High Performance Computing
EECE5640

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Required text:
"Introduction to High Performance Scientific Computing," Victor Eijkhout, Edmond Chow and Roberg van de Gejin, 2nd Edition, 2016, online.

The book can be downloaded for free at:
http://www.tacc.utexas.edu/~eijkhout/istc/istc.html and is available on Blackboard.

Optional texts:
"Introduction to Parallel Computing," Ananth Grama, Anshul Gupta, George Karypis and Vipin Kumar, 2nd Edition, Pearson/Addison Wesley, 2003. ISBN: 978-9-201-64865-2

"Computer Architecture: A Quantitative Approach," John L. Hennessy and David A. Patterson, 5th Edition, Elsevier, 2012. ISBN: 978-0-12-383872-8

"Programming Massively Parallel Processors: A Hands-on Approach," David B. Kirk and Wen-mei W. Hwu, 3rd Edition, Morgan Kaufmann, 2017. ISBN 978-0-12-811986-0

Course Objectives

1. Review the fundamental system elements in a high performance computer system.
2. Develop a good understanding of parallelism in both hardware and software.
3. Develop skills in parallel programming, including use of common libraries, frameworks, and profiling tools.
4. Develop an appreciation for the power of parallel algorithms.
5. Develop quantitative analysis methods to evaluate different parallelization strategies.
6. Understand how to exploit accelerators in challenging applications.
7. Explore current trends in HPC systems, including many-core, heterogeneity, GPUs, accelerators and quantum computing.

Homework

During the semester there will be homework problem sets assigned bi-weekly. Most of the problems will be open-ended questions that will challenge you. Some of the homework

assignments will involve small projects. The homework assignments are the most important element of this course. They should be done independently (see note about plagiarism below and take it seriously).

Quizzes

There will be pop quizzes, which will be closed book and open notes. Each quiz will be given at the beginning of class and will cover material from prior classes and papers assigned for reading. No makeups will be given for pop quizzes. If you are going to miss class, you need to notify Prof. Kaeli prior to the date you miss the class. The best way to prepare for the quizzes is to review your notes from the previous class before arriving at class. Please make sure that you keep your eyes on your own paper during these quizzes. Any instances of perceived cheating will be referred to OSCCR.

Final Exam

There will be a final exam. For students that obtain an average of 95 or above on their quizzes, they will automatically receive a 100 on the final and exempt from taking the final.

Project

There will be a major project assigned. See the course website for details when assigned. Plan on starting the project immediately after it is assigned, or else you will run out of time.

Computing

All homework that involves a computer should be done on either the MGHPCC Discovery Cluster, or the College of Engineering Linux systems. All Northeastern COE students have an account on the COE system. You will be instructed on how to obtain an account on the Discovery Cluster. It is your responsibility to obtain these accounts and use them to complete homework assignments. If you are not familiar with Unix/Linux, now is the time to learn how to use this operating system. Do not wait until the work has been assigned. A Unix/Linux tutorial will be provided in the first 2 weeks of the semester.

Academic Honesty Policy

All assignments are due in class on the day they are due. All work can be discussed in groups, but all submitted work must be developed independently. Make sure to carefully cite your sources. Any instances of copying without proper citation, and any instances of misrepresentation of individual work, will be dealt with by referring the matter to the NU Office of Student Conduct and Conflict Resolution (OSCCR). Please take this warning very seriously.

Class Management

All materials for the class will be available on Blackboard. We will also utilize Piazza for handling communication with the TA and the instructor. The goal is to provide prompt feedback, and share information with the entire class.

Grading

Homework - 40%

Major Project - 25%

Quizzes – 20%

Final – 15%

Schedule (subject to change) – (sections from the textbook)

Week 1: Introduction, multi-core architectures and the memory hierarchy (1.1 – 1.6)
Week 2: Parallel computing concepts, metrics, history, and silver bullets (1.7 – 2.10)
Week 3: Granularity of parallelism, threads and the pthreads API (2.6, pthreads tutorial)
Week 4: Computer arithmetic, formats, and precision, the role of the compiler (3.1-3.6)
Week 5: More threads, hyperthreading and introduction to OpenMP (2.6)
Week 6: OpenMP programming and other parallel languages (2.6)
Week 7: Message passing paradigms and topologies (2.6, 2.7)
Week 8: MPI programming (2.6)
Week 9: Parallel libraries and high performance linear algebra (5, 23)
Week 10: GPU architecture (notes) Introduction to CUDA (notes, CUDA tutorial)
Week 11: Advanced CUDA features and GPU applications (notes)
Week 12: Frameworks for data analytics, MapReduce and Spark (notes)
Week 13: Emerging accelerators and quantum computing (notes)
Week 14: Project Presentations