CSCI-UA.0480-051: Parallel Computing

Practice Exam (October 26th, 2023)

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.
- You have up to 24 hours to complete this exam.
- 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 neatly.
- You may use course materials (textbook, slides, notes) but may NOT collaborate with others or use online resources.

Honor code (copy and paste to the first page of your exam)
"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: Shared Memory vs. Distributed Memory (20 points)

a. [10] Explain the difference between shared memory and distributed memory parallel programming models. Provide an example of a programming paradigm suitable for each.

b. [10] What are the main challenges associated with programming for distributed memory systems that are not present in shared memory systems?

Problem 2: Amdahl's Law (15 points)

A program has a serial portion that takes 20% of the execution time on a single core.

a. [5] What is the maximum speedup achievable by using an arbitrarily large number of cores? Show your work.

b. [10] If we use 4 cores, what is the expected speedup? Show your work.

Problem 3: Task Scheduling (15 points)

Consider the following task graph with dependencies:
A -> B, C
B -> D
C -> D
D -> E

Each task takes the following time to execute:
A: 5, B: 10, C: 5, D: 15, E: 5

a. [10] What is the minimum execution time to complete all tasks? Draw a schedule showing the execution order.

b. [5] What is the critical path in this task graph?

Problem 4: Deadlocks (10 points)

a. [5] Define what a deadlock is in the context of parallel programming.

b. [5] Describe two common scenarios that can lead to deadlocks in parallel programs.

Problem 5: Race Conditions (10 points)

a. [5] Explain what a race condition is. Provide a simple code example illustrating a race condition.

b. [5] Describe two ways to prevent race conditions.

Problem 6: Cache Coherence (10 points)

Explain the concept of cache coherence and describe at least two protocols used to maintain cache coherence in multiprocessor systems.

Problem 7: Multiple Choice (10 points)

1. Which of the following is NOT a type of parallel computer architecture?

a) Shared memory

b) Distributed memory

c) Sequential memory

d) Hybrid

2. Amdahl's Law describes the limitations of:

a) Speedup in parallel systems

b) Memory bandwidth

c) Cache coherence

d) Network latency

Problem 8: OpenMP (10 points)

Write a short OpenMP code snippet that calculates the sum of an array of numbers in parallel.

Problem 9: MPI (10 points)

What are the main functions used in MPI for communication between processes? Briefly describe their purpose.

Problem 10: Load Balancing (10 points)

Explain why load balancing is important in parallel computing and discuss one technique for achieving load balancing.