

Parallel Computing in High School

LA-SiGMA Research Experience for Teachers

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13 July 2012



The Problem (Nationwide)

- ▶ Schools teach C++, Python, and/or Java
- ▶ Only teach serial programming
- ▶ Students write serial code on laptops/desktops
with multiple CPU cores and hundreds of GPU cores
- ▶ We don't teach students to use the power in their hands



- ▶ LA-SiGMA RET 2011
- ▶ Wonderful Ideas
- ▶ Great Aspirations
- ▶ Big plans for “Computational Thinking Program”
- ▶ Did not adequately consider student motivation
- ▶ Steaming Pile of Failure





Seattle, WA
Connecting communities
through HPC



LittleFe



(pun on “Big Iron”)

Six Intel Atom nodes
with hub

Each node has
two CPU cores and
one GPU

Student sandbox



Matrix Multiplication with MPI/CUDA

Head Node Initialization

Goal: $A \times B = C$

$$\begin{array}{c} A \\ \square \end{array} \times \begin{array}{c} B \\ \square \end{array} = \begin{array}{c} C \\ \square \end{array}$$



Matrix Multiplication with MPI/CUDA

Head Node Initialization

Generate random A and B on head node

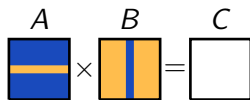
$$\begin{array}{c} A \\ \color{blue}\square \end{array} \times \begin{array}{c} B \\ \color{orange}\square \end{array} = \begin{array}{c} C \\ \square \end{array}$$



Matrix Multiplication with MPI/CUDA

Head Node Initialization

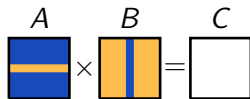
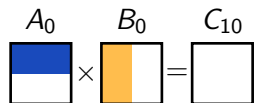
Cut A and B each in half



Matrix Multiplication with MPI/CUDA

Work Nodes

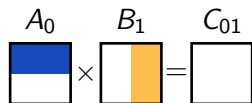
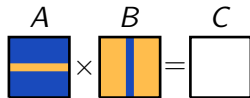
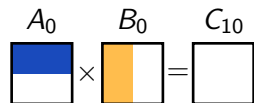
Move one pair of halves to each node with `MPI_Send()`



Matrix Multiplication with MPI/CUDA

Work Nodes

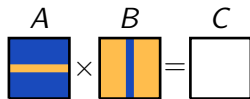
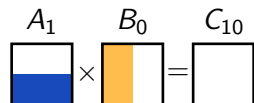
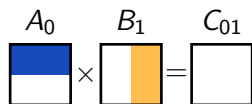
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Matrix Multiplication with MPI/CUDA

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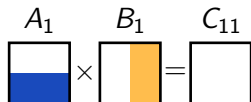
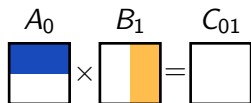
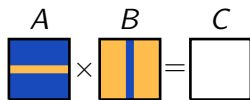
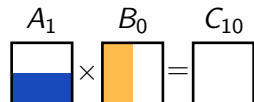
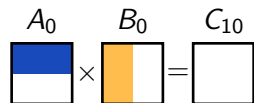
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Matrix Multiplication with MPI/CUDA

Work Nodes

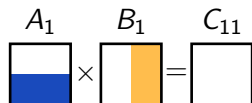
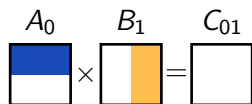
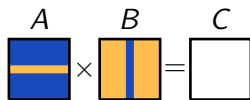
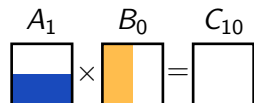
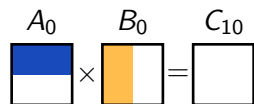
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Matrix Multiplication with MPI/CUDA

Work Nodes

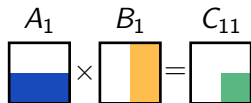
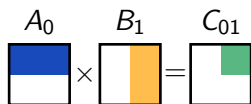
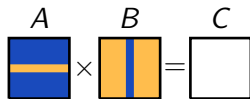
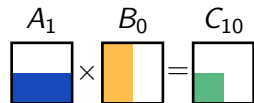
Copy the arrays to the GPU with `cudaMemcpy()`



Matrix Multiplication with MPI/CUDA

Work Nodes

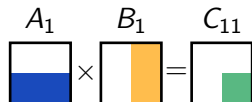
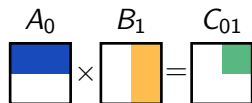
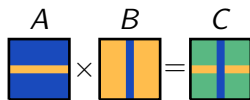
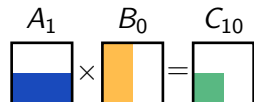
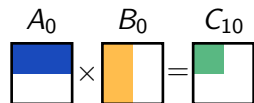
Compute each element of the array on a different GPU thread



Matrix Multiplication with MPI/CUDA

Head Node

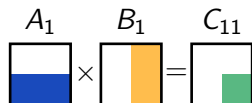
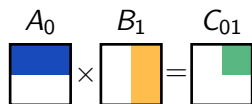
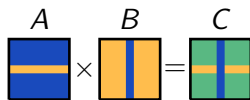
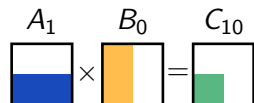
Reverse the communication and collect the results



Matrix Multiplication with MPI/CUDA

Student Project:

Optimize and Profile



Student Difficulties: Two Extremes

- ▶ Lack of Motivation
 - ▶ Visiting Speakers
 - ▶ Attending Symposia
 - ▶ Faculty Research
 - ▶ Student Summer Research
 - ▶ XSEDE resources (BIG toys)
- ▶ Obsession
 - ▶ Mentoring
 - ▶ Students work on my HPC projects
 - ▶ I monitor their coursework



Outreach

- ▶ LittleFe roadtrip to middle schools
- ▶ XSEDE Campus Champion
 - ▶ Louisiana Scholars' College
 - ▶ Sister schools (Alabama, Arkansas, Mississippi, Oklahoma)
- ▶ Presenting at conferences



Many Thanks

LA-SIGMA

Louisiana Alliance for Simulation-Guided Materials Applications

LSU CENTER FOR COMPUTATION
& TECHNOLOGY



Many Thanks



Many Thanks

XSEDE

Extreme Science and Engineering
Discovery Environment



Insights from a Poet-for-Hire

“Write me a poem about several people working together on a project.”



Rumi said when one part hurts
the whole body is uncomfortable
Try to play a song you know well
With missing piano keys
Or write a poem without every letter
It's more: the sun is made of us
And music is made of colors
There are no trees without bouts
of tears on Sunday afternoons
It's more: we are joined, not separated
from the world by our skin
Each one of us is a finger
on a single hand. Lift high
not only the work, but the workers
if you want to see creation from above.

-Erin Lierl
Frenchmen Street, New Orleans
July 5, 2012



