Project Title: Comparative Analysis of Parallel Programming Models using Monte Carlo Simulation for Pi Estimation

Name: Diyunugala D.T.N.
Reg No: EG/2020/3918
Module: High Performance Computing

1. Introduction

The objective of this project is to estimate the value of π using the Monte Carlo method and analyze the performance of different parallel programming approaches. Monte Carlo simulations are computationally intensive yet embarrassingly parallel, making them ideal for testing shared-memory (OpenMP), distributed-memory (MPI), and hybrid (MPI + OpenMP) models. This project will highlight trade-offs in speed, scalability, and ease of implementation.

2. Proposed Approach

OpenMP (Shared Memory):
The main simulation loop will be parallelized using OpenMP directives to distribute workload across multiple CPU threads on a single system.

MPI (Distributed Memory):
The simulation will be divided across multiple MPI processes running either on a single multicore machine or across nodes, with final aggregation via MPI_Reduce.

Hybrid (MPI + OpenMP):
Combines the above two models where each MPI process runs a multithreaded simulation using OpenMP. This approach will evaluate both inter-process and intra-process parallelism.

3. Tools & Technologies

- Language: C/C++
- Libraries: OpenMP, MPI (MPICH or OpenMPI)
- Compiler: GCC, MPICC
- Platform: Ubuntu

4. Expected Outcome

The final output will be a comparative analysis report including:

- Execution time, speedup, and efficiency comparisons across all three models
- Accuracy of the estimated π value compared to the mathematical constant
- Graphs illustrating performance with varying thread and process counts
- Insights into scalability and the complexity of implementation

This study will offer a comprehensive evaluation of parallel computing techniques applicable to high-performance scientific simulations.