Lecture 01—Introduction

ECE 459: Programming for Performance

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[Thanks to Jon Eyolfson for slides!]

Course Website

`http://patricklam.ca/p4p/`

Resources on github:

`git@github.com:patricklam/p4p-2015.git`

I also added everyone enrolled as of Sunday to Piazza.

Staff

Instructor

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Schedule

Lectures:	January 5—April 7
	MWF 9:30 AM, MC 2065
Tutorials:	not used
Midterm:	TBA

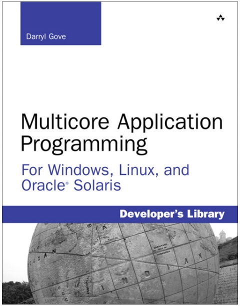
Office Hours

Wednesdays, 10:30-12:20, DC2597D,

or check `http://patricklam.ca/in`

[Academic, and other, advice also available!]

Recommended Textbook



Darryl Gove

Multicore Application Programming

For Windows, Linux, and Oracle® Solaris

Developer's Library

Multicore Application Programming For Windows, Linux, and Oracle Solaris. Darryl Gove. Addison-Wesley, 2010.

Goal

Make programs run faster!

Making Programs Faster

Two main ways:

[1]

[2]

[1] credit: Chensiyuan, Wikimedia Commons, CC-BY-SA

[2] credit: me

Making Programs Faster

- Increase bandwidth (tasks per unit time); or
- Decrease latency (time per task).

Examples of bandwidth/latency:
Network (connection speed/ping), traffic (lanes/speed)

Our Focus

Primarily on increasing bandwidth (more tasks/unit time).

- Do tasks in parallel

Decreasing time/task usually harder, with fewer gains.

CPUs have been going towards more cores rather than raw speed.

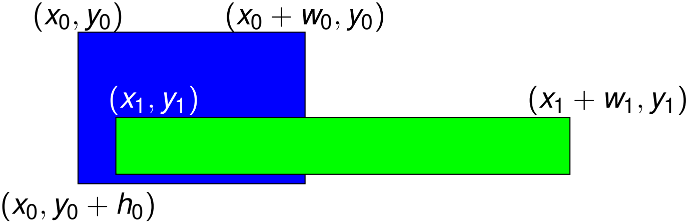
A Bit on Improving Latency

We won’t return to these topics, but we’ll touch on them now.

- Profile the code;
- Do less work;
- Be smarter; or
- Improve the hardware.

Intermission

While working on Assignment 1, I ran into this puzzle:



When do these rectangles intersect?

Increasing Bandwidth: Parallelism

Some tasks are easy to run in parallel.

Examples: web server requests, computer graphics, brute-force searches, genetic algorithms

Others are more difficult.

Example: linked list traversal (why?)

Hardware

- Use pipelining (all modern CPU do this):
  - Implement this in software by spliting a task into subtasks and running the subtasks in parallel
- Increase the number of cores/CPUs.
- Use multiple connected machines.
- Use specialized hardware, such as a GPU which contains hundreds of simple cores.

Barriers to parallelization

- Independent tasks (“embarrassingly parallel problems”) are trivial to parallelize, but dependencies cause problems.
- Unable to start task until previous task finishes.
- May require synchronization and combination of results.
- More difficult to reason about, since execution may happen in any order.

Limitations

- Sequential tasks in the problem will always dominate maximum performance
- Some sequential problems may be parallelizable by reformulating the implementation
- However, no matter how many processors you have, you won't be able to speed up the program as a whole (known as **Amdahl's Law**)

Data Race

- Two processors accessing the same data.

- For example, consider the following code:

  ```
  x = 1
  print x
  ```

  You run it and see it prints 5

- **Why?** Before the print, another thread wrote a new value for `x`. This is an example of a data race.

Deadlock

Two processors trying to access a shared resource.

- Consider two processors trying to get two resources:

Processor 1	**Processor 2**
`Get Resource 1`	`Get Resource 2`
`Get Resource 2`	`Get Resource 1`
`Release Resource 2`	`Release Resource 1`
`Release Resource 1`	`Release Resource 2`

- Processor 1 gets Resource 1, then Processor 2 gets Resource 2, now they both wait for each other **(deadlock)**.

Objectives

- Implement parallel programs which use 1) synchronization primitives and 2) asynchronous I/O

- Describe and use parallel computing frameworks

- Be able to investigate software and improve its performance

- Use and understand specialized GPU programming/programming languages

Assignments

1. Manual parallelization using Pthreads/async I/O
2. Automatic parallelization and OpenMP
3. Application profiling and improvement
4. GPU programming

Breakdown

- 40% Assignments (10% each)

- 10% Midterm

- 50% Final

Grace Days

- 4 grace days to use over the semester
  for late assignments.

- **No mark penalty** for using grace days.

- Try not to use them just because they're there.

Homework for Wednesday

We'll be doing exercises based on this presentation:

`http://www.infoq.com/presentations/click-crash-course-modern-hardware`

I'll post the exercises on Tuesday.

Suggestions?

- Just let me know