NATIONAL UNIVERSITY
of Computer & Emerging Sciences, Lahore

Department of Computer Science

CS3006 – Parallel and Distributed Computing

SPRING 2024

Instructor Name: Dr. Rana Asif Rehman
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TA Name (if any):
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Office Location/Number: N/A
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Course Information

Program: BS
Credit Hours: 3
Type: Core
Pre-requisites (if any): CS220
Course Website: Google Classroom
Class Meeting Time: Section BDS-6C: Mon, Wed 08.30 – 09.50 PM
Section BCS-6L: Mon, Wed 10.00 – 11.20 AM
Section BCS-6J: Mon, Wed 01.00 – 02.20 PM

Class Venue: Section BDS-6C: NB-303
Section BCS-6J: NB-201
Section BCS-6L: NB-309

Course Description/Objectives/Goals:

This course covers a broad range of topics related to parallel and distributed computing, including parallel and distributed architectures and programming paradigms of parallel and distributed systems. Basic goal of this course is to understand the fundamental concepts of parallel and distributed computing, analyze different problems and develop programming solutions of parallel problems.

First part of this course consists of introduction to Parallel and Distributed Systems, categorization of multiprocessor systems according to Flynn's Taxonomy. Overall the course is divided into two parts. First part covers the parallel shared memory systems and programming shared memory machines with Pthreads and OpenMP. Second part covers the distributed systems, Distributed System Architectures, types of distributed systems (Clusters, Grid and Cloud computing), Fault Tolerance techniques and finally programming distributed systems using MPI.

Course Learning Outcomes (CLOs):

At the end of the course students will be able to:

- Learn about parallel and distributed computers
- Code and analyze complex problems of shared memory systems with OpenMP
- Analytical modeling and performance evaluation of parallel programs
- Write portable programs for distributed architectures using Message-Passing Interface (MPI) library

Course Textbook

- Introduction to Parallel Computing by Ananth Grama and Anshul Gupta
- Distributed Systems: Concept and Design by George Coulouris, Gordon Blair
- Using OpenMP: Portable Shared Memory Parallel Programming by Barbara Chapman, Gabriele Jost, Ruud van der Pas.

Reference books

- Distributed Systems: Principles and Paradigms, A. S. Tanenbaum and M. V. Steen,Prentice Hall, 2nd Edition, 2007.
- Distributed and Cloud Computing: Clusters, Grids, Clouds, and the Future Internet, K Hwang, J Dongarra and GC. C. Fox, Elsevier, 1st Ed.

Tentative Weekly Schedule

Week	Topics to be covered	Assignments/Projects?
1	Motivating parallelism (evolution, need, and future), Scope of the parallel computing in commercial, scientific, and engineering and design applications. Parallel architecture: Multicore processors, Shared vs. distributed memory.	
2	Flynn's taxonomy (SISD, MISD, SIMD, MIMD), Physical organization of parallel platforms, Network topologies for parallel architectures.	Quiz 1
3	Evaluating static inter-connections in-terms of diameter, arc-connectivity, bisection width, and cost. Cut-through Routing and Cost-performance tradeoffs.	Assignment 1
4	Principles of parallel algorithm design- De-composition, Tasks, Dependency Graphs, Granularity, Concurrency, Decomposition Techniques, Parallel Algorithm models	
5	Basic Communication Operations (Broadcast, Reduction, Scatter, Gather and Circular Shift)- Parallel Cost analysis for the operations over Ring, 2D-Mesh, Hypercube, and 3d-cube.	Quiz 2
	Midterm I	
6	Programming Shared Address Space Platforms using POSIX Thread API and OpenMP (Thread Basics, Motivation, Synchronization Primitives)	
7	Decompositions techniques, Shared memory programming with OpenMP	Project Proposals
8	Parallel programming with OpenMP, work sharing constructs, Synchronization Constructs in OpenMP, OpenMP Library Functions, Environment variables	Assignment 2
9	Introduction to Distributed Systems, Types of Distributed System Architectures, Distributed Operating Systems	Quiz 3
10	Types of Distributed Systems: Cluster Computing Grid Computing Utility Computing	Project phase 1

	Cloud Computing	
	Midterm II	
11	Introduction to distributed programming using message passing paradigm- Principles of message-Passing programming, Building blocks, (Blocking MPO vs Non-Blocking MPO)	
12	Program structure using MPI. Collective Communication and Computation Operations (Barrier, Broadcast, reduction, prefix, Gather, scatter, All-to-All)	Assignment 3
13	Designing hybrid parallel algorithms (i.e., hybrid of MPI and OpenMP). Applications- Matrix Algorithms, Sorting, Parallel Prefix, Graph Algorithms.	Quiz 4
14	Fault Tolerance Techniques (Hardware Redundancy, Information Redundancy, Time Redundancy	Project/Phase 2
15	Revisions/Project presentations	

(Tentative) Grading Criteria

1. Assignments + Quizzes (15%)
2. Project (10%)
3. 2 Midterm Exam(s) (30%)
4. Final Exam (45%)

Grading scheme

The grading scheme followed will be **absolute** in accordance with the university standards.

Passing Criteria

Students need to score a minimum of **50%** to pass the course.

Course Policies

1. Students are expected to attend all sessions. However, they might avail 20% leaves in emergency situations. Beyond this the student will not be allowed to appear in the final exam.
2. Plagiarism is not tolerable in any of its form. Minimum penalty would be an 'F' grade in the course. Automated tools may be deployed to detect pirated copies. Students bear all the responsibility for protecting their assignments. In case of cheating, both parties will be considered equally responsible.
3. Assignments must be submitted in time. No late submissions will be accepted and/or awarded. REMEMBER that the overall submission time allowed includes the extra time given during which SLATE/Google Classroom doesn't work. Therefore, deadlines are firm.
4. Rechecking of quizzes/assignments must be done within one week of it being uploaded on FLEX. In case they are shown to you during the class, the week starts thereon.