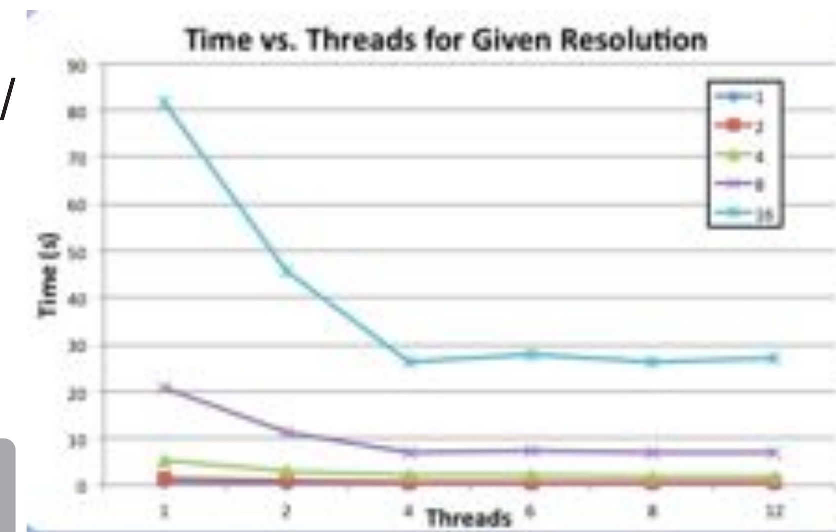
INTRODUCING HPC AND MULTITHREADED COMPUTING TO MIDDLE SCHOOL GIRLS USING SCRATCH

Kansas State
College of Engineering
Computing and Information Sciences

Russell Feldhausen, Scott Bell, Dr. Daniel A. Andresen
http://people.cis.ksu.edu/~russfeld/presentations/kawse2013/
russfeld@ksu.edu



GOALS

-Introduce students to the concept of HPC in a brief (40 minute) presentation and hands on experiment

-Increase student awareness of the pervasiveness of computing

-Demonstrate the benefits of using computing (specifically HPC) When tackling large scale, complex problems

-Have students discover the trade-offs between model resolution and number of threads and the limitations of multithreading benefits due to system specifications

ACTIVITY

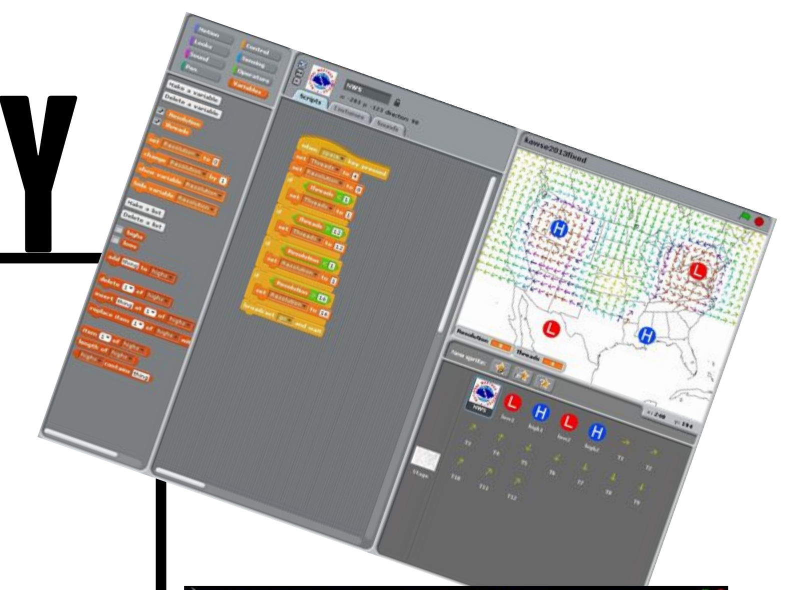
-Designed using the Scratch programming environment from MIT (scratch.mit.edu)

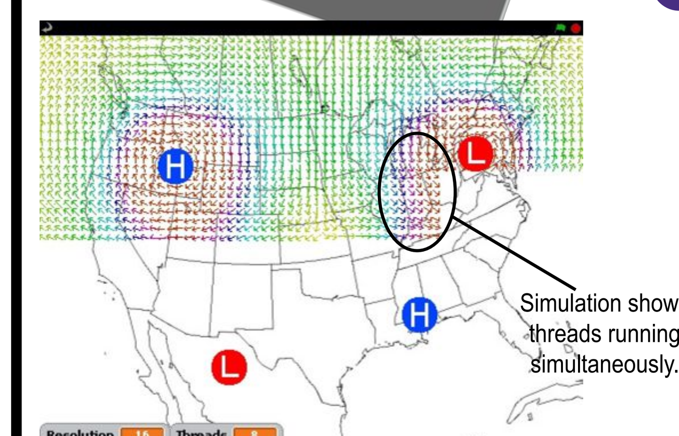
-Contains four different pressure centers

-Simulates the calculation of wind velocity based on pressure center locations

-Students can control the model resolution and number of threads used

-Simulation performance depends on hardware limitations





OUTCOMES

-After our presentation:
- -22 of 41 students showed interest in a job using HPC to solve problems
- -27 of 37 students felt they can learn how to write computer programs

-This activity will now be used in our “Introduction to Computing Science” class and other undergraduate classes to help introduce HPC

-We developed a framework in Scratch for teaching HPC concepts that can be easily adapted to simulate a multitude of real world problems

PROCEDURES

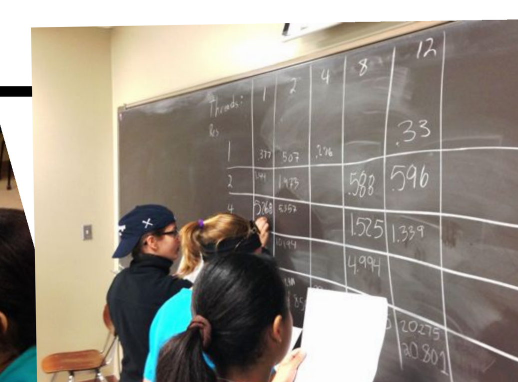
-Discuss parallelization are why it is needed for complex tasks such as weather modeling that are time sensitive

-Students worked in pairs to run the simulation activity, varying number of threads and model resolution and recorded the elapsed time

-Results were compared between groups to ensure data accuracy

-Data was summarized to show the benefits and limitations of performing multithreaded calculations on available hardware

Students performing activity



Recording results

Scott introducing activity

Tour of “Beocat” cluster

PRESENTATION

-Discussed everyday uses of HPC such as weather forecasting, and medical diagnosis

-Explained the basics of multithreaded computing and trade-offs that may be encountered

-Presented to 4 groups of around 20 middle school and high school girls

-Students toured an actual HPC cluster called “Beocat”

FUTURE WORK

-Improve the mathematical model used in the simulation to better simulate a real world computation

-Give the students more opportunity to customize the simulation in Scratch and learn programming fundamentals

-Improve our before and after survey questions to get better data on student understanding of and interest in HPC

-Schedule longer time periods with students to give us enough time to more fully explore HPC

Introducing HPC and Multi-Threaded Computing to Middle School Girls Using Scratch

Russell Feldhausen, Scott Bell, and Daniel A. Andresen
Kansas State University

Introduction

We present details and outcomes from an outreach activity designed to spark interest in middle and high-school aged girls to consider a future in science. This activity involved the use of a simple to build and explain high performance computing (HPC) experiment. Students attending this HPC session were given a brief background covering the breadth of uses for HPC in today's world, a tour of the Beocat cluster[1], and then spent time working with a wind forecasting simulation built using the Scratch development environment[2]. This activity allowed the students to see the benefits and limitations of multi-threaded applications, and a post-session survey of participants showed that many of them felt confident in their ability to learn computer programming, and over half would consider pursuing a career that involved using HPC to solve problems.

Background

This outreach activity was sponsored by the K-State Office for the Advancement of Women in Science and Engineering (KAWSE)[3], which holds a variety of events each year to foster STEM interest in middle to high school aged girls. Students who attend the Girls Researching Our World (GROW) and the Exploring Science, Technology and Engineering (EXCITE) workshops participate in numerous hands-on activities on campus. The goals of our 40 minute sessions were to encourage scientific interest, increase student awareness of the pervasiveness of computing, and show the benefits and limitations of computing when tackling large scale problems.

Instructional Design

In order to show the benefits of high performance computing in some tangible way, we decided to work with a simulation, and since students in our target age group would be familiar with weather maps, we focused specifically on a weather simulation. However, given the time constraints (approximately 40 minutes per session), we were not able to ask the students to do any real development on the application. Thus, we chose to pre-build an application and let the students experiment with it to measure performance benefits and limitations.

We selected Scratch as the development environment because it provides very easy to use graphical operations and an easy to follow programming interface. This would allow us to explain the basic operations of our simulation to students with no programming background.

We began each session with a brief overview of high performance computing, then discussed multi-threaded applications and finally introduced the idea of having multiple processors handle individual tasks simultaneously. Once the students began to grasp the tradeoffs involved in these operations, we introduced our simulation. This program calculates the wind direction and magnitude at every point based on the distance and direction to each of four indicated high or low pressure centers on the map. It is a very simplistic model, but it allows for an effective discussion of how similar (but much more accurate) values might be calculated in real weather models utilized by meteorologists. We included the ability for the user to manipulate both the resolution of the model (number of points to calculate per inch on the map) and also the number of threads the system would employ to calculate these points.

Students worked in pairs and were assigned a set of tests to run (yes, we parallelized the testing to improve efficiency due to our limited time budget!). Results were entered into a grid on the board and then graphed to compare the elapsed time vs resolution for a given number of threads.

Technical Accomplishments

As a result of this project, we have developed a simple, easy to follow application that can demonstrate the benefits and limitations of using multiple threads to compute simulation data[4]. We plan to further develop this topic and utilize it in introductory programming courses for freshmen Computer Science students this fall. This course already utilizes Scratch for several projects, but the ability to introduce such a concrete example of high performance computing so early in our curriculum is a huge benefit from this work.

Students were able see how a multi-core system can improve application performance when utilized correctly and *also* see the limitations of that improvement in performance. Students were surveyed at the end of the GROW Summer Workshop, and 22 of 41 indicated that they had an interest in a job using HPC to solve problems while 27 of 37 felt they could learn how to write computer programs.

Lessons Learned

We used very simple calculations for our simulator, and plan to improve the model used for future versions. This was not a big problem with this program, but more accurate models would allow for more in-depth uses of the simulator. We also felt that more time with the students would have been extremely useful. The time restrictions made our discussions and student exploration of the application very abrupt. In the future, we will try to find a way to increase this time so that we can more effectively engage students and allow them to explore the material on their own.

Summary

This was a very practical, every day application of high performance computing. By using such a common centerpiece for our demonstration, we felt students were able to grasp the implications of relatively complex concepts such as multi-threading and multi-core processing more quickly. Feedback from participants was positive, with over two thirds of the students feeling that computer programming was something they could do and a little over half of the students interested in the use of high performance computing.

References

1 Kansas State University Computing and Information Sciences. Beocat. `http://beocat.cis.ksu.edu/`.
2 MIT Lifelong Kindergarten. Scratch. `http://scratch.mit.edu`.
3 K-State Office for the Advancement of Women in Science and Engineering. `http://www.k-state.edu/kawse/`.
4 Russell Feldhausen. Wind simulation code. `http://people.cis.ksu.edu/~russfeld/presentations/kawse2013/`.