COURSE PLAN
for
High Performance Computing (ECSE302L)

Faculty Name : Dr. Sridhar Swaminathan

Course Type : Core

Semester and Year: VI Semester and III Year

L-T-P : 3-0-2

Credits : 4

Department : Computer Science Engineering

Course Level : UG

SCHOOL OF ENGINEERING AND APPLIED SCIENCES

Department of Computer Science Engineering

Bennett University

Greater Noida, Uttar Pradesh

ECSE302L: High Performance Computing

Course Type:	Elective

L	T	P	Credits
3	0	2	4

Pre-requisites: NA

Course Learning Outcomes:

CLO1: Understand the mapping of parallel programs to the physical processors and analyse the different types of communicative behaviour in between the processes.

CLO2: Analyse the algorithmic design for Work-span models, topological models, and deep memory hierarchies.

CLO3: Design and analyse appropriate searching and sorting techniques for high-performance systems.

Module 1 (Contact hours:12)

Intro to High Performance Computing. Parallel Programming Platforms: Implicit parallelism, limitations of memory, Control Structure, communication model, architecture, static and dynamic interconnection networks and their evaluation, topologies, communication costs, routing mechanism, impact of processor-processor mapping and its techniques. Algorithm Design: Preliminaries, decomposition techniques, task characteristics, mapping techniques, handling interaction overheads, algorithm models, the Multithreaded DAG Model, Brent's Theorem, Work Optimality and Weak Scaling, Basic Concurrency Primitives, Data Races and Race Conditions; Introduction and Tutorial of OpenMP with relevant examples

Module 2 (Contact hours: 10)

Communication operations: Broadcast and Reduction, personalized communication, Prefix Sum, scatter and gather, Parallel Scans, Segmented Scans, Linked list as array pools. Analytical Modeling: overhead, performance metrics, effect of granularity, scalability, minimum execution and cost optimal execution time, asymptotic analysis, scalability metrics. Intro to MPI. Comparison based sorting: Comparator networks, Bitonic Sequences, Bitonic Splits, Bitonic Merge, Bitonic Sort

Module 3 (Contact hours: 10)

Tree Computations: Parallel Independent Sets; Euler Tour Technique. Shared Memory Parallel BFS: High Level Approach to Parallel BFS. Intro to Dist Memory Models: A Basic Model of Distributed Memory, Point to Point Completion Semantics, Vector Reductions. Dist Dense Matrix Multiply: A geometric view, Applying Loomis Whitney, Efficiency and 1D algorithm, A 2D Algorithm and its efficiency, Matrix-Matrix multiplication. Distributed BFS: Graphs and adjacency Matrix, Matrix based BFS, 1D distributed BFS.

Module 4 (Contact hours: 12)

Dist. Memory Sorting: Distributed Bitonic Merge via binary exchange, Bitonic merge via transposes, Linear time distributed sort. Graph partitioning: Graph bisection and planar separators; Kernighan Lin Algorithm, Graph Coarsening, Computing a maximal matching, Spectral partitioning. I/O Avoiding algorithms: External Memory Mergesort, Two way external memory Merging, Multiway Merging; Cache oblivious algorithms: The ideal cache model, LRU replacement, Proof of LRU OPT Competitiveness, The Tall-cache assumption, Cache oblivious matrix multiplication, cache oblivious binary search.

Lab Experiments

Implementing the concepts of parallel programming using OpenMP and MPI in Python.

Suggested Textbooks:

1. Ananth Grama, Anshul Gupta, George Karypis and Vipin Kumar, Introduction to Parallel Computing (2nd Edition), Pearson, 2003. ISBN-13: 978-0201648652.

References:

1. Georg Hager and Gerhard Wellein, Introduction to High Performance Computing for Scientists and Engineers (1st Edition), CRC Press, Taylor and Francis Group, 2010. ISBN-13: 978-1439811924.
2. Parallel Algorithms https://nptel.ac.in/courses/106/103/106103188/
3. Introduction to Parallel Programming in OpenMP https://nptel.ac.in/courses/106/102/106102163/
4. High Performance Computing - https://www.udacity.com/course/high-performance-computing--ud281

Evaluation Components:

Components of Course Evaluation	Percentage
Assignment	10
Mid Term Examination	15
End Term Examination	25
Continuous Lab Evaluation	15
Quiz	10
Project	25