Lab: Controlling Processes

Any program that is running on your system is a process. In this lab, you will learn all about Linux processes. You will learn how to view process information. You will also learn how to send different signals to a process. Furthermore, you will understand the differences between foreground and background processes.

To list all the processes that are owned by a specific user, you can run the command [ps -u] followed by the username:

```
ps -u username
```

For example, to list all the processes that are owned by [elliot], you can run:

```
root@ubuntu-linux:~# ps -u elliot

PID TTY          TIME CMD
645 pts/0    00:00:00 bash
675 pts/0    00:00:00 bash
2387 pts/0    00:00:00 bash
4955 pts/0    00:00:00 bash
.
.
.
.
```

You can use the [ps -e] command to list all the processes that are running on your system:

```
root@ubuntu-linux:~# ps -e
PID TTY     TIME  CMD
1  ?     00:00:01 systemd
2  ?     00:00:00 kthreadd
4  ?     00:00:00 kworker/0:0H
6  ?     00:00:00 mm_percpu_wq
7  ?     00:00:00 ksoftirqd/0
8  ?     00:00:00 rcu_sched
9  ?     00:00:00 rcu_bh
10 ?     00:00:00 migration/0
11 ?     00:00:00 watchdog/0
12 ?     00:00:00 cpuhp/0
13 ?     00:00:00 kdevtmpfs
.
.
.
.
```

You can also use the [-f] option to get more information:

```
root@ubuntu-linux:~# ps -ef
UID    PID  PPID C STIME TTY    TIME    CMD
root      1    0 0 11:23    ? 00:00:01 /sbin/init splash
root      2    0 0 11:23    ? 00:00:00 [kthreadd]
root      4    2 0 11:23    ? 00:00:00 [kworker/0:0H]
root      6    2 0 11:23    ? 00:00:00 [mm_percpu_wq]
```

```
root      7    2 0 11:23    ? 00:00:00 [ksoftirqd/0]
root      8    2 0 11:23    ? 00:00:01 [rcu_sched]
root      9    2 0 11:23    ? 00:00:00 [rcu_bh]
root     10    2 0 11:23    ? 00:00:00 [migration/0]
elliot 1835 1393 1 11:25 tty2 00:00:58 /usr/bin/gnome-shell
elliot 1853 1835 0 11:25 tty2 00:00:00 ibus-daemon --xim --panel disable
elliot 1857 1365 0 11:25    ? 00:00:00 /usr/lib/gnome-shell/gnome-shell
elliot 1865 1853 0 11:25 tty2 00:00:00 /usr/lib/ibus/ibus-dconf
elliot 1868    1 0 11:25 tty2 00:00:00 /usr/lib/ibus/ibus-x11 --kill-daemon
elliot 1871 1365 0 11:25    ? 00:00:00 /usr/lib/ibus/ibus-portal
.
.
.
```

The first column of the output lists the usernames of the process owners. The third column of the output lists the **parent process identifiers** (**PPIDs**). Well, what the heck is a parent process?

Parent process versus child process

A parent process is a process that has started one or more child processes. A perfect example will be your terminal and your bash shell; when you open your terminal, your bash shell is started as well.

To get the PID of a process, you can use the [pgrep] command followed by the process name:

```
pgrep process_name
```

For example, to get the PID of your terminal process, you can run:

```
elliot@ubuntu-linux:~$ pgrep terminal
10009
```

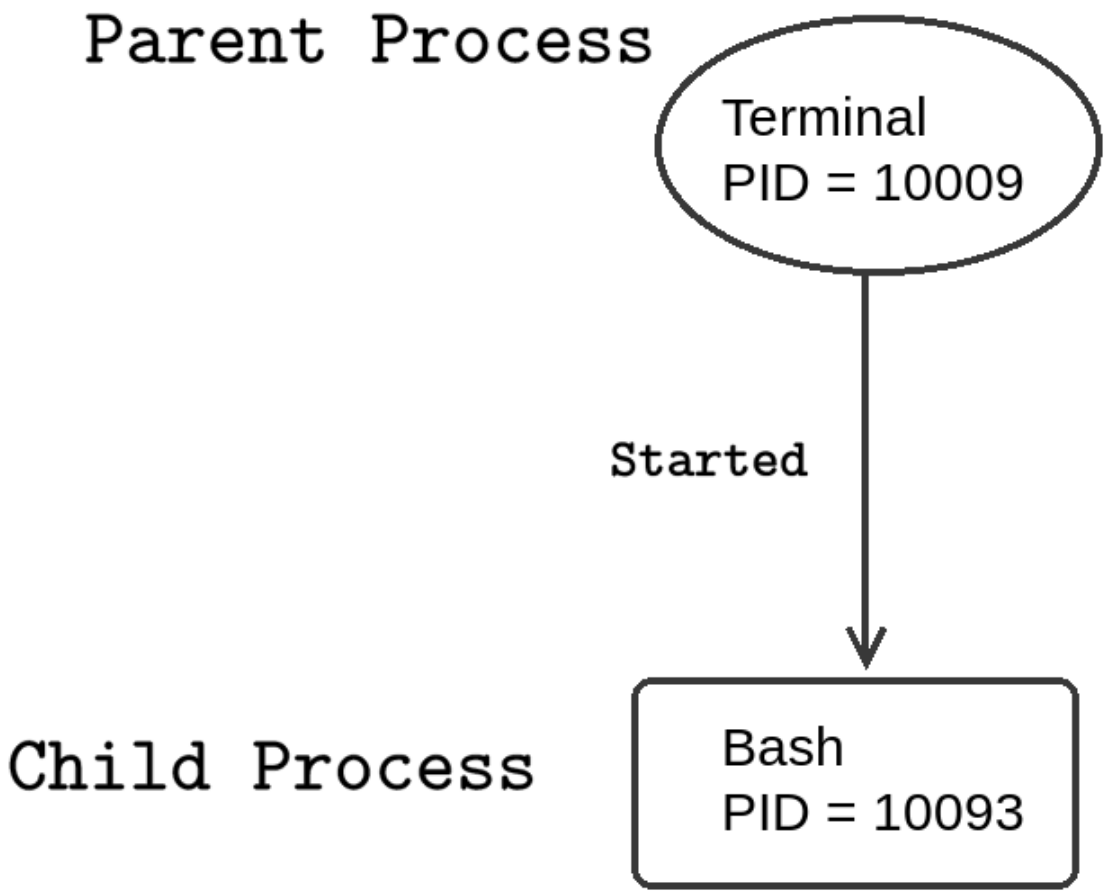
The PID of my terminal is [10009]. Now, let's get the PID of the bash process:

```
elliot@ubuntu-linux:~$ pgrep bash
10093
```

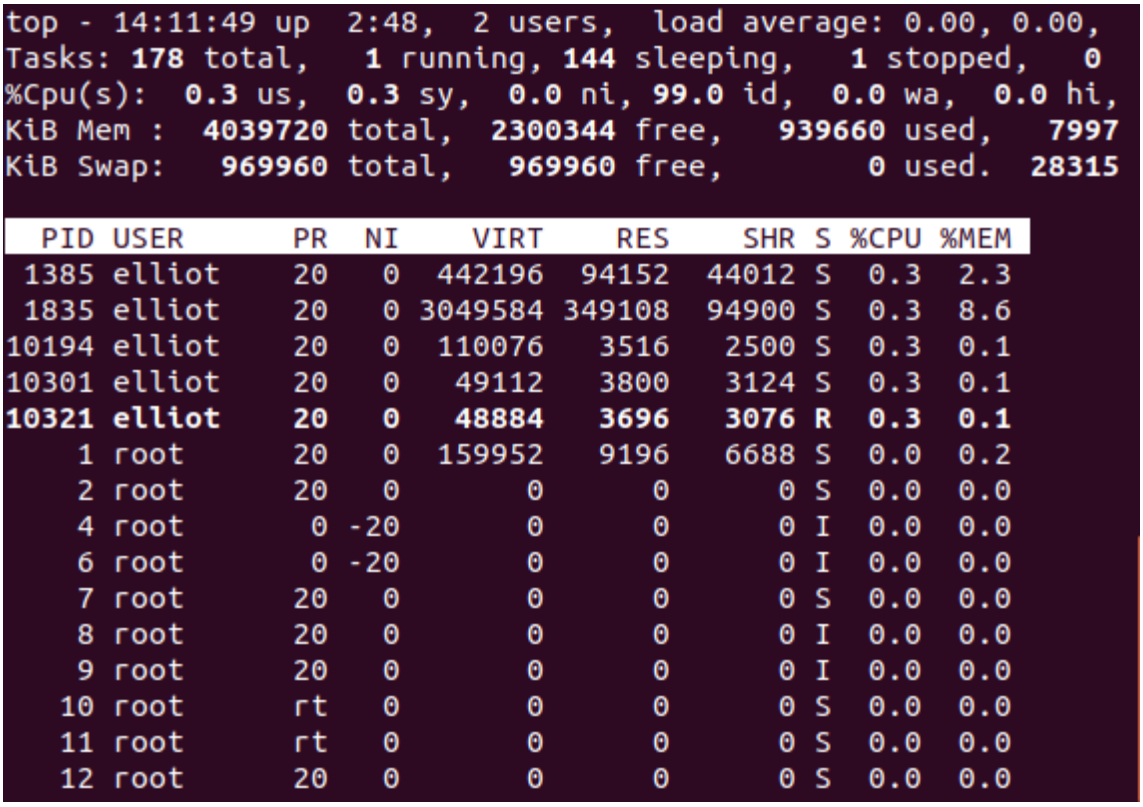
The PID of my bash shell is [10093]. Now, you can get the information of your bash process by using the [-p] option followed by the bash PID:

```
elliot@ubuntu-linux:~$ ps -fp ADD_YOUR_BASH_PROCESS_ID
UID     PID   PPID  C  STIME  TTY   TIME   CMD
elliot 10093 10009  0  13:37 pts/1 00:00:00 bash
```

You can see from the output that the PPID of my bash process is equal to the PID of my terminal process. This proves that the terminal process has started the bash process. In this case, the bash process is referred to as the child process of the terminal process:



The [top] command is a very useful command that you can use to view processes' information in real time. The output for the preceding command is shown in the following screenshot:



Foreground versus background processes

There are two types of processes in Linux:

- Foreground processes
- Background processes

The [yes] command outputs any string that follows it repeatedly until killed:

```
elliot@ubuntu-linux:~$ whatis yes
yes (1)              - output a string repeatedly until killed
```

For example, to output the word [hello] repeatedly on your terminal, you can run the command:

```
elliot@ubuntu-linux:~$ yes hello
hello
hello
hello
hello
hello
hello
hello
hello
hello
hello
.
```

```
.
.
```

Notice that it will keep running, and you can't do anything else on your terminal; this is a prime example of a foreground process. To claim back your terminal, you need to kill the process. You can kill the process by hitting the *Ctrl + C* key combination as follows:

```
hello
hello
hello
hello
hello
^C
elliot@ubuntu-linux:~$
```

As soon as you hit *Ctrl + C*, the process will be killed, and you can continue using your terminal. Let's do another example; you can use the [firefox] command to start up Firefox from your terminal:

```
elliot@ubuntu-linux:~$ firefox
```

The Firefox browser will start, but you will not be able to do anything on your terminal until you close Firefox; this is another example of a foreground process. Now, hit *Ctrl + C* to kill the Firefox process so you can claim back your terminal.

You can start up Firefox as a background process by adding the ampersand character as follows:

```
elliot@ubuntu-linux:~$ firefox &
[1] 3468
elliot@ubuntu-linux:~$
```

Firefox is now running as a background process, and you can continue using your terminal without having to close Firefox.

Sending signals to processes

You can interact and communicate with processes via signals. There are various signals, and each signal serves a different purpose. To list all available signals, you can run the [kill -L] command:

```
elliot@ubuntu-linux:~$ kill -L
1) SIGHUP 2) SIGINT 3) SIGQUIT 4) SIGILL 5) SIGTRAP
6) SIGABRT 7) SIGBUS 8) SIGFPE 9) SIGKILL 10) SIGUSR1
11) SIGSEGV 12) SIGUSR2 13) SIGPIPE 14) SIGALRM 15) SIGTERM
16) SIGSTKFLT 17) SIGCHLD 18) SIGCONT 19) SIGSTOP 20) SIGTSTP
21) SIGTTIN 22) SIGTTOU 23) SIGURG 24) SIGXCPU 25) SIGXFSZ
26) SIGVTALRM 27) SIGPROF 28) SIGWINCH 29) SIGIO 30) SIGPWR
31) SIGSYS 34) SIGRTMIN 35) SIGRTMIN+1 36) SIGRTMIN+2 37) SIGRTMIN+3
38) SIGRTMIN+4 39) SIGRTMIN+5 40) SIGRTMIN+6 41) SIGRTMIN+7 42) SIGRTMIN+8
43) SIGRTMIN+9 44) SIGRTMIN+10 45) SIGRTMIN+11 46) SIGRTMIN+12 47) SIGRTMIN+13
48) SIGRTMIN+14 49) SIGRTMIN+15 50) SIGRTMAX-14 51) SIGRTMAX-13 52) SIGRTMAX-12
53) SIGRTMAX-11 54) SIGRTMAX-10 55) SIGRTMAX-9 56) SIGRTMAX-8 57) SIGRTMAX-7
58) SIGRTMAX-6 59) SIGRTMAX-5 60) SIGRTMAX-4 61) SIGRTMAX-3 62) SIGRTMAX-2
63) SIGRTMAX-1 64) SIGRTMAX
```

Notice that every signal has a numeric value. For example, [19] is the numeric value for the [SIGSTOP] signal.

To see how signals work, let's first start Firefox as a background process:

```
elliot@ubuntu-linux:~$ firefox &
[1] 4218
```

Notice that the PID of Firefox is [4218] on my system. I can kill (terminate) Firefox by sending a [SIGKILL] signal as follows:

```
elliot@ubuntu-linux:~$ kill -SIGKILL ADD_FIREFOX_PROCESS_ID
[1]+ Killed              firefox
```

This will immediately shut down Firefox. You can also use the numeric value of the [SIGKILL] signal instead:

```
elliot@ubuntu-linux:~$ kill -9 ADD_FIREFOX_PROCESS_ID
```

In general, the syntax for the [kill] command is as follows:

```
kill -SIGNAL PID
```

Let's start Firefox again as a background process:

```
elliot@ubuntu-linux:~$ firefox &
[1] 4907
```

Notice that the PID of Firefox is [4907] on my system. Now go ahead and open google.com on Firefox. After you have done that, go back to your terminal and send the [SIGSTOP] signal to Firefox:

```
elliot@ubuntu-linux:~$ kill -SIGSTOP ADD_FIREFOX_PROCESS_ID
```

You will notice that Firefox becomes unresponsive; no problem -- we can fix that by sending the [SIGCONT] signal to Firefox:

```
elliot@ubuntu-linux:~$ kill -SIGCONT ADD_FIREFOX_PROCESS_ID
```

This will resurrect Firefox, and your webpage will now resume.

So far, you have learned three signals:

- [SIGKILL]: Terminates a process
- [SIGSTOP]: Stops a process
- [SIGCONT]: Continues a process

You can use process names instead of process identifiers with the [pkill] command. For example, to close your terminal process, you can run the command:

```
elliot@ubuntu-linux:~$ pkill -9 terminal
```

Now let's do something funny; open your terminal and run the command:

```
elliot@ubuntu-linux:~$ pkill -SIGSTOP terminal
```

Haha! Your terminal is now frozen. I will let you handle that!

Viewing a process priority

Start Firefox as a background process:

```
elliot@ubuntu-linux:~$ firefox &
 [1] 6849
```

Note: Replace `6849` with your firefox processId in commands below.

You can use the [ps] command to view a process' nice value:

```
elliot@ubuntu-linux:~$ ps -o nice -p 6849
NI
0
```

My Firefox process has a nice value of **0**, which is the default value (average priority).

Setting priorities for new processes

You can use the [nice] command to start a process with your desired priority.

Let's say you are about to upgrade all the packages on your system; it would be wise to give such a process the highest priority possible. To do that, you can run the following command as the [root] user:

```
root@ubuntu-linux:~# nice -n -20 apt-get upgrade
```

Changing a process priority

You can use the [renice] command to change the priority of a running process. We have already seen that Firefox was running with a default process priority of zero; let's change Firefox's priority and give it the lowest priority possible:

```
root@ubuntu-linux:~# renice -n 19 -p 6849
6849 (process ID) old priority 0, new priority 19
```

Cool! Now I hope Firefox will not be very slow for me; after all, I just told my CPU not to give much attention to Firefox!

The /proc directory

Every process in Linux is represented by a directory in [/proc]. For example, if your Firefox process has a PID of [6849], then the directory [/proc/6849] will represent the Firefox process:

```
root@ubuntu-linux:~# pgrep firefox
6849
root@ubuntu-linux:~# cd /proc/6849
root@ubuntu-linux:/proc/6849#
```

Inside a process' directory, you can find a lot of valuable and insightful information about the process. For example, you will find a soft link named [exe] that points to the process' executable file:

```
root@ubuntu-linux:/proc/6849# ls -l exe
lrwxrwxrwx 1 elliot elliot 0 Nov 21 18:02 exe -> /usr/lib/firefox/firefox
```

You will also find the [status] file, which stores various pieces of information about a process; these include the process state, the PPID, the amount of memory used by the process, and so on:

```
root@ubuntu-linux:/proc/6849# head status
Name: firefox
Umask: 0022
State: S (sleeping) Tgid: 6849
Ngid: 0
Pid: 6849
PPid: 1990
TracerPid: 0
Uid: 1000 1000 1000 1000
Gid: 1000 1000 1000 1000
```

The [limits] file displays the current limits set for the process:

```
root@ubuntu-linux:/proc/7882# cat limits
Limit                     Soft Limit   Hard Limit   Units
Max cpu time              unlimited    unlimited    seconds
Max file size             unlimited    unlimited    bytes
Max data size             unlimited    unlimited    bytes
Max stack size            8388608      unlimited    bytes
Max core file size        0            unlimited    bytes
Max resident set          unlimited    unlimited    bytes
Max processes             15599        15599        processes
Max open files            4096         4096         files
Max locked memory         16777216     16777216     bytes
Max address space         unlimited    unlimited    bytes
Max file locks            unlimited    unlimited    locks
Max pending signals       15599        15599        signals
Max msgqueue size         819200       819200       bytes
Max nice priority         0            0
Max realtime priority     0            0
Max realtime timeout      unlimited    unlimited    us
```

The [fd] directory will show you all the files that the process is currently using on your system:

```
root@ubuntu-linux:/proc/6849# cd fd
root@ubuntu-linux:/proc/6849/fd# ls -l | tail
lrwx------ 1 elliot elliot 64 Nov 21 18:12 83 -> /home/elliot/.mozilla/firefox/places.sqlite-wal
lr-x------ 1 elliot elliot 64 Nov 21 18:12 84 -> /home/elliot/.mozilla/firefox/wkgfiatj.default
/favicons.sqlite
lrwx------ 1 elliot elliot 64 Nov 21 18:12 85 -> /home/elliot/.mozilla/firefox/wkgfiatj.default
/favicons.sqlite-wal
lrwx------ 1 elliot elliot 64 Nov 21 18:12 86 -> /home/elliot/.mozilla/firefox/wkgfiatj.default
/content-prefs.sqlite
lrwx------ 1 elliot elliot 64 Nov 21 18:12 88 -> /home/elliot/.mozilla/firefox/wkgfiatj.default
/webappsstore.sqlite
lr-x------ 1 elliot elliot 64 Nov 21 18:12 89 -> /usr/lib/firefox/browser/features
/formautofill@mozilla.org.xpi
lr-x------ 1 elliot elliot 64 Nov 21 18:12 9 -> /dev/shm/org.mozilla.ipc.6849.5 (deleted)
lrwx------ 1 elliot elliot 64 Nov 21 18:12 90 -> /home/elliot/.mozilla/firefox/wkgfiatj.default
/webappsstore.sqlite-wal
lr-x------ 1 elliot elliot 64 Nov 21 18:12 92 -> /home/elliot/.mozilla/firefox/wkgfiatj.default
/webappsstore.sqlite
lrwx------ 1 elliot elliot 64 Nov 21 18:12 93 -> /home/elliot/.mozilla/firefox/wkgfiatj.default
/webappsstore.sqlite-wal
```

You can also use the [lsof] command to list all the files a process is using:

```
root@ubuntu-linux:~# lsof -p 6849 | tail
lsof: WARNING: can't stat() fuse.gvfsd-fuse file system /run/user/1000/gvfs
      Output information may be incomplete.
firefox 6849 elliot  164u     unix 0xffff918255ae1c00       0t0  77045 type=SEQPACKET
firefox 6849 elliot  165u     unix 0xffff918255ae1800       0t0  77046 type=SEQPACKET
firefox 6849 elliot  166r      REG               0,23     58086     48 /dev/shm/org.mozilla.ipc.6849.41
firefox 6849 elliot  168u     unix 0xffff918255ae2000       0t0  77049 type=STREAM
firefox 6849 elliot  170r      REG               0,23     21518     49 /dev/shm/org.mozilla.ipc.6849.42
firefox 6849 elliot  172r      REG               0,23       170     50 /dev/shm/org.mozilla.ipc.6849.43
firefox 6849 elliot  174r      REG               0,23      1918     51 /dev/shm/org.mozilla.ipc.6849.44
firefox 6849 elliot  176r      REG               0,23      1772     52 /dev/shm/org.mozilla.ipc.6849.45
firefox 6849 elliot  178r      REG               0,23     20920     53 /dev/shm/org.mozilla.ipc.6849.46
firefox 6849 elliot  180r      REG               0,23      5808     54 /dev/shm/org.mozilla.ipc.6849.47
```

Knowledge check

For the following exercises, open up your Terminal and try to solve the following tasks:

1. List the process ID of your running terminal.
2. List the parent process ID of your running terminal.
3. Use the [kill] command to close your terminal.
4. Start Firefox as a background process.
5. Change Firefox's priority to a maximum priority.