CS-425/625

Parallel Programming and Algorithms

DEPARTMENT Computer Science

COORDINATOR Rui Zhu, Assistant Professor of Computer Science

CATALOG DESCRIPTION

The CS-425 course introduces you to the foundations of parallel computing including the principles of parallel algorithm design, analytical modeling of parallel programs, programming models for shared- and distributed-memory systems, parallel computer architectures, along with numerical and non-numerical algorithms for parallel systems. The course will include material on emerging multicore hardware, shared-memory programming models, message passing programming models used for cluster computing, data-parallel programming models for GPUs, and problem-solving on large-scale clusters using MapReduce. A key aim of the course is for you to gain a hands-on knowledge of the fundamentals of parallel programming by writing efficient parallel programs using some of the programming models that you learn in class. Graduate students will go into greater depth on certain topics and have additional readings, homework assignments, additional exam questions, and a more complex project. Students may not receive credit for both CS-425 and CS-625.

PREREQUISITES CS-601 Programming Methods for Data Science or BS in CS for CS-625
CS-231 Programming Paradigms for CS-425

CLASS/LAB SCHEDULE 240 minutes of lecture (4-0-0-4)

TEXTBOOKS

- Introduction to Parallel Computing, 2nd Ed, Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar (2003)
- Parallel Programming in C with MPI and OpenMP by M.J. Quinn, McGraw-Hill Science/Engineering/Math, 1 st edition, 2003, ISBN: 0072822562
- Using OpenMP: Portable Shared Memory Parallel Programming - Barbara Chapman, Gabriele Jost, Ruud van der Pas (2008)
- Using MPI: Portable Parallel Programming with the Message-Passing Interface, 3rd Ed - William Gropp, Ewing Lusk, Anthony Skjellum (2014)
- Programming Massively Parallel Processors: A Hands-on Approach, 3rd Ed. - David B. Kirk, Wen-mei W. Hwu (2016)

TOPICS

1. Introduction to Parallel Computing

2. Parallel Programming Platforms
3. Principles of Parallel Algorithm Design
4. Basic Communication Operations
5. Analytical Modeling of Parallel Programs (graduate students will cover additional modeling techniques)
6. Programming Using the Message Passing Paradigm (graduate students have additional material on Message-Passing Interface (MPI))
7. Programming Shared Address Space Platforms
8. Dense Matrix, Sorting, Searching, and Graph Algorithms (graduate students will cover and be expected to implement additional algorithms)
9. Graphics Processing Units (GPUs) (graduate students have additional material and assignment on GPU)
10. Compute Unified Device Architecture (CUDA) (graduate students have additional material and assignment on CUDA)

COURSE LEARNING OBJECTIVES

Each student who receives credit for CS-425/625 will have demonstrated the ability to do all of the following tasks:

- Students will be able to apply the concepts of a **Parallel Computer Architecture** by creating a parallel program that will maximize the performance of the parallel program.
- Students will be able to apply the concepts of **Message Passing** to the creation of a program that executes efficiently on the parallel computer architecture.
- Students will be able to apply the concepts of **CUDA** to the creation of a program that executes efficiently on the parallel computer architecture.
- Students can apply the concepts of **Performance** to the analysis of computer performance problems.
- Students can apply the concepts of **Performance Counters** to the analysis of parallel program performance.

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