Peachy Unplugged Parallels

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Abstract: In attempting to introduce concepts of Parallel and Distributed Computing (PDC) topics into early Computer Science curriculum the skill level and comprehension of the students limit us. For the majority of the students, CS0 and CS1 are their first exposure to coding and expecting them to master the concepts to allow for a complete understanding of the theories is problematic. Those students who have had exposure to programming are unfamiliar parallelism. For these reasons, I have initiated presenting 'unplugged' activities during lectures to help illustrate these principles.

Modelled after similar lessons detailed in Neeman, Lee et al, and at Code.org [1, 2] these modules have the student take a step back from the computer and concentrate instead in a hands-on activity that can highlight complicated ideas. By successful completion of these tasks, the students learn concurrency and the threaded model of parallelism without the complication of having to be encumbered with concerns on how to code the concept and instead can observe its effect.

First exercise: Sequential Dependency

Learning objectives: Concurrency, synchronization, speedup.

For this exercise, a single student competes against a team of their fellow students in sorting a deck of well shuffled cards. Each side is given a deck of cards and instructions to sort the cards, by suit and then from 2 through ace. The larger team is given no further instructions and it is up to the student leader to decide how to best use his teammates to accomplish the task.

As the teams work through the completion of the task, they demonstrate the concept of speedup, as the team with more members should be able to work at a faster speed than the individual. In addition, the students show that while the team may sort the cards quicker, they are still constrained by sequential dependency and the speed of the lead of the team in assigning tasks to the other members.

Second exercise: Deadlock

Learning objectives: Bottlenecks, Deadlock

In this exercise, once again a single student competes against a larger group of their classmates, this time in making peanut butter and jelly sandwiches for their classmates. A constraint is attached to this scenario in that while several knives are available for use, both teams only have access to a single jar of peanut butter.

By limiting access to this ingredient, we can introduce more complicated concepts. While synchronization and speedup are still present in this exercise, I am now able to show the concepts of bottlenecks, deadlocks, and race conditions, since the team will have to plan and work around this mutual exclusion restriction if they wish to take full advantage of their team size. How this challenge is overcome opens discussions into their detection and prevention.

Learning Outcomes

Using these activities, complicated concepts can be understood without the need to understand how implementation would work in code. Students can ignore how they would include code for parallel programming into their assignments and instead can work toward comprehending the idea and begin to understand on their own how the concepts of parallelism. In this manner, they can begin to see how the thinking of solutions in parallel will improve their own code as they progress through the major.

These implementations have been used for the last two semesters in the CS1 course with a positive results and learning outcomes from surveys taken from the students. Differences from pre and post surveys show that qualitatively, the students feel they have learned a "moderate amount" of the material through the exposure of the material

References:

[1] H. Neeman, L. Lee, J. Mullen and G. Newman, "Analogies for Teaching Parallel Computing to Inexperienced Programmers," in *Proceedings of ITiCSE-WGR '06 Working group reports on ITiCSE on Innovation and technology in computer science education*, Bologna, Italy, 2006.

[2] "CS Fundamentals Unplugged," 3 2018. [Online]. Available: https://code.org/curriculum/unplugged