Homework 5: Theory of Performance Engineering

Due: 11:59 P.M. (ET) on Tuesday, October 12, 2021

Last Updated: October 10, 2021

The focus of this homework is on the theoretical side of the material taught in class, and it also serves as a warm-up exercise for the quiz. This homework should be done ***individually****. Please treat it like a take-home quiz. Do not discuss problems with classmates.*

Contents

1 Getting started

As preparation for the homework and quiz, read Chapter 26 of Introduction to Algorithms by Cormen, Leiserson, Rivest, and Stein (CLRS) 4th edition. You can find the chapter in PDF format on Canvas, in the Supplemental Readings module.

Please submit a write-up of your answers on Gradescope by the deadline.

Note: It may be helpful to take advantage of Gradescope's built-in LaTeX support to nicely typeset math in your responses. See `https://help.gradescope.com/article/3vm6obxcyf-latex-guide` for more information on the LaTeX syntax that Gradescope supports.

2 Greedy scheduling

Checkoff Item 1: Prove that a greedy scheduler achieves the following time bound, which is slightly stronger than the bound seen in class:

$$T_P \leq \frac{T_1 - T_\infty}{P} + T_\infty \,.$$

Ben Bitdiddle measures the running time of his deterministic parallel program on an ideal parallel computer with 4 and 64 processors using a greedy scheduler. He obtains running times of $T_4 = 100$ seconds and $T_{64} = 10$ seconds.

In Checkoff Item 1, we proved that any greedy scheduler schedules a computation with work T_1 and span T_∞ in time $T_P \leq (T_1 - T_\infty)/P + T_\infty$ on an ideal P-processor computer. We also showed in lecture that $T_P \geq T_1/P$ (Work Law) and $T_P \geq T_\infty$ (Span Law). Based on these formulas, please answer the following questions.

Write-up 1:

1. What is the best lower bound you can prove for the parallelism of the program?
2. What is the best upper bound you can prove for the parallelism of the program?

Ben Bitdiddle now measures the running time of another deterministic parallel program on an ideal parallel computer with 4, 10, and 64 processors using a greedy scheduler. Ben obtains the following running times:

$$T_4 = 80 \text{ sec},$$
$$T_{10} = 42 \text{ sec},$$
$$T_{64} = 9 \text{ sec}.$$

Write-up 2: Argue that Ben messed up at least one of his measurements.

3 Multithreading reductions and prefix computations

Write-up 3: Solve Problem 26-4 parts a–c on pages 784–786 in Chapter 26 of CLRS 4th ed.

Note: In order to produce the ⊗ operator that appears in this question, use the `\otimes` LaTeX command in your response.