Raspberry Pi - Monitor the resource usage of a process

This post presents a custom script to execute a process and monitor the CPU and Memory usage of that process using linux utilities such as top, grep, and awk. The result is exported to a text file, and optionally an image if gnuplot is installed.

#raspberry-pi #bash #performance

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Table of Content

The final script

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

Add below line to `~/.bashrc`:

```
source monitor.sh
```

Usage:

```
monitor "title" program params
```

> This post is written as a walk through guide, step by step, to help understanding how the script was made.

1. Export a function in bash

In a bash file, a function with a name and its body can be defined and then exported 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
`$BASHPID`	Process ID of the current instance of Bash. This is not the same as the `$$` variable, but it often gives the same result.
`$PPID`	Process ID of the parent process
`$$`	Process ID of the script itself

Macro	Description
`$!`	Process ID of last job run in background
`$PWD`	The current directory that process is in at the time
`$SECONDS`	The number of seconds the script has been running
`$1`, `$2`, `$n`	The first, the second and the n-th param
`$#`	The number of command-line arguments
`$*`	All of the positional parameters, seen as a single word, must be quoted
`$@`	Same as `$*`, 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
`$?`	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 the 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 the 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^{th} and 10^{th} 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 the 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 the 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 the standard input and write to the standard output and a file. That is simple enough to clone the output to a log 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 twp issues happened:

- an empty *log.txt* file
- the *usage.txt* content is invalid

7.1. Fix empty log

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

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

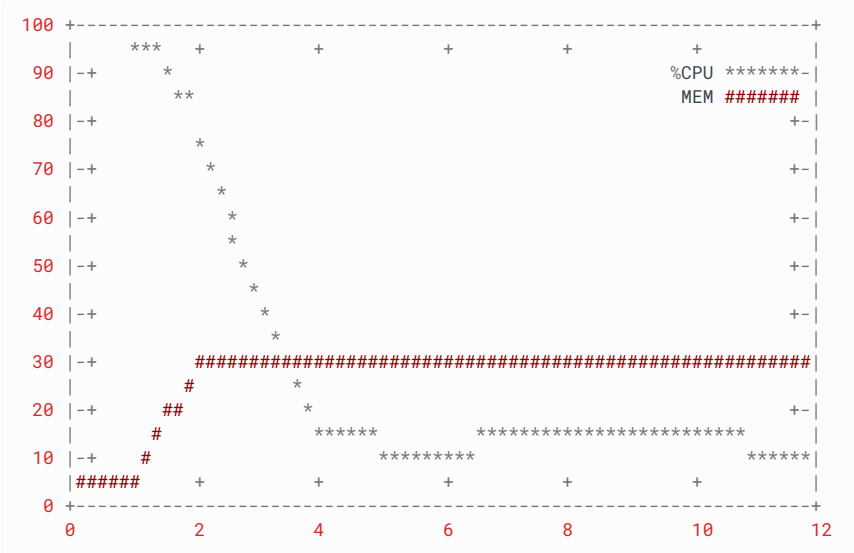
```
gnuplot -e " \
    set term png size 640, 480; \
```

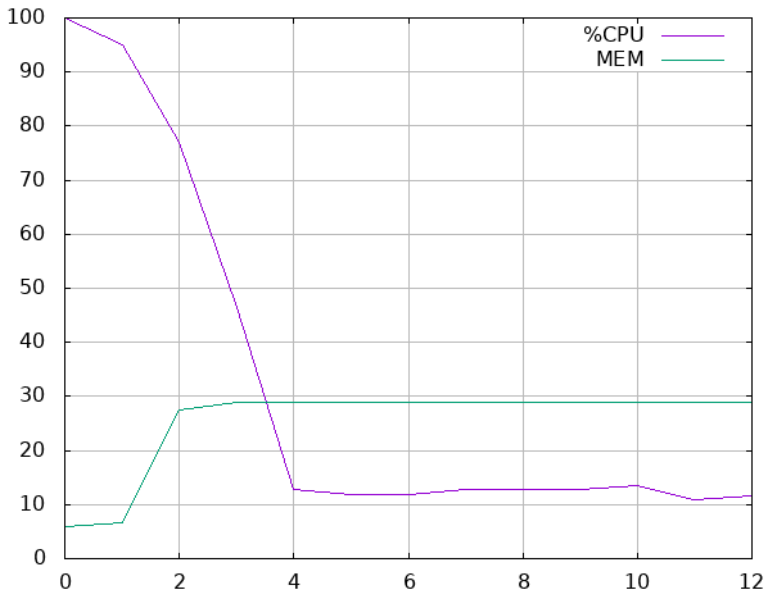
```
    set output 'usage.png'; \
    set grid xtics lc rgb '#bbbbbb' lw 1 lt 1; \
    set grid ytics lc rgb '#bbbbbb' lw 1 lt 1; \
    plot \
        'usage.txt' using 1 title '%CPU' with lines, \
        '' using 2 title 'MEM' with lines \
"
```

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. Some enhancements

Some small modifications to make script run in multiple sessions:

1. Set title for a new session

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
    ...
)
```

The *title* will be used to name the session, to create a folder to save log files.

2. Save output to a separated folder

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

3. Change output format to `CPU= X MEM= Y`

It needs to 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 \
    "
```

10. The final script

Download the final script in the top of this page.