Report by Xiaoyi Zheng 120090733

Environment

Linux distribution

```
vagrant@csc3150:~/csc3150/source/program1$ cat /etc/issue
Ubuntu 16.04.7 LTS \n \l
```

Linux Kernel Version

```
vagrant@csc3150:~/csc3150/source/program1$ uname -r
5.10.146
```

GGC Version

```
gcc version 5.4.0 20160609 (Ubuntu 5.4.0-6ubuntu1~16.04.12)
```

To set up the linux environment, first we should install dependency and development tools in VM. Then extract the kernel source file in VM and copy config to it. Then go to the kernel source directory and clean the previous setting and start to configuration. After that, we can bulid kernel image and module by “make -j”. Then install the kernel modules and the kernel. After all, the environment is already.

1. Program1

This program is under the user mode to run a process. It will fork a child process to excute a program and get the return singal. After that, the parent process will print information about the signal.

At the beginning, fork() function is used to fork a child process. Then the program get the pid and handle the corresponding operations. If pid ==0, it is a child, the program will let it execute the test program. If not 0 or -1, it is a parent, which will wait for the signal(waitpid () function). Then it will print out the termination information of the child process.

how to excute the program:

i. go to the program1 directory.

ii. Type “make”.

iii. Type “./program1 x”. where x is the test file.

Here are the outputs:

Abort

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 abort
process start to fork
I'm Parent Process, my pid = 2839
I'm the Child Process, my pid = 2840
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGABRT program

Parent process receives the SIGCHLD signal
child process gets SIGABRT signal
child process is abort by abort signal
CHILD EXECUTION FAILED:6
root@csc3150:/home/vagrant/csc3150/source/program1#
```

Alarm

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 alarm
process start to fork
I'm Parent Process, my pid = 2978
I'm the Child Process, my pid = 2979
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGALRM program

Parent process receives the SIGCHLD signal
child process gets SIGALRM signal
child process is terminated by alarm signal
CHILD EXECUTION FAILED:14
root@csc3150:/home/vagrant/csc3150/source/program1#
```

Bus

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 bus
process start to fork
I'm Parent Process, my pid = 3120
I'm the Child Process, my pid = 3121
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGBUS program

Parent process receives the SIGCHLD signal
child process gets SIGBUS signal
child process gets bus error
CHILD EXECUTION FAILED:7
root@csc3150:/home/vagrant/csc3150/source/program1#
```

Floating

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 floating
process start to fork
I'm Parent Process, my pid = 3207
I'm the Child Process, my pid = 3208
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGFPE program

Parent process receives the SIGCHLD signal
child process gets SIGFPE signal
child process gets floating point exception
CHILD EXECUTION FAILED:8
root@csc3150:/home/vagrant/csc3150/source/program1#
```

Hangup

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 hangup
process start to fork
I'm Parent Process, my pid = 3306
I'm the Child Process, my pid = 3307
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGHUP program

Parent process receives the SIGCHLD signal
child process gets SIGHUP signal
child process is hung up
CHILD EXECUTION FAILED:1
root@csc3150:/home/vagrant/csc3150/source/program1#
```

Illegal_instr

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 illegal_instr
process start to fork
I'm Parent Process, my pid = 3359
I'm the Child Process, my pid = 3360
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGILL program

Parent process receives the SIGCHLD signal
child process gets SIGILL signal
child process gets illegal instruction
CHILD EXECUTION FAILED:4
root@csc3150:/home/vagrant/csc3150/source/program1#
```

Interrupt

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 interrupt
process start to fork
I'm Parent Process, my pid = 3438
I'm the Child Process, my pid = 3439
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGINT program

Parent process receives the SIGCHLD signal
child process gets SIGINT signal
child process is interrupted
CHILD EXECUTION FAILED:2
root@csc3150:/home/vagrant/csc3150/source/program1#
```

Kill

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 kill
process start to fork
I'm Parent Process, my pid = 3554
I'm the Child Process, my pid = 3555
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGKILL program

Parent process receives the SIGCHLD signal
child process gets SIGKILL signal
child process is killed
CHILD EXECUTION FAILED:9
root@csc3150:/home/vagrant/csc3150/source/program1#
```

Normal

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 normal
process start to fork
I'm Parent Process, my pid = 3620
I'm the Child Process, my pid = 3621
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the normal program

------------CHILD PROCESS END------------
Parent process receives the SIGCHLD signal
Normal termination with EXIT STATUS = 0
root@csc3150:/home/vagrant/csc3150/source/program1#
```

Pipe

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 pipe
process start to fork
I'm Parent Process, my pid = 3676
I'm the Child Process, my pid = 3677
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGPIPE program

Parent process receives the SIGCHLD signal
child process gets SIGPIPE signal
child process writes to pipe without readers
CHILD EXECUTION FAILED:13
root@csc3150:/home/vagrant/csc3150/source/program1#
```

Quit

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 quit
process start to fork
I'm Parent Process, my pid = 3741
I'm the Child Process, my pid = 3742
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGQUIT program

Parent process receives the SIGCHLD signal
child process gets SIGQUIT signal
child process is quited
CHILD EXECUTION FAILED:3
root@csc3150:/home/vagrant/csc3150/source/program1#
```

Segment_fault

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 segment_fault
process start to fork
I'm Parent Process, my pid = 3818
I'm the Child Process, my pid = 3819
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGSEGV program

Parent process receives the SIGCHLD signal
child process gets SIGSEGV signal
child process uses invalid reference
CHILD EXECUTION FAILED:11
root@csc3150:/home/vagrant/csc3150/source/program1#
```

Stop

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 stop
process start to fork
I'm Parent Process, my pid = 3952
I'm the Child Process, my pid = 3953
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGSTOP program

Parent process receives the SIGCHLD signal
child process gets SIGSTOP signal
child process stopped
CHILD PROCESS STOPPED:19
root@csc3150:/home/vagrant/csc3150/source/program1#
```

Terminate

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 terminate
process start to fork
I'm Parent Process, my pid = 4018
I'm the Child Process, my pid = 4019
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGTERM program

Parent process receives the SIGCHLD signal
child process gets SIGTERM signal
child process is terminated by SIGTERM signal
CHILD EXECUTION FAILED:15
root@csc3150:/home/vagrant/csc3150/source/program1#
```

Trap

```
root@csc3150:/home/vagrant/csc3150/source/program1# ./program1 trap
process start to fork
I'm Parent Process, my pid = 4075
I'm the Child Process, my pid = 4076
Children process start to execute test program:
------------CHILD PROCESS START------------
This is the SIGTRAP program

Parent process receives the SIGCHLD signal
child process gets SIGTRAP signal
chid process is terminated by trap signal
CHILD EXECUTION FAILED:5
root@csc3150:/home/vagrant/csc3150/source/program1#
```

2. Program2

First, since we will use some functions like kernel_clone, do_execve, do_wait, getname_kernel, we need to go to the corresponding files and export them use EXPORT_SYMBOL. After that, compile the kernel again. Then we can use those function by using extern to import them.

This program creates a kernel thread to fork a child process to execute another program. The parent will wait for the signal from child and print the information. Function program_init() is used to initialize the kernel as well as create the thread. Function my_wait() is used to wait for the child process and send signal. Function my_exec() is used to get the test file and test the kernel by using do_execve(). Function my_fork() is used to fork a process and get the pid by using kernel_clone and call my_wait() to get the signal of child and print the information.

How to execute the program:

i. Modify the kernel files where “kernel_clone”, “do_wait”, “getname_kernel” and “do_execve” in. Then rebuild the module by using: make blzmage, make modules, make modules_install, make install, reboot.

ii. Go to the program2 directory.

iii. Use gcc -o test test.c to complie the test file.

iv. Type “sudo insmod program2.ko” to insert the module and “sudo rmmod

program2" to remove the module.

v. Type "dmesg" to display.

Here are the outputs:

SIGHUP

```
[ 5445.039154] [program2] : Module_init {Xiaoyi Zheng} {120090733}
[ 5445.051137] [program2] : module_init create kthread start
[ 5445.065323] [program2] : module_init Kthread start
[ 5445.090361] [program2] : The Child process has pid = 28825
[ 5445.092169] [program2] : This is the parent process, pid = 28824
[ 5445.113580] [program2] : child process
[ 5445.113581] [program2] : get SIGHUP signal
[ 5445.177034] [program2] : child process is hung up
[ 5445.209382] [program2] : The return signal is 1
[ 5453.503332] [program2] : Module_exit
vagrant@csc3150:~/csc3150/source/program2$
```

SIGINT

```
[ 5538.966491] [program2] : Module_init {Xiaoyi Zheng} {120090733}
[ 5539.007948] [program2] : module_init create kthread start
[ 5539.050997] [program2] : module_init Kthread start
[ 5539.076353] [program2] : The Child process has pid = 28924
[ 5539.090443] [program2] : This is the parent process, pid = 28923
[ 5539.110942] [program2] : child process
[ 5539.110943] [program2] : get SIGINT signal
[ 5539.146534] [program2] : terminal interrupt
[ 5539.162122] [program2] : The return signal is 2
[ 5544.686439] [program2] : Module_exit
vagrant@csc3150:~/csc3150/source/program2$
```

SIGQUIT

```
[ 5918.485132] [program2] : Module_init {Xiaoyi Zheng} {120090733}
[ 5918.547266] [program2] : module_init create kthread start
[ 5918.591524] [program2] : module_init Kthread start
[ 5918.610046] [program2] : The Child process has pid = 29017
[ 5918.621258] [program2] : This is the parent process, pid = 29016
[ 5918.727745] [program2] : child process
[ 5918.727747] [program2] : get SIGQUIT signal
[ 5918.778224] [program2] : terminal quit
[ 5918.814064] [program2] : The return signal is 3
[ 5922.822948] [program2] : Module_exit
vagrant@csc3150:~/csc3150/source/program2$
```

SIGILL

```
[ 6006.106379] [program2] : Module_init {Xiaoyi Zheng} {120090733}
[ 6006.131027] [program2] : module_init create kthread start
[ 6006.151158] [program2] : module_init Kthread start
[ 6006.172644] [program2] : The Child process has pid = 29173
[ 6006.175733] [program2] : This is the parent process, pid = 29172
[ 6006.302209] [program2] : child process
[ 6006.302211] [program2] : get SIGILL signal
[ 6006.348997] [program2] : child process has illegal instruction error
[ 6006.379773] [program2] : The return signal is 4
[ 6010.842525] [program2] : Module_exit
vagrant@csc3150:~/csc3150/source/program2$
```

SIGTRAP

```
[ 6075.328547] [program2] : Module_init {Xiaoyi Zheng} {120090733}
[ 6075.371904] [program2] : module_init create kthread start
[ 6075.409047] [program2] : module_init Kthread start
[ 6075.447958] [program2] : The Child process has pid = 29314
[ 6075.451397] [program2] : This is the parent process, pid = 29313
[ 6075.571323] [program2] : child process
[ 6075.571325] [program2] : get SIGTRAP signal
[ 6075.624591] [program2] : child process has trap error
[ 6075.675568] [program2] : The return signal is 5
[ 6082.145154] [program2] : Module_exit
vagrant@csc3150:~/csc3150/source/program2$
```

SIGABRT

```
[ 6138.622593] [program2] : Module_init {Xiaoyi Zheng} {120090733}
[ 6138.666839] [program2] : module_init create kthread start
[ 6138.684757] [program2] : module_init Kthread start
[ 6138.717028] [program2] : The Child process has pid = 29398
[ 6138.719350] [program2] : This is the parent process, pid = 29397
[ 6138.838824] [program2] : child process
[ 6138.838826] [program2] : get SIGABRT signal
[ 6138.879296] [program2] : child process has abort error
[ 6138.899465] [program2] : The return signal is 6
[ 6142.854451] [program2] : Module_exit
vagrant@csc3150:~/csc3150/source/program2$
```

SIGBUS

```
[ 5106.487784] [program2] : Module_init {Xiaoyi Zheng} {120090733}
[ 5106.489216] [program2] : module_init create kthread start
[ 5106.490262] [program2] : module_init Kthread start
[ 5106.493190] [program2] : The Child process has pid = 28599
[ 5106.510688] [program2] : This is the parent process, pid = 28598
[ 5106.617832] [program2] : child process
[ 5106.617834] [program2] : get SIGBUS signal
[ 5106.657471] [program2] : child process has bus error
[ 5106.724548] [program2] : The return signal is 7
[ 5111.685867] [program2] : Module_exit
vagrant@csc3150:~/csc3150/source/program2$
```

SIGFPE

```
[ 6238.760017] [program2] : Module_init {Xiaoyi Zheng} {120090733}
[ 6238.823668] [program2] : module_init create kthread start
[ 6238.858684] [program2] : module_init Kthread start
[ 6238.900894] [program2] : The Child process has pid = 29482
[ 6238.903738] [program2] : This is the parent process, pid = 29481
[ 6239.031135] [program2] : child process
[ 6239.031138] [program2] : get SIGFPE signal
[ 6239.103985] [program2] : child process has float error
[ 6239.145225] [program2] : The return signal is 8
[ 6243.561147] [program2] : Module_exit
vagrant@csc3150:~/csc3150/source/program2$
```

SIGKILL

```
[ 6365.454362] [program2] : Module_init {Xiaoyi Zheng} {120090733}
[ 6365.511685] [program2] : module_init create kthread start
[ 6365.555363] [program2] : module_init Kthread start
[ 6365.578079] [program2] : The Child process has pid = 29563
[ 6365.578962] [program2] : This is the parent process, pid = 29562
[ 6365.583420] [program2] : child process
[ 6365.583422] [program2] : get SIGKILL signal
[ 6365.603944] [program2] : child process is killed
[ 6365.616949] [program2] : The return signal is 9
[ 6370.112102] [program2] : Module_exit
vagrant@csc3150:~/csc3150/source/program2$
```

SIGSEGV

```
[ 6565.930565] [program2] : Module_init {Xiaoyi Zheng} {120090733}
[ 6565.974365] [program2] : module_init create kthread start
[ 6566.012663] [program2] : module_init Kthread start
[ 6566.013476] [program2] : The Child process has pid = 29655
[ 6566.015393] [program2] : This is the parent process, pid = 29654
[ 6566.154234] [program2] : child process
[ 6566.154236] [program2] : get SIGSEGV signal
[ 6566.227852] [program2] : child process has segmentation fault error
[ 6566.275393] [program2] : The return signal is 11
[ 6570.248948] [program2] : Module_exit
vagrant@csc3150:~/csc3150/source/program2$
```

SIGPIPE

```
[ 6619.092160] [program2] : Module_init {Xiaoyi Zheng} {120090733}
[ 6619.093557] [program2] : module_init create kthread start
[ 6619.105581] [program2] : module_init Kthread start
[ 6619.107050] [program2] : The Child process has pid = 29738
[ 6619.110488] [program2] : This is the parent process, pid = 29737
[ 6619.152076] [program2] : child process
[ 6619.152077] [program2] : get SIGPIPE signal
[ 6619.193301] [program2] : child process has pipe error
[ 6619.224905] [program2] : The return signal is 13
[ 6623.077857] [program2] : Module_exit
vagrant@csc3150:~/csc3150/source/program2$
```

SIGALARM

```
[ 6705.324275] [program2] : Module_init {Xiaoyi Zheng} {120090733}
[ 6705.364384] [program2] : module_init create kthread start
[ 6705.399370] [program2] : module_init Kthread start
[ 6705.424530] [program2] : The Child process has pid = 29829
[ 6705.430283] [program2] : This is the parent process, pid = 29828
[ 6705.440204] [program2] : child process
[ 6705.440204] [program2] : get SIGALARM signal
[ 6705.467713] [program2] : child process has alarm error
[ 6705.490894] [program2] : The return signal is 14
[ 6708.846003] [program2] : Module_exit
vagrant@csc3150:~/csc3150/source/program2$
```

SIGTERM

```
[ 6806.901686] [program2] : Module_init {Xiaoyi Zheng} {120090733}
[ 6806.942298] [program2] : module_init create kthread start
[ 6806.969983] [program2] : module_init Kthread start
[ 6806.989337] [program2] : The Child process has pid = 29946
[ 6806.990740] [program2] : This is the parent process, pid = 29945
[ 6806.991613] [program2] : child process
[ 6806.991614] [program2] : get SIGTERM signal
[ 6806.994240] [program2] : child process is terminated
[ 6806.996379] [program2] : The return signal is 15
[ 6810.702812] [program2] : Module_exit
vagrant@csc3150:~/csc3150/source/program2$
```

SIGSTOP

```
[ 7565.263928] [program2] : Module_init {Xiaoyi Zheng} {120090733}
[ 7565.318104] [program2] : module_init create kthread start
[ 7565.353330] [program2] : module_init Kthread start
[ 7565.379457] [program2] : The Child process has pid = 31465
[ 7565.380822] [program2] : This is the parent process, pid = 31464
[ 7565.416734] [program2] : child process
[ 7565.416735] [program2] : get SIGSTOP signal
[ 7565.439736] [program2] : child process is terminated
[ 7565.471918] [program2] : The return signal is 19
[ 7568.469278] [program2] : Module_exit
vagrant@csc3150:~/csc3150/source/program2$
```

What I learn:

I learn how to compile kernel and execute the program in codes. I learn how to modify the kernel code to make the kernel symbols to invoke in LKM visible. Since this course is very challenging, tutors encourage us to solve the problems we meet during the assignment by ourselves, my debugging skill is improved and I learn how to fully use google to solve my problems. I am more skillful in VM and Linux system.