First Course Handout

January 2025

Course Title: Parallel Computing (CS633)

Credits: 3-0-0-9

Lecture Hours

MW: 3:35 - 5:00 PM (L16)

Office Hour

W: 5 - 6 PM (KD-221) *Other times by appointment.*

Extra Class

Saturday (time and venue will be announced via email)

Prerequisites:

Exposure to CS330 (Operating Systems), CS422 (Computer Architecture) and CS425 (Computer Networks) is desirable. Familiarity with C/C++ is a must.

1 Course Objectives

Parallel programming is ubiquitous in today's multi-core era and solves many real-world scientific problems. Massive parallelism entails significant hardware and software challenges. The course is structured so that the participants understand challenges in efficient execution of large-scale parallel applications. This course will cover topics related to programming on multiple compute nodes using the message passing interface paradigm. The assignment will be designed to strengthen understanding of parallel programming.

2 Course Content

1. Introduction: Why parallel computing? Amdahl's law, speedup and efficiency.
2. Message passing: MPI basics, point-to-point communication, collective communication, synchronous/asynchronous send/recv, parallel algorithms for collectives.

3. Parallel communication: Network topologies, network evaluation metrics, communication cost, routing in interconnection networks, process-to-processor mapping.
4. Performance: Scalability, benchmarking, performance modeling, impact of network topologies, parallel code analysis and profiling.
5. Parallel code design: Domain decomposition, communication-to-computation ratio, load balancing, adaptivity, case studies: weather and material simulation codes.
6. Parallel I/O: MPI I/O algorithms, contemporary large-scale I/O architecture, I/O bottlenecks.
7. Supercomputer design: Study of most powerful supercomputers, exascale.
8. Advanced topics from recent research papers including parallel machine learning.

Approximate estimate of lecture hours may be found in [1].

3 Evaluation Scheme

We will follow relative grading scheme. The grading policy is shown in Figure 1. The quizzes (3–4) will be pre-announced; there will be no make-up quiz if you miss a quiz. The assignment will be based on programming in C/C++ with MPI, this will be a group assignment (group of 5). All group members will be individually evaluated. Minimum 75% attendance is mandatory.

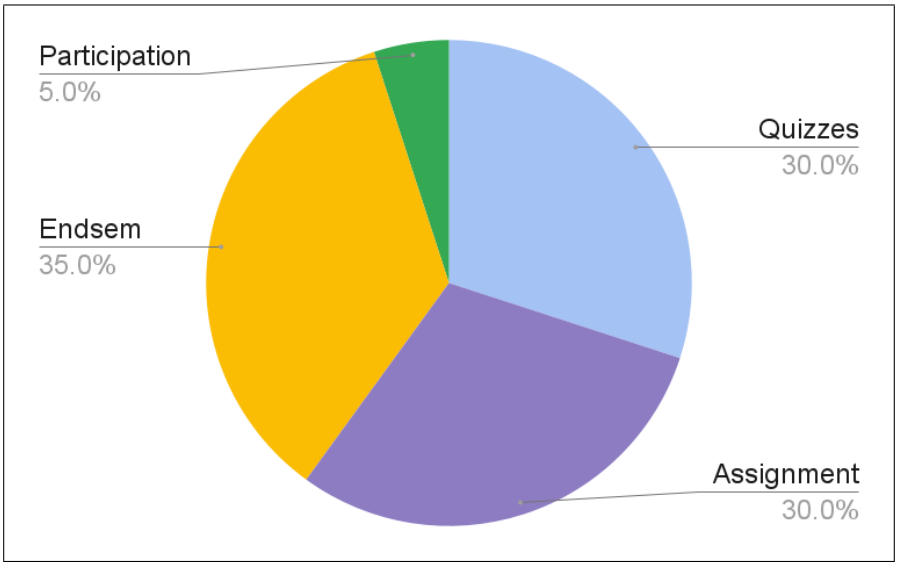

Figure 1: Grading Policy

4 Books/References

1. DE Culler, JP Singh and A Gupta, Parallel Computer Architecture: A Hardware/Software Approach Morgan-Kaufmann, 1998.
2. A Grama, A Gupta, G Karypis, and V Kumar, Introduction to Parallel Computing. 2nd Ed., Addison-Wesley, 2003.
3. Marc Snir, Steve W. Otto, Steven Huss-Lederman, David W. Walker and Jack Dongarra, MPI - The Complete Reference, Second Edition, Volume 1, The MPI Core.

4. William Gropp, Ewing Lusk, Anthony Skjellum, Using MPI: portable parallel programming with the message-passing interface, 3rd Ed., Cambridge MIT Press, 2014.

5. Peter S Pacheco, An Introduction to Parallel Programming, Morgan Kaufmann, 2011.

6. Research papers (will be notified during class).

5 Course Policy

Please refer to the CSE policy on plagiarism [2]. This will be strictly followed. You will not be allowed to drop the course and reported to higher authorities if you are found to be involved in unfair means. A minimum of 75% attendance is compulsory.

References

[1] CS633 Course Content. `https://www.cse.iitk.ac.in/pages/CS633.html`.

[2] CSE Plagiarism Policy. `https://www.cse.iitk.ac.in/pages/AntiCheatingPolicy.html`.