Educational Resources for Parallelism and Multi-cores 1st Testing Phase Report

Introduction

On the week beginning 10th July 2017, as part of my research into creating educational resources for schools to teach about parallelism and multi-cores, I ran a series of tests for the first round of prototypes for the resources. I first met with a computing science Masters student, my own 18 year old sister, and a group of 16-18 year old summer school students. All of the groups of students apart from my sister had studied computing science at a level higher than second year of high school (age 13-14). This report will outline my experiences, any notable points and suggestions for improvement with the resources after testing.

I had tested the resources with Malcolm in the Master's lab in the Boyd Orr building for an hour, with my sister in our home for a couple of hours, and with the summer school students in the 2nd year lab in groups of 3-6 for an hour. I would say that it definitely takes longer than an hour to demonstrate all the activities appropriately, as my sister was the only real subject who fully understood everything as I had more time to explain it to her.

Parallelism and Amdahl's Law

The first resource that I had developed was to demonstrate to students the general idea of parallelism and also to introduce Amdahl's law. The resource is a board that mimics a computer with four cores, and then a 'program' is laid out along the top of the first core to imitate it taking a long time. Cutting up the 'program' into separate chunks and placing them along the three other cores demonstrates the idea of parallelism and how it speeds up execution. When demonstrating it to Malcolm, he mentioned that also teaching that the idea of some programs needing steps running in order was also important, and by maybe having the program have numbered steps that can't be done out of order was a way of demonstrating it. He also outlined that for younger students, it could be more useful to have the parallelisable section and non-parallelisable sections to be different colours to indicate exactly what each portion of the program would do. This is a good idea as it would help students see exactly what the different parts of the program are doing on each core. When demonstrating this example to my sister, she understood the example perfectly, and understood what parallelism was, why it was useful, and what Amdahl's law was and how to use it, although I would say I had more time to explain things to her as we were in a more relaxed environment. After demonstrating this resource to the summer school students, from the results of the questionnaires we handed out, nearly none of the students seemed overly confused and all got the idea of parallelism very well. The students who were confused however were merely unsure about Amdahl's law at the end - which could be due to rushing

the demonstration or by using decimal numbers which is what a student has suggested was confusing about it. I think to improve this would be to generate a few more examples that the students could work through themselves that might help solidify their understanding of Amdahl's law. Another point that was noted was that it sometimes took a little bit of extra explaining in order to demonstrate the point, however I think it was just due to my own personal goal to make sure things were explained right. It would be better if the material was a little more intuitive, i.e less explanation needed in order to successfully show the point. A way to achieve this would be to perhaps let students cut up their own pieces of a program to see what would happen in order to let them interact with it - however a problem might be that they would be unsure of what the real point could be.

MapReduce

The second exercise I demonstrated was the MapReduce Harry Potter exercise. The aim of this exercise was to outline the Hadoop function MapReduce through giving each member of the group a section from a chapter from Harry Potter, and counting up how many times the names Harry, Ron and Hermione appeared in their section. They would then tally mark the number they had counted as they went along, and then at the end there would be an overall total from each group. The idea was to mimic the 'mapping' which was splitting it up and tallying the count, and then 'reducing' which was bringing it back together with the totals. I couldn't really test this exercise with the masters student or my sister, as it was really aimed towards a group of at least 3 people, even better with a full class. I had tried it out with a group of three students when demonstrating to the summer school students. They all understood the exercise very well, especially as I had run this exercise after the first demonstration of the parallel concepts and Amdahl's law, so they could really see how parallelism relates to a real use of it. One student commented that Harry Potter was a good choice as it was a story that everybody knew and could enjoy - making the exercise a little bit more fun. This exercise I feel is near perfect but if I had to change anything I would definitely enforce that the concepts of parallelism (perhaps through the first resource) are taught first as the exercise could be considered confusing or misunderstood if taught alone.

Atomic Operations

The third and final exercise I had tested was a resource to demonstrate the need for atomic operations and consistency. The idea behind it was to have a series of 'building blocks' that each have a line of code written on them, to represent actions in a bank transaction. There were three blocks for each transaction, to represent the read-modify-write method of updating a bank account. There were two transactions (both withdrawals) each shown to be separate as they were printed on pink and yellow paper. The idea behind the resource was to show that it is important for actions to go in the right order otherwise the wrong results can occur, for example the bank account having more than one potential value for it after a withdrawal. I found this resource the most difficult to explain and go through, because it was hard to mention the need for parallelism when this example sort of proves otherwise. When

testing it out on the masters student, he mentioned that to make it more interactive I could explain one set of instructions (the pink set for example) and they could generate the other set themselves (the yellow set) rather than showing them both transactions. Another suggestion he made was to perhaps introduce another type of transaction in a bank, like a deposit or even introduce interest. Although this is a good idea, I feel like it may be slightly too complicated to explain to teenagers in order to get the general idea across. When demonstrating this to my sister, she understood the idea/reasoning perfectly, but started to propose further questions about the topic using the materials that I myself could not answer. It was for this reason that I decided not to demonstrate the materials to the summer school students as I was worried I wouldn't be able to demonstrate it effectively. After speaking over about it with some of the senior staff, the questions were answered, however it was considered that the example used was perhaps a little too complicated to explain. In order to alleviate this problem I would perhaps not use code to explain the example, and maybe use English statements instead, however the example itself might be too complicated in which I would have to rethink the whole idea from the beginning again.

Conclusion

In conclusion, this testing phase was very useful in seeing where we should be going in developing our materials. The different sessions with students of different levels of knowledge was very useful, as it helped us understand what was too confusing for some and what was too simple for some. Most of the resources first prototype was a very successful one, with very little changes needing to be made, although the last exercise will need a little more work done in order to be nearly finished. The students overall were happy to learn about parallelism, the majority of them weren't confused or displeased with the resources, so with some more improvements made to the materials they will be near perfect.