Fundamentos de los Sistemas Operativos

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fSO

Lab session 3
Process monitoring in LINUX

Content

1. Goals

The aim of this lab session is to be able to observe processes behavior in the system (i.e. CPU utilization, memory occupancy, PIDs, etc).
In order to achieve this, you will acquire skills about using the following tools:

- Process management (**ps** and **top**) and signalization (**kill**) commands.
- File system **/proc** where Linux collects all the process monitoring information.
- Tools to automate monitoring reports and process control:
    - Text filtering commands (**grep**).
    - Shell scripts programming.
    - **awk** programming.

2. Utilities and commands shell for processes

Using command mkdir create a new directory named fso_pract3 to put all your lab files:

```
$ mkdir fso_pract3
$ cd fso_pract3
```

2.1. ps command

To monitor processes on Linux **ps** command is available.

```
$ ps u
   USER       PID  %CPU %MEM      VSZ    RSS   TT  STAT STARTED      TIME COMMAND
   gandreu    251   0,0  0,0  2435492   1112 s000  S     4:20PM   0:00.01 -bash
```

This command displays the list of processes in the system and is based on information stored in the file system **/proc**. Depending on the parameters of **ps** command it will show us more or less information. It has a lot of options and depending on them will display several columns of process information, like:

PID	Process id
PPID	Parent process id
UID	Process user owner id
TTY	Terminal associated to the process. If there is none it appears ?
TIME	Cumulated CPU time taken by the process
CMD	Program or command name that has initiated the process
RSS	Memory size (in Kbytes) of the process resident part
SIZE	Virtual size of the process image
NI	Process priority value (nice). Less means more priority
PCPU	Percentage of CPU used by the process
STIME	Process starting time
STAT	Process state

Process states that appear in the STAT column can be:

- R (Runnable): In execution.
- S (Sleeping): Process waiting for some event to continue.
- T (sTopped): Process completely stopped. It can be restarted.
- Z (Zombie): Zombie process.
- D (uninterruptible sleep): Process in uninterruptable waiting that they are associated to I/O actions.

Along with the letter indicating the status of the process, additional characters may appear, giving more information about the process status. The most common are:

- +: The process is running in the foreground.
- X: The process being debugged or traced.

By default, **`ps`** command displays information regarding PID, TTY, TIME and CMD. Running it with different options, we can control which information is displayed. `ps` is usually used in conjunction with `grep` command, explained later.

1. Exercise:

Execute the following commands and observe the differences in their outputs.

$ ps

$ ps u

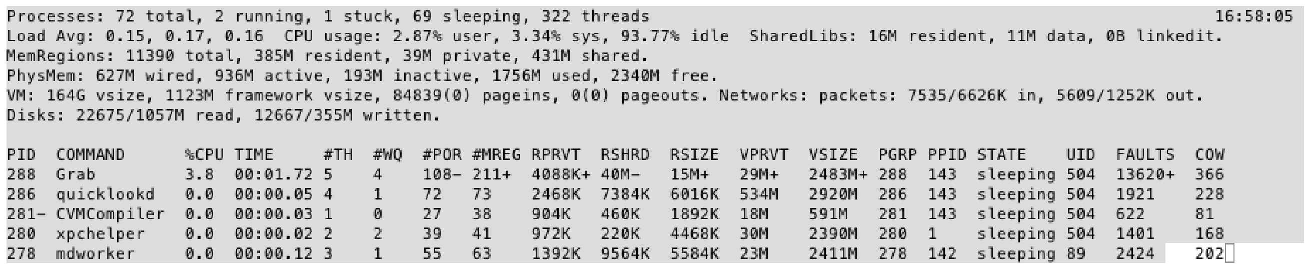
$ ps -la

$ ps f

$ ps aux

2.2. `top` command

`top` command shows in real time the list of processes currently running on the system, specifying the % of CPU and memory consumed, their PIDs, owner users, and so on. Execute the **`top`** command and the terminal will display information divided in two parts, like this:



```
Processes: 72 total, 2 running, 1 stuck, 69 sleeping, 322 threads                                      16:58:05
Load Avg: 0.15, 0.17, 0.16  CPU usage: 2.87% user, 3.34% sys, 93.77% idle  SharedLibs: 16M resident, 11M data, 0B linkedit.
MemRegions: 11390 total, 385M resident, 39M private, 431M shared.
PhysMem: 627M wired, 936M active, 193M inactive, 1756M used, 2340M free.
VM: 164G vsize, 1123M framework vsize, 84839(0) pageins, 0(0) pageouts. Networks: packets: 7535/6626K in, 5609/1252K out.
Disks: 22675/1057M read, 12667/355M written.

PID  COMMAND      %CPU TIME     #TH  #WQ  #POR #MREG RPRVT  RSHRD  RSIZE  VPRVT  VSIZE  PGRP PPID STATE    UID  FAULTS  COW
288  Grab         3.8  00:01.72 5    4    108- 211+  4088K+ 40M-   15M+   29M+   2483M+ 288  143  sleeping 504  13620+  366
286  quicklookd   0.0  00:00.05 4    1    72   73    2468K  7384K  6016K  534M   2920M  286  143  sleeping 504  1921    228
281- CVMCompiler  0.0  00:00.03 1    0    27   38    904K   460K   1892K  18M    591M   281  143  sleeping 504  622     81
280  xpchelper    0.0  00:00.02 2    2    39   41    972K   220K   4468K  30M    2390M  280  1    sleeping 504  1401    168
278  mdworker     0.0  00:00.12 3    1    55   63    1392K  9564K  5584K  23M    2411M  278  142  sleeping 89   2424    202
```

To exit **`top`** just press ‘q’ key . The **`top`** output shows, among other things, the system uptime, number of connected users, average load, number of processes running on the system, as well as disk, memory and CPU(s) utilization. In the second part, we can see the list of processes currently running. They can be sorted by CPU usage (**`top -o %CPU`**) or memory usage (**`top -o %MEM`**), which is an excellent aid to detect processes that consume excessive resources. This list shows several attributes of every process, such as the process PID, the user running it, %CPU and memory space consumed, command associated to the process and process execution time, among others.

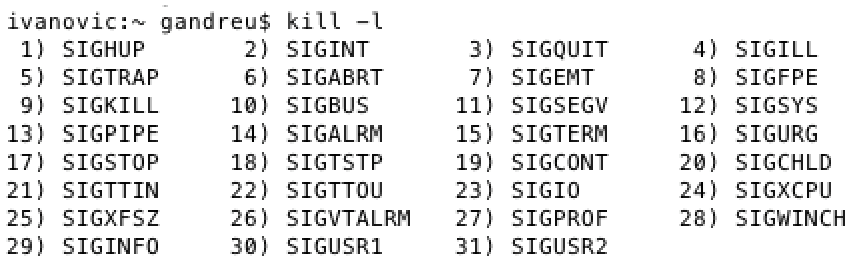
2.3. `kill` command

`kill` command serves not only to kill or terminate processes, but mainly to send signals to processes. Its syntax is:

```
$ kill SIGNAL PID
```

Where SIGNAL is the signal to send and PID is the process ID to which the signal SIGNAL is delivered. The default signal (when none is indicated) is to finish or kill the process. Get a list of all the signals of your machine by executing:

```
$ kill –l
```



```
ivanovic:~ gandreu$ kill -l
 1) SIGHUP       2) SIGINT       3) SIGQUIT      4) SIGILL
 5) SIGTRAP      6) SIGABRT      7) SIGEMT       8) SIGFPE
 9) SIGKILL     10) SIGBUS      11) SIGSEGV     12) SIGSYS
13) SIGPIPE     14) SIGALRM     15) SIGTERM     16) SIGURG
17) SIGSTOP     18) SIGTSTP     19) SIGCONT     20) SIGCHLD
21) SIGTTIN     22) SIGTTOU     23) SIGIO       24) SIGXCPU
25) SIGXFSZ     26) SIGVTALRM   27) SIGPROF     28) SIGWINCH
29) SIGINFO     30) SIGUSR1     31) SIGUSR2
```

Signal SIGKILL (9) does process termination; this signal cannot be neither handled, masked or ignored.

2. Exercise:
Launch the **`yes`** command and end up the process by typing Ctrl-c in the keyboard. Ctrl-c sends the SIGINT signal to interrupt the process:

```
$ yes
Y
Y
 ctrl-c
```

Now launch the command **`yes`** in background (with & symbol), find its PID and finish the process using **`kill.`** Then, check with **`ps`** that the process no longer exists.

```
$ yes > /dev/null &
$ ps -la
$ kill -SIGKILL PID
```

The comand **`kill`** permit to reference the signals by its number or name, example:

```
$ kill -9 11428         (ends process with PID 11428)
$ kill -SIGKILL 11428   (does the same as the former command)
```

`killall` is similar to kill with SIGKILL signal but instead of the PID it is specified the program name. `killall` ends all processes with the specified program name.

3. Exercise:
Check **`killall`** command using the following command sequence:

```
$ yes > /dev/null &
$ yes > /dev/null &
$ yes > /dev/null &
$ ps -la
…
$ killall yes
$ ps -la
```

4. Exercise:
Launch the Kate editor from a terminal in background. In the same terminal, run the **`ps`** command to find the started process PID. Use the **`kill`** command to kill the Kate process.

3. “/proc” directory

This directory maintains information about the processes currently running. By processing the information in **`/proc`** we can get the same data provided by commands like **`ps`** or **`top`**.

Note. MacOS has not a **/proc** directory. System info is stored in another place. If interested, look at annex 7.

In **`/proc`** directory there is a sub-directory **`/proc/$pid`** for each running process and a set of files with system information:

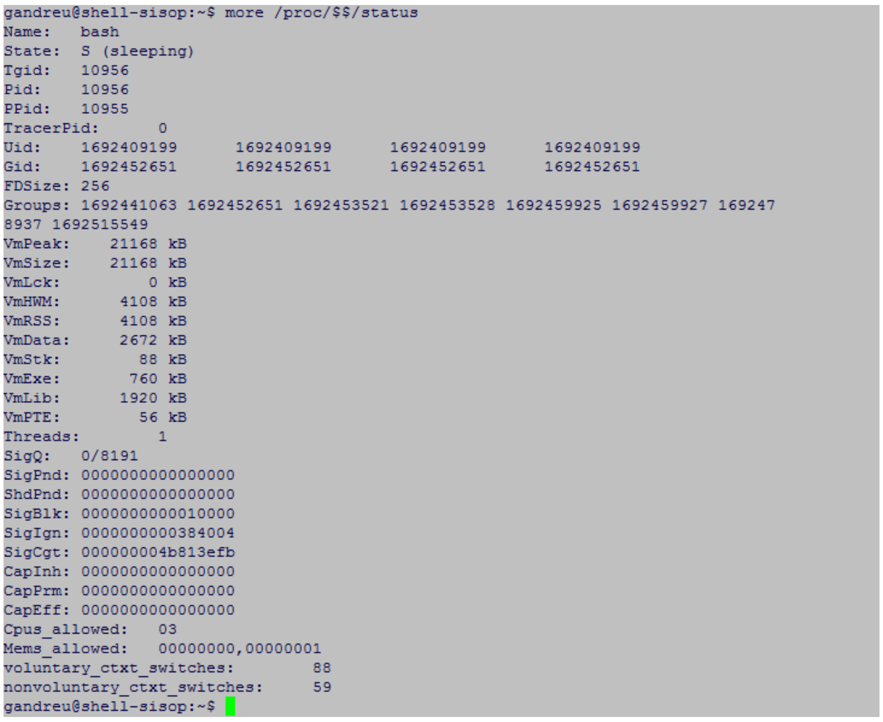
- **cpuinfo**: where lots of information can be found about the processor.
- **stat**: it contains information about the processor performance, it includes information about the time the processor has been on, the number of running processes, etc.
- **version**: it contains information about the kernel version, gcc compiler, Linux distribution, etc.

5. Exercise: Run the following orders to check the contents of **/proc**.
Run the **ps** command to find the PID of your shell and notice that there is a directory in **/proc** whose name is that PID. To list the content of that directory, replace **`/$pid_bash`** with the PID of your shell:

```
$ ps

$ ls /proc

$ ls /proc/$pid_bash

$ more /proc/cpuinfo
```

Within each process folder (**`/proc/$pid`**) we will find several files. Some of them are:

- **/proc/$pid/cmdline**: it contains information about the name of the process, including its full path.
- **/proc/$pid/stat**: it contains much information about the process. It is a text file made up of several fields, which are separated by the space character. Among the several fields available we have the PID, process name (just the name of the process, not the full path, etc.).
- **/proc/$pid/maps:** it contains information about process memory map.
- **/proc/$pid/status:** It contains information related to a particular process like its PID, PPID, state and attributes related to memory consumption.



```
gandreu@shell-sisop:~$ more /proc/$$/status
Name:   bash
State:  S (sleeping)
Tgid:   10956
Pid:    10956
PPid:   10955
TracerPid:      0
Uid:    1692409199      1692409199      1692409199      1692409199
Gid:    1692452651      1692452651      1692452651      1692452651
FDSize: 256
Groups: 1692441063 1692452651 1692453521 1692453528 1692459925 1692459927 169247
8937 1692515549
VmPeak:    21168 kB
VmSize:    21168 kB
VmLck:         0 kB
VmHWM:      4108 kB
VmRSS:      4108 kB
VmData:     2672 kB
VmStk:        88 kB
VmExe:       760 kB
VmLib:      1920 kB
VmPTE:        56 kB
Threads:        1
SigQ:   0/8191
SigPnd: 0000000000000000
ShdPnd: 0000000000000000
SigBlk: 0000000000010000
SigIgn: 0000000000384004
SigCgt: 000000004b813efb
CapInh: 0000000000000000
CapPrm: 0000000000000000
CapEff: 0000000000000000
Cpus_allowed:   03
Mems_allowed:   00000000,00000001
voluntary_ctxt_switches:        88
nonvoluntary_ctxt_switches:     59
gandreu@shell-sisop:~$
```

The previous screen shows the “status” file content:

- **VmSize**: Total virtual space demanded by the process.
- **VmLck**: Space taken by pages that the process has blocked in its virtual space. This blocking mechanism avoids these pages to be selected as victims by the page replacement algorithm.
- **VmRSS**: It gives the “resident set size”, that is, the size of the page set actually loaded in memory. In other words, it indicates how much physical memory is consuming the process.
- **VmData**: It indicates the virtual size assigned to the process data.
- **VmStk**: It indicates the virtual size assigned to the process stack.
- **VmExe**: It indicates the virtual size assigned to the program code that executes the process.
- **VmLib**: It indicates the virtual size assigned to the dynamic libraries being used by the process.

Full and comprehensive information about these files and others can be found using command:

```
$ man proc
```

4. Tools to automate process monitoring

4.1. grep command

grep command searches for a regular expression in a file or in the standard input. For instance:

```
$ grep hello file        //  shows the lines that contain the string "hello" in "file"
$ grep -i Hello file     //  shows the lines that contain "hello" in "file" ignoring case
$ ls –l | grep pract3   //   shows the lines that contain "pract3" in the input stream produced by the output
                             of ls -l
```

6. Exercise:
Write a command line that shows on the screen the clock frequency of the processors in the system. You have to access file **/proc/cpuinfo** and use the **grep** command to select the appropriate line.

7. Exercise:
Write a command line that shows on the screen the cache memory size of the processors in the system. You have to access file **/proc/cpuinfo** and use the **grep** command to select the appropriate line.

4.2. Shell script

The Linux shell (i.e. bash) is an executable program which is available on any Linux system and whose purpose is to read commands (text lines) that specify program executions, analyze them and make the system calls that are necessary to run them.

This interpreter defines, as with any other interpreter or translator, a programming language that has features like:

- Procedures, better known as shell scripts
- Words and reserved characters (also known as wildcards)
- Variables
- Structures for flow control, such as if, while, etc.
- Interrupt handling

Actually, in Linux there are several shells. The most basic shell is Bourne shell, or sh, which is available on any system. Other common shells are ksh (Korn shell), csh (C like syntax shell) and bash (Bourne-Again Shell) that is fully compatible with sh while incorporating features from ksh and csh.

This lab session will introduce the features and syntax of sh, which are also applicable to ksh and bash.

Commands to be executed by the shell can be provided via the keyboard or by a program contained in a file. In the latter case, the file is called a shell script. It contains commands to be executed by the shell, line by line. For example, you can create a file with the following content:

```
#!/bin/bash
# content
Num_process=$(ls -d /proc/[1-9]* | wc -l)
echo Number of System process is: $Num_process
```

Lines beginning with a # character are comments. The rest are statements that will be executed by the shell. In particular, the **echo** command shows on the console the specified string, the `ls -d` command is used to obtain a list of directories, while `wc -l` compute the number of lines.

8. Exercise:

Create the previous file using a text editor (i.e. Kate) and name it "content". You must give execution permission to content to execute it:

```
$ chmod +x content
$ ./content
```

Notice that the program is executed with `./content`, not just `content`. The `./` indicates that the file to run is in the current working directory (directory "."). To avoid having to specify the path of an executable file each time it is called, we can use the environment variable PATH (see annex 1).

- A shell script can be invoked with arguments, which can be referenced as **$0**, **$1**, **$2**, **$3**, etc.
- The reference **$0** points to the program name
- **$@** references all the arguments (excluding **$0**)
- **$#** is the number of arguments (excluding **$0**)

9. Exercise:

Create a file named “arguments” with the following content:

```
#!/bin/bash
# arguments
echo The number of arguments is: $#
echo The full command line entered is: $0 $@
echo The command name is: $0
echo The first argument is: $1
echo The second argument is: $2
echo The third argument is: $3
```

Then, give execution permission to file “arguments” and execute it with different parameters, like this:

```
$ ./arguments one two three

$ ./arguments FSO TCO ESO
```

4.2.1. Variables

A variable is created using **“=”** to assign a value or content to its identifier, this is, **`identifier=content`**. You access to a variable content using **$** before the variable identifier. For instance:

```
$ name=Alberto
$ subject=FSO
$ msg=”Hello World”
$
$ echo $name
    Alberto
$ echo $subject
  FSO
$ echo $msg
 Hello World
```

Warning: Do not leave spaces between the identifier and “=” nor between “=” and the value/content. Otherwise, the shell will take it as if they were shell commands instead of a variable assignment.

4.2.2. for loops

The **for** statement is controlled by an associated variable that iterates over a list of values:

```
for variable in value list
do
  sentencias
done
```

We can use a **for** loop to list the arguments in a command:

```
#!/bin/bash
echo The number of arguments is: $#
echo The entered command line is: $0 $@
echo The command arguments are:
for i in "$@"
do
  echo $i
done
```

The list of values in a **for** loop can also be the current directory file list. For example, the following program creates a backup of every file in the current directory:

```
for k in *
do
  cp $k $k.bak
  echo $k copy created
done
```

Finally, the list of values in a **`for`** loop can also come from a command execution using **`$()`**. For example:

```
for i in $(ls)
do
  echo $i
done
```

4.2.3. if statement

The **`if`** statement allows conditional execution of commands. Its syntax is the following:

```
if command executes ok then
  command block
else
  alternative command block
fi
```

Notice that the condition in the **`if`** statement is not an expression but a command. The condition is true if the command "completes successfully" (in this case the statements following "**then**" are executed) and false otherwise (in this case the statements following "**else**" are executed). The "**else**" clause is optional.

4.2.4. test command

The **test** command allows evaluating conditions and, therefore, it is useful to use in conjunction with the **`if`** sentence. The types of expressions that it can evaluate are:

Numerical expressions. The general form of numerical expressions is:

```
test N <primitive> M
```

where N and M are interpreted as numerical values. The primitives that can be used are:

-eq	True if N y M are equal
-ne	True if N y M are not equal
-gt	True if N is greater than M
-lt	True if N is less than M
-ge	True if N is equal or greater than M
-le	True if N is less or equal than M

10. Exercise:

Edit a file named “**my_processes**” with the following commands and execute it:

```
#!/bin/bash
# my_processes
process=$(ps u | grep $USER | wc -l)
if test $process -gt $1
then
echo "More than $1 user processes active”
else
echo "Equal or less than $1 user processes active”
fi
```

```
$./my_processes 1
```

Alphanumeric expressions. Let S and R be strings. We can have two types of expressions:

test <primitive> S
test S <primitive> R

The primitives that can be used are:

S=R	S and R are the same
S != R	S and R are not the same
-z S	True if S is empty
-n S	True if S in not empty

File type. The general form of the expressions is:

test <primitive> file

The primitives that can be used are:

-s	True if the file exists and it is not empty
-f	True if the file exists and it is a regular file (not a directory)
-d	True if the file is a directory
-r	True if the file has reading permission
-w	True if the file has writing permission
-x	True if the file has execution permission

11. Exercise: Implement a script “**del_file**”, with one argument that will be a file name. The script has to check if the file exists and that it is not a directory. If it does not exist a message on the screen will notice it, else if it is a regular file it will be deleted. In case of being a directory, a message on the screen will tell that it is a directory and that it cannot be deleted.

4.3. awk

awk is a tool that is useful to modify files, search and transform databases, and create simple reports. It is a programming language with many capabilities, but this section is intended to illustrate its basic use.

The basic function of **awk** is to find lines in files or other text units that contain certain patterns. When a pattern is found in a line, **awk** performs the action specified in that line and continues processing the lines until it reaches the end of file.

4.3.1. Syntax

awk can be invoked in different ways, but in any case we must indicate what patterns it has to look for, what actions has to perform on the lines containing those patterns and from where it takes the input lines.

```
$ awk 'awk_program' input_file_1 input_file_2 ...
```

This format tells the shell to run "awk_program" using **awk** to process the lines in the input files "input_file_1" and "input_file_2".

When the program is long it is more convenient to put the program into a file and execute it as follows:

```
$ awk -f program-file input_file_1 input_file_2 ...
```

In this case, "program-file" is the file that contains the program.

An **awk** program consists of a set of rules. Each rule specifies a pattern to search and an action to perform when that pattern is found. The action is enclosed in brackets to separate it from the patterns.

```
pattern { action }
pattern { action }
...
pattern { action }
```

4.3.2. Patterns

Patterns can be specified by regular expression enclosed in slashes "**/**". The simplest regular expression is a sequence of letters, numbers or both. For example, the pattern **`/root/`** matches any record containing the string "root".

4.3.3. Actions

An action causes something to happen when a pattern is found. If no action is specified, **awk {print}** is applied as default action. This action copies the record (usually a line) of the input file to the standard output. The **`print`** statement can be followed by arguments to force **awk** to print selected content. The following examples show the use of **awk**.

If file test.txt is generated as follows:

```
echo -e "Column1\tColumn2\tColumn3\tColumn4\n" > example.txt
```

Then the following **cat** command:

```
cat example.txt
```

will return on the console the following output:

```
Column1         Column2         Column3         Column4
```

If you use **awk** to display only column 1 and column 3 as follows:

```
awk '{ print $1, $3}' example.txt
```

The output will be:

```
Column1 Column3
```

If you add data to the file as follows:

```
echo -e "Data1\tData2\tData3\tData4\n" >> example.txt
echo -e "Data5\tData6\tData7\tData8\n" >> example.txt
echo -e "Data9\tData10\tData11\tData12\n" >> example.txt
```

Then the following cat command:

```
cat example.txt
```

will give:

```
Column1  Column2  Column3  Column4
Data1    Data2    Data3    Data4
Data5    Data6    Data7    Data8
Data9    Data10   Data11   Data12
```

If you use **awk** again to display only column3 and column1 (in that order):

```
awk '{ print $3, $1}' example.txt
```

the output will be:

```
Column3 Column1
Data3 Data1
Data7 Data5
Data11 Data9
```

You can use **awk** to display only the line that contains the regular expression **/Data5/**, with the following command:

```
awk '/Data5/ { print }' example.txt
```

The output will be:

```
Data5   Data6   Data7   Data8
```

If you want to output only columns 1 and 4 then:

```
awk '/Data5/ { print $1, $4}' example.txt
```

will give:

```
Data5 Data8
```

12. Exercise:
Look for the "root" string into the file **/etc/passwd**, and print out the line where the string is found.

13. Exercise:
Implement a Shell script named **inf_process** that takes as argument a process PID and prints on the terminal in column format its PID, PPID, STATE and COMMAND. Remember that this information can be found in files **`/proc/$pid/status`** and **`/proc/$pid/cmdline`**. The output should be like the following:

```
PID    PPID      STATE   COMMAND
8900   8880       S      /bin/bash
```

14. Exercise:
Implement a Shell script named **system_processes** that supplies to script **inf_process** all the running processes PIDs, in order to print their PID, PPID, STATE and COMMAND.

4.3.4.Splitting the input into records and fields

The input to a typical **awk** program is read in units called records, and they are processed by the rules one by one. By default, a record is a line in the input file.

The **awk** language divides its input records into fields. The way **awk** splits records into fields is controlled by the field separator, which is a single character or a regular expression. By default, fields are separated by spaces. However, the field separator can be specified in the command line using the argument '-F'. For example:

```
$ awk -F: 'program' input_files
```

Set as field separator the character **':'**. For example, the following line:

maria:x:1000:1000:Maria Garcia Garcia:/home/maria:/bin/bash

will be partitioned into 7 fields:

'maria', 'x', '1000', '1000', Maria Garcia Garcia', '/home/maria' and '/bin/bash'.

To refer to a field in an **awk** program, use the **$** symbol followed by the number of the field. So **$1** refers to the first field, **$2** the second and so on. **$0** is a special case, it represents the entire input record.

Another example, if we write:

```
$ awk -F: '/model name/ {print $2}' /proc/cpuinfo
```

It would print the second field separated by ':' of lines containing "model name" in the file "/proc/cpuinfo".

Optional Exercise:
Start five **`Kate`** processes, one of them in the foreground and the others in the background. Make a script "**running_processes**" that counts the number of Kate process running using **ps** and looks for information in **`/proc`**. It has to show in the screen the number of Kate processes running and their PID, status and memory use.

5. Annex

5.1. Annex 1: PATH variable

To avoid having to specify the path of an executable file when it is started to run, we can use environment variable PATH. This variable contains the list of directory names (separated by the character ":") where the shell searches for executable files.

We can see the value of PATH with the following command:

```
$ echo $PATH
```

Check if the value of the PATH environment variable, that the shell uses, contains the current working directory. If so check that the result of executing the file "content" is the same using with or without the prefix "./".

```
$contenido
```

If it is not the case, the local working directory can be appended to PATH with the following command:

```
$ PATH=$PATH:.
```

This change will only last until the end of the active shell instance (i.e. until closing the terminal). If you want this change to be permanent then you should edit the configuration file $HOME/.bashrc and append at the end the previous command.

Exercise:
Edit as described previously file $HOME/.bashrc, then open a new terminal and verify the new persistent PATH VALUE with:

```
$xemacs $HOME/.bashrc

$ echo $PATH
```

5.2. Annex 2: Arithmetic operations

The shell can evaluate an arithmetic expression:

```
$((expression))
    evaluates the arithmetic expression and replaces it by the result
```

Example:

```
$ echo 1+1
```

```
1+1
$ echo $((1+1))
2
```

Some arithmetic operators supported are:

```
+    addition
*    mutiplication
-    substraction
/    integer division
%    integer division remainder
( )  operation grouping
```

5.3. Annex 3: while loops

This is another loop structure that can run a block of commands while a condition evaluates to true:

```
while CONDITION; do
     command block
done
```

At the beginning of every iteration the condition is evaluated and then the loop ends if it is not true.

while loop examples:

```
# while loop controlled by an integer variable (equivalent to seq 1 5)
i=1
while [ $i -lt 6 ]; do
     echo $i
     i=$(($i+1))
done

# reads a line from the standard input until the line be 'quit'
read line
while [ "$line" != "quit" ]; do
  read line
done
```

5.4. Annex 4: awk patterns BEGIN and END

BEGIN and END are special patterns. They are used to supply to awk what to do before it starts processing and after it ends processing the input records. A BEGIN rule is executed once before reading the first input record. The END rule is executed once after awk has read all the input records. For example:

The following command specifies to start printing the phrase "Hello World" and the finish.

```
awk 'BEGIN { print "Hola mundo"; exit }'
```

This will return an output like this:

```
Hola mundo
```

Another example:

```
$ awk 'BEGIN {print "How many times appears Data4" ; data=0 ; }
>/Data4/ {++data}
>END {print "Data4 appears "data" times"}' example.txt
```

This program finds how many times appears Data4 in the file generated in the previous examples "example.txt". The BEGIN rule prints a title for the report and initializes the counter data to 0, this initialization is not required since awk does this by default.

The second rule increments the variable "data" every time awk reads in the input a record that contains pattern /Data4/. The END rule prints the final value of "data" variable.

5.5. Annex 5: awk IF statement

The if-else is a sentence for decision making in awk. It looks like this:

if (condition) then-body [else else-body]

where condition is an expression that controls what does the rest of the sentence. If the condition is true, then it executes the "body-then" sentences, otherwise else-body sentences are executed (assuming that the else clause is present). The else part of the sentence is optional. The condition is considered false if its value is 0 or a null string, otherwise it will be considered true.

Here there is an example:

```
$ awk '{ if ($0 % 2 == 0)
> print $0 "it is even"
> else
> print $0 "it is odd" }'
```

In this example, if expression "$0 % 2 == 0" is true (i.e. the value passed to it is divisible by 2), then it executes the first print statement, otherwise it executes the second print statement.

If "else" appears in the same line as "then-body" and the "then-body" is a compound statement (not between braces), then a semicolon must separate the "then-body" from the "else-body". To illustrate this consider the following example.

```
$ awk '{ if ($0 % 2 == 0) print $0 "it is even"; else print $0 "x is odd"}'
```

If you forget to put ";" it will cause a syntax error. It is recommended not to enter the else statement like this, because it may lead to confusion.

Exercise:
Use what you have learned so far to make a script that kills the process Kate with lower PID among several Kate processes that have been previously started.

5.6. Annex 6: `tr` utility

This command allows changing or translating the characters from the input according to rules specified. Its general format is:

```
$ tr [options] string_1 string_2
```

Some examples using this command are:

- *To change a character by another.*
  Example: replace the character used as separator between fields (':') to tab character.

  ```
  $ tr ':' '\t' < input_file
  ```

  Example: replace null characters by spaces.

  ```
  $ tr "\0" " " < input_file
  ```

- *To change a set of characters*.
  Example: capitalize all characters that appear in a file:

  ```
  $ tr '[a-z]' '[A-Z]' < input_file
  ```

Exercise:
Replace string Data4 by Data5 in file example.txt.

5.7. Annex 7: Getting system info in Mac OSX

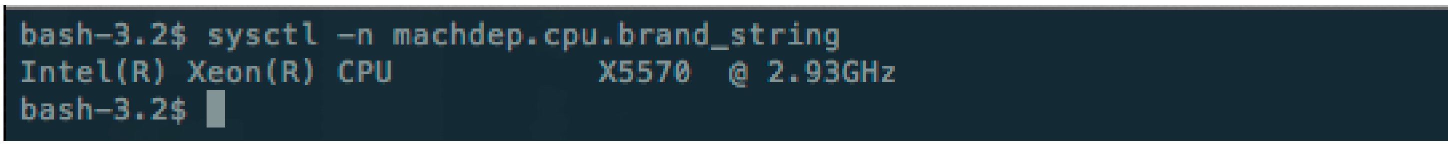
In Mac OSC, appart from apps "System information" and "Activity monitor" that deliver graphic information in real time about processes and system behaviour, you can also get information by means of the command line.

In Linux CPU information is located in file `/proc/cpuinfo` .For instance to get the CPU type you do:

```
$ cat /proc/cpuinfo | grep "model name"
```

In OSX, you use **sysctl** command to get information from several sides of the OSX kernel states. For instance, you get the OSX name by doing:

```
$sysctl -n machdep.cpu.brand_string
```



```
bash-3.2$ sysctl -n machdep.cpu.brand_string
Intel(R) Xeon(R) CPU           X5570  @ 2.93GHz
bash-3.2$
```

And in order to get complete CPU information you do:

```
$sysctl -a | grep machdep.cpu
```

To get the number of cores and threads you can do:

```
$sysctl -a | grep machdep.cpu | grep core_count
$sysctl -a | grep machdep.cpu | grep thread_count
```