Lecture 01—Introduction

ECE 459: Programming for Performance

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[Thanks to Jon Eyolfson for slides!]

Course Website

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

Staff

Instructor

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Schedule

Lectures: January 8—April 4, TTh, 8:30 AM, RCH 103

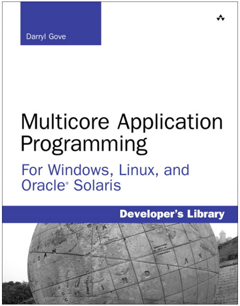
Tutorials: January 11—April 5, F, 4:30 PM, RCH 103

Midterm: February 27, W, 7:00 PM—8:20PM, RCH 301/309

Office Hours

- Suggestions?

Recommended Textbook



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:

- 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.

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

- Implementation of parallel programming involving synchronization
- Understanding of parallel computing frameworks
- Ability to investigate software and improve its performance
- Specialized GPU programming/programming languages

Assignments

1. Manual parallelization using Pthreads
2. Automatic parallelization and OpenMP
3. Application profiling and improvement (groups of 2)
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

Suggestions?

- Just let me know