

## Homework 4 MPI, OpenMP, and GPU Programming Assignments

Total: 100 points

The homework assignment will be graded based on the following criteria:

- Accuracy: 1) the solution meets specific requirements in the problem description; 2) the solution produces correct results; 2) the procedures adopted in the solution are technically sound.
- Efficiency: efficiency will be one of the criteria when grading programming assignment. The solution should produce the desired results efficiently.
- Effort/neatness: the solution includes excellent effort, and all related work is shown neatly and organized well.

Homework assignment feedback will be available through the DropBox folder on D2L.

For all the programming assignments, you can choose any operating systems you want. I will usually provide C/C++ samples for the programming assignments. If you prefer to use other languages, e.g., Java, they are accepted too. A README.txt is required to submit any programming assignments. In the README.txt, you need to provide the following information:

- 1) How to compile your program?
- 2) How to run your program?
- 3) What is the average running time of your program?
- 4) What are the expected output results when I run your program?
- 5) Any descriptions which may help me to compile, run, and verify your answers. (FYI: I check every programming assignment turned in!)

Zip all your source code, project files, supporting files, and README.txt and submit the all-in-one zip file together to the D2L Dropbox. If you have any questions about the homework, please let me know.

(10 points) What are the strengths and limitations of GPU programming?

(15 points) Among the four parallel frameworks, multithreaded programming, MPI programming, openMP programming, and GPU programming (e.g., CUDA), we discussed in the class, what will be the strategies you are going to use in general when selecting a parallel framework for your applications?

(10 points) Benchmarking of a sequential program reveals that 95 percent of the execution time is spent inside functions that are amenable to parallelization. What is the maximum speed up we could expect from executing a parallel version of this program on 10 processors using Amdahl's Law?

(65 points) Programming Assignment: A small college wishes to assign unique identification numbers to all of its present and future students. The administration is thinking of using a given various constraints that have been placed on what is considered to be an "acceptable" identifier. The "acceptable" identifier must meet the following constraints:

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- The identifier is a six-digit combination of the numerals 0-9
  - The first digit may not be a 0.
  - Two consecutive digits may not be the same.
  - The sum of the digits may not be 7, 11, or 13.
1. (15 points) Write a sequential program to count the different identifiers given these constraints.
  2. (20 points) Convert the sequential program to an MPI parallel program.
  3. (20 points) (choose only one: A or B, not both)
    - A. Convert the sequential program to an openMP parallel program.
    - B. Convert the sequential program to a GPU program using a parallel framework at your choice (e.g., CUDA, OpenCL, etc.)
  4. (10 points) Benchmark the three programs based on your choice in 3).

Problem	1 process/ 1 thread	2 processes / 2 threads	3 processes / 3 threads	4 processes / or 4 threads
Program1.c (sequential)		n/a	n/a	n/a
Program2.c (MPI)				
Program3.c (openMP or CUDA)				