CSCI 4320 Assignment 4 Report

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How to run my code:

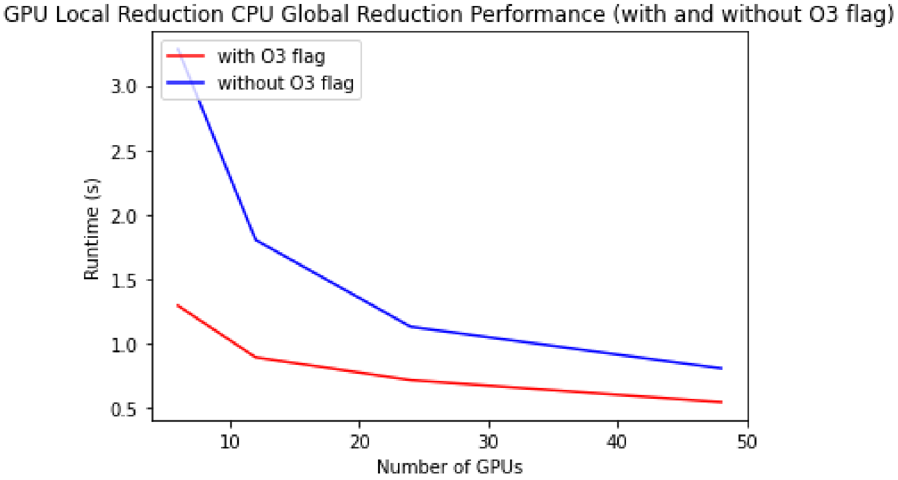
My code for gpu local reduction + cpu global reduction are `cuda-reduce.cu`, `gpu-local.sh`, `mpi-reduce-gpu.c`, and `Makefile`. You can compile my file by `make`, and then submit my `gpu-local.sh` to slurm.

And my code for cpu local reduction is `cpu-local.sh`, `mpi-reduce-cpu.c`, you can just compile with mpixlc and submit my `cpu-local.sh` to slurm.

Here are the result from the experiments with local GPU reduction and global CPU reduction:

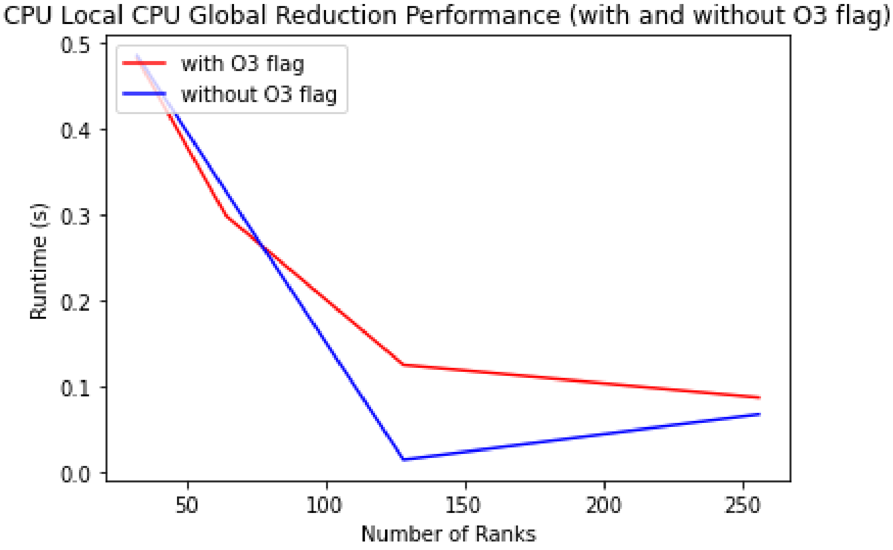
GPU Configuration	O3 Flag	Runtime (s)
6 GPUs	Enabled	1.2927
12 GPUs	Enabled	0.8923
24 GPUs	Enabled	0.7151
48 GPUs	Enabled	0.5447
6 GPUs	Disabled	3.2824
12 GPUs	Disabled	1.8033
24 GPUs	Disabled	1.1289
48 GPUs	Disabled	0.8062

Table 1: GPU Runtimes with and without O3 flag



CPU Configuration	**O3 Flag**	**Runtime (s)**
32 ranks	Enabled	0.4813
64 ranks	Enabled	0.2984
128 ranks	Enabled	0.1247
256 ranks	Enabled	0.0865
32 ranks	Disabled	0.4848
64 ranks	Disabled	0.3266
128 ranks	Disabled	0.0143
256 ranks	Disabled	0.0671

Table 2: CPU Runtimes with and without O3 flag



- Speedup with O3 flag: For GPU with O3 flag, the average speed up is:
  - 6 GPUs: $\frac{3.2824s}{1.2927s} = 2.54x$ faster
  - 12 GPUs: $\frac{1.8033s}{0.8923s} = 2.02x$ faster
  - 24 GPUs: $\frac{1.1289s}{0.7151s} = 1.58x$ faster
  - 48 GPUs: $\frac{0.8062s}{0.5447s} = 1.48x$ faster

  For CPU with O3 flag, the average speed up is:

  - 32 ranks: $\frac{0.4848s}{0.4813s} = 1.007x$ faster
  - 64 ranks: $\frac{0.3266s}{0.2984s} = 1.094x$ faster
  - 128 ranks: $\frac{0.0143s}{0.1247s} = 0.114x$ slower
  - 256 ranks: $\frac{0.0671s}{0.0865s} = 0.776x$ slower

- maximum speedup across all cases relative to using a single compute-node using 32 MPI in total:
  - Maximum speedup relative to using 6 GPUs:
    - 48 GPUs: $\frac{3.2824s}{0.5447s} = 6.04x$ faster
  - Maximum speedup relative to using 32 MPI ranks:
    - 256 ranks: $\frac{0.4848s}{0.0865s} = 5.60x$ faster
- Did GPUs always outperform the CPU cases. Why or why not for your code?
  No, in fact, CPU always outperforms GPU. I think this is because it's not a fair comparison: First, this is not a large enough test for GPU to show it's ability, since it's not large enough and GPU takes time to initialize the CUDA, CPU performs better. Second, GPU and CPU here is not comparing in the same scale, we used at most 48 GPUs but we used 256 ranks of CPU. I can't say which configuration is better. Third, our `reduce7` only reduce to an array of sum, we still need to calculate further to get the local sum by cpu addition with for loop. Fourth, `MPI_Reduce` with `MPI_Sum` might be better optimized for this task. In conclusion, for this case, I would prefer CPU over GPU simply because it's faster.
- Finally, explain why you think FASTEST configuration was faster than others.
  My fastest configuration is 128 ranks without O3 flag. This configuration being the fastest doesn't mean it's always the fastest, since the task not not large enough for 128 ranks and above to see the difference. My guess for 128 ranks being faster than 256 ranks is because the more ranks we use, the more time it takes to initialize the MPI, and the more time it takes to communicate between ranks. Therefore, 128 ranks is the fastest configuration for this size of task.