Design And Analysis Of A Plastic Parallel Programming System

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Abstract

This is the scond part of an MInf project which has spaned two years. In this project, we investigate the performance implications of plastic parallel programs which adapt to the current state of the host system, and explicitly cooperate to share and optimize the use of system resources.

In the first year of this project, we created an example of a parallel programming library which implemented these features, and gained some promising preliminary results into it's performance. In this second year, we develop upon this further by investigating a more insteresting parallel pattern...EXPAND

Contents

Chapter 1

Background

In this chapter, we will detail the current approaches to parallel programming. We will then explore the three key ideas requisite to this project, such that we can discuss how they are combined and their implications. Then we will cover what was done in the first phase of this project [4], and the intentions for this second phase.

The main idea in this project is dynamic contention aware scheduling and optimisation. It has been shown to be an important factor in multiprogramming systems with performance implications [2]. The intention of this project is to investigate if we can exploit plasticity to mitigate this contention, and what benefits this could bring. Integrating plasticity into parallel programs results in complex code, making it hard to ensure correctness. Since the ideas of this project requires the cooperation of multiple different programs, it is in our interest to make using these techniques as easy as possible, to encourage their use by programmers. Thus, to abstract this complexity away from the programmer, we employ skeletal programming. It also has the beneficial side effect of dividing the challenge into a pattern-by-pattern basis.

In the first phase of this project [4], we investigated a basic parallel programming pattern, map-array. We incorporated this into a feasible estimate of a contention aware plastic parallel programming library, and measured the performance. The main conclusion was that there were performance gains to be had, but more investigation was necessary.

Another conclusion form the previous phase of this project is that the overhead of the contention aware plastic parallel programming library was not significant. To build on these findings, in this phase, we focus on the analysis of a more complex parallel pattern, without integrating it into a complete contention aware plastic parallel programming library.

1.1 Current Solutions

1.2 Contention Aware Scheduling

1.3 Plastic Programming

1.4 Skeleton Programming

1.5 Previous Work

Details of previous work etc, explain weaknesses and plan for different parallel pattern (Jacobi)

1.6 This Year

In linear algebra, the Jacobi method is an algorithm for finding the solutions of a system of linear equations. It is an example of stencil code, as it updates array elements according to a fixed pattern, then the process is iterated until it converges. The Jacobi method is used for many applications, and as such we use it as an example of a real world application. [6] [1] [5]

Chapter 2

Design

Since the purpose of this year of the project is to analyse the performance characteristics of stencil codes, we do not need the full capabilities of a plastic parallel programming system. We just need enough functionality to assess the performance.

In this section, we cover the design of the system that was produced for this purpose, and the design decisions behind it. We then detail the justification of and process of finding specific stencil codes with which to assess our system.

2.1 Design of Experiment Platform

2.1.1 Basic Stencil Code

The first step was to implement a basic stencil code.

Two arrays are used, one to store the values from the previous iteration, and one to contain the newly computed values. After an iteration, the roles of these arrays are reversed. This technique of using two arrays is done to minimise the necessary synchronisation overhead.

Arrays are partitioned between threads, with a row level granularity. Shared data occurs at the edges of a particular thread's chunk.

Parallel code implemented using the c++ threads library (Based upon pthreads.)

2.1.2 Adding Variable Configurations

variables numthreads etc kernels [3]

1. Number of iterations
2. Thread pinning
3. Combinations of multiple different workloads
4. Grid size
5. Number of workers

2.1.3 Adding Plasticity

plasticity

2.1.4 Experiment Scripts

experiment scripts

2.2 Interesting Use Cases

2.2.1 Reasoning

In order to be able to do our investigations, we need to select a couple of interesting use cases of stencil code.

The potential for experiments is massive, due to the large amount of variables we have access to. In our investigation, we have access to the following:

EXPAND UPON THESE

1. Number of iterations
2. Thread pinning
3. Combinations of multiple different workloads
4. Grid size

5. Number of workers

All of these can be changed from stage to stage. Beyond these parameters, we can have many different combinations of programs running simultaneously.

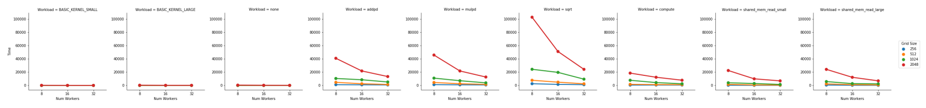
For the purposes of this project, we will select a few interesting use cases of the stencil pattern, and focus on testing these in a few different configurations.

2.2.2 Finding Interesting Use Cases

In order to find interesting use cases, we performed an initial foray into the experiment space we have access to.

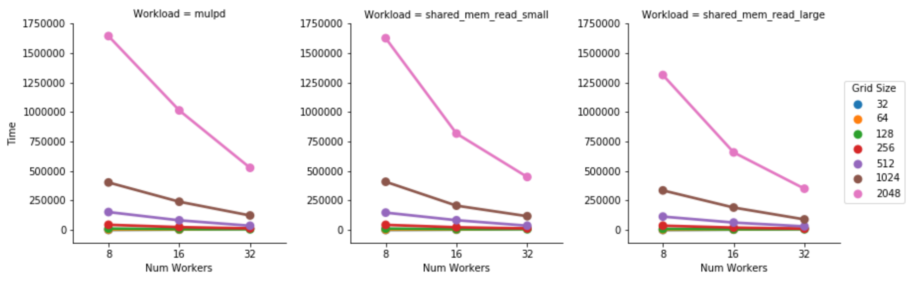
First

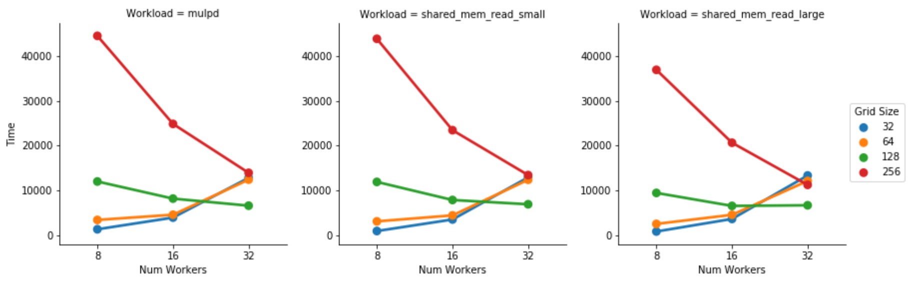
Firstly we compared the performance characteristics of each of our different workloads, and how they performed with different numbers of threads.



Second

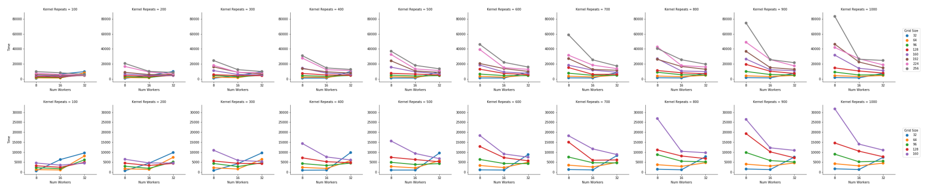
Next we picked some interesting kernels form the previous experiment, and investigated them further, with some smaller grid sizes. This was because we were interested in a use case where at a certain point, adding more threads is no longer optimal.





Third

Next, we focused on the mulpd kernel, and and tested a variety of kernel repeats, and some more fine grained grid sizes. This is so that we could identify the point at which, as the grid size shrinks, increasing the number of threads will be sub-optimal.



As you can see from the graphs, for gridsizes 32-128, going beyond 16 threads did not increase performance in all cases.

Another interesting take from the graphs is that we can see that as the grid size increases, the runtime curves 'flip' at 32 threads such that smaller grid sizes take longer. However, as the number of kernel repeats increases, this flipping gradually lessens. This is because the increased independent workload per thread starts to

2.3 Selected Use Cases

List selected patterns

Chapter 3

Implementation

3.1

Chapter 4

Experimental Methodology And Program

4.1

Chapter 5

Results

5.1

Chapter 6

Future Work And Conclusions

6.1

Chapter 7

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