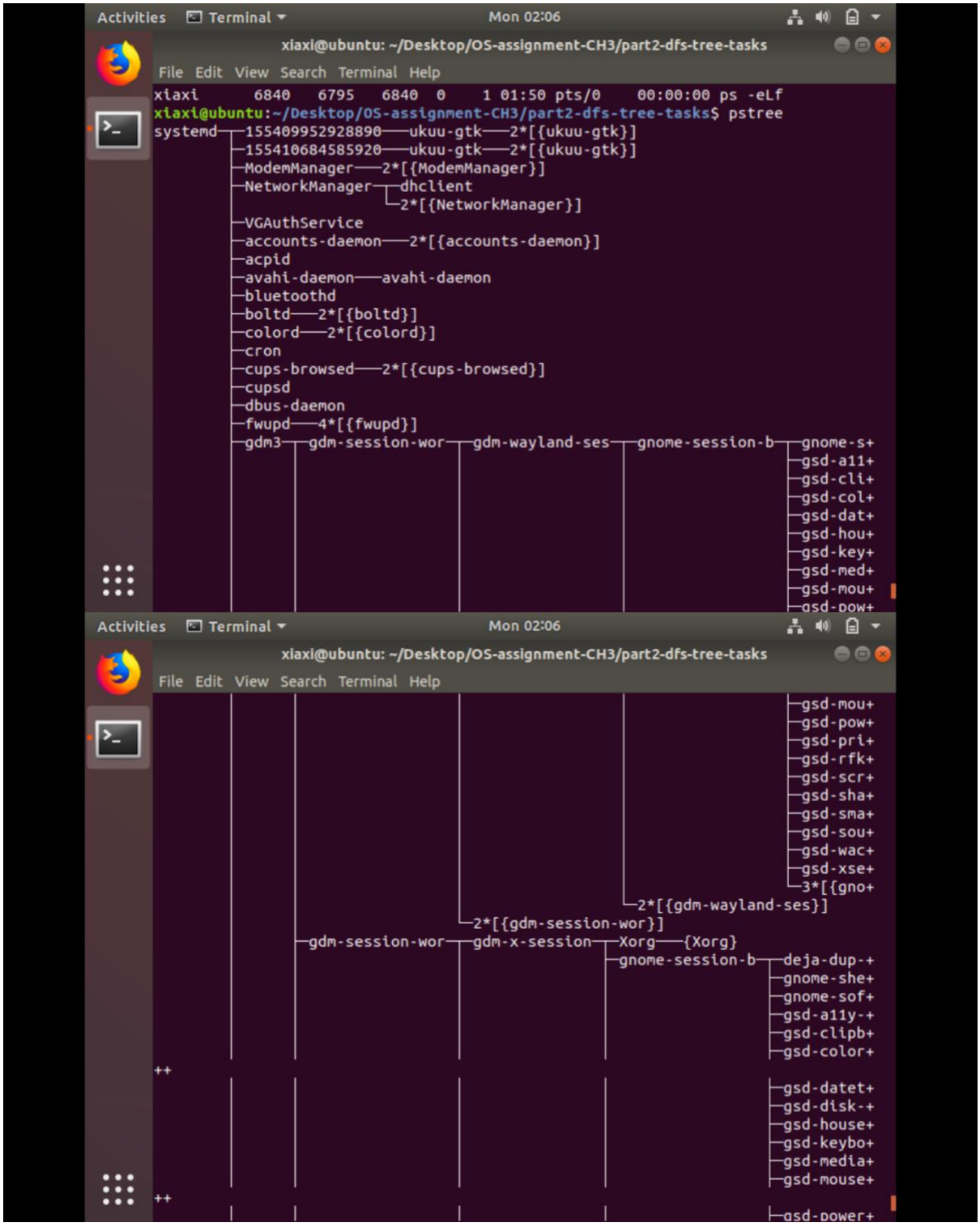
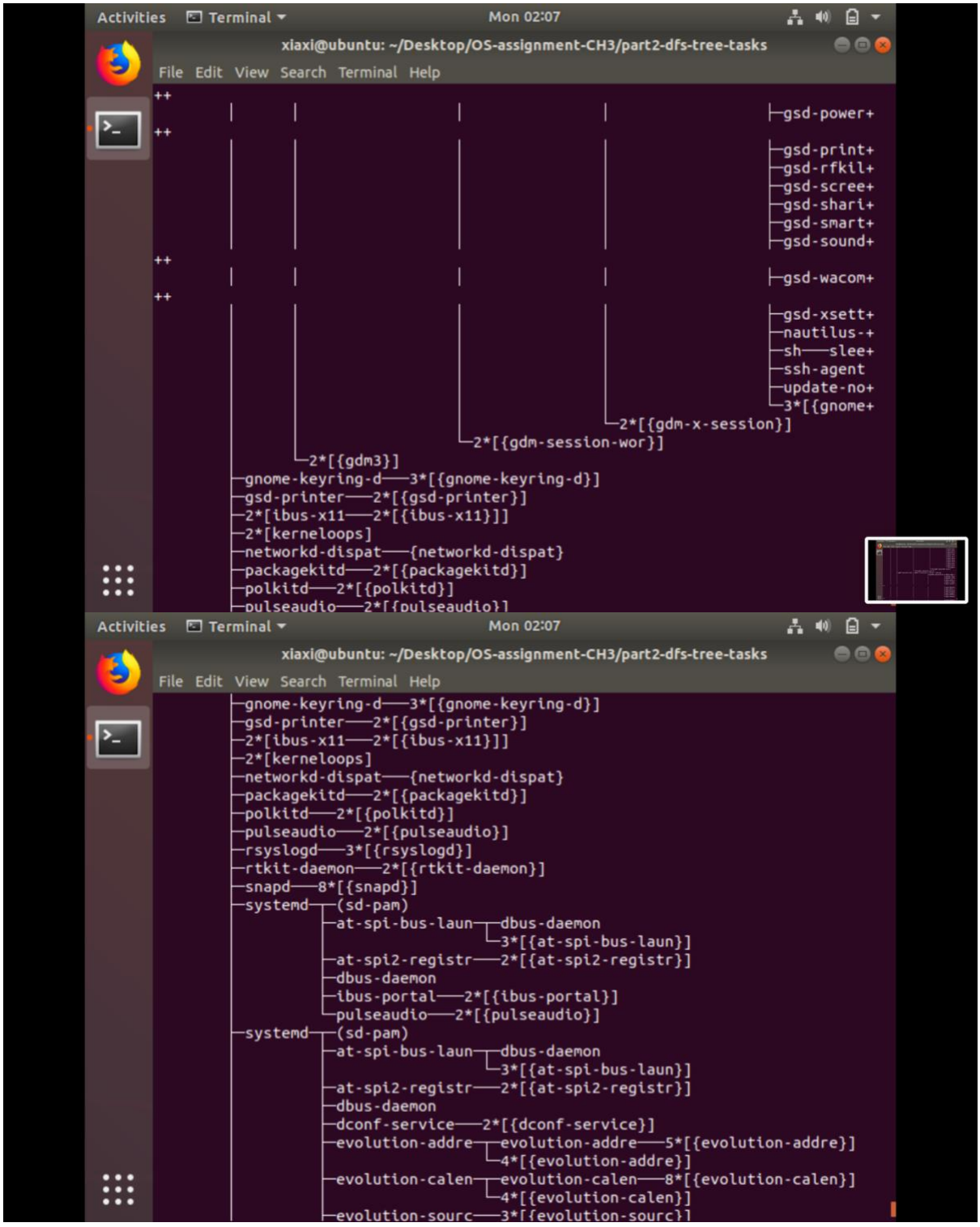
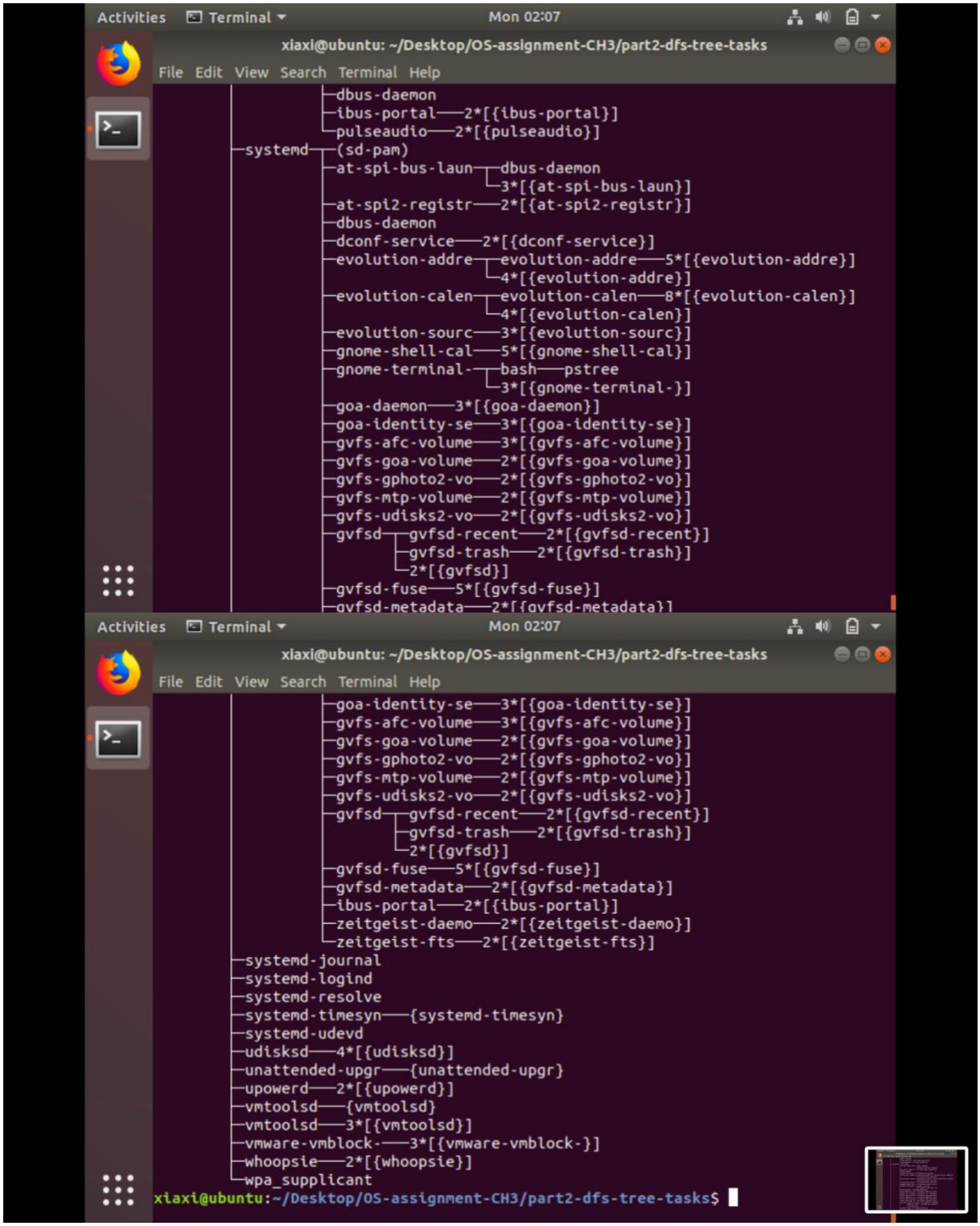
```
root       2832      2   2832  0    1 Mar31 ?        00:00:00 [loop13]
root       2912      2   2912  0    1 Mar31 ?        00:00:00 [loop14]
root       3076      2   3076  0    1 00:04 ?        00:00:00 [loop15]
root       4698      2   4698  0    1 00:17 ?        00:00:00 [loop16]
root       4747      1   4747  0    9 00:17 ?        00:00:00 /usr/lib/snapd/sn
root       4747      1   4754  0    9 00:17 ?        00:00:00 /usr/lib/snapd/sn
root       4747      1   4755  0    9 00:17 ?        00:00:00 /usr/lib/snapd/sn
root       4747      1   4756  0    9 00:17 ?        00:00:00 /usr/lib/snapd/sn
root       4747      1   4757  0    9 00:17 ?        00:00:00 /usr/lib/snapd/sn
root       4747      1   4760  0    9 00:17 ?        00:00:00 /usr/lib/snapd/sn
root       4747      1   4761  0    9 00:17 ?        00:00:00 /usr/lib/snapd/sn
root       4747      1   4806  0    9 00:17 ?        00:00:00 /usr/lib/snapd/sn
root       4747      1   4807  0    9 00:17 ?        00:00:00 /usr/lib/snapd/sn
xiaxi      5491      1   5491  0    1 01:20 tty2     00:00:00 /bin/bash /tmp/uk
xiaxi      5492   1507   5492  0    1 01:20 tty2     00:00:00 sleep 2h
xiaxi      5493   5491   5493  0    3 01:20 tty2     00:00:00 ukuu-gtk --notify
xiaxi      5493   5491   5494  0    3 01:20 tty2     00:00:00 ukuu-gtk --notify
xiaxi      5493   5491   5495  0    3 01:20 tty2     00:00:00 ukuu-gtk --notify
root       5530    538   5530  0    1 01:23 ?        00:00:00 /sbin/dhclient -d
root       5602      2   5602  0    1 01:23 ?        00:00:00 [kworker/u256:2-]
xiaxi      6785   1145   6785  0    4 01:43 ?        00:00:01 /usr/lib/gnome-te
xiaxi      6785   1145   6786  0    4 01:43 ?        00:00:00 /usr/lib/gnome-te
xiaxi      6785   1145   6787  0    4 01:43 ?        00:00:00 /usr/lib/gnome-te
xiaxi      6785   1145   6788  0    4 01:43 ?        00:00:00 /usr/lib/gnome-te
xiaxi      6795   6785   6795  0    1 01:43 pts/0    00:00:00 bash
root       6803      2   6803  0    1 01:44 ?        00:00:00 [kworker/u256:0-]
xiaxi      6840   6795   6840  0    1 01:50 pts/0    00:00:00 ps -eLf
xiaxi@ubuntu:~/Desktop/OS-assignment-CH3/part2-dfs-tree-tasks$
```

5. pstree 检查


Activities
Terminal
Mon 02:06
xiaxi@ubuntu: ~/Desktop/OS-assignment-CH3/part2-dfs-tree-tasks
File Edit View Search Terminal Help
xiaxi 6840 6795 6840 0 1 01:50 pts/0 00:00:00 ps -eLf
xiaxi@ubuntu:~/Desktop/OS-assignment-CH3/part2-dfs-tree-tasks$ pstree
systemd─┬─155409952928890───ukuu-gtk───2*[{ukuu-gtk}]
├─155410684585920───ukuu-gtk───2*[{ukuu-gtk}]
├─ModemManager───2*[{ModemManager}]
├─NetworkManager─┬─dhclient
└─2*[{NetworkManager}]
├─VGAuthService
├─accounts-daemon───2*[{accounts-daemon}]
├─acpid
├─avahi-daemon───avahi-daemon
├─bluetoothd
├─boltd───2*[{boltd}]
├─colord───2*[{colord}]
├─cron
├─cups-browsed───2*[{cups-browsed}]
├─cupsd
├─dbus-daemon
├─fwupd───4*[{fwupd}]
├─gdm3─┬─gdm-session-wor─┬─gdm-wayland-ses─┬─gnome-session-b─┬─gnome-s+
├─gsd-a11+
├─gsd-cli+
├─gsd-col+
├─gsd-dat+
├─gsd-hou+
├─gsd-key+
├─gsd-med+
├─gsd-mou+
├─gsd-pow+
Activities
Terminal
Mon 02:06
xiaxi@ubuntu: ~/Desktop/OS-assignment-CH3/part2-dfs-tree-tasks
File Edit View Search Terminal Help
├─gsd-mou+
├─gsd-pow+
├─gsd-pri+
├─gsd-rfk+
├─gsd-scr+
├─gsd-sha+
├─gsd-sma+
├─gsd-sou+
├─gsd-wac+
├─gsd-xse+
└─3*[{gno+
└─2*[{gdm-wayland-ses}]
└─2*[{gdm-session-wor}]
├─gdm-session-wor─┬─gdm-x-session─┬─Xorg───{Xorg}
├─gnome-session-b─┬─deja-dup-+
├─gnome-she+
├─gnome-sof+
├─gsd-a11y-+
├─gsd-clipb+
├─gsd-color+
++
├─gsd-datet+
├─gsd-disk-+
├─gsd-house+
├─gsd-keybo+
├─gsd-media+
├─gsd-mouse+
++
├─gsd-power+


Activities
Terminal
Mon 02:07
xiaxi@ubuntu: ~/Desktop/OS-assignment-CH3/part2-dfs-tree-tasks
File Edit View Search Terminal Help
++
├─gsd-power+
++
├─gsd-print+
├─gsd-rfkil+
├─gsd-scree+
├─gsd-shari+
├─gsd-smart+
├─gsd-sound+
++
├─gsd-wacom+
++
├─gsd-xsett+
├─nautilus-+
├─sh───slee+
├─ssh-agent
├─update-no+
└─3*[{gnome+
└─2*[{gdm-x-session}]
└─2*[{gdm-session-wor}]
└─2*[{gdm3}]
├─gnome-keyring-d───3*[{gnome-keyring-d}]
├─gsd-printer───2*[{gsd-printer}]
├─2*[ibus-x11───2*[{ibus-x11}]]
├─2*[kerneloops]
├─networkd-dispat───{networkd-dispat}
├─packagekitd───2*[{packagekitd}]
├─polkitd───2*[{polkitd}]
├─pulseaudio───2*[{pulseaudio}]
Activities
Terminal
Mon 02:07
xiaxi@ubuntu: ~/Desktop/OS-assignment-CH3/part2-dfs-tree-tasks
File Edit View Search Terminal Help
├─gnome-keyring-d───3*[{gnome-keyring-d}]
├─gsd-printer───2*[{gsd-printer}]
├─2*[ibus-x11───2*[{ibus-x11}]]
├─2*[kerneloops]
├─networkd-dispat───{networkd-dispat}
├─packagekitd───2*[{packagekitd}]
├─polkitd───2*[{polkitd}]
├─pulseaudio───2*[{pulseaudio}]
├─rsyslogd───3*[{rsyslogd}]
├─rtkit-daemon───2*[{rtkit-daemon}]
├─snapd───8*[{snapd}]
├─systemd─┬─(sd-pam)
├─at-spi-bus-laun─┬─dbus-daemon
└─3*[{at-spi-bus-laun}]
├─at-spi2-registr───2*[{at-spi2-registr}]
├─dbus-daemon
├─ibus-portal───2*[{ibus-portal}]
└─pulseaudio───2*[{pulseaudio}]
├─systemd─┬─(sd-pam)
├─at-spi-bus-laun─┬─dbus-daemon
└─3*[{at-spi-bus-laun}]
├─at-spi2-registr───2*[{at-spi2-registr}]
├─dbus-daemon
├─dconf-service───2*[{dconf-service}]
├─evolution-addre─┬─evolution-addre───5*[{evolution-addre}]
└─4*[{evolution-addre}]
├─evolution-calen─┬─evolution-calen───8*[{evolution-calen}]
└─4*[{evolution-calen}]
├─evolution-sourc───3*[{evolution-sourc}]



可以看到各进程的树关系。