Process States and Signals

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Abstract— **For this report, several programs were created and tested in order to have a better understanding of processes, signals, and process states.**

Keywords*— *Process, state, signal, Cloud9, C

I. Introduction

Processes, according to the third chapter of *Operating Systems Concepts* (9th ed.), can be simply defined as an instance of a program in execution. They may also be in one of five states, as described next:

- **New:** The process is in the stage of being created.
- **Ready:** The process has all the resources available needed for it to run, but the CPU is not currently working on its instructions.
- **Running:** The CPU is working on the process's instructions.
- **Waiting:** The process cannot run at the moment, as it is waiting for some resource to become available or for some event to occur.
- **Terminated:** The process has completed.

Signals, on the other hand, are events generated by the system in response to a specific condition. Sahitya Maruvada from *100 Days of Linux* explains that this means that when a process receives a signal, it will take action according to the data being passed on to it.

A. Materials

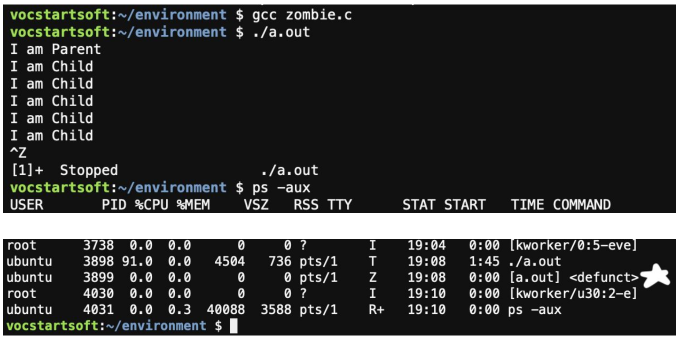
- MacBook Pro, with a 2.2 GHz 6-Core Intel Core i7 processor and macOS Catalina 10.15.6
- *Amazon Web Services (AWS) Educate* membership
  - EC2+Cloud 9 Instance

II. Development

A. Process States

For the first part of this report, it was necessary to create a program(s) where one could observe the change of states in corresponding processes. In order to achieve this, 3 programs were created; each containing a zombie, a suspended, and a terminated process, respectively.

Zombie process: Considered to be a "zombie" as it has already finished executing but still has an entry in the process table (the parent has not finished its child process.

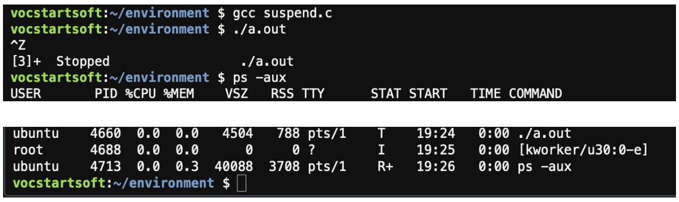


```
vocstartsoft:~/environment $ gcc zombie.c
vocstartsoft:~/environment $ ./a.out
I am Parent
I am Child
I am Child
I am Child
I am Child
I am Child
^Z
[1]+  Stopped                 ./a.out
vocstartsoft:~/environment $ ps -aux
USER       PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
```

```
root      3738  0.0  0.0      0     0 ?        I    19:04   0:00 [kworker/0:5-eve]
ubuntu    3898 91.0  0.0   4504   736 pts/1    T    19:08   1:45 ./a.out
ubuntu    3899  0.0  0.0      0     0 pts/1    Z    19:08   0:00 [a.out] <defunct>
root      4030  0.0  0.0      0     0 ?        I    19:10   0:00 [kworker/u30:2-e]
ubuntu    4031  0.0  0.3  40088  3588 pts/1    R+   19:10   0:00 ps -aux
vocstartsoft:~/environment $ 
```

Figures 1-2. Compiling zombie.c and confirming its defunct/zombie state.

Suspended process: Waiting for an event to occur or for a resource in order to finish.

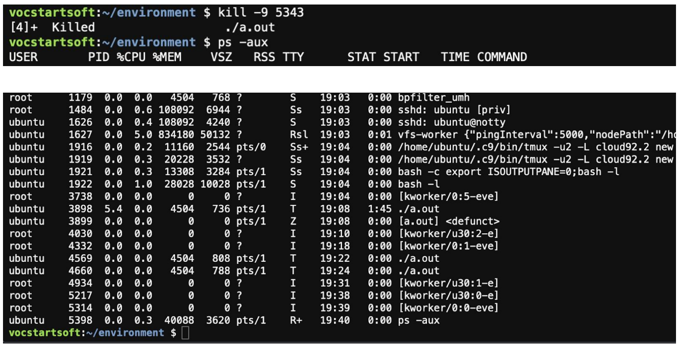


```
vocstartsoft:~/environment $ gcc suspend.c
vocstartsoft:~/environment $ ./a.out
^Z
[3]+  Stopped                 ./a.out
vocstartsoft:~/environment $ ps -aux
USER       PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
```

```
ubuntu    4660  0.0  0.0   4504   788 pts/1    T    19:24   0:00 ./a.out
root      4688  0.0  0.0      0     0 ?        I    19:25   0:00 [kworker/u30:0-e]
ubuntu    4713  0.0  0.3  40088  3708 pts/1    R+   19:26   0:00 ps -aux
vocstartsoft:~/environment $ 
```

Figures 3-4. Compiling and stopping suspend.c; the T indicates that it has been stopped.

Terminated process: Has completed execution and no longer appears on the process table.



```
vocstartsoft:~/environment $ kill -9 5343
[4]+  Killed                  ./a.out
vocstartsoft:~/environment $ ps -aux
USER       PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
```

```
root      1179  0.0  0.0   4504   768 ?        S    19:03   0:00 bpfilter_umh
root      1484  0.0  0.6 108092  6944 ?        Ss   19:03   0:00 sshd: ubuntu [priv]
ubuntu    1626  0.0  0.4 108092  4240 ?        S    19:03   0:00 sshd: ubuntu@notty
ubuntu    1627  0.0  5.0 834180 50132 ?        Rsl  19:03   0:01 vfs-worker {"pingInterval":5000,"nodePath":"/ho
ubuntu    1916  0.0  0.2  11160  2544 pts/0    Ss+  19:04   0:00 /home/ubuntu/.c9/bin/tmux -u2 -L cloud92.2 new
ubuntu    1919  0.0  0.3  20228  3532 ?        Ss   19:04   0:00 /home/ubuntu/.c9/bin/tmux -u2 -L cloud92.2 new
ubuntu    1921  0.0  0.3  13308  3284 pts/1    Ss   19:04   0:00 bash -c export ISOUTPUTPANE=0;bash -l
ubuntu    1922  0.0  1.0  28028 10028 pts/1    S    19:04   0:00 bash -l
root      3738  0.0  0.0      0     0 ?        I    19:04   0:00 [kworker/0:5-eve]
ubuntu    3898  5.4  0.0   4504   736 pts/1    T    19:08   1:45 ./a.out
ubuntu    3899  0.0  0.0      0     0 pts/1    Z    19:08   0:00 [a.out] <defunct>
root      4030  0.0  0.0      0     0 ?        I    19:10   0:00 [kworker/u30:2-e]
root      4332  0.0  0.0      0     0 ?        I    19:18   0:00 [kworker/0:1-eve]
ubuntu    4569  0.0  0.0   4504   808 pts/1    T    19:22   0:00 ./a.out
ubuntu    4660  0.0  0.0   4504   788 pts/1    T    19:24   0:00 ./a.out
root      4934  0.0  0.0      0     0 ?        I    19:31   0:00 [kworker/u30:1-e]
root      5217  0.0  0.0      0     0 ?        I    19:38   0:00 [kworker/u30:0-e]
root      5314  0.0  0.0      0     0 ?        I    19:39   0:00 [kworker/0:0-eve]
ubuntu    5398  0.0  0.3  40088  3620 pts/1    R+   19:40   0:00 ps -aux
vocstartsoft:~/environment $ 
```

Figure 5-6. Successfully terminating the process, it no longer appears in the process table.

The code corresponding to the programs *(zombie.c, suspend.c, and term.c)* can be found attached to this report's *Canvas* submission.

[1] This report was sent for revision on September 24th, 2020.
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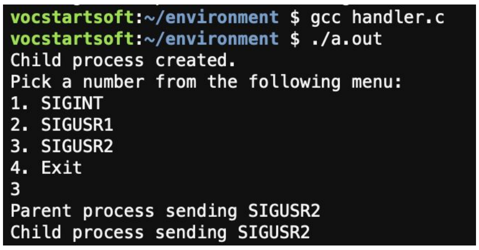
B. Process Signals

The second part constituting this lab report was to write a program that creates a child process, via the fork function, that handles the signals SIGNINT (the parent should also handle this one), SIGUSR1, and SIGUSR2. Every function should print a message specifying the signal being handled, and the parent process must ask the user which signal to send; finally sending it via the kill function. A sleep function was added after each signal in order to make the output easier to understand.

The code for this program can be found attached to this report's *Canvas* submission *(under the name handler.c).*



```
vocstartsoft:~/environment $ gcc handler.c
vocstartsoft:~/environment $ ./a.out
Child process created.
Pick a number from the following menu:
1. SIGINT
2. SIGUSR1
3. SIGUSR2
4. Exit
3
Parent process sending SIGUSR2
Child process sending SIGUSR2
```

Figure 7. Correct performance from handler.c.

III. Conclusion

Although working with signals can be a confusing process, it is important to understand how these functions are actually being handled. The first part of this report was a great tool for me to apply the theoretical knowledge obtained in class into a working code. The second part was much trickier, but once I understood the parts needed and what was being asked for me to do, it turned out to be much easier than what I originally thought.

For future references, I believe it would be interesting to try to perform additional processes in *handler.c* aside from just sending the signal and printing which signal was received.

References

Ghosh, B. (April, 2020). *How to use signal handlers in C language?* Linuxhint. Recovered on September 24th, 2020 from https://linuxhint.com/signal_handlers_c_programming_language/