MONASH University

Lecture Revision

OBJECTIVES

- Revise the materials and deepen the understanding of Week 6 to 7 lectures.

MARKS

- The applied session is worthed 3 of the unit final mark.

INSTRUCTIONS

1. **Preparation is required for this Applied session.** Please do NOT plan to complete the Applied preparation during the Applied class. **Late penalty** (5% per day) will apply if you submit late!
2. The purpose of these **flipped Applieds** is for students to get an opportunity to test their understanding of lecture/pre-reading material with a low cost in lost marks if they have not understood the material, rather than not understanding the material.
3. Students should produce **written answers** to the Applied questions prior to starting the Applied.
4. Students must submit their answers via Moodle in **PDF format** before their allocated class.
5. Students' answers will be reviewed in a question and answer format during the Applied. Each student will explain their answer.
6. For many of the questions, marks will be allocated for **both the correctness of the written answer and the correctness & clarity of the verbal answer.** Therefore, plan also for a brief 60 seconds summary explanation of each question. Try to focus on the most important and critical idea in the answer. Marks will be awarded on the student's ability to explain their submitted answers in the PDF: concise, focused and accurate answers will earn full marks, answers with errors and lengthy explanations will lose marks. Read the marking rubric for detailed instructions.
7. All questions are based on lecture/pre-reading slides, and lecture/pre-reading slides are in effect the answer sheets for these Applieds.
8. Worked answers will not be posted after Applieds as most of the answers are already in the lecture/pre-reading slides and discussed in the class.
9. Marks will not be awarded if you skip the class, or do not make any submissions, or make an empty submission to Moodle (unless a special consideration extension has been approved).
10. You are allowed to use AI tools to search for information and resources during pre-class preparation. **You must declare in your report!** AI tools are not allowed during the interview.

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Questions

Answer all the following questions.

Question 1 [Cluster Topology] (40%):

Given a cluster of 5 machines connected in a ring topology, over 1Gbps network links. Bob, a software developer, is running an Open MPI program on the cluster. For each machine, the program runs with 1 process. The root node (rank 0) will broadcast 50MB messages to all the other 4 machines every 5 seconds (i.e., one 50MB message for each non-root machine). Assume each message takes 0.5 seconds to transfer to a connected machine. Assume two messages **cannot** be sent at the same time (for every machine in the cluster).

A) If messages can only be sent in one direction (e.g., clockwise direction), draw a diagram to show how you would order the messages to minimize the time to broadcast the messages. Explain your answers.
B) Alice proposes to re-organise the machines into a star network to reduce broadcasting time. How would you organize the 5 nodes (including the root node)? Draw a diagram to explain your reasoning. Is it better than your answer in Part A?
C) If the network is upgraded and multiple messages can be sent at the same time. Assume each message still takes 0.5 seconds to transfer to a connected machine, regardless of how many messages the link is currently sending. For your solution in Part A, would you want to keep sending messages in one direction only? Explain your answers.
D) Bob now redesigns the program where only one message (of 50MB) will be sent throughout the whole network at all times. Suppose the message starts from the root node and the message is required to travel/visit all the other nodes. How would you design the program? Will you use star topology? Explain your answers.

Question 2 [Amdahl's Law] (30%):

Consider the Amdahl's Law in page 22 of Lecture Slide 7A.

A) Explain how the time spent on the network/fabric can impact the maximum speed-up of a program.
B) If Bob figures out that his program can only achieve a speed-up of 4, no matter how many processors/cores he is using. What is the percentage of serial code for his program?
C) Alice has just upgraded the network/fabric with better latency & bandwidth. Can we confirm that Bob's program must be able to gain a speed-up larger than 4? Explain your answers.

Question 3 [Partitioning] (30%):

Given a recurrence function f(n) = f(n-1)f(n-2) - f(n-3), $\forall n \geq 3$, with f(0) = 0.1, f(1) = 1.5, f(2) = 2.5. Bob wants to compute the function f(n), for all n: $3 \leq n \leq 300$. He has a machine with 64 CPU cores, and he decides to partition the problem into 298 independent problems, where each problem solves the function with a particular n. He starts solving the problem in an incremental order, with smaller n first. Whenever a core has finished processing the task, he will place the next task into the core for processing.

A) Explain why the partitioning of the problem is not ideal and why the workload distribution is not efficient.
B) Explain why recurrence relation/function in this example is not easy to be parallelized.
C) Explain why close-form expression (if exists) will usually be a better choice for parallel computing.