CSCI-UA.0480-051: Parallel Computing

Midterm Exam (Mar 14th, 2024)

Total: 100 points

Important Notes- READ BEFORE SOLVING THE EXAM

• If you perceive any ambiguity in any of the questions, state your assumptions clearly and solve the problem based on your assumptions. We will grade both your solutions and your assumptions.

• This exam is take-home.

• The exam is posted on Brightspace, at the beginning of the March 14th lecture (2pm EST).

• You have up to 24 hours to submit on Brightspace (i.e. till March 15th 2pm EST), in the same way as you submit an assignment. However, unlike assignments, you can only submit once.

• Your answers must be very focused. You may be penalized for giving wrong answers and for putting irrelevant information in your answers.

• Your answer sheet must be organized as follows:

• The very first page of your answer must contain only:

• Your Last Name

• Your First Name

• Your NetID

• Copy and paste the honor code shown in the rectangle at the bottom of this page.

• In your answer sheet, answer one problem per page. The exam has four main problems, each one must be answered in a separate page.

• Your answers can be typed or written by hand (but with clear handwriting). It is up to you. But you must upload one pdf file containing all your answers.

Honor code (copy and paste to the first page of your exam)

• You may use the textbook, slides, the class recorded lectures, the information in the discussion forums of the class on Brightspace, and any notes you have. But you may not use the internet.

• You may NOT use communication tools to collaborate with other humans. This includes but is not limited to Google-Chat, Messenger, E-mail, etc.

• You cannot use LLMs such as chatGPT, Gemini, Bard, etc.

• Do not try to search for answers on the internet, it will show in your answer, and you will earn an immediate grade of 0.

• Anyone found sharing answers, communicating with another student, searching the internet, or using prohibited tools (as mentioned above) during the exam period will earn an immediate grade of 0.

"I understand the ground rules and agree to abide by them. I will not share answers or assist another student during this exam, nor will I seek assistance from another student or attempt to view their answers."

Problem 1

a. [15 points] A processor only utilizes pipelining. Will adding more execution units improve performance? Justify your answer concisely.

b. [8 points] Can multiple processes execute concurrently on a shared-memory multiprocessor system? Explain the mechanism or the reason for impossibility.

c. [5 points] Is it possible for multiple threads within a single process to achieve the same performance on a distributed memory machine as on a multi-core machine? Explain your reasoning.

d. [15 points] A CPU core utilizes four-way hyperthreading. How many branch predictors are needed to optimize performance? Provide a justification for your answer.

Problem 2

a. [5 points] Given the following DAG and execution times for CPU types A and B, determine the minimum number of each CPU type needed to maximize speedup over sequential execution on a single CPU of type A. Specify which tasks each CPU executes and calculate the final speedup. (DAG and execution time table would be inserted here, mimicking the format of Problem 2 in the original document)

b. [12 points] Repeat Problem 2a, but this time optimize for speedup over sequential execution on a single CPU of type B.

c. [12 points] Analyze the DAG in Problem 2. Identify one arrow that, if removed, could potentially improve performance, and explain the reasoning behind your choice.

Problem 3

a. [10 points] Trace the execution of the following MPI code across the three processes (P0, P1, P2). What are the final values of x, y, and z for each process? (MPI code would be inserted here, mimicking the format of Problem 3 in the original document)

b. [10 points] In the MPI code from Problem 3, is there a risk of non-deterministic execution order for communication amongst the three processes? Explain why or why not.

Problem 4

b. [8 points] Two threads, with different computational workloads, are assigned to separate cores. Does this automatically imply load imbalance? Explain your answer using an example.