CS-425 Parallel Programming and Algorithms

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 (suggested by my mentor John), 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.

PREREQUISITES: CS-401 Programming Methods for Data Science
CS-231 Programming Paradigms

CLASS SCHEDULE: 240 minutes of lecture

TEXTBOOKS:
• Multicore and GPU Programming: An Integrated Approach 2nd Edition, Gerassimos Barlas (2022)
• Introduction to Parallel Computing, 2nd Edition, 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, 1st 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
6. Programming Using the Message Passing Paradigm, e.g., Message-Passing Interface (MPI)
7. Programming Shared Address Space Platforms
8. Dense Matrix, Sorting, Searching, and Graph Algorithms
9. Graphics Processing Units (GPUs)
10. Compute Unified Device Architecture (CUDA)

COURSE LEARNING OBJECTIVES

Each student who receives credit for CS-425 will have demonstrated the ability to do 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.