gprofng example: Mandelbrot

This page shows commands and screenshots to illustrate the usage of the gprofng tool, to resolve a scaling problem for the Mandelbrot example.

1. Pre-requisites: you must have an OpenMP version of the Mandelbrot example, which a 'schedule(runtime)' in the OpenMP for/do loop, compiled with '-fopenmp'. You should also comment the line, where writepng() is called (we don't want to time the writing of the PNG image!).

2. Run a first test, with 1 to 8 threads:

   $ echo "#thrds wall user sys"; for t in 1 2 4 8; \
   do echo -n " $t "; \
   OMP_SCHEDULE=static OMP_NUM_THREADS=$t time -f "%e %U %S" ./mandelbrot ; done

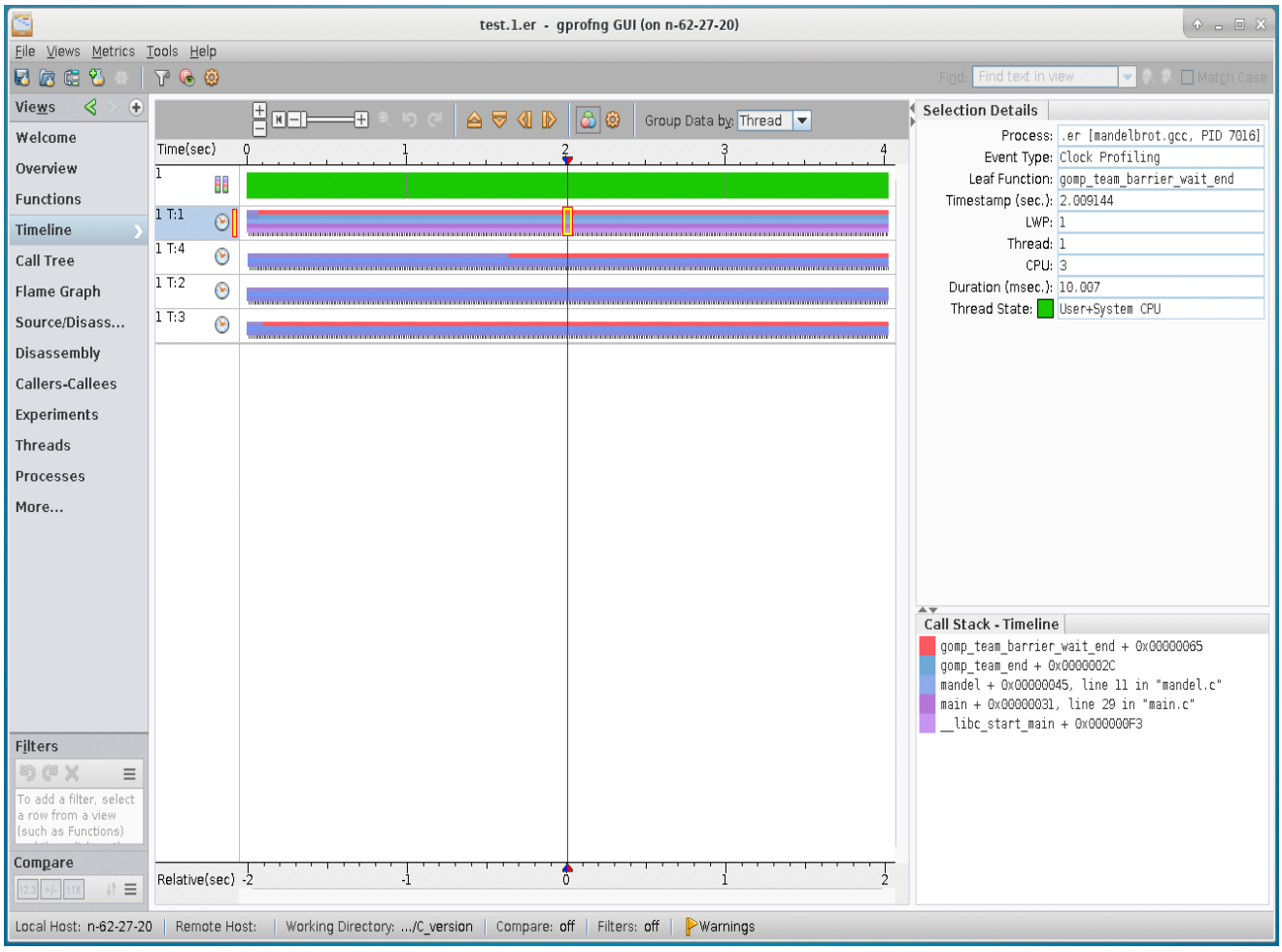
   ```
   #thrds wall user sys
     1    2.70 2.68 0.02
     2    1.92 2.70 0.01
     4    1.88 2.71 0.00
     8    1.03 2.73 0.02
   ```

   The run time (wall) is reduced by adding more threads, but the scaling is not linear!

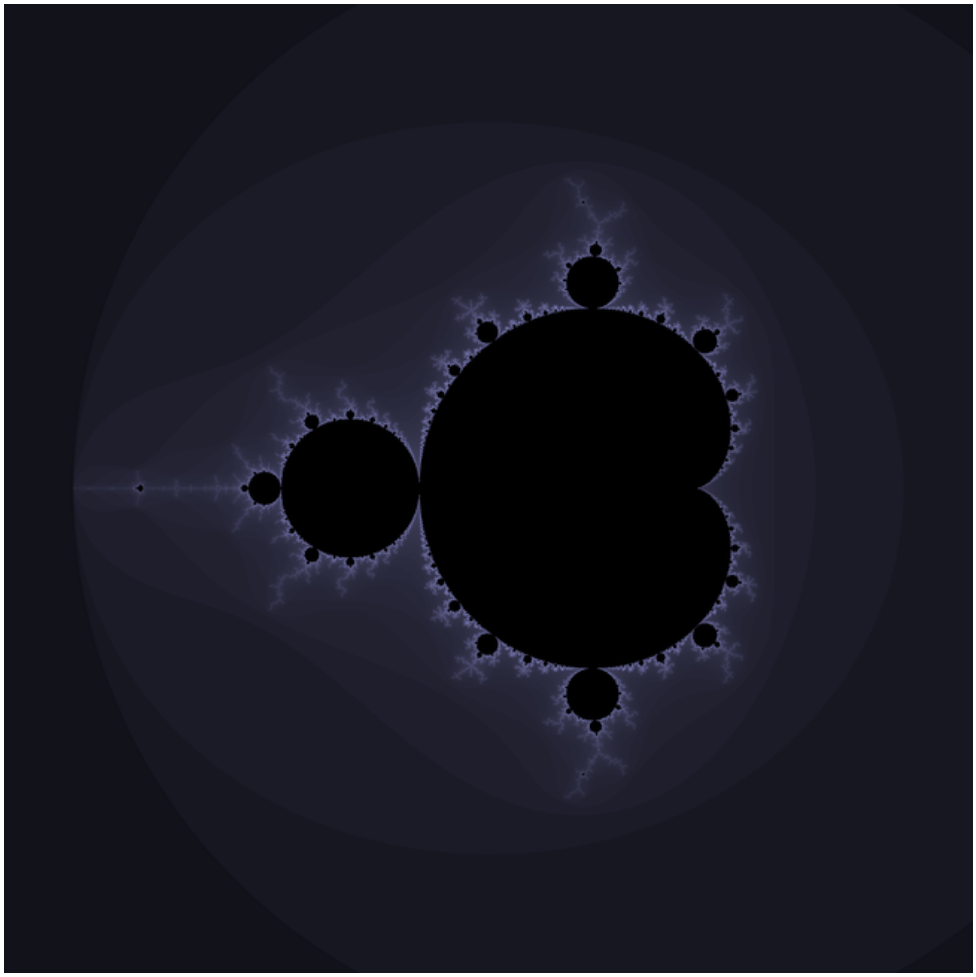
3. Let's do a first gprofng experiment, using 4 threads:

   $ OMP_WAIT_POLICY=active OMP_SCHEDULE=static OMP_NUM_THREADS=4 gprofng collect app ./mandelbrot
   Creating experiment database test.1.er (Process ID: 20107) ...

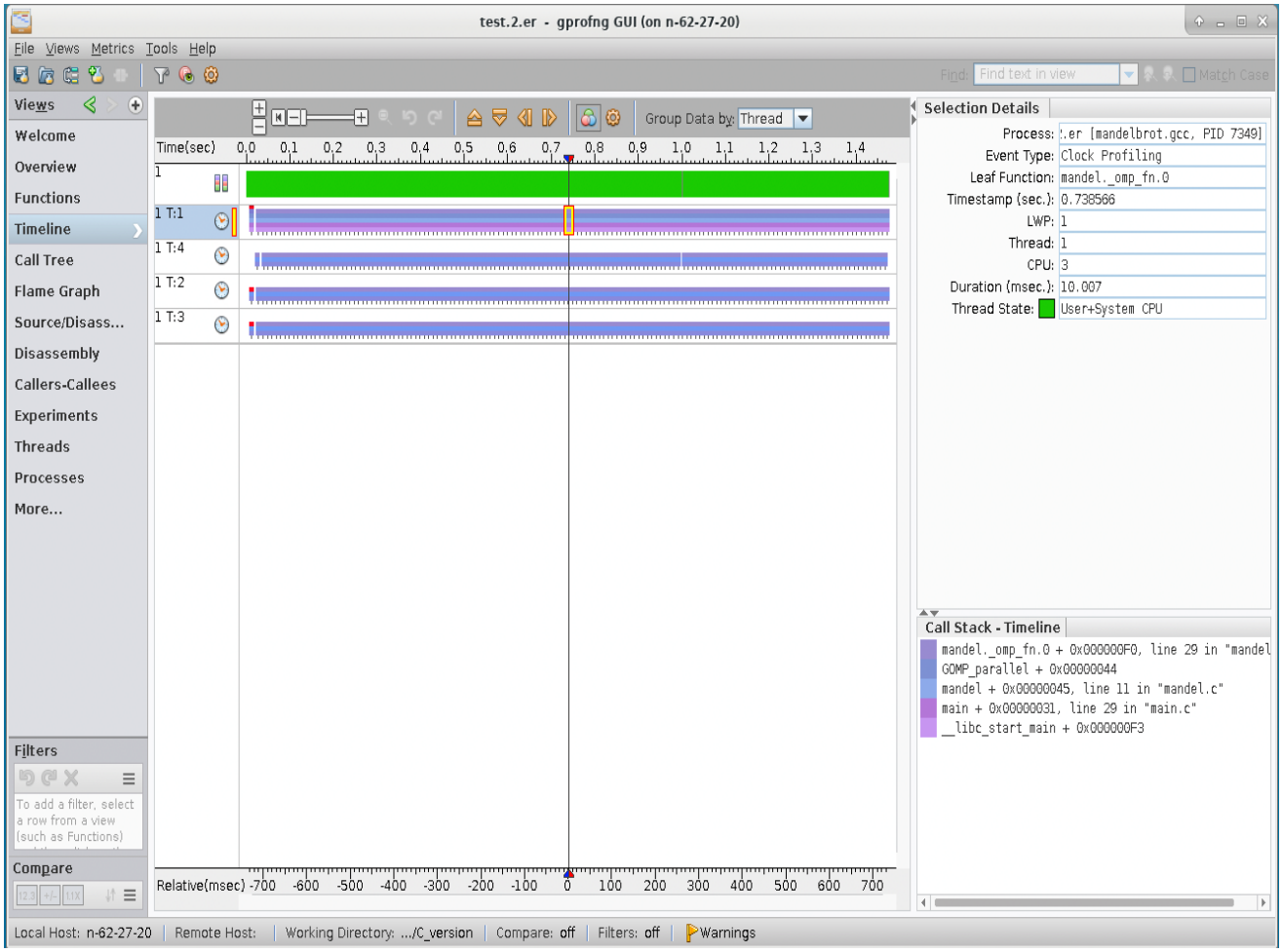
   $ gprofng display gui test.1.er



   In the timeline above, the OpenMP implicit barrier has been color coded in red, to make it more visible. As we can see, there is a load balancing issue, i.e. the 4 threads are doing different amounts work.
   This can be easily seen when looking at the Mandelbrot set - light pixels take more time:



4. Let's now adjust the schedule, using the OMP_SCHEDULE environment variable - and re-rerun the analyzer experiment above:
   $ OMP_WAIT_POLICY=active OMP_NUM_THREADS=4 OMP_SCHEDULE=dynamic,50 gprofng collect app ./mandelbrot
   Creating experiment database test.2.er (Process ID: 28634) ...
   $ gprofng display gui test.2.er



As we can see in the timelines above, the red spots, representing the implicit OpenMP barriers, are gone, i.e. the work is scheduled in a better way to our resources.

5. Now that we know how to get better scheduling with dynamic, let's re-run our little experiment from above (2.) again:

```
$ echo "#thrds wall user sys"; for t in 1 2 4 8; \
do echo -n " $t "; OMP_NUM_THREADS=$t OMP_SCHEDULE=dynamic,50 \
time -f "%e %U %S" ./mandelbrot ; done
```

```
#thrds wall user sys
 1     2.70 2.69 0.00
 2     1.35 2.68 0.01
 4     0.68 2.69 0.01
 8     0.35 2.72 0.02
```

That's good news: we get close to perfect scaling!