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Research Statement

Motivation

Most of the major High Performance Research centers are involved in building an exascale machine. The idea of a machine that can calculate a billion billion floating point operations in a single second is exciting. Application developers have started to port their code into a parallel framework using programming models such as OpenMP and MPI in order to take advantage of the powerful hardware. Added to this is the complexity of the performance portable code. Most of the big machines are a combination of a CPU and a multi-core processor or an accelerator such as Nvidia's GPU or an FPGA's or an Intel's Xeon Phi. An application code optimized for a single architecture may not necessarily give us the best performance on another. My current work is focussed on using various programming models such as OpenMP{3.0, 4.5}, Kokkos, Cuda, Raja and HPX to asses the effort needed to write codes using them and the portability provided by each. I find it challanging to write portable code that can take advantage of the underlying hardware to give us good performance I want to be associated in the area of developing application or tools for developing applications that can take advantage of the big machines of the future.

General Statement

My work and experience is in development and use of parallel programming models to port applications on multi-core architectures.

For my doctorate thesis I worked on synchronization of multiple threads on a multi-core processor. I extended the OMPSs framework to include compiler directives and the associated runtime support for speculative synchronization.

In my current work as a PostDoc, I am work on performance portability. I work on implementing portable application codes.

My research interests include working in the area of application development or tools for porting applications on big machines.

Specific Expertise

PostDoc In here I am involved in the following two projects

1. SW4 - Seismic Waves of 4th order accuracy.
   It is an Exascale Computing Project (ECP), where my role is to optimize the performance of the code

on Intel's Knights Landing (KNL) processors. For this, I use techniques such as cache-blocking, vectorization and reducing the overhead incurred due to OpenMP directives. We are currently working on running large scale simulations of SW4 on the Cori supercomputer. For this the goal is to use all 9K KNL nodes available on Cori.

2. Performance Portability - I also work on implementing portable application codes using programming models such as OpenMP{3.0, 4.5}, Kokkos, Cuda, Raja. The aim is to determine the effort required and the performance achieved when using these programming models. I am currently working on porting Berkeley GW (BGW), a set of material science application kernels using the above mentioned programming models.

PhD Thesis I graduated my Doctoral thesis from Barcelona Supercomputing Center (BSC), Barcelona, Spain in March, 2015. My advisors were Rosa M.Badia and Eduard Ayguade. During this period, I was art of the Programming Models group at the Barcelona Supercomputing Center (BSC). My Doctoral thesis was focused on speculative synchronization techniques for OMPSs, a task-based programming model.

I extended the framework to speculatively update shared memory locations using STM instead of the traditional lock and mutex based mechanisms. An extension to speculative memory updates is the speculative execution of tasks, where tasks can be scheduled before their presence in the execution flow can be confirmed. I implemented a lighweight rollback mechanism which can be used to undo the updates of tasks in case of speculation failure. The idea of greedy task execution improved the performance by an average of 20% for a select category of applications. At BSC, I also worked on porting applications from the domain of linear iterative solvers and graph algorithms using SMPSs, OMPSs implementation for SMPs. These applications are now a part of their application repository.

Rahulkumar Gayatri