ME344: Introduction to High Performance Computing

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Class Hours: Th 1.30-2:50pm
Location: 300-300 [Building 300 - Main Quad (01-300)]
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Course Description

ME 344 is an introductory course on High Performance Computing Clusters, providing a solid foundation in parallel computer architectures, parallel programming models, application performance monitoring & optimization techniques. This course will discuss fundamentals of parallel systems covering topics ranging from what an HPC cluster consists of to how to efficiently solve complex large scale problems in the areas of computational fluid dynamics, image processing, machine learning and analytics on these systems. The course will consist of lectures, practical hands-on homework assignments, and hands-on laboratory work where students will build their own HPC cluster from the ground up.

Students will explore shared- and distributed-memory parallel programming model based solutions to different applications, along with a deeper dive on solutions developed in an exascale-ready parallel programming model named Legion. Additionally, they will gain exposure to a comprehensive set of development tools from Intel® Parallel Studio XE Suite including the Intel® Vtune Amplifier and the Intel Advisor toolkit running on Intel® Xeon® and Xeon Phi Processors. In addition to classroom instruction and laboratory work, students will have access to the latest cutting-edge hardware and will interact with HPC experts from the industry.

As it's desirable to have a mix of students, the course will not assume a background in computer science. However, exposure to linux, and experience with scripting and/or programming languages like C/C++/Java are helpful to complete projects as this is a very hands-on practical application and use of HPC clusters. Students on a systems, computer engineering, or computational track do well with this course.

Schedule

The schedule is tentative and subject to change.

Week 01, 06/25 - 06/29:   Introduction to HPC Clusters

- Accessing and using course resources.

- Constructs of an HPC cluster.

Week 02, 07/02 - 07/06:   Benchmarking HPC Clusters

- Characterizing HPC Clusters

- Building an unified performance suite to evaluate computing clusters

Week 03, 07/09 - 07/13:   Introduction to Parallel Programming Models

- Overview of parallel programming concepts

- Introduction to shared- and distributed-memory programming models

Week 04, 07/16 - 07/20:   Shared Memory Programming Model

- Introduction to OpenMP

- Performance analysis for serial and threaded application with VTune Amplifier, including system-level profiling

Week 05, 07/23 - 07/27:   Vectorization

- Introduction to the Advisor tool.

- Thread prototyping and optimizations with Advisor.

Week 06, 07/30 - 08/03:   Computation vs Communication

- Optimizing applications by analyzing machine balance and loop balance

- Introduction to Roofline Analysis

Week 07, 08/06 - 08/10:   Legion

- Introduction to the Legion programming model

- Regions and Tasks

Week 08, 08/13 - 08/17:   Advanced Concepts in Legion

- Mapping of Regions and Tasks

- Partitioning of Regions

- Regent