High-Performance Computing (G63.2011.002/G22.2945.001), Fall 2010

Final Project

Proposal Due: Via email by November 2, 2010 (at the beginning of class)
Presentations: December 14/21, 2010 (tentative)

The final assignment is a project of your choice. A project related to a dissertation would be ideal, (and of course a proportionate amount of work suitable for a class project could be mapped out). Similarly if you are taking another class with a final programming assignment, you could combine the two and do it in parallel. Groups of 2 to 3 people are encouraged. At the end of the semester you should give a 15 minute presentation to the class as well as submit to us a written description of your project and its results.

Since the class interests and backgrounds are somewhat varied, we are very open to a range of projects. The only real requirement is that it be something in parallel. Come speak to us if you have doubts about the suitability of something you are interested in. If you need inspiration, you might try to investigate in one of these directions:

Partial Differential Equation solvers (This is where our expertise lies, so we're most likely to be of help to you here.) For example:

- Write an MPI-parallel finite-difference solver for a more challenging equation than what we treated in class–perhaps Maxwell's equations or compressible Navier-Stokes.
- Alternatively, do a solver for a simple equation with complicated boundary conditions on a GPU. You would likely approximate a non-square domain using a staircased mesh and then deal with the load balancing issue that arises.
- Investigate the use of Clawpack on the GPU. Clawpack (**?**) is a software package designed to compute numerical solutions to hyperbolic partial differential equations. Various flavors exist, supporting adaptive and MPI-parallel execution. Your job would be to try and add a GPU-based flavor. Clawpack is written in Fortran, but can also talk to Python programs–which could potentially be used to bring in the GPU parts.
- Implement a particle-based PDE solver using smoothed particle hydrodynamics. (**?**).

Algorithmic Questions Things like sorting, hashing and tree building quickly become complicated in parallel. Ample literature exists. You could focus on one problem and implement one or two approaches, giving an introduction to/survey of the literature in your talk. This could use either MPI or GPUs.

Tools Investigate a PGAS (Partitioned Global Address Space) language (e.g. UPC (**?**)) and implement one of the class homework assignments in the new language. Compare them with respect to expressiveness, ease of use, performance, etc.

Your Area? If you have knowledge about image processing, statistics, or some other field, there are usually interesting questions that need to be addressed–you might try talking to a professor in your area to see if they have anything that could use computational help.

Please email us a proposal for your final project during this coming week. Our goal is to discuss and approve within a few days so that you can get started, since there will be approximately one month left in the semester for these projects.

We would like to see the following things in your proposal:

- A "big-picture" description of the application you are targeting. Target this at non-experts (us). Don't be shy to use pictures if appropriate.

- Implementation aspects of the problem–what are the challenges? What scale does the application demand?
- What precisely are you setting out to do? Using what mechanism (OpenMP, GPUs, MPI)? At what scale?
- References to literature on the subject, both on the "science" and the "implementation" aspects.

You should aim for roughly two pages or less in your proposal.