Report for CSC3150 assignment 1

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Design

- Program1
    - Intro

      This program aims to run a process under user mode. It first fork a child process and execute it. The parent will wait for the child process to return a signal and print out the related information.

    - Implement

        1. use `fork()` to fork a child proccess
        2. check pid; pid = 0 -> in child process; pid > 0 -> in parent process
        3. use `execve()` to execute the child process while parent using `waitpid()` to wait for the signal
        4. print out related information according to the value of signal

- Program2
    - Intro

      Program2 is to implement program1 in kernel mode, which requires to implement `my_fork`, `my_wait`, `my_exec`. Some functions are exported for use. After modification, recompile kernel and install the updated modules.

    - Implement

        1. use EXPORT_SYMBOL to export `kernel_clone`, `do_execve`, `getname_kernel`, and `do_wait`; then we can `extern` them in program2.c
        2. initiate module: create a kernel thread by `kthread_create()` and call `wake_up_process()` to run
        3. implement `my_fork()`:
            1. `my_exec()`: use `getname_kernel()` to get test program; use `do_execve()` to execute
            2. `my_wait()`: call `do_wait()` to get returned signal
            3. print out related information according to the value of signal; use bitwise operation to get signal

- Bonus
    - Intro

      This program implements linux command `pstree`. It shows processes in a tree structure. It's like a simulation which requires many details. In this project, I implement `pstree` and its `5` `options`.

- Design

    1. Build a structure `proc` to store each process information such as pid, ppid, name etc. It also has a vector to instore the index of its child processes.
    2. Read `\proc\[PID]\status` to store relevant information and build the tree (proc structure).
    3. Process the tree: (1) reorder the tree node according to the process name; (2) compress identical tree. This follows BFS oder.
    4. Print out the tree by DFS. The function contain a `mode` parameter to perform options.

        1. -u: display user

            UID and username can be found in `\etc\passwd`; Print out username which is not root; If the child has the same UID, it will not print out agin (using a flag).

        2. -p: display PID

            Every process will show its PID.

        3. -g: display GPID

            Every process will show its GPID. (similar to 2)

        4. -n: Sort processes with the same ancestor by PID

            In Step 3(1), do not do reording since the original insertion is by pid order

        5. -c: disable compaction of identical subtrees

            In Step 3(2), the same subtree will be compressed into one node with `cnt` as its repeated times. The remaining nodes have `cnt=0` instead of being deleted. Thus, just ignore `cnt` and print out all nodes.

Environment and execution

- Environment
    - OS version: Linux Ubuntu 5.4.0-6ubuntu1~16.04.12s
    - Kernel version: 5.10.5
- Execution

    - program1

    ```
    make
    ./program1 TEST
    ```

    where TEST is the executable file, e.g. ./abort

    - program2

1. update the kernel source code (use EXPORT_SYMBOL)
2. compile kernel

```
sudo su
cd path/to/kernel/file
make mrproper
make clean
make menuconfig
make bzImage
make modules
make modules_install
make install
reboot
```

1. cd path/to/program2

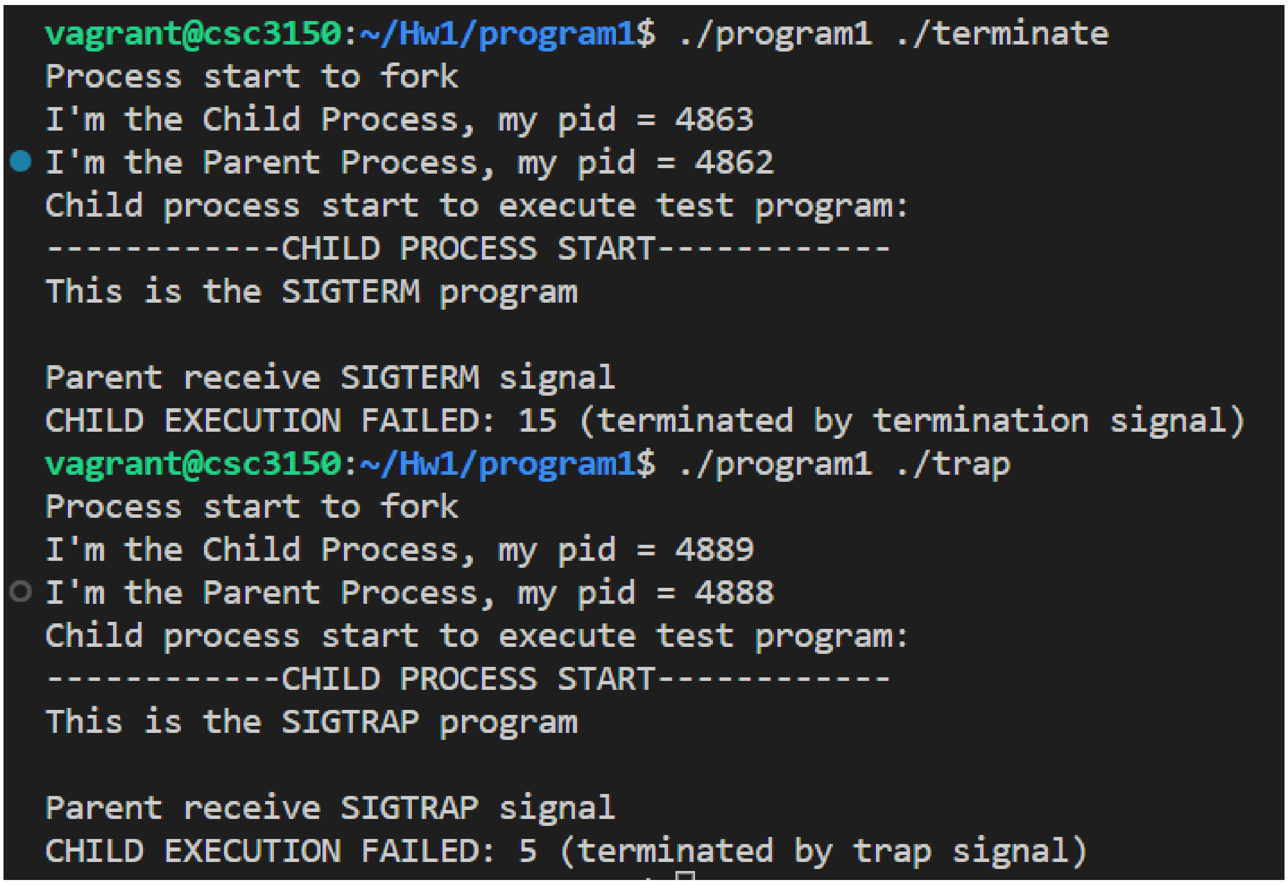
```
make
sudo insmod program2.ko
sudo rmmod program2
dmesg
```

dmesg is used to check the kernel log

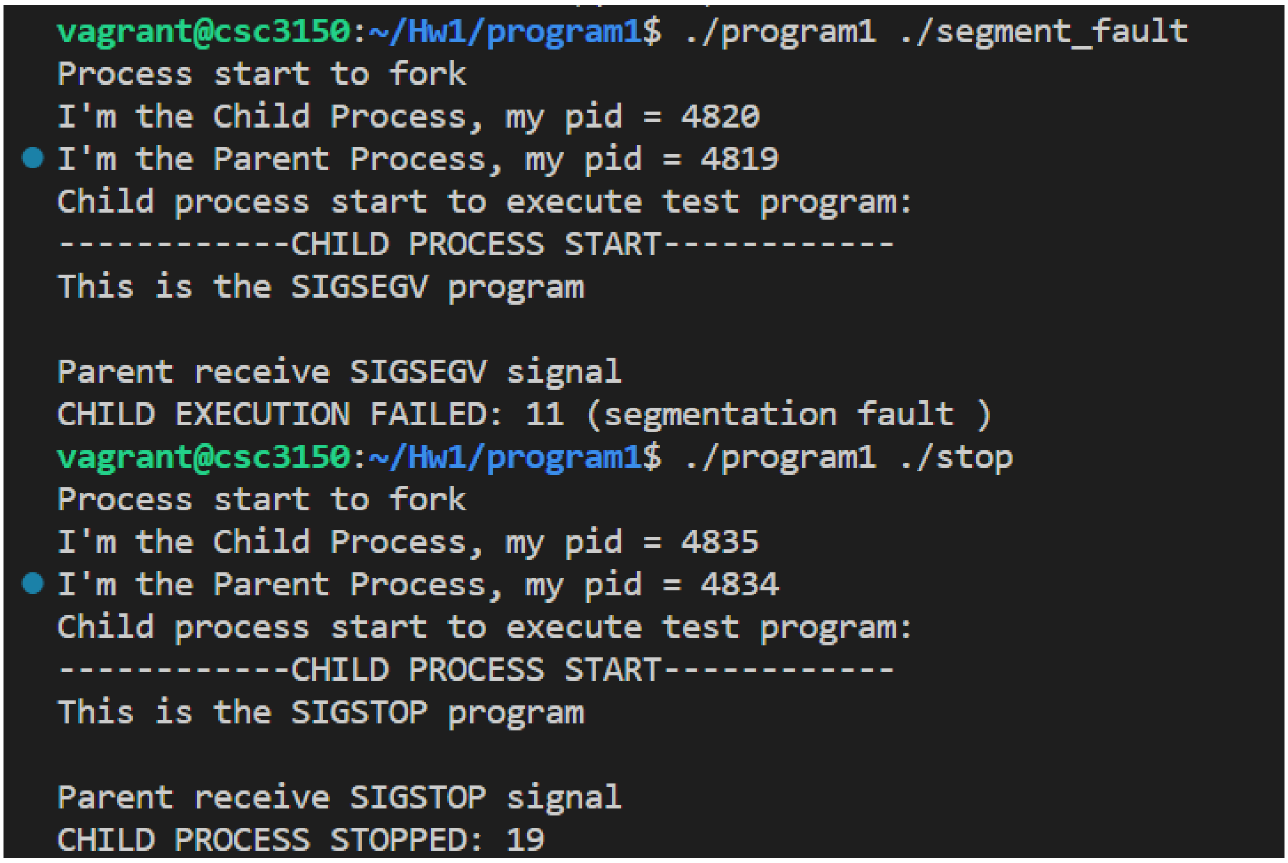
- bonus
  - use `make` to compile the file and get an executable file `pstree`.
  - Run `.\pstree -$option$`, e,g: `.\pstree -u`; for option:
    - empty: original pstree
      - `-u` show uid transitions
      - `-p` show PIDs
      - `-g` show PGIDs
      - `-n` Sort processes with the same ancestor by PID instead of name
      - `-c` disable compaction of identical subtrees

Output

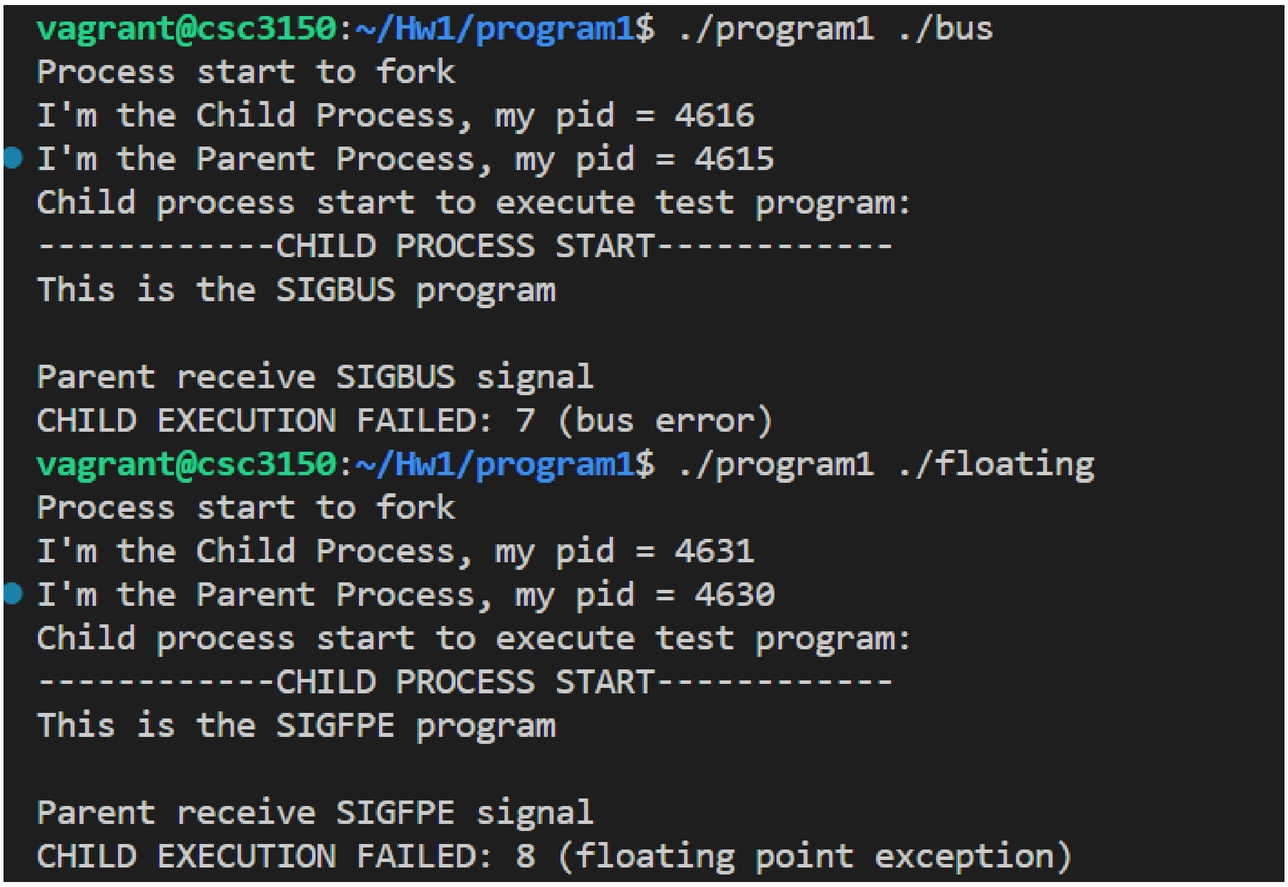
- Different tests for task 1 (15 cases)



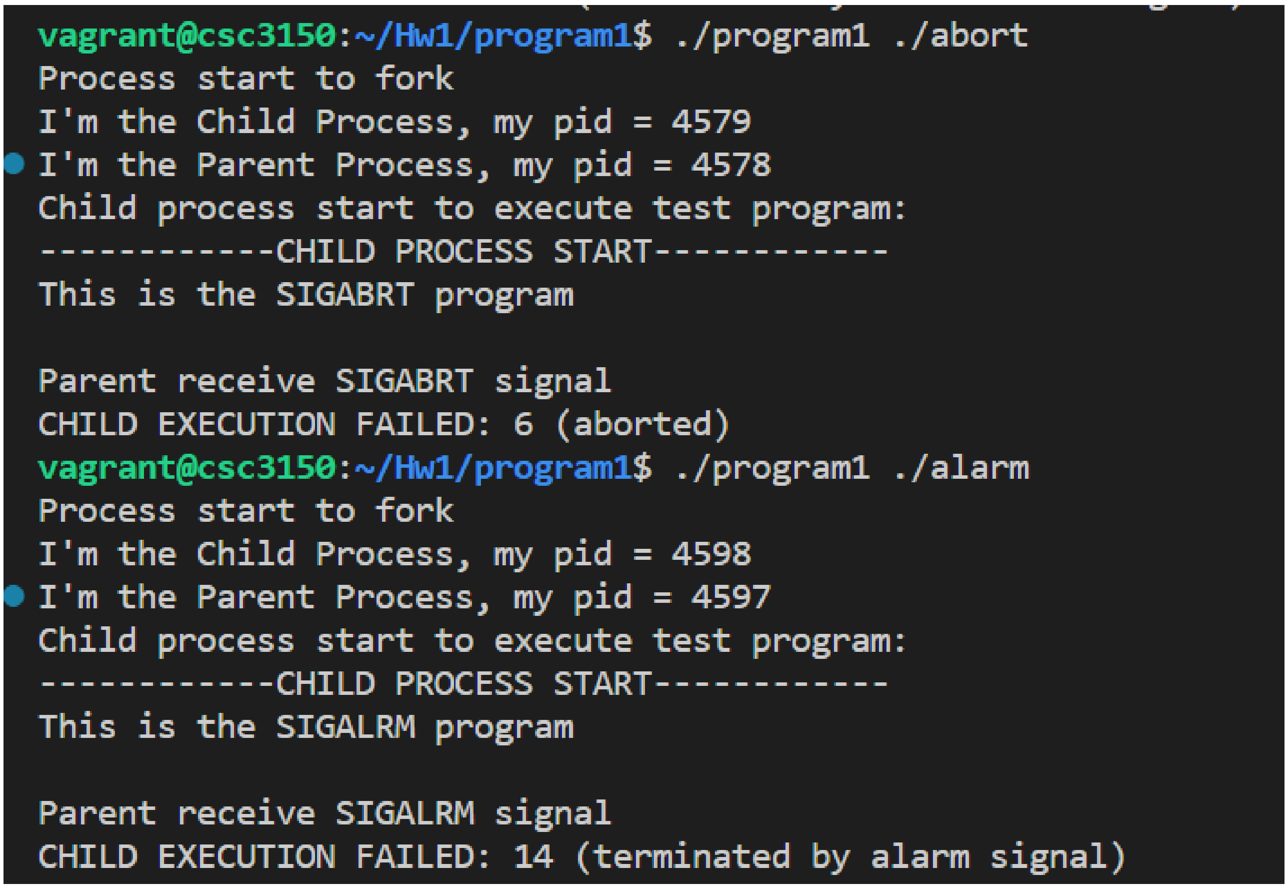
```
vagrant@csc3150:~/Hw1/program1$ ./program1 ./terminate
Process start to fork
I'm the Child Process, my pid = 4863
I'm the Parent Process, my pid = 4862
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGTERM program

Parent receive SIGTERM signal
CHILD EXECUTION FAILED: 15 (terminated by termination signal)
vagrant@csc3150:~/Hw1/program1$ ./program1 ./trap
Process start to fork
I'm the Child Process, my pid = 4889
I'm the Parent Process, my pid = 4888
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGTRAP program

Parent receive SIGTRAP signal
CHILD EXECUTION FAILED: 5 (terminated by trap signal)
```



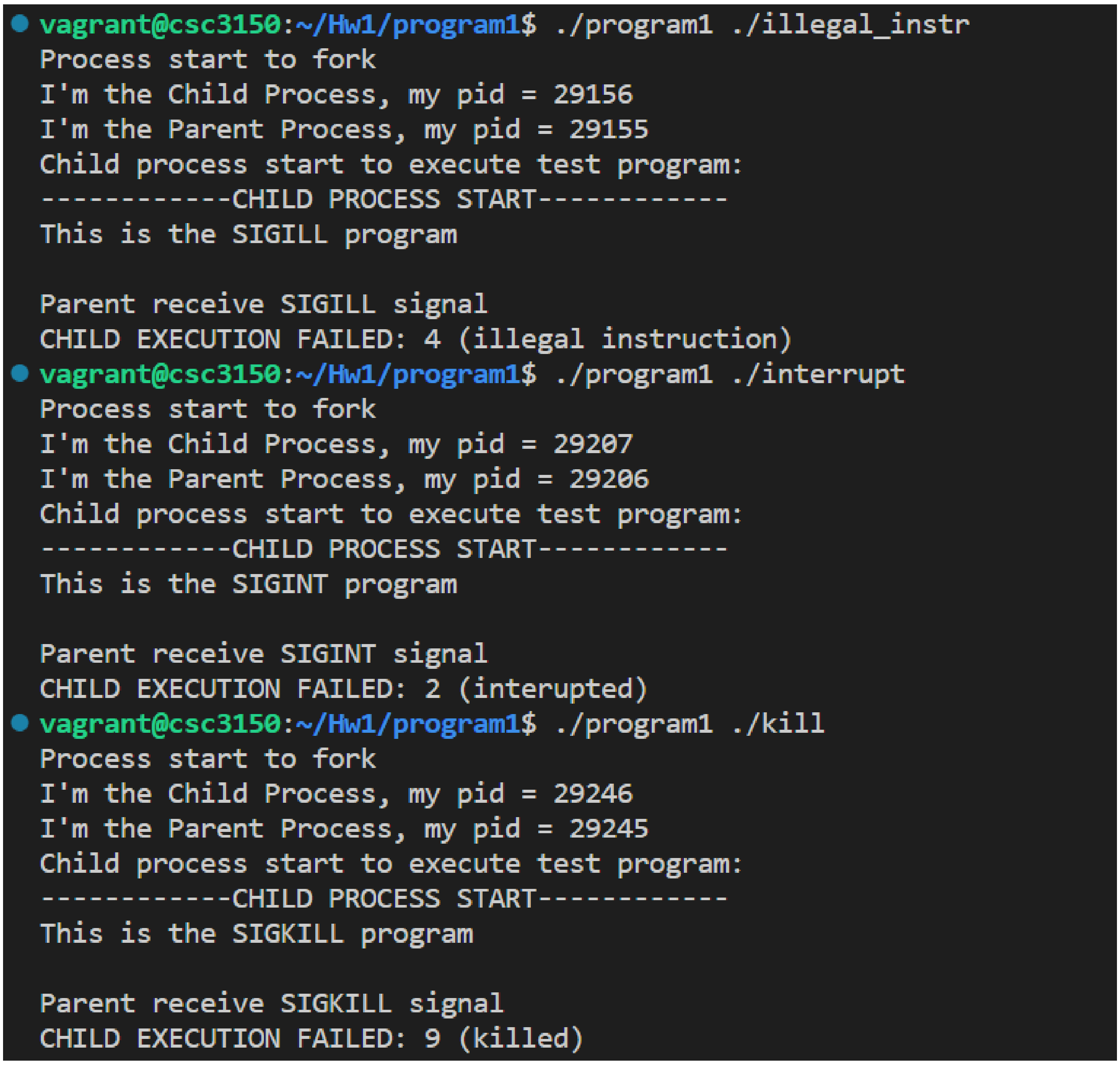
```
vagrant@csc3150:~/Hw1/program1$ ./program1 ./segment_fault
Process start to fork
I'm the Child Process, my pid = 4820
I'm the Parent Process, my pid = 4819
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGSEGV program

Parent receive SIGSEGV signal
CHILD EXECUTION FAILED: 11 (segmentation fault )
vagrant@csc3150:~/Hw1/program1$ ./program1 ./stop
Process start to fork
I'm the Child Process, my pid = 4835
I'm the Parent Process, my pid = 4834
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGSTOP program

Parent receive SIGSTOP signal
CHILD PROCESS STOPPED: 19
```



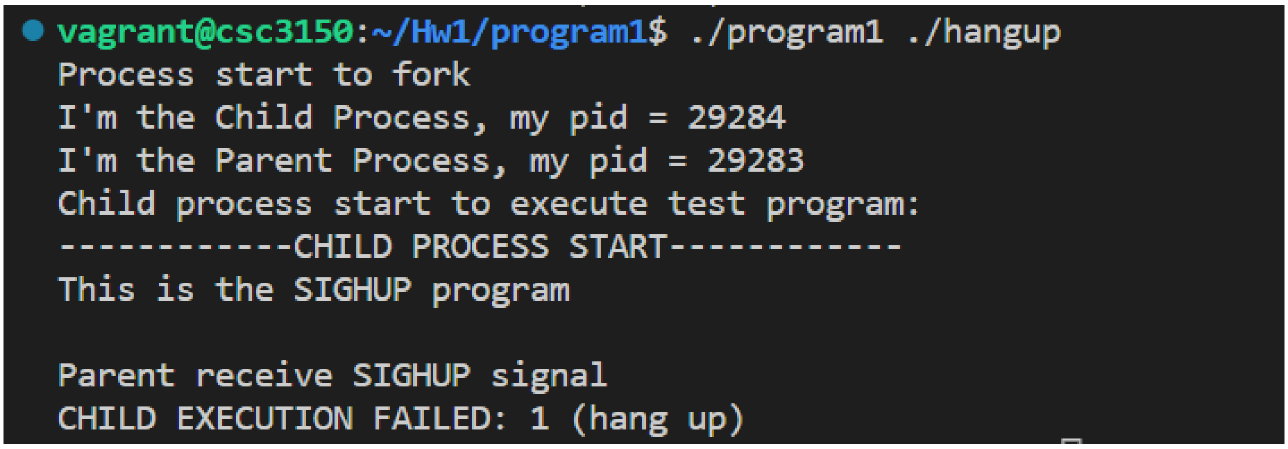
```
vagrant@csc3150:~/Hw1/program1$ ./program1 ./bus
Process start to fork
I'm the Child Process, my pid = 4616
I'm the Parent Process, my pid = 4615
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGBUS program

Parent receive SIGBUS signal
CHILD EXECUTION FAILED: 7 (bus error)
vagrant@csc3150:~/Hw1/program1$ ./program1 ./floating
Process start to fork
I'm the Child Process, my pid = 4631
I'm the Parent Process, my pid = 4630
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGFPE program

Parent receive SIGFPE signal
CHILD EXECUTION FAILED: 8 (floating point exception)
```



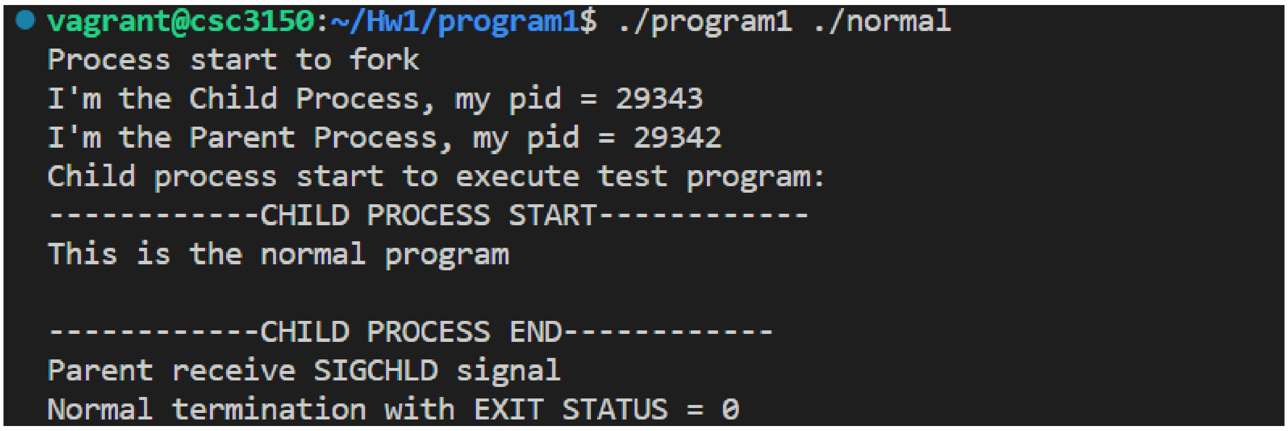
```
vagrant@csc3150:~/Hw1/program1$ ./program1 ./abort
Process start to fork
I'm the Child Process, my pid = 4579
I'm the Parent Process, my pid = 4578
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGABRT program

Parent receive SIGABRT signal
CHILD EXECUTION FAILED: 6 (aborted)
vagrant@csc3150:~/Hw1/program1$ ./program1 ./alarm
Process start to fork
I'm the Child Process, my pid = 4598
I'm the Parent Process, my pid = 4597
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGALRM program

Parent receive SIGALRM signal
CHILD EXECUTION FAILED: 14 (terminated by alarm signal)
```



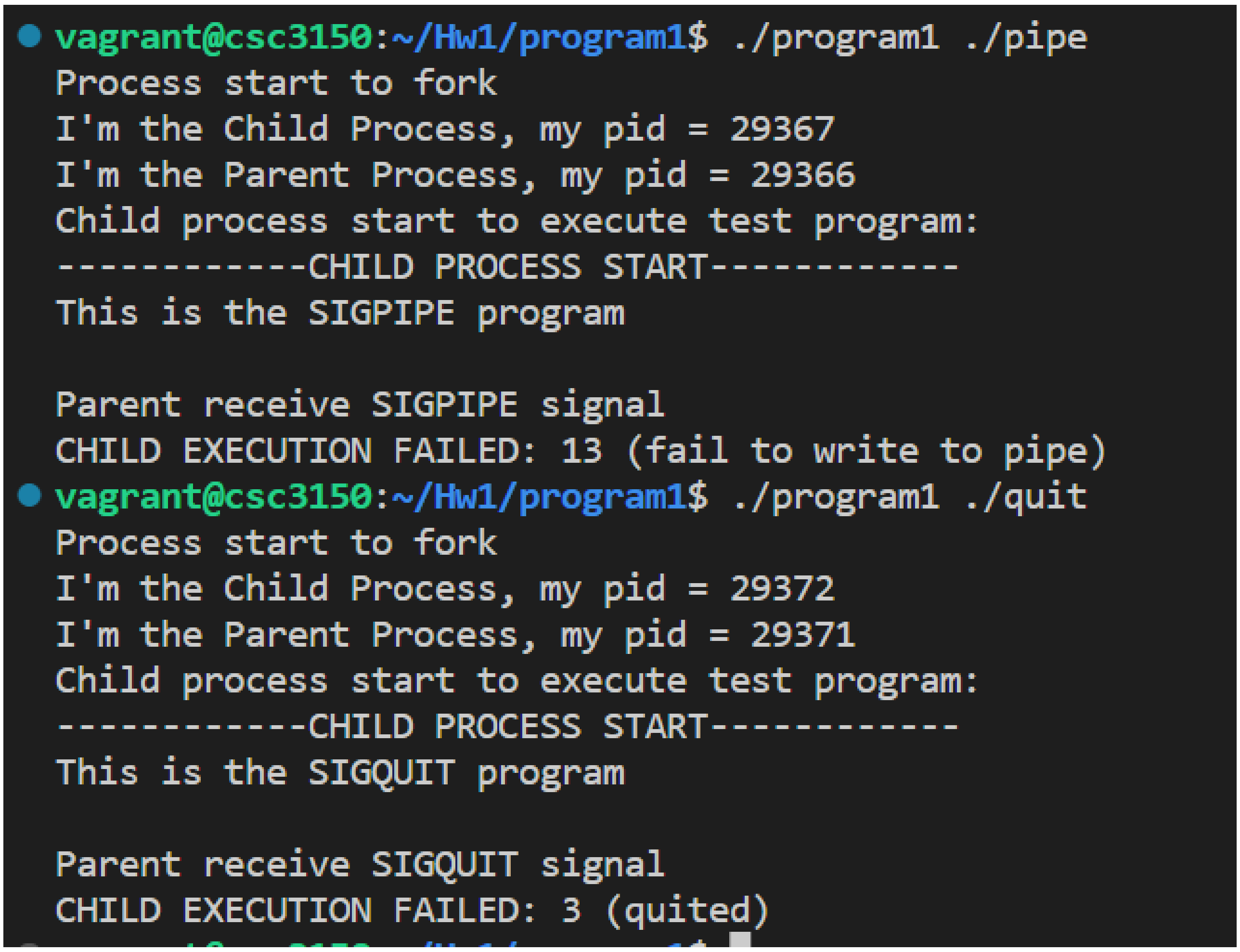
```
vagrant@csc3150:~/Hw1/program1$ ./program1 ./illegal_instr
Process start to fork
I'm the Child Process, my pid = 29156
I'm the Parent Process, my pid = 29155
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGILL program

Parent receive SIGILL signal
CHILD EXECUTION FAILED: 4 (illegal instruction)
vagrant@csc3150:~/Hw1/program1$ ./program1 ./interrupt
Process start to fork
I'm the Child Process, my pid = 29207
I'm the Parent Process, my pid = 29206
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGINT program

Parent receive SIGINT signal
CHILD EXECUTION FAILED: 2 (interupted)
vagrant@csc3150:~/Hw1/program1$ ./program1 ./kill
Process start to fork
I'm the Child Process, my pid = 29246
I'm the Parent Process, my pid = 29245
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGKILL program

Parent receive SIGKILL signal
CHILD EXECUTION FAILED: 9 (killed)
```



```
vagrant@csc3150:~/Hw1/program1$ ./program1 ./hangup
Process start to fork
I'm the Child Process, my pid = 29284
I'm the Parent Process, my pid = 29283
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGHUP program

Parent receive SIGHUP signal
CHILD EXECUTION FAILED: 1 (hang up)
```

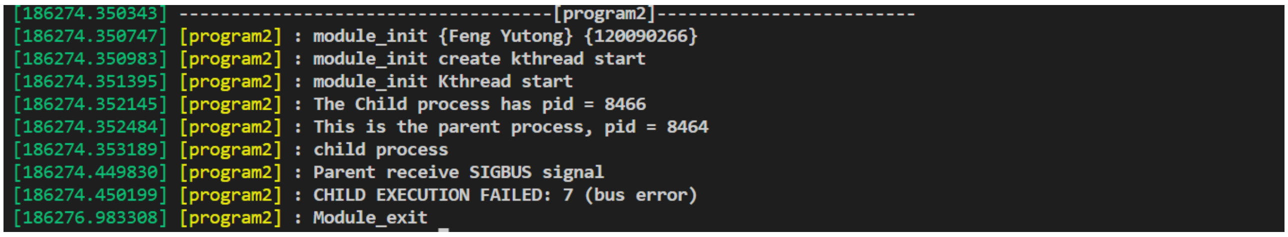


```
vagrant@csc3150:~/Hw1/program1$ ./program1 ./normal
Process start to fork
I'm the Child Process, my pid = 29343
I'm the Parent Process, my pid = 29342
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the normal program

------------CHILD PROCESS END------------
Parent receive SIGCHLD signal
Normal termination with EXIT STATUS = 0
```

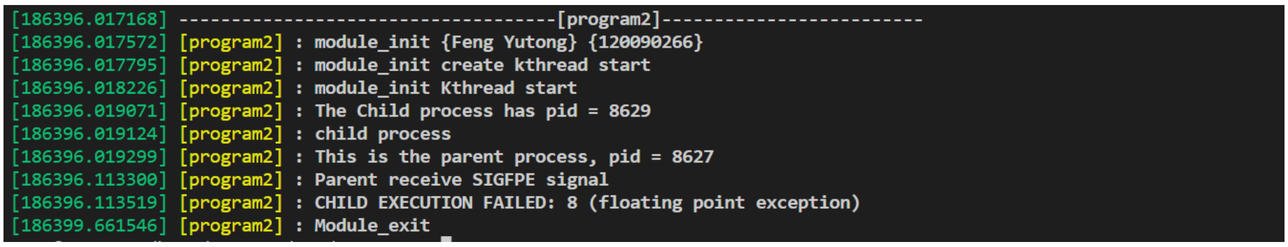


```
vagrant@csc3150:~/Hw1/program1$ ./program1 ./pipe
Process start to fork
I'm the Child Process, my pid = 29367
I'm the Parent Process, my pid = 29366
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGPIPE program

Parent receive SIGPIPE signal
CHILD EXECUTION FAILED: 13 (fail to write to pipe)
vagrant@csc3150:~/Hw1/program1$ ./program1 ./quit
Process start to fork
I'm the Child Process, my pid = 29372
I'm the Parent Process, my pid = 29371
Child process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGQUIT program

Parent receive SIGQUIT signal
CHILD EXECUTION FAILED: 3 (quited)
```

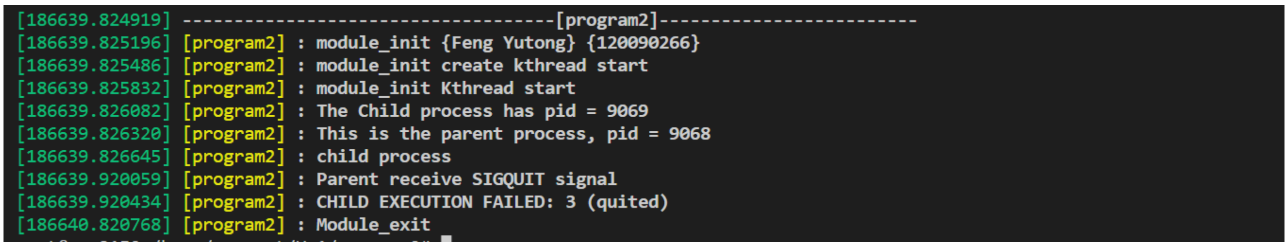
- Different tests for task 2 (15 cases)



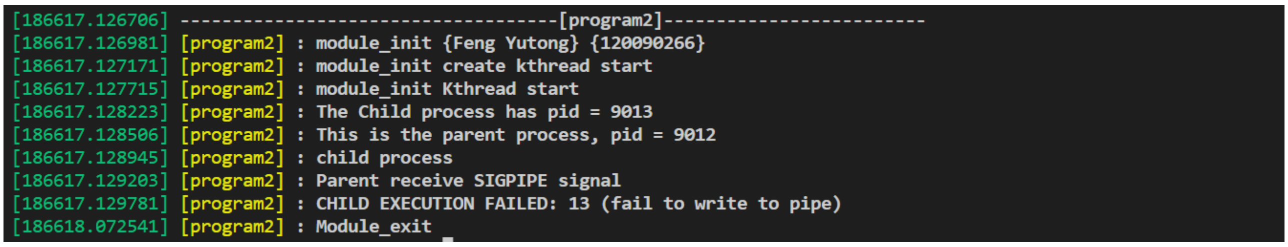
```
[186274.350343] ------------------------------------[program2]------------------------
[186274.350747] [program2] : module_init {Feng Yutong} {120090266}
[186274.350983] [program2] : module_init create kthread start
[186274.351395] [program2] : module_init Kthread start
[186274.352145] [program2] : The Child process has pid = 8466
[186274.352484] [program2] : This is the parent process, pid = 8464
[186274.353189] [program2] : child process
[186274.449830] [program2] : Parent receive SIGBUS signal
[186274.450199] [program2] : CHILD EXECUTION FAILED: 7 (bus error)
[186276.983308] [program2] : Module_exit
```



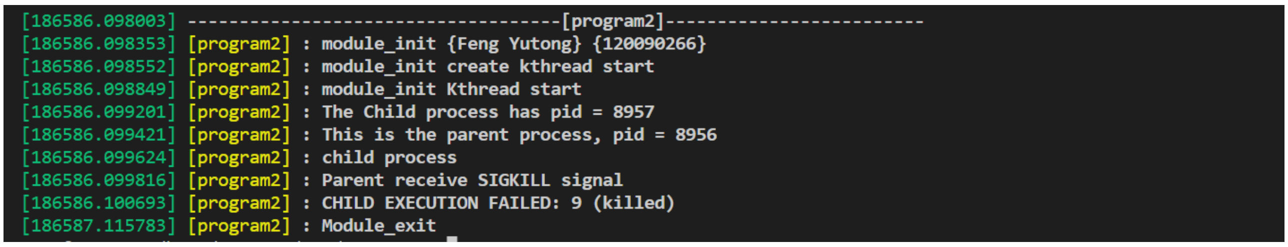
```
[186396.017168] ------------------------------------[program2]------------------------
[186396.017572] [program2] : module_init {Feng Yutong} {120090266}
[186396.017795] [program2] : module_init create kthread start
[186396.018226] [program2] : module_init Kthread start
[186396.019071] [program2] : The Child process has pid = 8629
[186396.019124] [program2] : child process
[186396.019299] [program2] : This is the parent process, pid = 8627
[186396.113300] [program2] : Parent receive SIGFPE signal
[186396.113519] [program2] : CHILD EXECUTION FAILED: 8 (floating point exception)
[186399.661546] [program2] : Module_exit
```



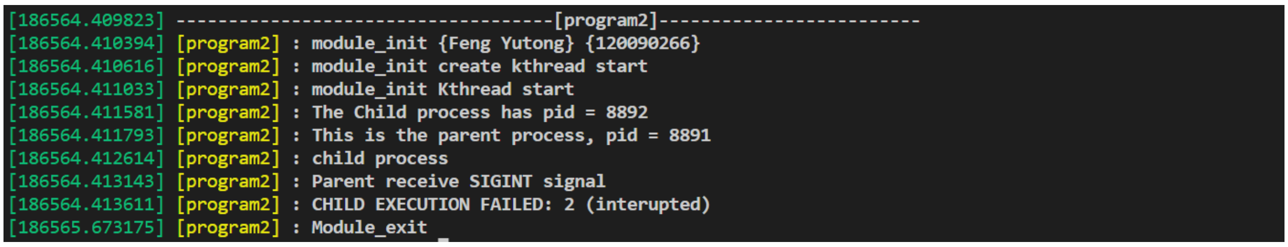
```
[186639.824919] -----------------------------------[program2]------------------------
[186639.825196] [program2] : module_init {Feng Yutong} {120090266}
[186639.825486] [program2] : module_init create kthread start
[186639.825832] [program2] : module_init Kthread start
[186639.826082] [program2] : The Child process has pid = 9069
[186639.826320] [program2] : This is the parent process, pid = 9068
[186639.826645] [program2] : child process
[186639.920059] [program2] : Parent receive SIGQUIT signal
[186639.920434] [program2] : CHILD EXECUTION FAILED: 3 (quited)
[186640.820768] [program2] : Module_exit
```



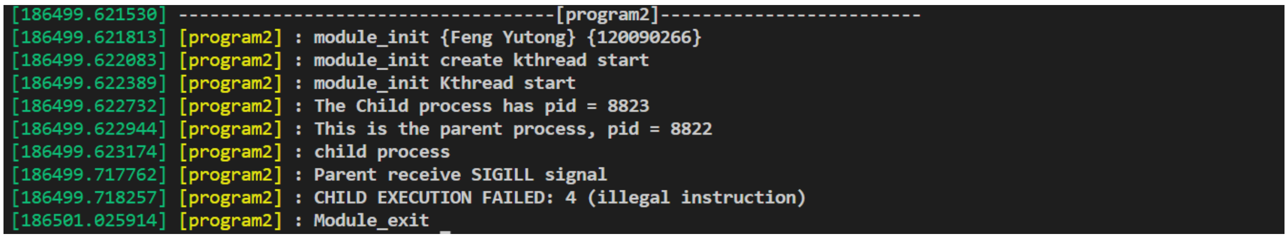
```
[186617.126706] -----------------------------------[program2]------------------------
[186617.126981] [program2] : module_init {Feng Yutong} {120090266}
[186617.127171] [program2] : module_init create kthread start
[186617.127715] [program2] : module_init Kthread start
[186617.128223] [program2] : The Child process has pid = 9013
[186617.128506] [program2] : This is the parent process, pid = 9012
[186617.128945] [program2] : child process
[186617.129203] [program2] : Parent receive SIGPIPE signal
[186617.129781] [program2] : CHILD EXECUTION FAILED: 13 (fail to write to pipe)
[186618.072541] [program2] : Module_exit
```



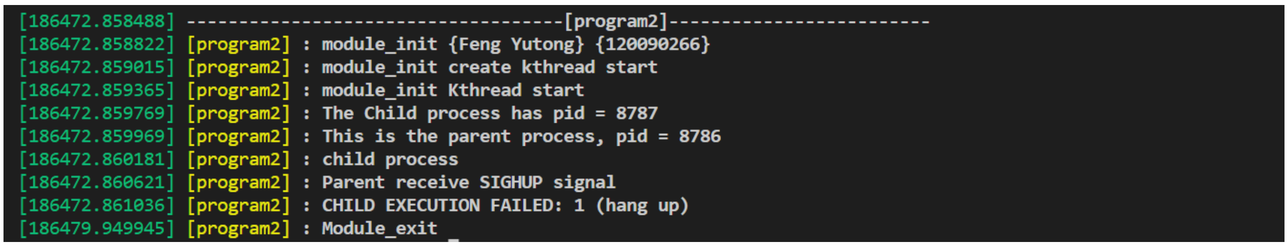
```
[186586.098003] -----------------------------------[program2]------------------------
[186586.098353] [program2] : module_init {Feng Yutong} {120090266}
[186586.098552] [program2] : module_init create kthread start
[186586.098849] [program2] : module_init Kthread start
[186586.099201] [program2] : The Child process has pid = 8957
[186586.099421] [program2] : This is the parent process, pid = 8956
[186586.099624] [program2] : child process
[186586.099816] [program2] : Parent receive SIGKILL signal
[186586.100693] [program2] : CHILD EXECUTION FAILED: 9 (killed)
[186587.115783] [program2] : Module_exit
```



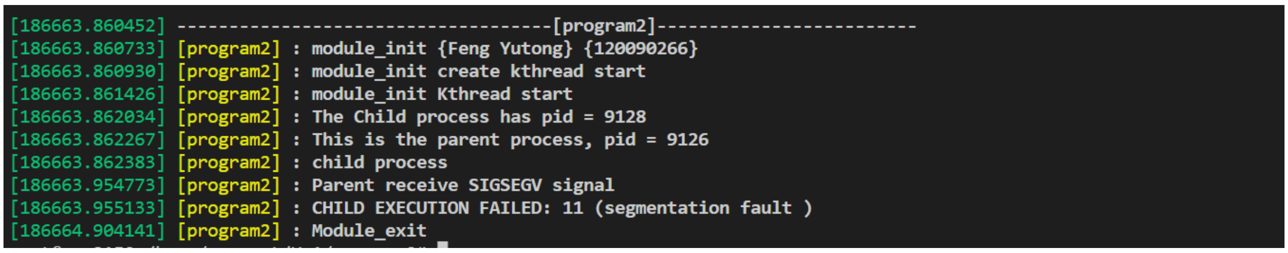
```
[186564.409823] -----------------------------------[program2]------------------------
[186564.410394] [program2] : module_init {Feng Yutong} {120090266}
[186564.410616] [program2] : module_init create kthread start
[186564.411033] [program2] : module_init Kthread start
[186564.411581] [program2] : The Child process has pid = 8892
[186564.411793] [program2] : This is the parent process, pid = 8891
[186564.412614] [program2] : child process
[186564.413143] [program2] : Parent receive SIGINT signal
[186564.413611] [program2] : CHILD EXECUTION FAILED: 2 (interupted)
[186565.673175] [program2] : Module_exit
```



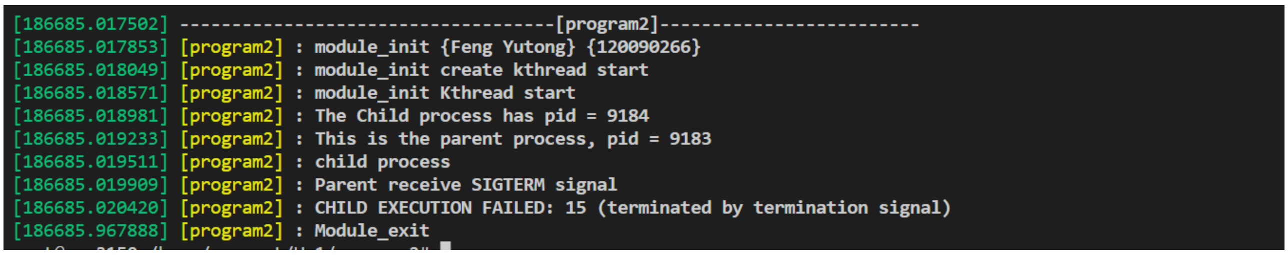
```
[186499.621530] -----------------------------------[program2]------------------------
[186499.621813] [program2] : module_init {Feng Yutong} {120090266}
[186499.622083] [program2] : module_init create kthread start
[186499.622389] [program2] : module_init Kthread start
[186499.622732] [program2] : The Child process has pid = 8823
[186499.622944] [program2] : This is the parent process, pid = 8822
[186499.623174] [program2] : child process
[186499.717762] [program2] : Parent receive SIGILL signal
[186499.718257] [program2] : CHILD EXECUTION FAILED: 4 (illegal instruction)
[186501.025914] [program2] : Module_exit
```



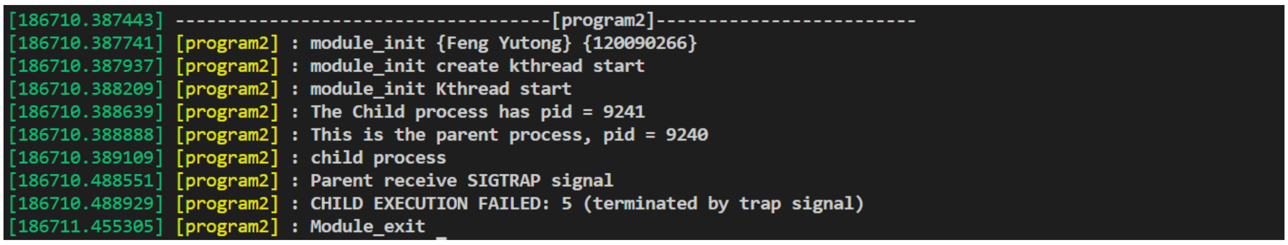
```
[186472.858488] -----------------------------------[program2]------------------------
[186472.858822] [program2] : module_init {Feng Yutong} {120090266}
[186472.859015] [program2] : module_init create kthread start
[186472.859365] [program2] : module_init Kthread start
[186472.859769] [program2] : The Child process has pid = 8787
[186472.859969] [program2] : This is the parent process, pid = 8786
[186472.860181] [program2] : child process
[186472.860621] [program2] : Parent receive SIGHUP signal
[186472.861036] [program2] : CHILD EXECUTION FAILED: 1 (hang up)
[186479.949945] [program2] : Module_exit
```



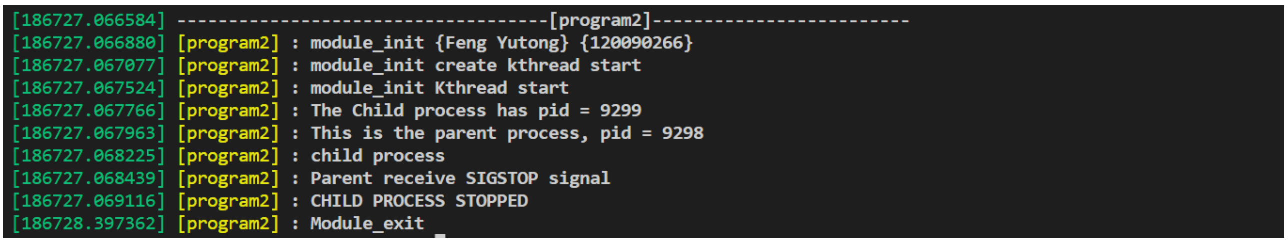
```
[186663.860452] -----------------------------------[program2]------------------------
[186663.860733] [program2] : module_init {Feng Yutong} {120090266}
[186663.860930] [program2] : module_init create kthread start
[186663.861426] [program2] : module_init Kthread start
[186663.862034] [program2] : The Child process has pid = 9128
[186663.862267] [program2] : This is the parent process, pid = 9126
[186663.862383] [program2] : child process
[186663.954773] [program2] : Parent receive SIGSEGV signal
[186663.955133] [program2] : CHILD EXECUTION FAILED: 11 (segmentation fault )
[186664.904141] [program2] : Module_exit
```



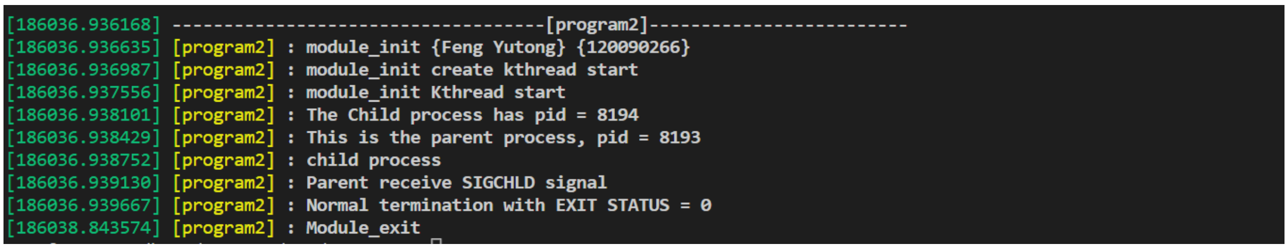
```
[186685.017502] -----------------------------------[program2]------------------------
[186685.017853] [program2] : module_init {Feng Yutong} {120090266}
[186685.018049] [program2] : module_init create kthread start
[186685.018571] [program2] : module_init Kthread start
[186685.018981] [program2] : The Child process has pid = 9184
[186685.019233] [program2] : This is the parent process, pid = 9183
[186685.019511] [program2] : child process
[186685.019909] [program2] : Parent receive SIGTERM signal
[186685.020420] [program2] : CHILD EXECUTION FAILED: 15 (terminated by termination signal)
[186685.967888] [program2] : Module_exit
```



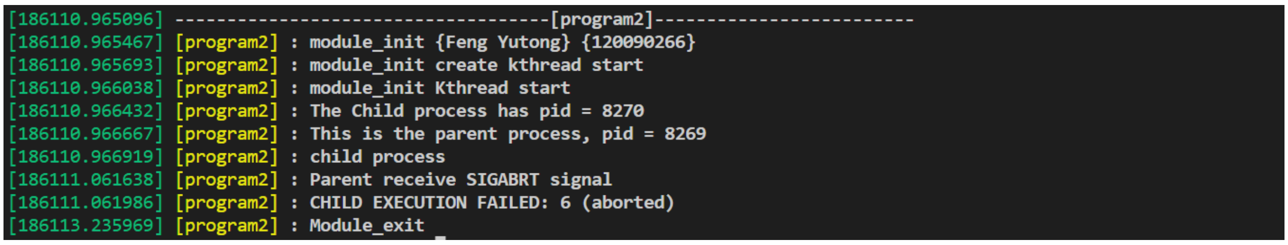
```
[186710.387443] -----------------------------------[program2]------------------------
[186710.387741] [program2] : module_init {Feng Yutong} {120090266}
[186710.387937] [program2] : module_init create kthread start
[186710.388209] [program2] : module_init Kthread start
[186710.388639] [program2] : The Child process has pid = 9241
[186710.388888] [program2] : This is the parent process, pid = 9240
[186710.389109] [program2] : child process
[186710.488551] [program2] : Parent receive SIGTRAP signal
[186710.488929] [program2] : CHILD EXECUTION FAILED: 5 (terminated by trap signal)
[186711.455305] [program2] : Module_exit
```



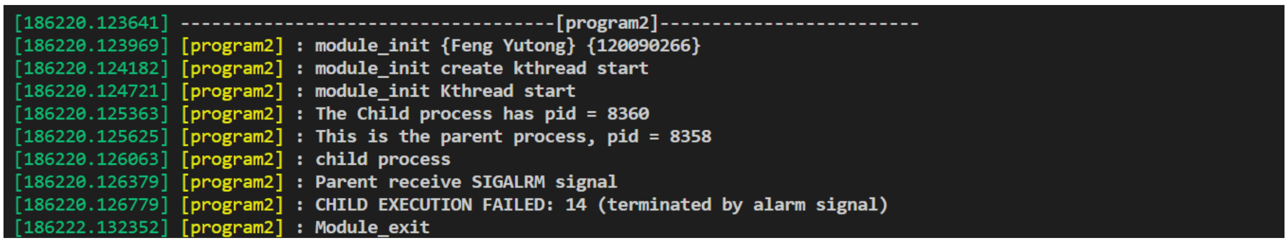
```
[186727.066584] -----------------------------------[program2]------------------------
[186727.066880] [program2] : module_init {Feng Yutong} {120090266}
[186727.067077] [program2] : module_init create kthread start
[186727.067524] [program2] : module_init Kthread start
[186727.067766] [program2] : The Child process has pid = 9299
[186727.067963] [program2] : This is the parent process, pid = 9298
[186727.068225] [program2] : child process
[186727.068439] [program2] : Parent receive SIGSTOP signal
[186727.069116] [program2] : CHILD PROCESS STOPPED
[186728.397362] [program2] : Module_exit
```



```
[186036.936168] -----------------------------------[program2]------------------------
[186036.936635] [program2] : module_init {Feng Yutong} {120090266}
[186036.936987] [program2] : module_init create kthread start
[186036.937556] [program2] : module_init Kthread start
[186036.938101] [program2] : The Child process has pid = 8194
[186036.938429] [program2] : This is the parent process, pid = 8193
[186036.938752] [program2] : child process
[186036.939130] [program2] : Parent receive SIGCHLD signal
[186036.939667] [program2] : Normal termination with EXIT STATUS = 0
[186038.843574] [program2] : Module_exit
```



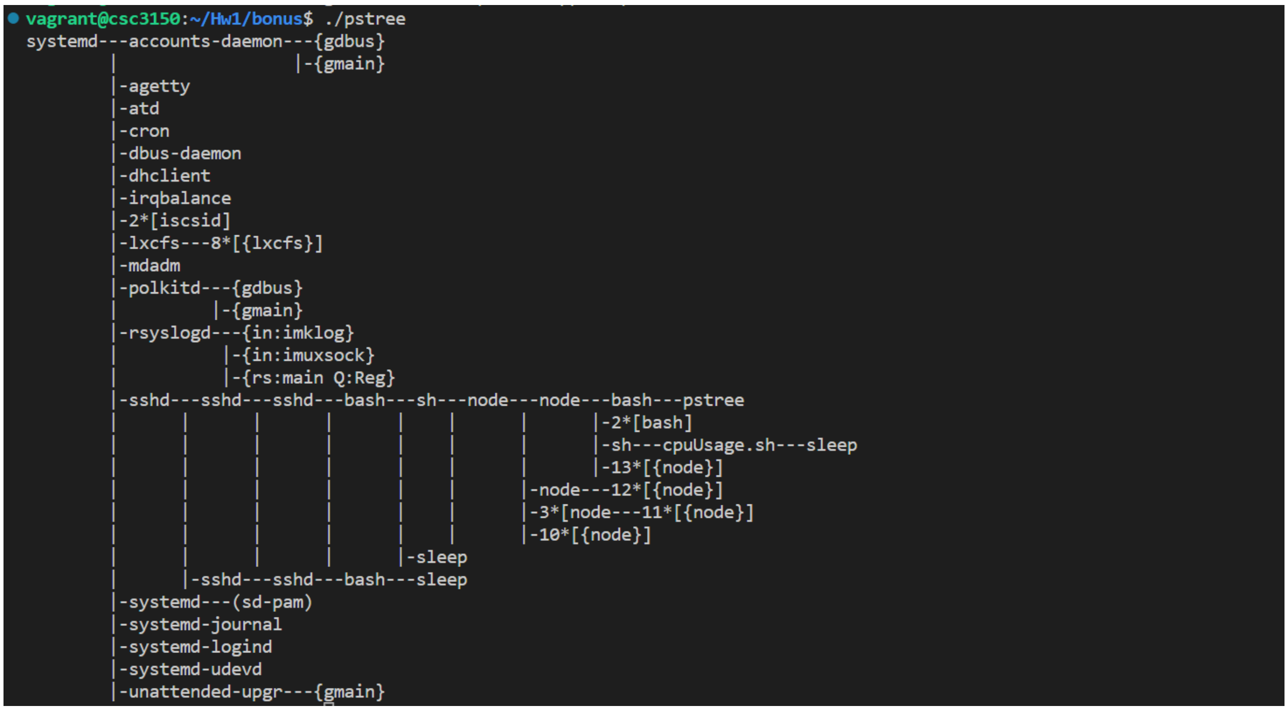
```
[186110.965096] -----------------------------------[program2]------------------------
[186110.965467] [program2] : module_init {Feng Yutong} {120090266}
[186110.965693] [program2] : module_init create kthread start
[186110.966038] [program2] : module_init Kthread start
[186110.966432] [program2] : The Child process has pid = 8270
[186110.966667] [program2] : This is the parent process, pid = 8269
[186110.966919] [program2] : child process
[186111.061638] [program2] : Parent receive SIGABRT signal
[186111.061986] [program2] : CHILD EXECUTION FAILED: 6 (aborted)
[186113.235969] [program2] : Module_exit
```



```
[186220.123641] -----------------------------------[program2]------------------------
[186220.123969] [program2] : module_init {Feng Yutong} {120090266}
[186220.124182] [program2] : module_init create kthread start
[186220.124721] [program2] : module_init Kthread start
[186220.125363] [program2] : The Child process has pid = 8360
[186220.125625] [program2] : This is the parent process, pid = 8358
[186220.126063] [program2] : child process
[186220.126379] [program2] : Parent receive SIGALRM signal
[186220.126779] [program2] : CHILD EXECUTION FAILED: 14 (terminated by alarm signal)
[186222.132352] [program2] : Module_exit
```

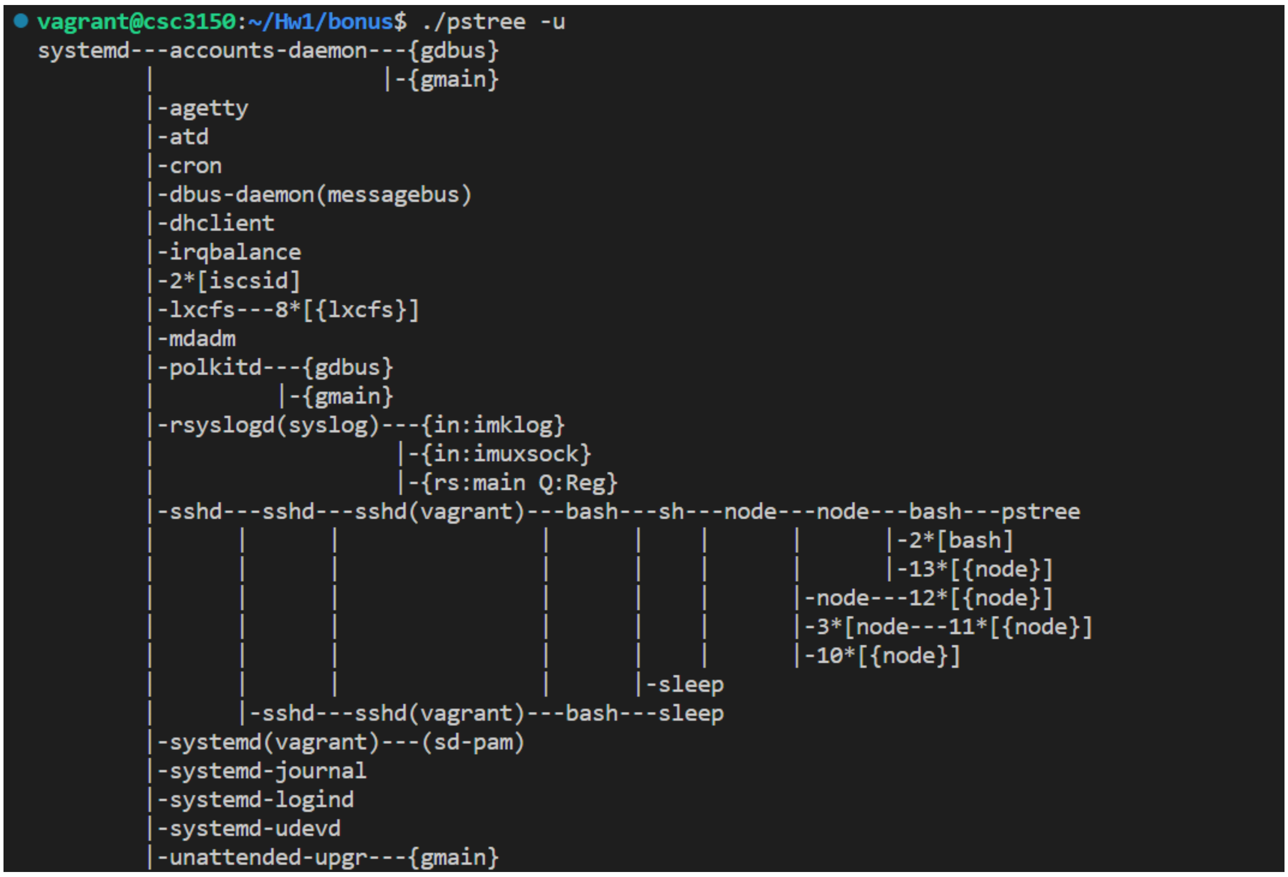
- Bonus (6 cases)

1. pstree



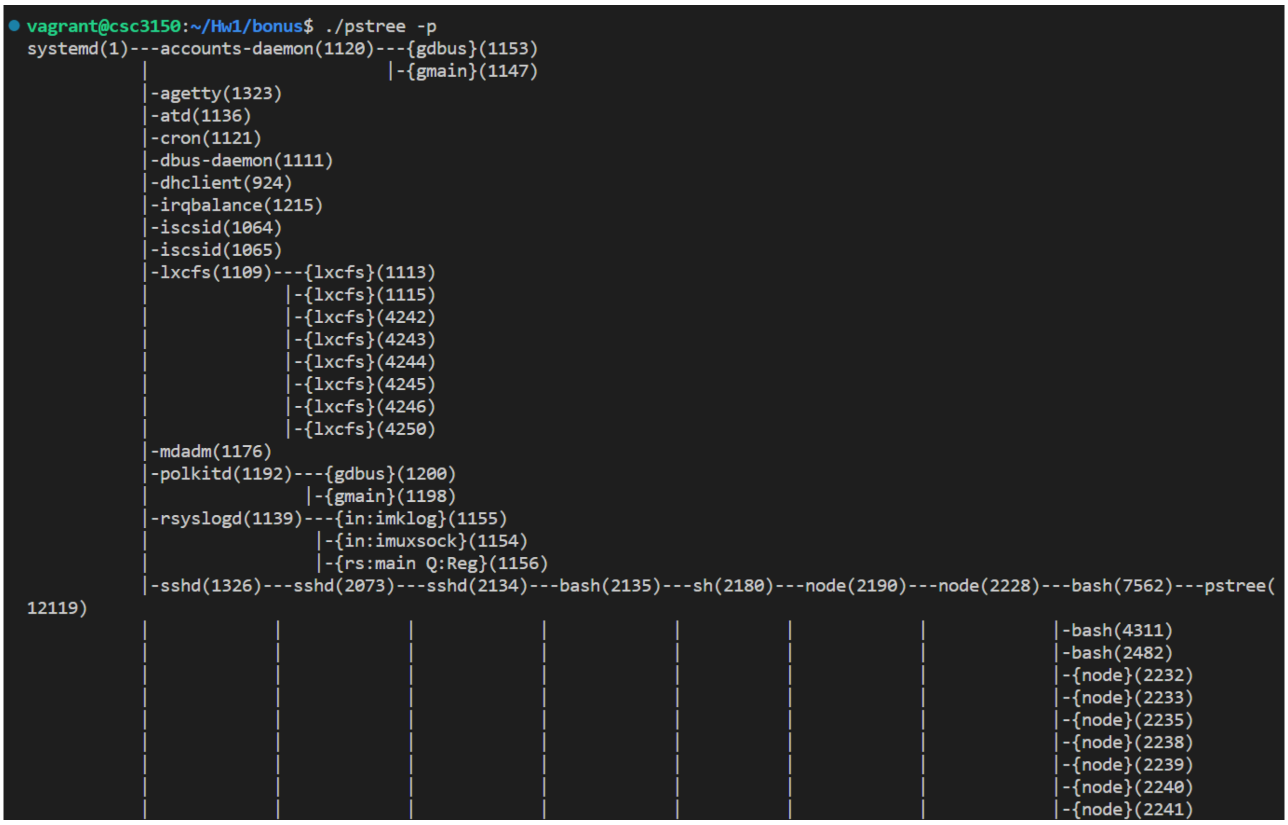
```
vagrant@csc3150:~/Hw1/bonus$ ./pstree
systemd---accounts-daemon---{gdbus}
        |                 |-{gmain}
        |-agetty
        |-atd
        |-cron
        |-dbus-daemon
        |-dhclient
        |-irqbalance
        |-2*[iscsid]
        |-lxcfs---8*[{lxcfs}]
        |-mdadm
        |-polkitd---{gdbus}
        |         |-{gmain}
        |-rsyslogd---{in:imklog}
        |          |-{in:imuxsock}
        |          |-{rs:main Q:Reg}
        |-sshd---sshd---sshd---bash---sh---node---node---bash---pstree
        |      |      |      |      |    |      |      |-2*[bash]
        |      |      |      |      |    |      |      |-sh---cpuUsage.sh---sleep
        |      |      |      |      |    |      |      |-13*[{node}]
        |      |      |      |      |    |      |-node---12*[{node}]
        |      |      |      |      |    |      |-3*[node---11*[{node}]
        |      |      |      |      |    |      |-10*[{node}]
        |      |      |      |      |-sleep
        |      |-sshd---sshd---bash---sleep
        |-systemd---(sd-pam)
        |-systemd-journal
        |-systemd-logind
        |-systemd-udevd
        |-unattended-upgr---{gmain}
```

2. pstree -u

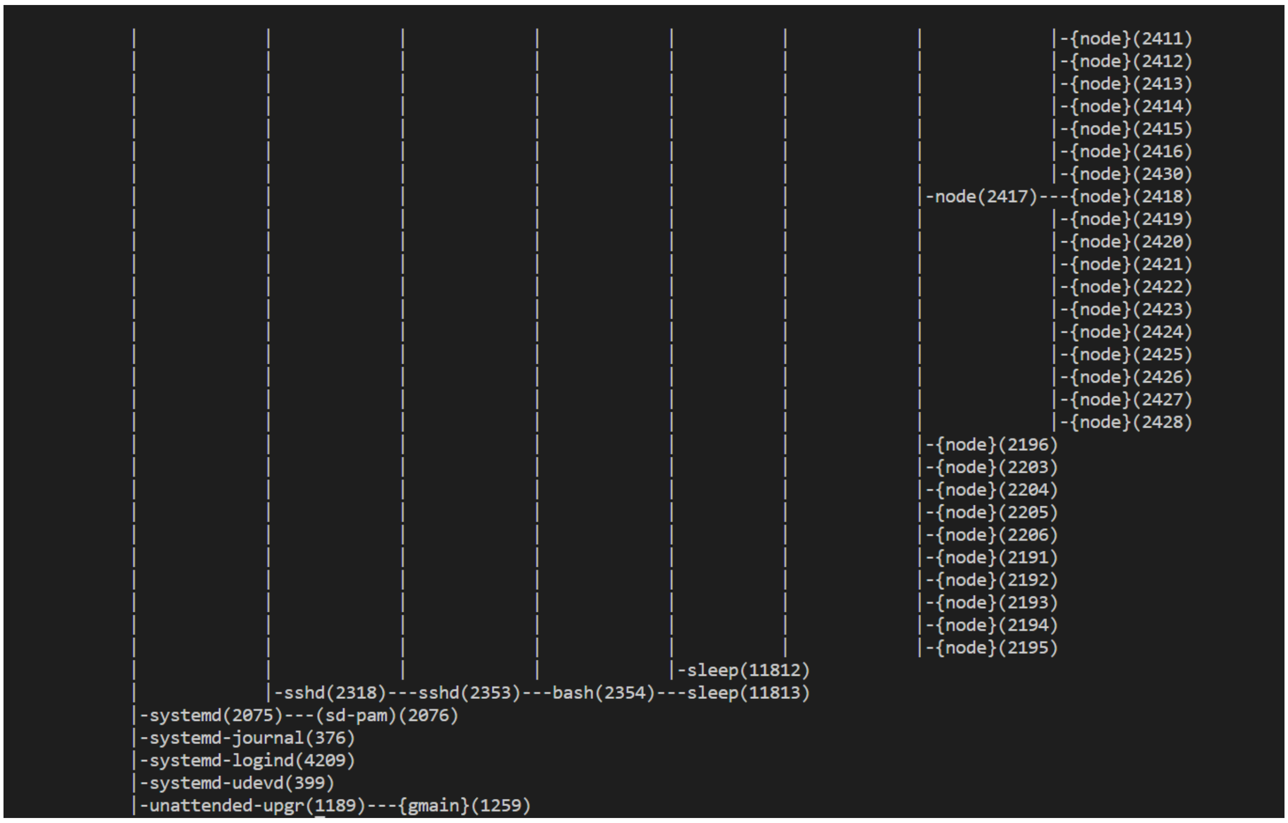


```
vagrant@csc3150:~/Hw1/bonus$ ./pstree -u
systemd---accounts-daemon---{gdbus}
        |                 |-{gmain}
        |-agetty
        |-atd
        |-cron
        |-dbus-daemon(messagebus)
        |-dhclient
        |-irqbalance
        |-2*[iscsid]
        |-lxcfs---8*[{lxcfs}]
        |-mdadm
        |-polkitd---{gdbus}
        |         |-{gmain}
        |-rsyslogd(syslog)---{in:imklog}
        |                  |-{in:imuxsock}
        |                  |-{rs:main Q:Reg}
        |-sshd---sshd---sshd(vagrant)---bash---sh---node---node---bash---pstree
        |      |      |               |      |    |      |      |-2*[bash]
        |      |      |               |      |    |      |      |-13*[{node}]
        |      |      |               |      |    |      |-node---12*[{node}]
        |      |      |               |      |    |      |-3*[node---11*[{node}]
        |      |      |               |      |    |      |-10*[{node}]
        |      |      |               |      |-sleep
        |      |-sshd---sshd(vagrant)---bash---sleep
        |-systemd(vagrant)---(sd-pam)
        |-systemd-journal
        |-systemd-logind
        |-systemd-udevd
        |-unattended-upgr---{gmain}
```

3. pstree -p (skip middle part for it's just too long nodes)

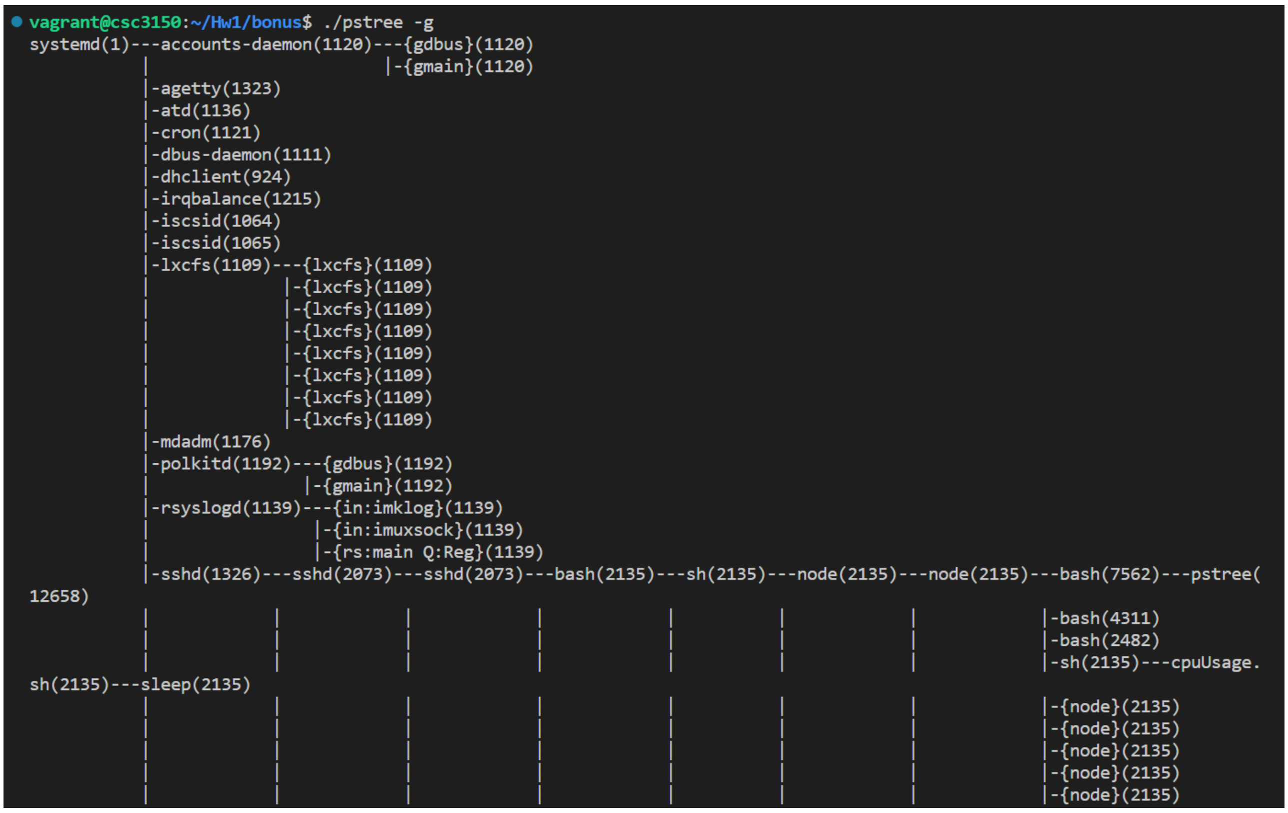


```
● vagrant@csc3150:~/Hw1/bonus$ ./pstree -p
systemd(1)---accounts-daemon(1120)---{gdbus}(1153)
           |                       |-{gmain}(1147)
           |-agetty(1323)
           |-atd(1136)
           |-cron(1121)
           |-dbus-daemon(1111)
           |-dhclient(924)
           |-irqbalance(1215)
           |-iscsid(1064)
           |-iscsid(1065)
           |-lxcfs(1109)---{lxcfs}(1113)
           |             |-{lxcfs}(1115)
           |             |-{lxcfs}(4242)
           |             |-{lxcfs}(4243)
           |             |-{lxcfs}(4244)
           |             |-{lxcfs}(4245)
           |             |-{lxcfs}(4246)
           |             |-{lxcfs}(4250)
           |-mdadm(1176)
           |-polkitd(1192)---{gdbus}(1200)
           |               |-{gmain}(1198)
           |-rsyslogd(1139)---{in:imklog}(1155)
           |                |-{in:imuxsock}(1154)
           |                |-{rs:main Q:Reg}(1156)
           |-sshd(1326)---sshd(2073)---sshd(2134)---bash(2135)---sh(2180)---node(2190)---node(2228)---bash(7562)---pstree(
12119)
           |            |            |            |            |          |            |            |-bash(4311)
           |            |            |            |            |          |            |            |-bash(2482)
           |            |            |            |            |          |            |            |-{node}(2232)
           |            |            |            |            |          |            |            |-{node}(2233)
           |            |            |            |            |          |            |            |-{node}(2235)
           |            |            |            |            |          |            |            |-{node}(2238)
           |            |            |            |            |          |            |            |-{node}(2239)
           |            |            |            |            |          |            |            |-{node}(2240)
           |            |            |            |            |          |            |            |-{node}(2241)
```

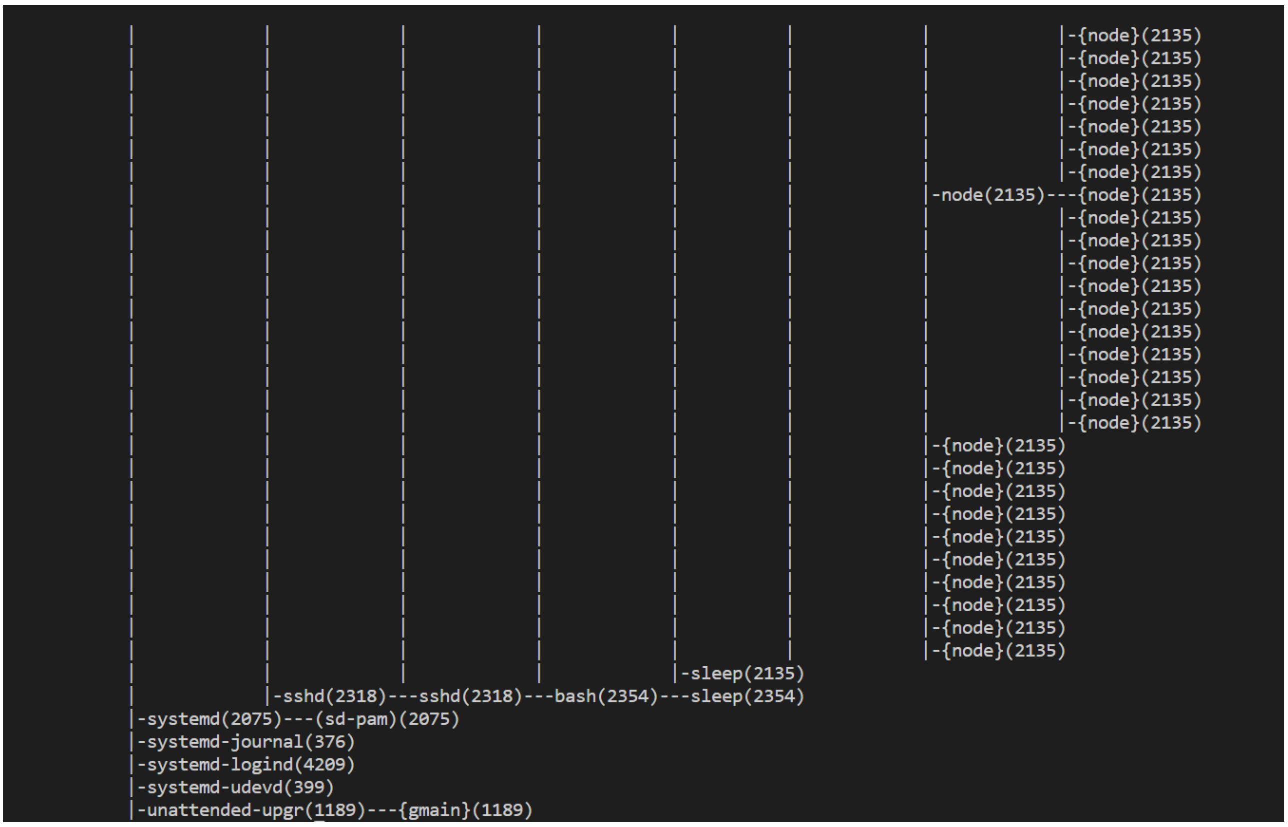


```
           |            |            |            |            |          |            |            |-{node}(2411)
           |            |            |            |            |          |            |            |-{node}(2412)
           |            |            |            |            |          |            |            |-{node}(2413)
           |            |            |            |            |          |            |            |-{node}(2414)
           |            |            |            |            |          |            |            |-{node}(2415)
           |            |            |            |            |          |            |            |-{node}(2416)
           |            |            |            |            |          |            |            |-{node}(2430)
           |            |            |            |            |          |            |-node(2417)---{node}(2418)
           |            |            |            |            |          |            |            |-{node}(2419)
           |            |            |            |            |          |            |            |-{node}(2420)
           |            |            |            |            |          |            |            |-{node}(2421)
           |            |            |            |            |          |            |            |-{node}(2422)
           |            |            |            |            |          |            |            |-{node}(2423)
           |            |            |            |            |          |            |            |-{node}(2424)
           |            |            |            |            |          |            |            |-{node}(2425)
           |            |            |            |            |          |            |            |-{node}(2426)
           |            |            |            |            |          |            |            |-{node}(2427)
           |            |            |            |            |          |            |            |-{node}(2428)
           |            |            |            |            |          |            |-{node}(2196)
           |            |            |            |            |          |            |-{node}(2203)
           |            |            |            |            |          |            |-{node}(2204)
           |            |            |            |            |          |            |-{node}(2205)
           |            |            |            |            |          |            |-{node}(2206)
           |            |            |            |            |          |            |-{node}(2191)
           |            |            |            |            |          |            |-{node}(2192)
           |            |            |            |            |          |            |-{node}(2193)
           |            |            |            |            |          |            |-{node}(2194)
           |            |            |            |            |          |            |-{node}(2195)
           |            |            |            |            |-sleep(11812)
           |            |-sshd(2318)---sshd(2353)---bash(2354)---sleep(11813)
           |-systemd(2075)---(sd-pam)(2076)
           |-systemd-journal(376)
           |-systemd-logind(4209)
           |-systemd-udevd(399)
           |-unattended-upgr(1189)---{gmain}(1259)
```

4. pstree -g (skip middle part for it's just too long nodes)

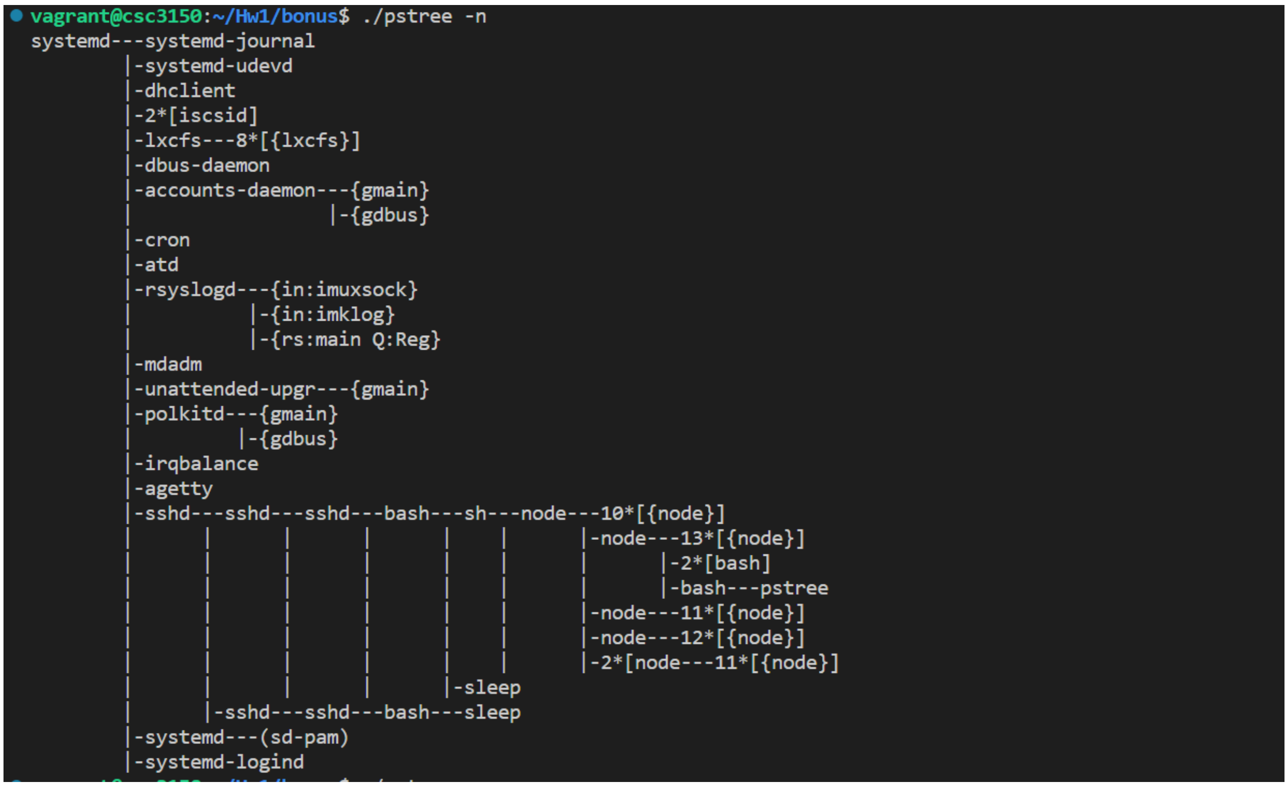


```
● vagrant@csc3150:~/Hw1/bonus$ ./pstree -g
systemd(1)---accounts-daemon(1120)---{gdbus}(1120)
            |                       |-{gmain}(1120)
            |-agetty(1323)
            |-atd(1136)
            |-cron(1121)
            |-dbus-daemon(1111)
            |-dhclient(924)
            |-irqbalance(1215)
            |-iscsid(1064)
            |-iscsid(1065)
            |-lxcfs(1109)---{lxcfs}(1109)
            |             |-{lxcfs}(1109)
            |             |-{lxcfs}(1109)
            |             |-{lxcfs}(1109)
            |             |-{lxcfs}(1109)
            |             |-{lxcfs}(1109)
            |             |-{lxcfs}(1109)
            |             |-{lxcfs}(1109)
            |-mdadm(1176)
            |-polkitd(1192)---{gdbus}(1192)
            |               |-{gmain}(1192)
            |-rsyslogd(1139)---{in:imklog}(1139)
            |                |-{in:imuxsock}(1139)
            |                |-{rs:main Q:Reg}(1139)
            |-sshd(1326)---sshd(2073)---sshd(2073)---bash(2135)---sh(2135)---node(2135)---node(2135)---bash(7562)---pstree(
12658)
            |            |            |            |            |          |            |            |-bash(4311)
            |            |            |            |            |          |            |            |-bash(2482)
            |            |            |            |            |          |            |            |-sh(2135)---cpuUsage.
sh(2135)---sleep(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
```



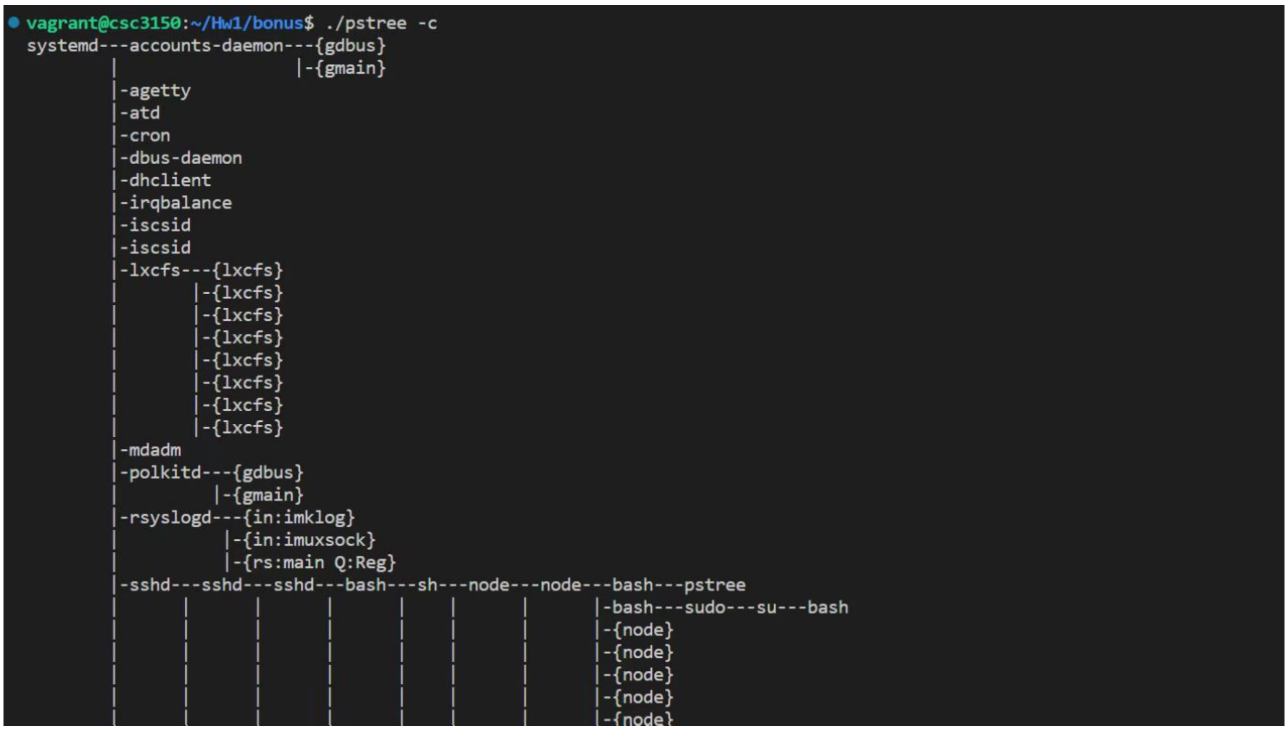
```
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |-node(2135)---{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |            |-{node}(2135)
            |            |            |            |            |          |            |-{node}(2135)
            |            |            |            |            |          |            |-{node}(2135)
            |            |            |            |            |          |            |-{node}(2135)
            |            |            |            |            |          |            |-{node}(2135)
            |            |            |            |            |          |            |-{node}(2135)
            |            |            |            |            |          |            |-{node}(2135)
            |            |            |            |            |          |            |-{node}(2135)
            |            |            |            |            |          |            |-{node}(2135)
            |            |            |            |            |          |            |-{node}(2135)
            |            |            |            |            |          |            |-{node}(2135)
            |            |            |            |            |-sleep(2135)
            |            |-sshd(2318)---sshd(2318)---bash(2354)---sleep(2354)
            |-systemd(2075)---(sd-pam)(2075)
            |-systemd-journal(376)
            |-systemd-logind(4209)
            |-systemd-udevd(399)
            |-unattended-upgr(1189)---{gmain}(1189)
```

5. pstree -n

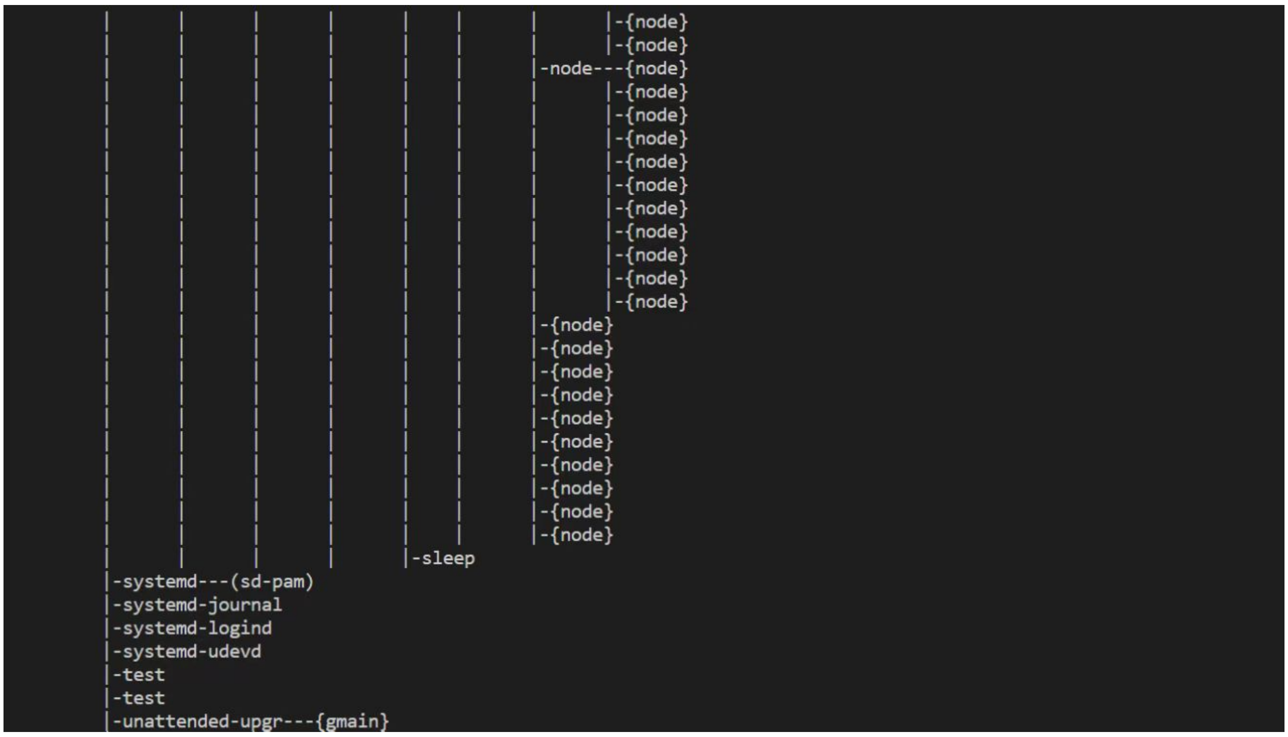


```
vagrant@csc3150:~/Hw1/bonus$ ./pstree -n
systemd---systemd-journal
        |-systemd-udevd
        |-dhclient
        |-2*[iscsid]
        |-lxcfs---8*[{lxcfs}]
        |-dbus-daemon
        |-accounts-daemon---{gmain}
        |                 |-{gdbus}
        |-cron
        |-atd
        |-rsyslogd---{in:imuxsock}
        |          |-{in:imklog}
        |          |-{rs:main Q:Reg}
        |-mdadm
        |-unattended-upgr---{gmain}
        |-polkitd---{gmain}
        |         |-{gdbus}
        |-irqbalance
        |-agetty
        |-sshd---sshd---sshd---bash---sh---node---10*[{node}]
        |      |      |      |      |    |      |-node---13*[{node}]
        |      |      |      |      |    |      |      |-2*[bash]
        |      |      |      |      |    |      |      |-bash---pstree
        |      |      |      |      |    |      |-node---11*[{node}]
        |      |      |      |      |    |      |-node---12*[{node}]
        |      |      |      |      |    |      |-2*[node---11*[{node}]]
        |      |      |      |      |-sleep
        |      |-sshd---sshd---bash---sleep
        |-systemd---(sd-pam)
        |-systemd-logind
```

6. pstree -c (skip middle part for it's just too long nodes)



```
vagrant@csc3150:~/Hw1/bonus$ ./pstree -c
systemd---accounts-daemon---{gdbus}
        |                 |-{gmain}
        |-agetty
        |-atd
        |-cron
        |-dbus-daemon
        |-dhclient
        |-irqbalance
        |-iscsid
        |-iscsid
        |-lxcfs---{lxcfs}
        |       |-{lxcfs}
        |       |-{lxcfs}
        |       |-{lxcfs}
        |       |-{lxcfs}
        |       |-{lxcfs}
        |       |-{lxcfs}
        |       |-{lxcfs}
        |-mdadm
        |-polkitd---{gdbus}
        |         |-{gmain}
        |-rsyslogd---{in:imklog}
        |          |-{in:imuxsock}
        |          |-{rs:main Q:Reg}
        |-sshd---sshd---sshd---bash---sh---node---node---bash---pstree
        |      |      |      |      |    |      |      |-bash---sudo---su---bash
        |      |      |      |      |    |      |      |-{node}
        |      |      |      |      |    |      |      |-{node}
        |      |      |      |      |    |      |      |-{node}
        |      |      |      |      |    |      |      |-{node}
        |      |      |      |      |    |      |      |-{node}
```



```
|      |      |      |      |    |      |      |-{node}
|      |      |      |      |    |      |      |-{node}
|      |      |      |      |    |      |-node---{node}
|      |      |      |      |    |      |      |-{node}
|      |      |      |      |    |      |      |-{node}
|      |      |      |      |    |      |      |-{node}
|      |      |      |      |    |      |      |-{node}
|      |      |      |      |    |      |      |-{node}
|      |      |      |      |    |      |      |-{node}
|      |      |      |      |    |      |      |-{node}
|      |      |      |      |    |      |      |-{node}
|      |      |      |      |    |      |      |-{node}
|      |      |      |      |    |      |      |-{node}
|      |      |      |      |    |      |-{node}
|      |      |      |      |    |      |-{node}
|      |      |      |      |    |      |-{node}
|      |      |      |      |    |      |-{node}
|      |      |      |      |    |      |-{node}
|      |      |      |      |    |      |-{node}
|      |      |      |      |    |      |-{node}
|      |      |      |      |    |      |-{node}
|      |      |      |      |    |      |-{node}
|      |      |      |      |    |      |-{node}
|      |      |      |      |-sleep
|-systemd---(sd-pam)
|-systemd-journal
|-systemd-logind
|-systemd-udevd
|-test
|-test
|-unattended-upgr---{gmain}
```

Learning

In summary, project1 is not difficult to understand. Task 1 and task 2 perform similar functions under user mode and kernel mode. The first challenge lies in environment setup. From Apple chip to windows, I changed three linux version and build different VMs. During this process, I became more skilled in environment setup which I used to be weak in. The second challenge is task 2. Though we do not need to know the detail of kernel code, we should understand the parameter meaning, big idea and how to export them to use. To 'overwrite' those method and structure needs paying attention to details and hard debug. At last, I found discussion is very important. Looking at the questions from other students from piazza and wechat saves me much more time.