

## Exercise 6

To compile: unzip our uploaded code, and run `make` inside `code/`. The slurm scripts are stored inside `code/slurm/`.

To debug: run the debug outputs (\*.dbg) and attach gdb to respective pids

### 6.1 Heat Relaxation II — Parallel Implementation

### 6.2 Heat Relaxation II — Experiments

The implementation in subsection 6.1 resulted in the values below (Table 1, Table 2, and Table 3). We choose the by-slot-Mapping (default of mpirun) as to reduce the number of hops between nodes. This Mapping starts filling a node's possible slots with ranks until full and then continues with another node. This results in rank 3 and 4 and ranks 7 and 8 communication between nodes (for 9 or more ranks).

Table 1: Time [ $\mu$ s] / iteration

	NP = 01	NP = 02	NP = 04	NP = 06	NP = 08	NP = 10	NP = 12
Grid size							
128x128	68	39	44	526	2373	693	743
512x512	3363	851	757	3007	932	1417	3294
1024x1024	19474	9524	5684	6003	2722	3068	2573
2048x2048	238361	134284	30991	22886	16389	13306	13621
4096x4096	855031	551723	365791	130806	78609	68622	61378

Table 2: Speedup

	NP = 01	NP = 02	NP = 04	NP = 06	NP = 08	NP = 10	NP = 12
Grid size							
128x128	1.0000	1.7289	1.5388	0.1299	0.0288	0.0987	0.0920
512x512	1.0000	3.9487	4.4397	1.1185	3.6086	2.3725	1.0209
1024x1024	1.0000	2.0447	3.4260	3.2438	7.1544	6.3462	7.5672
2048x2048	1.0000	1.7750	7.6911	10.4150	14.5433	17.9135	17.4986
4096x4096	1.0000	1.5497	2.3375	6.5366	10.8769	12.4600	13.9305

Table 3: Efficiency

	NP = 01	NP = 02	NP = 04	NP = 06	NP = 08	NP = 10	NP = 12
Grid size							
128x128	1.0000	0.8645	0.3847	0.0217	0.0036	0.0099	0.0077
512x512	1.0000	1.9743	1.1099	0.1864	0.4511	0.2373	0.0851
1024x1024	1.0000	1.0224	0.8565	0.5406	0.8943	0.6346	0.6306
2048x2048	1.0000	0.8875	1.9228	1.7358	1.8179	1.7913	1.4582
4096x4096	1.0000	0.7749	0.5844	1.0894	1.3596	1.2460	1.1609

- A speedup is observed, that correlates to the number of jobs (i.e. for 10 jobs we reach a speedup of approx 10, for a sufficiently large problem size)
- For problem sizes too small, performance drops, due to the communication overhead dominating
- Additionally super linear speedups were observed, probably due to better cache utilization.

### **6.3 Heat Relaxation II — Tracing**