DST 4030: PARALLEL COMPUTING

Prerequisite: DST4010: Distributed Systems

Course Description

This course covers the architecture and enabling technologies of parallel computing systems and its innovative applications. The goal of the course to introduce the students to the aspects of parallel computing: architecture, programming paradigms, algorithms and standards. Both traditional computer science algorithms (e.g. sorting, searching, and dynamic programming algorithms) as well as scientific computing algorithms (e.g. matrix computations) will be covered. Students learn how to apply the most widely used standards for writing parallel programs (MPI, Pthreads, and OpenMP) and to thoroughly quantify the performance of parallel programs by means of metrics for scalability.

Rationale

This is an introductory course on parallel computing. The course will teaches practical aspects of parallel computing, so that students will be able to effectively use parallel machines. It will be particularly useful for those who plan to perform research on parallel computing. It should also be useful for those who want to learn programming multicore processors.

Learning Outcomes

At the end of this course, students should be able to:

1. Define terminology commonly used in parallel computing, such as efficiency and speedup**.**
2. Describe different parallel architectures; inter-connect networks, programming models, and algorithms for common operations such as matrix-vector multiplication.
3. Develop an efficient parallel algorithm to solve a given problem.
4. Analyze the time complexity as a function of the problem size and number of processors for a given parallel algorithm,.
5. Given a parallel algorithm, an input to it, and the number of processors, show the steps performed by that algorithm on that input.
6. Given a parallel algorithm, implement it using MPI, OpenMP, pthreads, or a combination of MPI and OpenMP.
7. Given a parallel code, analyze its performance, determine computational bottlenecks, and optimize the performance of the code.
8. Given a parallel code, debug it and fix the errors.

Course Content

Single Processor Machines: Memory Hierarchies and Processor Features, Tuning Matrix Multiply. Introduction to Parallel Machines and Programming Models. Parallel Computer Architecture: A Hardware/Software Approach / Distributed Memory Machines and Programming. Distributed Memory Machines and Programming - MPI, Simulation. Simulation, Cost Model, Mapping, Platforms, Design. Design, Basic Communication. Analytical Modeling of Parallel Programs. Analytical Modeling of Parallel Programs, Dense Matrix Algorithms. Dense Matrix Algorithms, Sorting, graph algorithms. Search Algorithms for Discrete Optimization Problems. Dynamic Programming

Teaching and Learning Methodologies

Instruction will consist of both classroom lectures and computer lab tutorials and exercises.

Instructional material & equipment

Textbooks, whiteboard, handouts, electronic projector and laptop, Internet access, special graphics software's and library.

Methods of evaluation

Class assignments, take-home assignments, tests, small projects to demonstrate use and application of parallel Computing

Laboratory Work	20%	
Project		20%
Assignments	10%	
Mid-semester	20%	
Final semester exams	30%	
Total	**100%**	

Course Text

Parallel Computing: Numerics, Applications, and Trends by Roman Trobec, Marián Vajteršic, Peter Zinterhof – 2009

Parallel computing: architectures, algorithms, and applications by Christian Bischof – 2008

Parallel Computing by Bhujade Moreshwar R. - 2009

An Introduction to Parallel Computing, Design and Analysis of Algorithms, 2nd edition, A. Grama, V. Kumar, A. Gupta, Addison Wesley (2003) ISBN 0201648652

Recommended Reading

Parallel Computing: Theory and Practice, M J Quinn, McGraw Hill (1996) ISBN 0070512949

Parallel Computing in C and OpenMPI , M. J. Quinn, McGraw-Hill (2004) ISBN 0072822562

Parallel Processing with Communicating Process Architecture, I East, UCL Press (1995) ISBN

Designing and Building Parallel Programs, I Foster, Addison Wesley (1996) ISBN 0201575949

Programming with Threads, S Kleiman et al., Prentice Hall (1996) ISBN 0131723898