Teaching Parallel Programming in High School

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LA-SiGMA
Louisiana Alliance for Simulation-Guided Materials Applications

Problem

- Many high-school students learn the basics of programming:
  `for()` loops and `if()` statements
- The laptops on which the students write the code have several CPU cores and hundreds of GPU cores
- Many aspects of HPC are challenging, but basic parallel pragmas are not
- Most students never even learn that it is possible to fully utilize the hardware they already own.

Resources

- Five teachers with HPC experience:
  Math, Chemistry, and Physics
- Support from LONI, LSU, and XSEDE
- Summer research opportunities
  for faculty and students
- LittleFe cluster: Student Sandbox
  - Six nodes
  - Twelve CPU cores
  - Six CUDA-enabled GPU's

Project

- Teacher has written the rough code.
- Five students work in a team:
- Figure out how the code works,
- Clean it up,
- Optimize it for the LittleFe architecture,
- Profile it for various size matrices, and
- Write the documentation.

XSEDE
Extreme Science and Engineering Discovery Environment

Rough Code

Randomly Populate A & B

$$A \times B = C$$

`MPI_Send()` to Four Work Nodes

$$A_0 \times B_0 = C_{00} \qquad A_0 \times B_1 = C_{01}$$

$$A_1 \times B_0 = C_{10} \qquad A_1 \times B_1 = C_{11}$$

`cudaMemcpy()` Multiply on GPU

$$A_0 \times B_0 = C_{00} \qquad A_0 \times B_1 = C_{01}$$

$$A_1 \times B_0 = C_{10} \qquad A_1 \times B_1 = C_{11}$$

Reverse Communication and Collect Results

$$A \times B = C$$

Two Types of Students

The Scientist

Problem: Does Not Understand Why

- "Why is it important to multiply large matrices faster?"
- Student has taken `C++` and Data Structures before taking Linear Algebra, DiffEQ, or a second year of biology, chemistry, or physics
- She has never seen an application of multiplication of large matrices

Solution: Exposure to Computational Scientists

- SCALA Symposium Talks
- Summer Research
- Lectures
- Mentoring

The Coder

- Problem: Will work all night to get a one percent increase in efficiency, instead of writing lab reports and reading history
- Solution: Mentoring
- I have chosen three students to mentor this year

Plans for the Students

- Students are entering their junior year of high school
- After optimizing and profiling for LittleFe, they will do the same on the various architectures in the XSEDE consortium.
- Present results at XSEDE'13 in San Diego
- Spend summer 2013 doing research in computation-accelerated science
- Write senior thesis in fall 2013
- "Graduate with Distinction" in spring 2014
- Go to top universities with undergraduate research assistantships

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