TP n°6: Process management and process commands

1. Objectives

The aim of this practical course is to familiarize students with process management and the commands that manipulate processes.

2. Process concepts

A process is a running program, identified by a unique number called the PID (Process IDentifier). A process has a parent process whose identifier is represented by the PPID (Parent PID) except for the first process ***"init"***, which has no parent and whose PID=1. The special feature of a process is that it runs with the rights granted to the user who issued the command associated to the process.

The execution of a process must progress sequentially, i.e. at any time a single instruction at most is executed on behalf of the process.

2.1 Process states

Each process can be in any of the following states:

- ***Running*****:** Instructions are running (using the processor).
- ***Waiting***: The process is waiting for an event to occur (signal).
- ***Ready***: The process is waiting to be assigned to a processor.
- ***Zombie***: This is a process that has completed its task, like a parent process waiting for its children, but it still has an entry in the process table (it is not unloaded from memory).

A single process can be running on any processor at any time. However, several processes can be ready and waiting.

2.2 Process commands

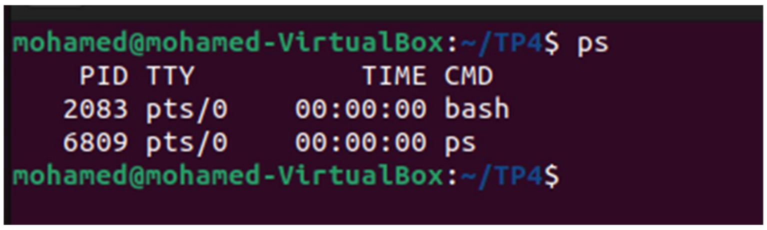
a) Command ps

The command ps is used to display the list of processes associated with the current terminal. Its syntax is as follows:

```
ps [options]
```

Without any options, ps does not display the full list of processes, nor much information. It only displays processes launched from the terminal in which it was run.

Example:



```
mohamed@mohamed-VirtualBox:~/TP4$ ps
    PID TTY          TIME CMD
   2083 pts/0    00:00:00 bash
   6809 pts/0    00:00:00 ps
mohamed@mohamed-VirtualBox:~/TP4$
```

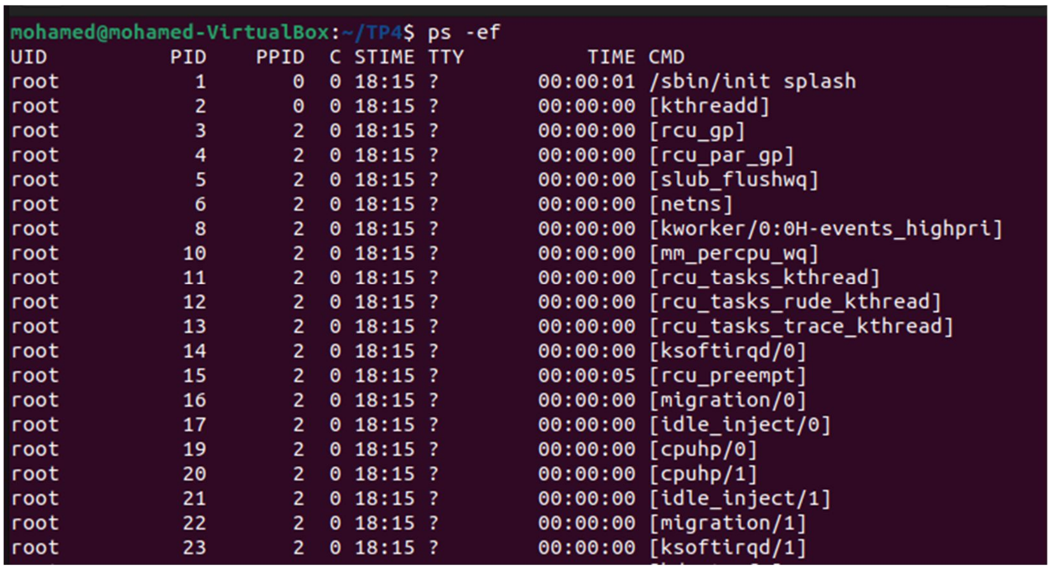
Options of command ps

To get more details about the processes on a machine, you can use one of the options:

- e: Displays the processes currently running for all users.
- f: Displays the complete list of the format (displays additional information about the running processes).
- a: processes for all users.
- u: display user-oriented format (displays additional information about running processes).
- x: list of processes which do not belong to any TTY (terminal).
- o: This option is used to filter the column so that only the desired column is displayed. For example, to display only the ***pid*** and ***comm*** columns:

```
ps -efo pid,comm
```

The information returned on processes by the command ***ps -ef*** is as follows:



```
mohamed@mohamed-VirtualBox:~/TP4$ ps -ef
UID          PID    PPID  C STIME TTY          TIME CMD
root           1       0  0 18:15 ?        00:00:01 /sbin/init splash
root           2       0  0 18:15 ?        00:00:00 [kthreadd]
root           3       2  0 18:15 ?        00:00:00 [rcu_gp]
root           4       2  0 18:15 ?        00:00:00 [rcu_par_gp]
root           5       2  0 18:15 ?        00:00:00 [slub_flushwq]
root           6       2  0 18:15 ?        00:00:00 [netns]
root           8       2  0 18:15 ?        00:00:00 [kworker/0:0H-events_highpri]
root          10       2  0 18:15 ?        00:00:00 [mm_percpu_wq]
root          11       2  0 18:15 ?        00:00:00 [rcu_tasks_kthread]
root          12       2  0 18:15 ?        00:00:00 [rcu_tasks_rude_kthread]
root          13       2  0 18:15 ?        00:00:00 [rcu_tasks_trace_kthread]
root          14       2  0 18:15 ?        00:00:00 [ksoftirqd/0]
root          15       2  0 18:15 ?        00:00:05 [rcu_preempt]
root          16       2  0 18:15 ?        00:00:00 [migration/0]
root          17       2  0 18:15 ?        00:00:00 [idle_inject/0]
root          19       2  0 18:15 ?        00:00:00 [cpuhp/0]
root          20       2  0 18:15 ?        00:00:00 [cpuhp/1]
root          21       2  0 18:15 ?        00:00:00 [idle_inject/1]
root          22       2  0 18:15 ?        00:00:00 [migration/1]
root          23       2  0 18:15 ?        00:00:00 [ksoftirqd/1]
```

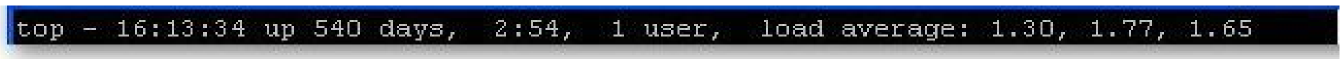
The information returned by the command ***ps -aux*** is :

- USER: the user running the process.
- %CPU: the processor utilization of the process.
- %MEM: the percentage of the size of the process's resident setting in the machine's physical memory.
- VSZ: size of the process's virtual memory in Kilobytes.
- RSS: the size of the physical memory used by the process.
- STAT: the process status code, such as Z (Zombie), S or I (Sleeping) and R (Running).

b) The command top

The command top displays continuous information about system activity. In particular, this command can be used to monitor the resources that processes are using (amount of RAM, percentage of CPU, how long the process has been running since it was started).

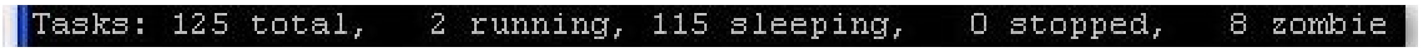
The command top can also be used to find out the load average of your server or machine. For example, the first line of the top command retrieves the following information:



```
top - 16:13:34 up 540 days,  2:54,  1 user,  load average: 1.30, 1.77, 1.65
```

- top - : command reminder.
- 16 :13 :34: machine time.
- up xx days (uptime): the time since which the machine has been running without interruption. Restarting the machine resets the uptime.
- n users: number of users currently logged on to the server.
- load average 1.30, 1.77, 1.65: average load of the machine (represents the average number of processes) is divided into 3 parts: the first is calculated over the last minute, the second 5 minutes and the last 15 minutes. In this example, an average of 1.30 processes have used the processor over the last minute, 1.77 over the last 5 minutes and 1.65 over the last 15 minutes.

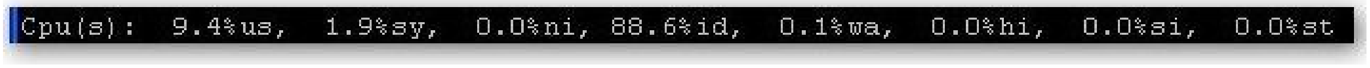
The second line contains the following information:



```
Tasks: 125 total,   2 running, 115 sleeping,   0 stopped,   8 zombie
```

- Number of tasks (Task 125 total) : Total number of processes,
- Number of processes (2 running): Number of active processes,
- Number of sleeping processes (115 sleeping): Number of sleeping processes, A sleeping process does nothing. It waits for a condition to become executable or active again.
- Number of stopped processes (0 stopped): Number of stopped processes. In this state, a process has been stopped, usually by receiving a signal. For example, a process that is being debugged.
- Number of zombie processes (8 zombie): These are processes that have actually finished running. It has finished executing and therefore no longer has any reason to exist, but it still has an entry in the process table. Only for various possible reasons, its parent has not been informed of this.

Use of the processor



```
Cpu(s):  9.4%us,  1.9%sy,  0.0%ni, 88.6%id,  0.1%wa,  0.0%hi,  0.0%si,  0.0%st
```

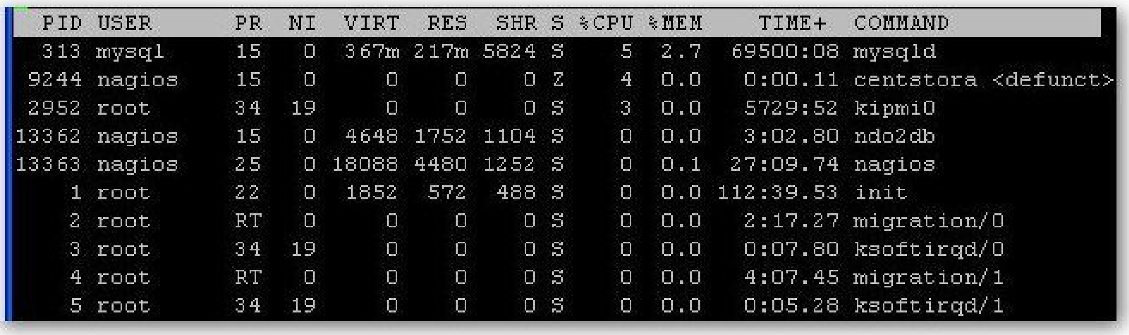
- xx%us (9.4%us): CPU time used by user processes.
- yy%sy (1.9%sy): CPU time used by the kernel and its processes (system processes).
- 0.0%ni: CPU time used by user processes that have been "nicated: processes launched with the command nice " (a "nicated" process gives priority to other processes).
- 88.6%id: Unsolicited CPU time.
- 0.1%wa: CPU time for waiting for I/O, if this figure is large all the time, such as 20 or more for example, this means that your computer has instructions waiting to be processed and is probably starting to struggle to do what you want it to do. This value should be close to 0 most of the time.
- 0.0%hi: CPU time used for hardware interrupts.
- 0.0%si : CPU time used for software interrupts.

- 0.0%st: CPU time "stolen" from this virtual machine for other tasks (for example using another VM). We know that when a VM is used, resources can be shared, especially CPU.

Use of physical and virtual memory

- Mem: Physical memory (total, used, free and buffers).
- Swap: Virtual memory (total, used, free and cached). This memory allows applications to use more RAM than the machine physically contains. This is equivalent to using a mass storage medium (hard disk) to simulate memory.

Process details



```
  PID USER      PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  COMMAND
  313 mysql     15   0  367m 217m 5824 S    5  2.7  69500:08 mysqld
 9244 nagios    15   0     0    0    0 Z    4  0.0   0:00.11 centstora <defunct>
 2952 root      34  19     0    0    0 S    3  0.0   5729:52 kipmi0
13362 nagios    15   0  4648 1752 1104 S    0  0.0   3:02.80 ndo2db
13363 nagios    25   0 18088 4480 1252 S    0  0.1  27:09.74 nagios
    1 root      22   0  1852  572  488 S    0  0.0 112:39.53 init
    2 root      RT   0     0    0    0 S    0  0.0   2:17.27 migration/0
    3 root      34  19     0    0    0 S    0  0.0   0:07.80 ksoftirqd/0
    4 root      RT   0     0    0    0 S    0  0.0   4:07.45 migration/1
    5 root      34  19     0    0    0 S    0  0.0   0:05.28 ksoftirqd/1
```

- PID: The process PID (the processes running simultaneously on a machine).
- USER: The user running this process.
- PR: The priority of the process (the smaller the number, the higher the priority).
- NI: The nice of the process.
- VIRT: Virtual size of a process, i.e. the amount of memory it actually uses in memory (not just RAM).
- RES: Amount of physical memory occupied by the process.
- SHR: Indicates how much of the VIRT column is actually shared.
- S: Process status. S (sleeping), D (uninterruptible sleep), R (running), Z (zombie), or T (stopped or traced).
- %CPU: CPU load.
- %MEM: Memory load.
- TIME+: Total processor usage time since the process was launched.
- COMMAND: Process name.

To switch top to background mode, type ***CTRL+Z***, and it will display :

[job-number]+ stopped being the PID of the top process, if you want to restart it in the background simply type the command :

```
bg job-number
```

To end the command ***top***, simply press the "q" key.

c) The command pstree

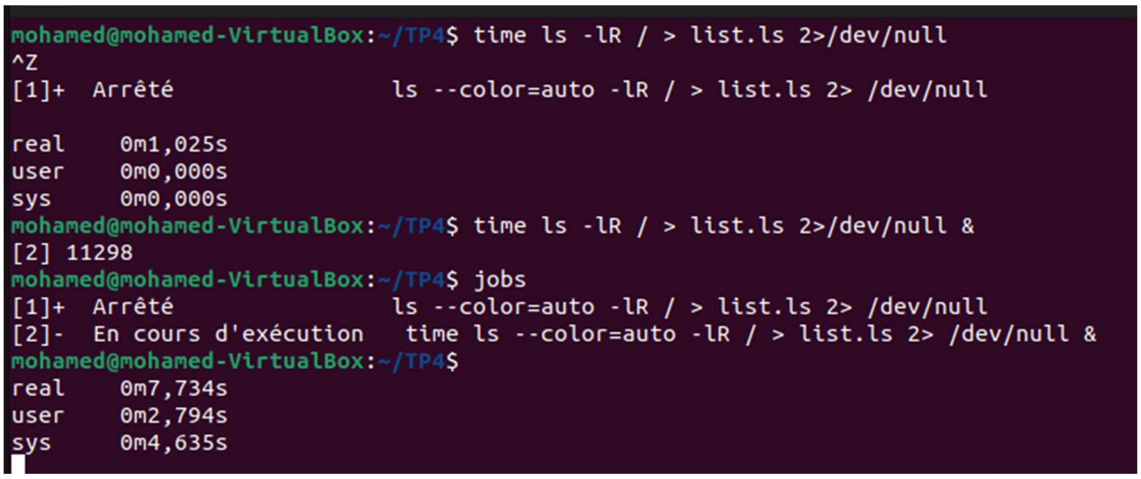
This command is used to list the relationships between processes by means of a graphical representation of the filiation relationships between processes. You can use the command “pstree”. The “-p” option also displays the process pid.

```
pstree -p
```

d) The command jobs

The command ***jobs*** is used to display the list of tasks (processes) in the current Shell (suspended or running in the background) with their job numbers, PIDs and process states.

Example :



```
mohamed@mohamed-VirtualBox:~/TP4$ time ls -lR / > list.ls 2>/dev/null
^Z
[1]+  Arrêté                  ls --color=auto -lR / > list.ls 2> /dev/null

real    0m1,025s
user    0m0,000s
sys     0m0,000s
mohamed@mohamed-VirtualBox:~/TP4$ time ls -lR / > list.ls 2>/dev/null &
[2] 11298
mohamed@mohamed-VirtualBox:~/TP4$ jobs
[1]+  Arrêté                  ls --color=auto -lR / > list.ls 2> /dev/null
[2]-  En cours d'exécution     time ls --color=auto -lR / > list.ls 2> /dev/null &
mohamed@mohamed-VirtualBox:~/TP4$
real    0m7,734s
user    0m2,794s
sys     0m4,635s
```

The information in square brackets represents the job number. It is followed by the PID, the state of the process and its name (command).

e) The command fg (foreground)

This command is used to restart the execution of a process in the background as a process in the foreground using the following syntax:

```
fg %n
```

n is the job number

f) The command bg (background)

The bg command is used to restart the execution of a suspended process as a background process. Its syntax is :

```
bg %n
```

n is the job number.

g) The command time

The command time measures the execution times of a command, ideal for determining processing times, and returns three values:

- real: total execution time of the process,

- user: duration of the CPU time required to execute the process,
- system: duration of CPU time needed to execute OS-related commands (system calls within a program).

If the result is less than 10, the machine has good performance but if the result is more than 20, the load on the machine is too heavy (low performance).

h) The command kill/killall

The command kill is used to send a signal to a process with its PID number. To terminate a process, its PID is first discovered, then the PID is passed to the kill command as argument.

If a process does not respond to a TERM signal, the KILL signal can be used. You can use kill with the -9 option using the following syntax:

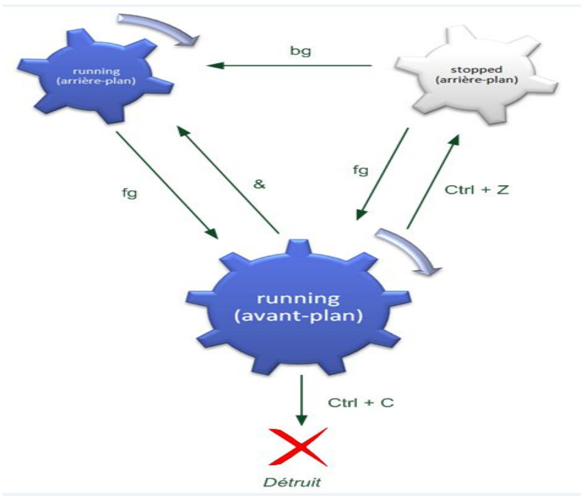
```
kill -9 pid
```

The command killall is used to kill several processes at once. The syntax is the same, simply indicate the name of the process. For example, if you want to kill all the gedit processes, use the following command:

```
kill -9 gedit
```

3. Switching between the different states of a process

Switching between the different states of a process is illustrated in the figure below:



4. Creation of processes (primitive fork())

A process can create a new process using the following function:

```
int fork(void)
```

The new process runs concurrently with the process that created it.

A call to fork() by a process, called the parent process, instructs UNIX to create a new process called the child process, which is an exact copy of the current process in most of its attributes.

This function returns:

- -1 on failure (the process child is not created),

- 0 in the child process,
- The number of the child process (PID) in the parent.

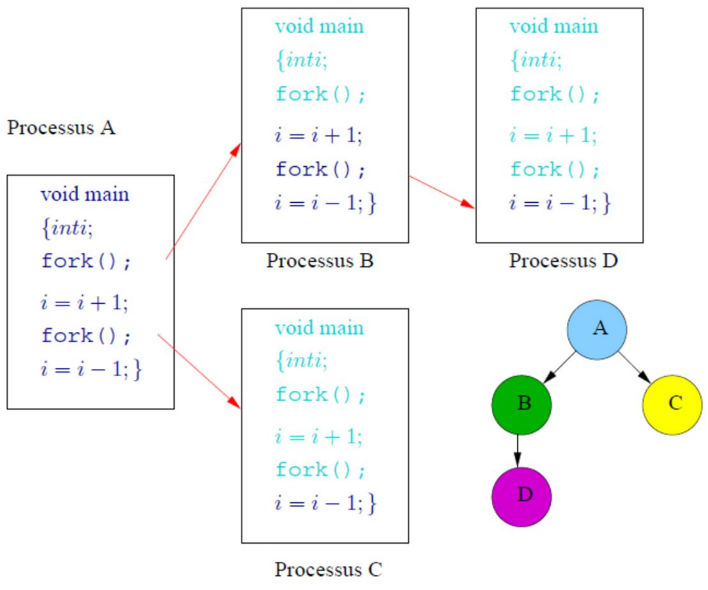
The two processes are exactly the same and run the same program on two separate copies of the data. The data spaces are completely separate: changing a variable in one is invisible in the other.

You generally want to run separate tasks in the parent and child processes. The value returned by fork() is therefore very important in differentiating the parent process from the child process. A test can be used to execute different parts of the code in the parent and child processes.

```
int code_retour ;
code_retour = fork ();
switch (code_retour ) {
 case -1 :
   printf ("Process creation failed \n");
   break;
 case 0 :
   printf ("I am the process child \n");
   break;
 default :
   printf ("I am the process parent \n");
   printf ("I have just created the child process whose pid is %d \n",code_retour);
   break;
}
```

A process has a single parent and can have 0 or more children.

To illustrate how the fork system call works, the details of which will be seen later, we offer the following example:



The first fork system call by process A creates process B and the second call creates process C, while the fork system call by process B creates process D. Each of the processes executes the parts that are highlighted, as shown in the figure above.

The generated tree shows the parent-child relationship between the processes.

Exercises

Exercise n°1

Use the compiler "c" under linux "gcc" to compile the various programs such that the syntax is as follows:

#gcc -c filename.c

#gcc -o exe-name filename.o

#./exe-name

Compile the following program with the compiler "gcc".

```
#include<sys/types.h>
#include<unistd.h> //pour fork()
#include<stdio.h> //pour printf()
#include <stdlib.h>

main()
{
int i;

i=1;

while (i<=10)

{
printf("TP LINUX\n");

sleep(5);

i=i+1;

}
}
```

1) What is the pid of this process and the pid of its parent?
2) Run the process in the background.
3) Return to the process foreground.
4) Pause execution of this process (stop the process).
5) Stop the execution of this process.
6) Use the kill -l command to view the 255 predefined linux system signals.

Exercise n°2

1) Any operating system allows users to find out about the properties and status of both the computer and the system. Linux provides a number of tools for this purpose. To begin this part, display the file "/proc/cpuinfo" (using the cat command). Using the command "grep" and a redirection (| the pipe), how can you find out the number of processors in a single command?
2) The command ps can be used to list the processes being run on a terminal. ps -aux, for example, can be used to list all the processes, regardless of who owns them. the PID is the unique identifier

for each process. Which column shows the PID? After running firefox, find its PID. You can use the command “grep”.

3) We are now going to send a signal to this process. The command kill sends a signal to a process (often to terminate a process). kill -9 xxx kills the process with PID xxx. For example, run “gedit” the text editor or another program (and then kill it using the command kill).
4) What is the difference, in terms of the state of the terminal, between these two runs of the editor gedit :

   gedit

   and

   gedit &
5) It is possible to switch the state of a process. If a process is running in foreground, it is possible to hand (the process is then "stopped") and then put the process in background. How do you do this (try using the command top)? Now make it run in foreground?
6) How to terminate a process in foreground?

Exercise n°3

1) What is the process whose pid is 1?
2) Run the program below with arguments 25, 45. Type the command ***ps -la*** in another terminal before the end of the parent, before the end of the child. What are the pids of the parent and the child? Give an explanation.
3) Run the program below with arguments 30, 0. Type the command ***ps -la*** in another terminal before the end of the parent. What do you find?

```
#include <sys/types.h> /* required for the function fork */
#include <unistd.h>    /* required for the function fork */
#include <stdio.h>     /* required for the function perror */

int main(int argc, char * argv[]) {
pid_t pid;
int wait_child,wait_parent;
if(argc != 3) perror("usage: ex1 n m\n");
wait_parent = atoi(argv[1]);
wait_child = atoi(argv[2]);
switch(pid=fork()) {
case -1:
   perror("fork error");
   break;
case 0:
   sleep(wait_child);
   printf("waiting time over for child \n");
   break;
default:
   sleep(wait_parent);
   printf("waiting time over for parent \n");
   break;
}
}
```