CSCI-UA.0480-051: Parallel Computing

Midterm Exam (Oct 17th, 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 Oct 17th lecture (2pm EST).

• You have up to 24 hours to submit on Brightspace (i.e. till Oct 18th 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 three main problems, each one must be answered in a separate page. If your solution for a problem takes more than a page, that is fine, but the following program must start on a new page.

• This exam consists of 3 problems, with a total of 100 points.

• 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 written.

• 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, 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

d. [12 points] Assume we have three cores (C1, C2, C3), each with a private cache using a MESI directory-based write-invalidate coherence protocol. All caches are write-through. Complete the table below showing the cache block state (M, E, S, I) for address A after each operation:

Time	Operation	Cache C1	Cache C2	Cache C3
1	C1 reads Block A			

2	C2 reads Block A			
3	C3 writes Block A			
4	C1 reads Block A			
5	C2 writes Block A			
6	C3 reads Block A			
7	C3 writes Block A			

Problem 2

[DAG Diagram - See original exam for visual representation]

[DAG Diagram - See original exam for visual representation]

[DAG Diagram - See original exam for visual representation]

[DAG Diagram - See original exam for visual representation]

[DAG Diagram - See original exam for visual representation]

```
x = 5;
y = x * x;
z = x + x;
k = y++;
l = y * h;
h = z * 4;
m = l + h + k;
```

Problem 3

a. [5 points] Processor A has 100% efficiency executing a code, while Processor B has 80% efficiency. Does this definitively mean the code will run faster on Processor A? Explain.

b. [8 points] The code `for (int i = 1; i < N; i++) { A[i] = B[i] – A[i - 1]; }` has loop-carried dependencies. Can this code be modified to allow for loop-level parallelization? If so, provide the modified code. If not, explain why.

c. 1. [5 points] A thread has the following instruction mix: 5 million add/sub, 2 million mult/div, and 1 million branch instructions. Each add/sub takes 2 cycles, each mult/div takes 10 cycles, and each branch takes 5 cycles. Calculate the MIPS (Million Instructions Per Second) if the clock frequency is 2 GHz. Show your work.

2. [5 points] Using the instruction mix from question 9, calculate the CPI (Cycles Per Instruction). Show your work.

3. [5 points] Using the instruction mix from question 9, calculate the total execution time for the thread. Show your work.