

Homework #4

cpe 631

Kyle Ray

February 14, 2018

Contents

[Purpose 2](#_Toc506333338)

[Problem 1 2](#_Toc506333339)

[Problem 2 2](#_Toc506333340)

[Appendix A 4](#_Toc506333341)

[Appendix B Daxpy Simulation Results 4](#_Toc506333342)

# Purpose

Become familiar with Multi2Sim – a simulation framework for CPU-GPU heterogenous computing platforms.

# Problem 1

Exploring the effectiveness of the blocking optimization for matrix multiplication.

Architecture Setup:

1. Default x86 processor configuration
2. Modified memory hierarchy with the following:
   1. Split Instruction L1I Cache
      1. 4 KB, 64-byte blocks, 4-way set associativity, 4 CC latency, LRU
   2. Split Data L1D 4KB Cache with 4-way set associativity and 64-byte blocks
      1. 4 KB, 64-byte blocks, 4-way set associativity, 4 CC latency, LRU
   3. Unified L2U 23 KB Cache
      1. 32 KB, 64-byte blocks, 4-way set associativity, 10 CC latency, LRU

The application used in the experiment is a serial matrix multiplication program written in the C language and compiled with gcc. Square matrix multiplication with matrix sizes 256x256 were used to test the performance of the architecture mentioned above.

# Problem 2

Evaluate the effectiveness of loop unrolling regarding execution time. Architecture setup is set to the Multi2Sim default setup. A C program performing a DAXPY kernel (aX + Y = Z) where X,Y,and Z are arrays of n elements and a is a constant 3.0. The program was ran with n = 2048 and the execution times were recorded for no unrolling up to four loop unrolls. The loop unrolls were executed in powers of 2 i.e. 2, 4, 8, and 16. The data from the runs is tabulated below.

**Table 2. Execution Times for Loop Unrolls (DAXPY with 2048 Elements)**

|  |  |
| --- | --- |
| Loop Unrolls | Execution Time (ns) |
| 0 | 187712.00 |
| 2 | 176189.00 |
| 4 | 178131.50 |
| 8 | 172611.00 |
| 16 | 171303.00 |

**Figure 2. Execution Time for Loop Unrolls (DAXPY with 2048 Elements)**

From the data above, we can see that loop unrolling in most cases does help the overall execution time. This makes sense because it is effectively cutting out many control instructions by working on more items in a single iteration. Unfortunately it does look as if the benefit to loop unrolling is quickly approaching a limit and there will likely be an insignificant change if the technique is pursued further.

# Appendix A

# Appendix B Daxpy Simulation Results

; Multi2Sim 4.2 - A Simulation Framework for CPU-GPU Heterogeneous Computing

; Please use command 'm2s --help' for a list of command-line options.

; Simulation alpha-numeric ID: AE5Fq

;

; Simulation Statistics Summary

;

[ General ]

RealTime = 0.43 [s]

SimEnd = ContextsFinished

SimTime = 187714.00 [ns]

Frequency = 2000 [MHz]

Cycles = 375429

[ x86 ]

RealTime = 0.43 [s]

Instructions = 138331

InstructionsPerSecond = 320484

Contexts = 1

Memory = 9121792

FastForwardInstructions = 0

CommittedInstructions = 106744

CommittedInstructionsPerCycle = 0.2843

CommittedMicroInstructions = 229683

CommittedMicroInstructionsPerCycle = 0.6118

BranchPredictionAccuracy = 0.9132

SimTime = 187712.00 [ns]

Frequency = 2000 [MHz]

Cycles = 375424

CyclesPerSecond = 869778

; Multi2Sim 4.2 - A Simulation Framework for CPU-GPU Heterogeneous Computing

; Please use command 'm2s --help' for a list of command-line options.

; Simulation alpha-numeric ID: AFV3I

;

; Simulation Statistics Summary

;

[ General ]

RealTime = 0.43 [s]

SimEnd = ContextsFinished

SimTime = 176431.00 [ns]

Frequency = 2000 [MHz]

Cycles = 352863

[ x86 ]

RealTime = 0.43 [s]

Instructions = 136934

InstructionsPerSecond = 316871

Contexts = 1

Memory = 9121792

FastForwardInstructions = 0

CommittedInstructions = 105740

CommittedInstructionsPerCycle = 0.3001

CommittedMicroInstructions = 222540

CommittedMicroInstructionsPerCycle = 0.6315

BranchPredictionAccuracy = 0.8983

SimTime = 176189.00 [ns]

Frequency = 2000 [MHz]

Cycles = 352378

CyclesPerSecond = 815418

; Multi2Sim 4.2 - A Simulation Framework for CPU-GPU Heterogeneous Computing

; Please use command 'm2s --help' for a list of command-line options.

; Simulation alpha-numeric ID: AHKDu

;

; Simulation Statistics Summary

;

[ General ]

RealTime = 0.40 [s]

SimEnd = ContextsFinished

SimTime = 178134.00 [ns]

Frequency = 2000 [MHz]

Cycles = 356269

[ x86 ]

RealTime = 0.40 [s]

Instructions = 136709

InstructionsPerSecond = 338955

Contexts = 1

Memory = 9121792

FastForwardInstructions = 0

CommittedInstructions = 105228

CommittedInstructionsPerCycle = 0.2954

CommittedMicroInstructions = 218956

CommittedMicroInstructionsPerCycle = 0.6146

BranchPredictionAccuracy = 0.8885

SimTime = 178131.50 [ns]

Frequency = 2000 [MHz]

Cycles = 356263

CyclesPerSecond = 883315

; Multi2Sim 4.2 - A Simulation Framework for CPU-GPU Heterogeneous Computing

; Please use command 'm2s --help' for a list of command-line options.

; Simulation alpha-numeric ID: Hlagz

;

; Simulation Statistics Summary

;

[ General ]

RealTime = 0.39 [s]

SimEnd = ContextsFinished

SimTime = 172611.00 [ns]

Frequency = 2000 [MHz]

Cycles = 345223

[ x86 ]

RealTime = 0.39 [s]

Instructions = 136243

InstructionsPerSecond = 351054

Contexts = 1

Memory = 9121792

FastForwardInstructions = 0

CommittedInstructions = 104972

CommittedInstructionsPerCycle = 0.3041

CommittedMicroInstructions = 217164

CommittedMicroInstructionsPerCycle = 0.6292

BranchPredictionAccuracy = 0.8831

SimTime = 172580.00 [ns]

Frequency = 2000 [MHz]

Cycles = 345160

CyclesPerSecond = 889365

; Multi2Sim 4.2 - A Simulation Framework for CPU-GPU Heterogeneous Computing

; Please use command 'm2s --help' for a list of command-line options.

; Simulation alpha-numeric ID: HmOEF

;

; Simulation Statistics Summary

;

[ General ]

RealTime = 0.38 [s]

SimEnd = ContextsFinished

SimTime = 171303.00 [ns]

Frequency = 2000 [MHz]

Cycles = 342607

[ x86 ]

RealTime = 0.38 [s]

Instructions = 135997

InstructionsPerSecond = 357318

Contexts = 1

Memory = 9121792

FastForwardInstructions = 0

CommittedInstructions = 104849

CommittedInstructionsPerCycle = 0.306

CommittedMicroInstructions = 216271

CommittedMicroInstructionsPerCycle = 0.6313

BranchPredictionAccuracy = 0.8808

SimTime = 171301.00 [ns]

Frequency = 2000 [MHz]

Cycles = 342602

CyclesPerSecond = 900151