Optimisations and Parallelism of d2q9-bgk.c

George Herbert
cj19328@bristol.ac.uk

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Abstract

`d2q9-bgk.c` implements the Lattice Boltzmann methods (LBM) to simulate a fluid density on a lattice. This report outlines the techniques I utilised to optimise and parallelise `d2q9-bgk.c`, as well as a detailed analysis of those techniques. To do so, this report is split into several sections corresponding to different iterations of my code.

1 Original code

I compiled the original `d2q9-bgk.c` using the GNU Compiler Collection (GCC) with the following command:

```
gcc -std=c99 -Wall d2q9-bgk.c -lm -o
    d2q9-bgk.
```

Table 1: Total time of the original code for test cases of different sizes

Test Case Size	Time (s)
128×128	0
128×256	0
256×256	0
1024×1024	0

Figure 1 contains the total time to initialise, compute and collate each of the test cases when running the ELF file. It was important to measure the original code, so that I could quantify the performnace improvements of my latter implementations. I measured each of the total times by taking an average of 10 runs on BlueCrystal Phase 4's (BC4's) compute nodes. Each of BC4's compute nodes is a Lenovo nx360 M5, which contains two 14-core 2.4 GHz Intel E5-2680 v4 (Broadwell) CPUs and 128 GiB of RAM [1]. I took an average of multiple runs because of the variation between runs, which exists due to the inconsistent performance of compute nodes.

2 Serial optimisations

2.1 Compiler

2.2 Code changes

2.3 Results

Table 2: Total time of the serial optimised code for test cases of different sizes

Test Case Size	Time (s)
128×128	0
128×256	0
256×256	0
1024×1024	0

3 Vectorization

3.1 Code changes

3.2 Results

Table 3: Total time of the vectorized code for test cases of different sizes

Test Case Size	Time (s)
128×128	0
128×256	0
256×256	0
1024×1024	0

4 Parallelism

4.1 OpenMP

4.2 Results

Table 4: Total time of the parallelised code for test cases of different sizes

Test Case Size	Time (s)
128×128	0
128×256	0
256×256	0
1024×1024	0

References

[1] *BlueCrystal technical specifications.* URL: https://www.bristol.ac.uk/acrc/high-performance-computing/hpc-systems-tech-specs/ (visited on Feb. 19, 2022).