CPEG/ELEG 652: Principles of Parallel Computer Architectures
Spring 2019 - *tentative*

Title:

Principles of Parallel Computer Architectures

Time/Room:

Tuesdays 3:35pm - 6:35pm, Purnell Hall Room 324A
First class: February 12; Last Class: May 14; No class on April 2 (Spring Break)
Midterm Exam: March 26 (last class before Spring Break)
Final Exam: Wednesday, May 22, 7pm-9pm, same room as class

Instructor:

Rudolf Eigenmann eigenman@udel.edu 202 Evans Hall, x0678

Communication and Office Hours:

We will reserve some time at the beginning of each lecture for questions and answers.
You are welcome to stop by when you see my office door open.
You can also call or send me email for an appointment.
I will try to respond to emails within 24hrs. If I haven't, be sure to let me know in class.

Course Description:

This course provides an introduction to the principles of parallel computer architecture, both hardware and software, with examples of real-world systems and applications. Topics include, but are not limited to: relevance of parallel computing today; levels of parallelism; programming models with abstract view of the underlying architecture; components of parallel architectures; system topologies; special-purpose architectures; parallel programming languages, libraries, and tools; porting and optimizing parallel applications; performance evaluation; national and international parallel systems; parallel applications.

What You Will Learn in This Course:

All of today's computer architectures are parallel. Computer architects, developers of the software stack, application programmers, and even end users need to be aware of the way the omnipresent parallelism affects their work. In this course, you will learn the basic structures of parallel hardware and software, how parallel hardware is exposed to system and application software, and how software can best take advantage of the potential offered by parallelism. As time permits, the end-user view will be discussed, including how to access large, national parallel computer systems for computational science projects, and how to exploit parallelism if your primary objective is to do physics, chemistry, or biology. This course will expose you to a large range of topics related to parallelism, so it is introductory. For in-depth studies of the materials you will have to take additional, advanced course offerings.

Pre-requisites:

Begins at a level that assumes experience in introductory undergraduate courses such as digital system design, computer architecture, and microprocessor based systems.

Textbooks:

These books are recommended resources. They include much more than presented in the course. The lectures will include additional material from research papers and other sources.

- *Computer Architecture: A Quantitative Approach, 5th Edition* by John Hennessy and David Patterson, Morgan Kaufmann 2011.
- *Parallel Computer Organization and Design* by Michel Dubois, Murali Annavaram, and Per Stenstrom, Cambridge 2012.
- *Using OpenMP, Portable Shared Memory Parallel Programming* by Barbara Chapman, Gabriele Jost and Ruud van der Pas, MIT Press 2007.
- *Beginning MPI (An Introduction in C)* by Wesley Kendall, Amazon Digital Services LLC 2013.
- *Parallel Programming in C with MPI and OpenMP* by Michael J. Quinn, McGraw-Hill Education 2008.

Grading:

- Midterm (March 26): 20%
- Final exam (May 22): 30%
- Projects: 25%
- Homework: 15%
- Class Participation: 10%

Approximate schedule:

week

1. Introduction and relevance of parallel computing today
   Levels of parallelism
2. Programming models with abstract view of the underlying architecture
3. Components of parallel architectures
4. System topologies
5. Special-purpose systems
6. Parallel programming languages, libraries, and tools
7. **Midterm Exam**
   --- *Spring Break* ---
8. Porting and optimizing parallel applications
9. Porting and optimizing parallel applications (continued)
10. Performance evaluation
11. National and international parallel high-performance computer systems
12. Parallel applications
13. Review
14. **Final Exam**

Exams:

The midterm exam will cover material discussed in class up to that point. The final exam is comprehensive. The midterm will have a 1-hour preparatory Q&A session, after which the actual exam begins. Exams are open book (no communication devices on the desk, though please.)

At the beginning of most lectures we will discuss questions in the style that will be used in exams. Please bring a notepad to class to write down your answers.

Homework:

The homework assignment each week will be to do background research on any topic related to the material presented in class that week. In half a page to one page, provide a reference to the material you found (a paper, a textbook, a magazine article, a video, a quote from a person, etc.) and *describe in what way the information supports, contradicts, or complements the material presented in class*.

Format and submission: Send your homework before the end of each week to eigenman@udel.edu with subject line "CPEG/ELEG652 Homework for week X".

The expectation is that you will spend one to two hours per week on this assignment.

Projects:

Every student will propose a computational application that you will execute on a parallel machine of your choice. Improve the application in some way that enhances parallelism and measures the resulting performance. Describe your experience in 4-6 pages.

The objective of this project is that you gain experience in

- identifying code sections in a program that can be parallelized,
- learning about a parallel programming model and language,
- possibly installing a compiler and/or library to facilitate your project,
- identifying a parallel machine on which to run and measure the program, and
- analyzing parallel program performance.

For obtaining a good grade, what counts is not so much that you can speed up your program, but that you demonstrate in your report an understanding of these five points. The expectation is that you spend two to three hours per week on this project.

Format and submission: At the end of the second week of classes, submit a project proposal of ½ to 1 page. The proposal should begin with the course number, a project title, and your name. Email the proposal to the instructor with subject line CPEG/ELEG652 Project Proposal.

By the end of the semester, expand this text into a 4-6 page report and submit by May 17 (hard deadline) with subject line CPEG/ELEG652 Project Report Your Name.

Policies:

UD has a number of policies to make learning and campus life as smooth and enjoyable as possible for everyone. Please familiarize yourself with these policies.
http://www1.udel.edu/stuguide/17-18/code.html