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Assignment 4
Parallel Programming
03/29/24

Total execution time for each run:

A.) 1 node, 1 GPU, 16Kx16K world size each MPI rank, 128 iterations with 256 CUDA thread block size and pattern 5: 0.643961

B.) 1 node, 2 GPUs/MPI ranks, 16Kx16K world size each MPI rank, 128 iterations with 256 CUDA thread block size and pattern 5: 0.656310

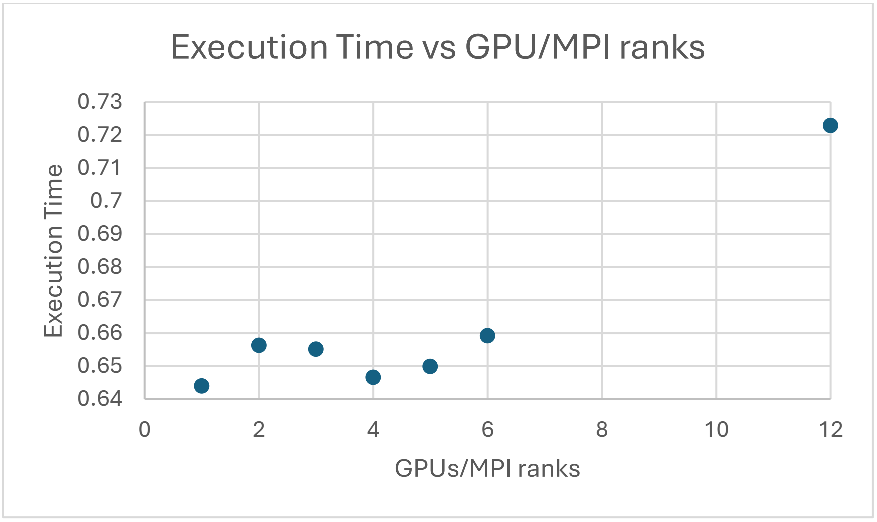
C.) 1 node, 3 GPUs/MPI ranks, 16Kx16K world size each MPI rank, 128 iterations with 256 CUDA thread block size and pattern 5: 0.655127

D.) 1 node, 4 GPUs/MPI ranks, 16Kx16K world size each MPI rank, 128 iterations with 256 CUDA thread block size and pattern 5: 0.646586

E.) 1 node, 5 GPUs/MPI ranks, 16Kx16K world size each MPI rank, 128 iterations with 256 CUDA thread block size and pattern 5: 0.649848

F.) 1 node, 6 GPUs/MPI ranks, 16Kx16K world size each MPI rank, 128 iterations with 256 CUDA thread block size and pattern 5: 0.659207

G.) 2 nodes, 12 GPUs/MPI ranks, 16Kx16K world size each MPI rank, 128 iterations with 256 CUDA thread block size and pattern 5: 0.722893



Maximum speedup relative to using a single GPU:

Time with single GPU:
Speedup with 2: 0.643961/0.656310 = 0.981x
Speedup with 3: 0.643961/0.655127 = 0.982x
Speedup with 4: 0.643961/0.646586 = 0.996x
Speedup with 5: 0.643961/0.649848 = 0.991x
Speedup with 6: 0.643961/0.659207 = 0.977x
Speedup with 12: 0.643961/0.722893 = 0.891x
Maximum speedup: 0.996x

Configuration that yields the fastest "cells updates per second" rate:

A.) 1 node, 1 GPU: World of 16384^2 that runs for 128 iterations with 0.643961 execution time:
16384^2 * 128 = 34,359,738,368 cell updates
34,359,738,368 / 0.643961 = 53,356,862,244.8 cell updates per second

B.) 1 node, 2 GPUs/MPI ranks: World of 16384^2 that runs for 128 iterations with 0.656310 execution time:
2(16384^2) * 128 = 68,719,476,736 cell updates
68,719,476,736 / 0.656310 = 104,705,820,018 cell updates per second

C.) 1 node, 3 GPUs/MPI ranks: World of 16384^2 that runs for 128 iterations with 0.655127 execution time:
3(16384^2) * 128 = 103,079,215,104 cell updates
103,079,215,104 / 0.655127 = 157,342,339,888.3 cell updates per second

D.) 1 node, 4 GPUs/MPI ranks: World of 16384^2 that runs for 128 iterations with 0.646586 execution time:
4(16384^2) * 128 = 137,438,953,472 cell updates
137,438,953,472 / 0.646586 = 212,560,979,470.6 cell updates per second

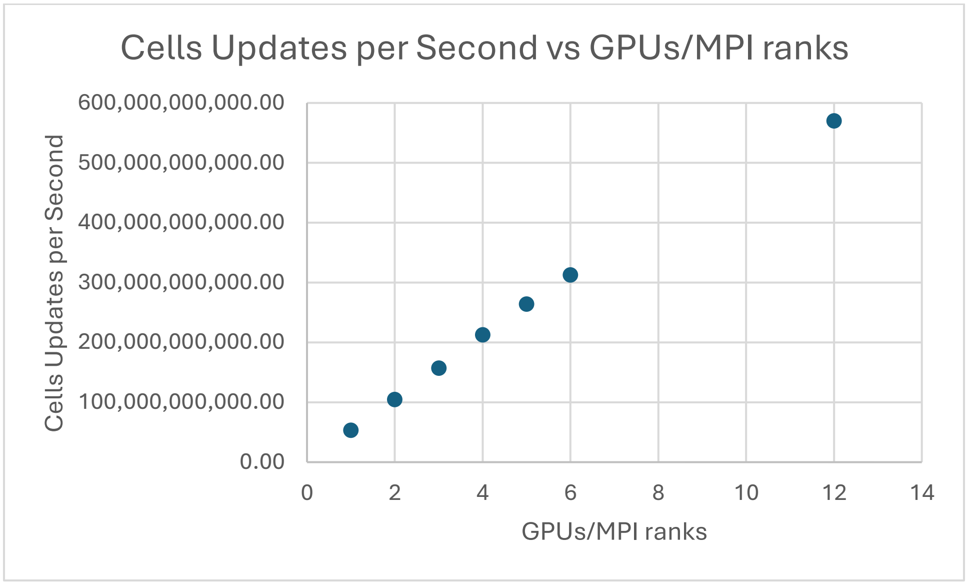
E.) 1 node, 5 GPUs/MPI ranks: World of 16384^2 that runs for 128 iterations with 0.649848 execution time:
5(16384^2) * 128 = 171,798,691,840 cell updates
171,798,691,840 / 0.649848 = 264,367,501,077.2 cell updates per second

F.) 1 node, 6 GPUs/MPI ranks: World of 16384^2 that runs for 128 iterations with 0.659207 execution time:
6(16384^2) * 128 = 206,158,430,208 cell updates
206,158,430,208 / 0.659207 = 312,737,016,154.3 cell updates per second

G.) 2 nodes, 12 GPUs/MPI ranks: World of 16384^2 that runs for 128 iterations with 0.722893 execution time:
12(16384^2) * 128 = 412,316,860,416 cell updates
412,316,860,416 / 0.722893 = 570,370,525,673.9 cell updates per second

<u>Fastest "cells updates per second" rate:</u>

2 nodes, 12 GPUs/MPI ranks, 16Kx16K world size each MPI rank, 128 iterations with 256 CUDA thread block size and pattern 5 with 570,370,525,673.9 cell updates per second



<u>Why this configuration was faster than others:</u>

The configuration with the fastest cells updates per second was 2 nodes, 12 GPUs/MPI ranks, 16Kx16K world size each MPI rank, 128 iterations with 256 CUDA thread block size and pattern 5 with 570,370,525,673.9 cell updates per second. To understand why this configuration was faster than the others, we can compare the number of cell updates and execution time for this run to the other runs. First, the world size and number of iterations remained constant for each run. However, each rank creates its own world of 16Kx16K, so the number of cell updates increased greatly. In other words, running it on 12 GPUs/MPI ranks had a world 12 times bigger than on 1 GPU, and therefore, on 12 GPUs/MPI ranks there was 12 times the number of cell updates. With that being said, the execution times remained similar across all runs. The average execution time across all runs was 0.661990, while the execution time for 12 GPUs/MPI ranks was 0.722893, a difference of only 0.060903. Therefore, with the number of cell updates being much greater than other runs, and the execution time remaining largely consistent, this configuration was faster than others.

Contributions:

All group members engaged in a collaborative effort to review and test the C and CUDA code to ensure correctness. Additionally, all group members effectively communicated with one another in regard to dividing up work and completing various tasks in a timely manner.
Other individual contributions:
Theodore Wu: Corrections and bug fixes in code
Charlie Liu: C and CUDA code
Alexa Daigle: Report and calculations
Espie Taylor: AIMOS runs

How to run the code:

To compile the code run the provided makefile. To run the code you can either modify the .sh file or use mpirun -np <ranks> ./mpi-cuda-exe <pattern number> <world size> <cuda thread block size>