Inge5SE – Parallel Programming
Lab1: PThreads

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0. Know your hardware

During this course, you will measure the performances of many programs running under Linux. You'd better use a native Linux machine, or a Mac, or if not available, use Windows' Subsytem for Linux (WSL, https://doc.ubuntu-fr.org/wsl) or Oracle Virtualbox.

For your performance measurements to be actually useful, **always** check that:

- code are evaluated on the same machine for the whole lab,
- your machine runs at least 4 CPU cores (especially in Virtualbox),
- your laptop is plugged in, and battery charged (otherwise, the OS might activate power-saving mode),
- minimize background load (quit all games, interaction-heavy web page, etc.),
- measure at least twice, to ensure that measurements are more or less constant.

Q1 : *What is your OS/hypervisor system configuration?*
How many CPU physical and logical cores does your PC run? How much RAM memory (in GiB)?
Use the commands cat /proc/cpuinfo, and cat /proc/meminfo to answer.

Prepare your environment:

- install (or verify that you have already)
  - time (Mac users: brew install gnu-time),
  - imagemagick (for displaying/converting images): sudo apt-get install imagemagick

1. Memory organization in C

Q2 : From the code mem.c, identify what segment the following variables/data will be stored in.

	Static (code+data)	Stack	Heap
f			
g			
n			
res			
cnt			
str			
str[0…]			
str2			
str2[0…]			

2. Performance measurements

1.1 Sequential performance

To complete this part, please work in the folder named 'sequential' in the provided archive.

The shell command `/usr/bin/time -p {command}` is an easy way to measure the performance of a command or program. Test the following: `/usr/bin/time -p sleep 1`. Look up the manual to understand the meaning of the `real`, `user` and `sys` fields.

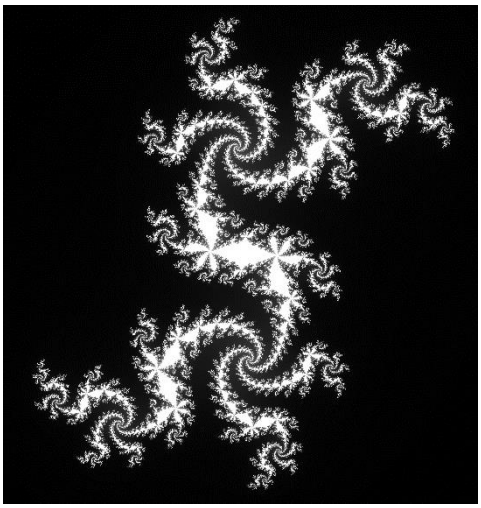
To compile all projects, we are providing multiple Makefiles to help you during this course. USE THEM !

To compile the integrate exercise, use the command `make integrate` in the folder 'sequential'.
To execute the sequential integrate compiled program, use the command `make run_integrate` in the folder 'sequential'. This command will execute the program with the time command.

Q4: What is the value of: real, user, sys, $\frac{user+sys}{real}$*?*

Q5: What does the ratio $\frac{user+sys}{real}$ *represent?*

To compile the fractals exercise, use the command `make fractals` in the folder 'sequential'.
To execute the sequential fractals compiled program, use the command `make run_fractals` in the folder 'sequential'.



You can visualize the output images with:
`display {image}.pgm &`

Q6 : What is the value of: real, user, sys, $\frac{user+sys}{real}$*.*

Q7 : Why is the $\frac{user+sys}{real}$ *ratio different from Q5?*

1.2 Parallel programming in practice!

To complete this part, please work in the folder named 'parallel' in the provided archive.

Q8 : Parallelize integrate.c using Pthreads. Read a number of threads from command line arguments (argc, argv). Verify that the outcome is the same (to at least 0.001 *precision)!*

Measure the latency of your parallel program with `/usr/bin/time -p`, with 1 to 20 threads. To help you, we provided the `time_integrate` and `time_fractals` rules to run the programs with different number of threads. **Don't forget to use argc,argv in your programs to pass number of threads !**

Q9 : Draw a graph of latency (real), as a function of thread number

Q10 : Draw a graph of the ratio $\frac{real_{seq}}{real(n)}$ *as a function of thread number (*$real_{seq}$ *being the value measured in Q4 above). What is the maximum value? Explain what happens when* $n \geq$ *your PC's core count.*

Q11 : Parallelize fractal.c using Pthreads similarly. Verify that images are correct!

Q12 : Draw the graph of latency (real) as a function of thread number

Q13 : Draw a graph of the ratio $\frac{real_{seq}}{real(n)}$ *as a function of thread number (*$real_{seq}$ *for fractal was measured in Q6).*

Q14 : Based on your experiments with integrate and fractal, what does $\frac{real_{seq}}{real(n)}$ *represent? Explain.*

When the lab is completed, please use the submit script to create the archive to post in BOOSTCAMP !

You have to change the NAMES variable in the script with your names !

Separate names with '-' an do not use spaces (instead use '_') for example :

NAMES="DUPONT-DE_LA_RIVIERE**"**

If you don't respect this format to publish your work, teachers will not correct your work !