

## Monitor resource usage of an process

Create a bash script to execute a process and monitor its CPU and Memory usage using top, grep, and awk. The result is exported to text file, and optionally to a graph if gnuplot available.

```
#bash #top #grep #awk #performance #gnuplot
```

---

Last update: April 23, 2021

## Table of Content

1. Export a function in bash
2. Command-Grouping
3. Run a process
4. ps or top
5. grep and awk
6. Line buffered mode
7. Save log with tee
  - 7.1. Fix empty log
  - 7.2. Fix wrong data
8. Graph with gnuplot
9. Command template
10. Some enhanced modifications
11. The final script

## ✓ The final *monitor.sh*

Download  **monitor.sh** then save to `~/monitor.sh`.

Add below line to `~/.bashrc`:

```
source monitor.sh
```

Usage:

```
monitor title command params
```

*This post is written as a walk through guide to help understanding how the script is made.*

## 1. Export a function in bash

In a bash file, define a function with a name and its body, then export the function with `export -f` command:

*myfunc.sh*

```
#!/bin/bash
myfunc() {
    echo "Params: $@"
}
export -f myfunc
```

To make function available outside of the script, run `source` command before calling the function:

```
source myfunc.sh
myfunc abc
```

All params are implicit saved into local macros. Refer to [Advanced Bash-Scripting Guide](#):

Macro	Description
<code>\$BASHPID</code>	Process ID of the current instance of Bash. This is not the same as the <code>\$\$</code> variable, but it often gives the same result.
<code>\$PPID</code>	Process ID of the parent process
<code>\$\$</code>	Process ID of the script itself
<code>\$!</code>	Process ID of last job run in background

Macro	Description
<code>\$PWD</code>	The current directory that process is in at the time
<code>\$FUNCNAME</code>	Name of the current function, effective inside a function only
<code>\$SECONDS</code>	The number of seconds the script has been running
<code>\$1</code> , <code>\$2</code> , <code>\$n</code>	The first, the second and the n-th param
<code>\$#</code>	The number of command-line arguments
<code>\$*</code>	All of the positional parameters, seen as a single word, must be quoted
<code>@</code>	Same as <code>\$*</code> , but each parameter is a quoted string, that is, the parameters are passed on intact, without interpretation or expansion. This means, among other things, that each parameter in the argument list is seen as a separate word
<code>\$?</code>	Exit status of a command, function, or the script itself

## 2. Command-Grouping

Refer to [Bash Manual - Command Grouping](#).

Bash provides two ways to group a list of commands to be executed as a unit. When commands are grouped, re-directions may be applied to the entire command list.

`( list )`

Placing a list of commands between parentheses causes a sub-shell environment to be created (see Command Execution Environment), and each of the commands in list to be executed in that sub-shell. Since the list is executed in a sub-shell, variable assignments do not remain in effect after the sub-shell completes.

`{ list; }`

Placing a list of commands between curly braces causes the list to be executed in the current shell context. No sub-shell is created. The semicolon (or newline) following list is required.

In addition to the creation of a sub-shell, there is a subtle difference between these two constructs due to historical reasons:

- The braces are reserved words, so they must be separated from the list by blanks or other shell meta-characters.
- The parentheses are operators, and are recognized as separate tokens by the shell even if they are not separated from the list by whitespace.

### 3. Run a process

The basic idea is to run a process in background and while it's running, report its resource usage:

*monitor.sh*

```
#!/bin/bash

monitor() (
    # run process in background
    echo "Executing $*"
    $* &

    # get PID of last job in background
    pid=$!
    echo "Executed in PID: $pid"
    ps --no-headers -p $pid

    echo 'CPU MEM'
    # check if a process is running
    while [ -e /proc/$pid ]
    do
        # use ps to get cpu and memory usage
        ps --no-headers -o '%cpu,%mem' -p $pid
        sleep 1
    done
)

export -f monitor
```

### 4. ps or top

Both **ps** and **top** report CPU Usage, but returned values are different. Let's check the manual of each command:

**ps**

CPU usage is currently expressed as the percentage of time spent running during the entire lifetime of a process. This is not ideal, and it does not conform to the standards that **ps** otherwise conforms to. CPU usage is unlikely to add up to exactly 100%. It means **ps** does not show the instant CPU usage, it shows an average CPU usage over the lifetime of the process.

**top**

%CPU -- CPU Usage, The task's share of the elapsed CPU time since the last screen update, expressed as a percentage of total CPU time. It means if interval is 1 second, **top** will report CPU usage for the last 1 second. That can be considered as instant report.

Let's check **top**'s options

**-b** : Batch-mode operation

Starts top in Batch mode, which could be useful for sending output from top to other programs or to a file. In this mode, top will not accept input and runs until the iterations limit set with the `-n` command-line option or until killed.

**-d** : Delay-time interval as: -d ss.t (secs.tenths)

Specifies the delay between screen updates, and overrides the corresponding value in one's personal configuration file or the startup default. Later this can be changed with the `d` or `s` interactive commands.

**-p** : Monitor-PIDs mode as: -pN1 -pN2 ... or -pN1,N2,N3 ...

Monitor only processes with specified process IDs.

Switch to use `top` get the the process information:

*monitor.sh*

```
#!/bin/bash

monitor() (
    # run process in background
    $* &

    # get PID of last job in background
    pid=$!

    # use top to monitor the process
    top -b -d 1 -p $pid &

    # save top PID to control it
    toppid=$!

    echo 'CPU MEM'
    # check if a process is running
    while [ -e /proc/$pid ]
    do
        sleep 1
    done

    # kill top
    sleep 1
    kill -9 $toppid
)

export -f monitor
```

Run a test:

```
monitor ffmpeg -y -hide_banner -i /dev/video0 -c:v h264_omx -t 10 test.mp4
```

and result:

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
2286	pi	20	0	336612	129848	121960	R	34.5	52.5	0:03.36	ffmpeg

## 5. grep and awk

Refer to [grep manual](#)

Use **grep** to extract process information lines using *pid* number as the keyword:

```
top -b -d 1 -p $pid | grep $pid &
```

Refer to [awk manual](#)

Use **awk** to cut out 2 columns: *%CPU* and *%MEM* (at the 9<sup>th</sup> and 10<sup>th</sup> column) from the filtered lines:

```
top -b -d 1 -p $pid | grep $pid | awk '{print $9, $10}' &
```

So, this is a modified version:

*monitor.sh*

```
#!/bin/bash

monitor() (
    # run process in background
    $* &

    # get PID of last job in background
    pid=$!

    # use top to monitor the process
    # use grep to catch useful lines
    # use awk to extract data columns
    top -b -d 1 -p $pid | grep $pid | awk '{print $9, $10}' &

    # save top PID to control it
    toppid=$!

    echo 'CPU MEM'
    # check if a process is running
    while [ -e /proc/$pid ]
```

```

do
    sleep 1
done

# kill top
sleep 1
kill -9 $toppid
)

export -f monitor

```

Run a test command:

```
monitor ffmpeg -y -hide_banner -i /dev/video0 -c:v h264_omx -t 10 test.mp4
```

and result:

```
CPU  MEM
```



### Bug: No output value

Surprisingly, there is no output for CPU and MEM usage reported in the output. Search on google, there is a glue of missing data when using `grep` in a pipeline.

## 6. Line buffered mode

When using pipeline of commands, there is *pipeline buffer* between them.

The output from `grep` is no longer line buffered but block buffered, usually the block is 4KB, leading to the problem that the next `awk` command cannot see new data immediately on its input.

Notes from manuals:

`man grep`

```
--line-buffered
```

Use line buffering on output. This can cause a performance penalty.

`man awk`

```
-W interactive
```

sets un-buffered writes to stdout and line buffered reads from stdin. Records from stdin are lines regardless of the value of RS.



Combining them together and testing again:

*monitor.sh*

```
#!/bin/bash

monitor() (
    # run process in background
    $* &

    # get PID of last job in background
    pid=$!

    # use top to monitor the process
    # use grep to catch useful lines, use line buffered mode
    # use awk to extract data column, read input in line buffered mode
    top -b -d 1 -p $pid | grep --line-buffered $pid | awk -W interactive '{print
$9, $10}' &

    # save top PID to control it
    toppid=$!

    echo 'CPU MEM'
    # check if a process is running
    while [ -e /proc/$pid ]
    do
        sleep 1
    done

    # kill top
    sleep 1
    kill -9 $toppid
)

export -f monitor
```

Run a test:

```
monitor ffmpeg -y -hide_banner -i /dev/video0 -c:v h264_omx -t 10 test.mp4
```

and result comes with expected values:

```
CPU MEM
20.0 0.8
21.0 3.5
67.3 5.1
89.1 6.0
77.2 9.4
```

## 7. Save log with tee

Use `tee` to read from standard input and write to standard output and files. That is simple enough to clone the output to a file:

```
$* | tee log.txt &
top -b -d 1 -p $pid | grep --line-buffered $pid | awk -W interactive '{print $9, $10}' | tee usage.txt &
```

Then modify the script:

*monitor.sh*

```
#!/bin/bash

monitor() (
    # run process in background
    $* | tee log.txt &

    # get PID of last job in background
    pid=$!

    # use top to monitor the process
    # use grep to catch useful lines, use line buffered mode
    # use awk to extract data columns, read input in line buffered mode
    top -b -d 1 -p $pid | grep --line-buffered $pid | awk -W interactive '{print $9, $10}' | tee usage.txt &

    # save top PID to control it
    toppid=$!


    echo 'CPU MEM'
    # check if a process is running
    while [ -e /proc/$pid ]
    do
        sleep 1
    done

    # kill top
    sleep 1
    kill -9 $toppid
)

export -f monitor
```

Run a test:

```
monitor ffmpeg -y -hide_banner -i /dev/video0 -c:v h264_omx -t 10 test.mp4
```

 **Bug: Empty log and invalid output**

After using `tee`, there are too issues happened:

- an empty `log.txt` file
- `usage.txt` content is invalid

## 7.1. Fix empty log

When making pipeline to `tee`, only STDOUT (1) is forwarded, while `ffmpeg` prints output on STDERR (2) not on STDOUT (1).

Fix it by redirect `ffmpeg` STDERR to STDOUT:

```
$* 2>&1 | tee log.txt &
```

## 7.2. Fix wrong data

Add some debug lines `ps -p $pid` to check the process ID after creating the process:

*monitor.sh*

```
#!/bin/bash

monitor() (
    # run process in background
    $* | tee log.txt &

    # get PID of last job in background
    pid=$!
    ps -p $pid
    # use top to monitor the process
    # use grep to catch useful lines, use line buffered mode
    # use awk to extract data columns, read input in line buffered mode
    top -b -d 1 -p $pid | grep --line-buffered $pid | awk -W interactive '{print
$9, $10}' | tee > usage.txt &

    # save top PID to control it
    toppid=$!
    ps -p $toppid

    echo 'CPU MEM'
    # check if a process is running
    while [ -e /proc/$pid ]
    do
        sleep 1
    done

    # kill top
    sleep 1
    kill -9 $toppid
)
```

```
export -f monitor
```

Then, it prints out the PID of `tee`, not the PID of `ffmpeg` or `top`.

```
PID TTY          TIME CMD
647 pts/0        00:00:00 tee
PID TTY          TIME CMD
652 pts/0        00:00:00 tee
```

## Get PID of a process in pipeline

In bash, pipeline cause commands to run in a sub-shell!

For example, `$* | tee > log.txt &` will run `$*` in a sub-shell, and `tee > log.txt` will run in current shell, therefore tee's PID will be saved in the macro `$!`.

The solution is to save the pid in the newly created sub-shell in which `$!` returns correct PID, then load that PID later:

```
# save to pid.txt
($* 2>&1 & echo $! > pid.txt) | tee > log.txt &
# load from pid.txt
pid=$(<pid.txt)
```

Then modify the script:

*monitor.sh*

```
#!/bin/bash

monitor() (
    # run process in background
    ($* 2>&1 & echo $! > pid.txt) | tee log.txt &

    # get PID of last job in background
    pid=$(<pid.txt)
    ps -p $pid
    # use top to monitor the process
    # use grep to catch useful lines, use line buffered mode
    # use awk to extract data columns, read input in line buffered mode
    (top -b -d 1 -p $pid & echo $! > pid.txt) | grep --line-buffered $pid | awk -
W interactive '{print $9, $10}' | tee usage.txt &

    # save top PID to control it
    toppid=$(<pid.txt)
    ps -p $toppid

    echo 'CPU  MEM'

    # check if a process is running
    while [ -e /proc/$pid ]
```

```

do
    sleep 1
done

# kill top
sleep 1
kill -9 $toppid

# clean up
rm pid.txt
)

export -f monitor

```

Run a test:

```
monitor ffmpeg -y -hide_banner -i /dev/video0 -c:v h264_omx -t 10 test.mp4
```

and got correct PIDs for `ffmpeg` and `top`:

```

PID TTY          TIME CMD
2352 pts/0        00:00:00 ffmpeg
PID TTY          TIME CMD
2360 pts/0        00:00:00 top

```

## 8. Graph with gnuplot

Gnuplot is a portable command-line graph utility for Linux, OS/2, MS Windows, OSX, VMS, and many other platforms. It can produce many different types of output, including terminal and file.

### Terminal output

```

gnuplot -e " \
    set term dumb; \
    plot \
        'usage.txt' using 1 title '%CPU' with lines, \
        '' using 2 title 'MEM' with lines \
"

```

### PNG Image output

```

gnuplot -e " \
    set term png size 640, 480; \
    set output 'usage.png'; \
    set grid xtics lc rgb '#bbbbbb' lw 1 lt 1; \
    set grid ytics lc rgb '#bbbbbb' lw 1 lt 1; \
    plot \
        'usage.txt' using 1 title '%CPU' with lines, \

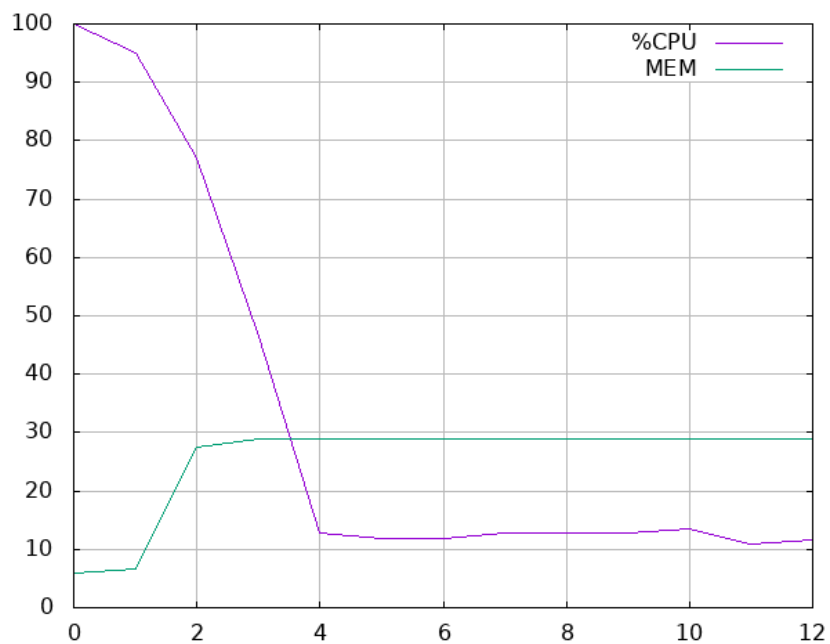
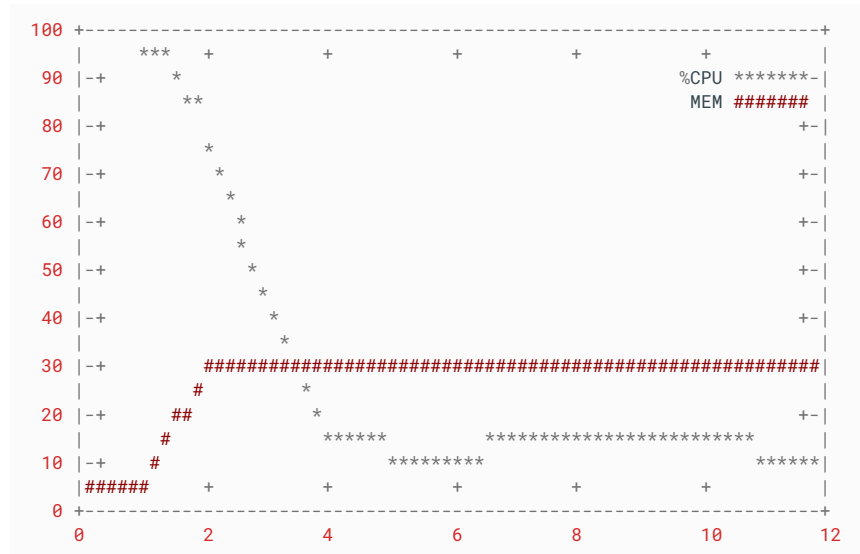
```

```
'' using 2 title 'MEM' with lines \
"
```

Run a test:

```
monitor "test" "ffmpeg -y -hide_banner -i /dev/video0 -c:v h264_omx -t 10
test.mp4"
```

It prints out a good graph in the terminal as well as in a PNG image:



*Resource Usage*

## 9. Command template

Let's modify the script to accept params in this format:

```
monitor title command
```

by extracting those params at the beginning of the script:

```
monitor() (
    # extract params
    title=$1
    command=${@:2} # get params from the 2nd one
```

## 10. Some enhanced modifications

1. Save output to a separated folder:

```
# create result folder if not existed
[ !-d $title ] && mkdir $title
```

2. Change output format to **CPU= X MEM= Y** then change the data column index in **gnuplot**:

```
# *-usage.txt content:
# CPU= X MEM= Y
# X is at 2nd column,
# Y is at 4th column
gnuplot -e " \
    set term dumb; \
    plot \
        '${title}/${title}-usage.txt' using 2 title '%CPU' with lines, \
        '' using 4 title 'MEM' with lines \
    "
```

## 11. The final script

[!\[\]\(51514032c8ca341817228f39f1307b05\_img.jpg\) monitor.sh](#)

```
#!/bin/bash
# vuquangtrong@gmail.com
#
# usage:
#     monitor title command params
# example
#     monitor test ffmpeg -y -hide_banner -i /dev/video0 -c:v h264_omx -t 10 test.mp4
#
monitor() (
    # extract params
```

```

title=$1
command=${@:2} # get command and params from the 2nd one

# create result folder if not existed
[ ! -d $title ] && mkdir $title

# measure execution time
start=$SECONDS

# run command in background
($command 2>&1 & echo $! > pid.txt) | tee "${title}/${title}_log.txt" &
sleep 1
# get command's PID of last job in background
pid=$(<pid.txt)

# use top to monitor the process
# use grep to catch useful lines, using line buffered mode to send output in
lines
# use awk to extract data columns, reading input in line buffered mode
(top -b -d 1 -p $pid & echo $! > pid.txt) \
| grep --line-buffered $pid \
| awk -W interactive '{printf "\nCPU= %d MEM= %d\n", $9, $10}' \
| tee >(grep CPU > "${title}/${title}_usage.txt") &
sleep 1
# save top's PID to control it
toppid=$(<pid.txt)

# check if the command is running
while [ -e /proc/$pid ]
do
    sleep 1
done

# kill top
sleep 1
kill -9 $toppid

# clean up
rm pid.txt

# output average data, exclude sleeping time
echo -e "\nTotal time: $((SECONDS-$start-3)) seconds"
cat "${title}/${title}_usage.txt" \
| awk '\
{ sum1 += $2; sum2 += $4; n++ } \
END { printf "Average: CPU= %d MEM= %d\n", sum1/n, sum2/n } \
'

# draw to terminal
gnuplot -e " \
set term dumb; \
set yrange [0:100]; \
plot \
'${title}/${title}_usage.txt' using 2 title 'CPU' with lines, \
'' using 4 title 'MEM' with lines \
"

# export to image

```



```
gnuplot -e " \  
    set term png size 640, 480; \  
    set output '${title}/${title}_usage.png'; \  
    set yrange [0:100]; \  
    set grid xtics lc rgb '#bbbbbb' lw 1 lt 1; \  
    set grid ytics lc rgb '#bbbbbb' lw 1 lt 1; \  
    plot \  
        '${title}/${title}_usage.txt' using 2 title 'CPU' with lines lw 2, \  
        '' using 4 title 'MEM' with lines lw 2 \  
    "  
)  
  
export -f monitor
```