
Add-On Course: Basics and Introduction to Parallel Computing

Course Duration: 30 Hours

Module 1: Introduction to Parallel Computing

Duration: 6 Hours

Objectives:

- Understand the fundamental concepts of parallel computing.
- Identify the types of parallelism and their applications.

Topics:

1. **Overview of Parallel Computing** (2 Hours)
 - Definition and history
 - Importance and benefits
2. **Types of Parallelism** (2 Hours)
 - Data parallelism
 - Task parallelism
 - Pipeline parallelism
3. **Basic Parallel Computing Models** (2 Hours)
 - Shared memory model
 - Distributed memory model
 - Hybrid models

Activities:

- Group discussion on real-world parallel computing applications.
 - Interactive quiz to reinforce concepts.
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Module 2: Parallel Architectures and Hardware

Duration: 6 Hours

Objectives:

- Explore different parallel computing architectures and hardware.
- Understand their strengths and limitations.

Topics:

1. **Parallel Computer Architectures** (3 Hours)
 - Multi-core processors
 - Symmetric Multiprocessing (SMP)
 - Massively Parallel Processing (MPP)
 - Graphics Processing Units (GPUs)
2. **Memory and Communication Models** (2 Hours)
 - Cache coherence
 - Interconnection networks
 - Memory consistency models
3. **Hardware Considerations** (1 Hour)
 - Performance metrics
 - Cost vs. performance trade-offs

Activities:

- Lab exercise: Exploring the architecture of a multi-core processor.
- Case study review of different parallel hardware implementations.

Module 3: Parallel Algorithms and Programming Models

Duration: 8 Hours

Objectives:

- Learn about parallel algorithms and how to implement them.
- Understand various programming models and frameworks.

Topics:

1. **Parallel Algorithms** (3 Hours)
 - Basics of parallel algorithms
 - Examples: Parallel sorting, matrix multiplication, and search algorithms
2. **Programming Models and Frameworks** (3 Hours)
 - Message Passing Interface (MPI)
 - OpenMP
 - CUDA for GPU programming
3. **Designing Parallel Algorithms** (2 Hours)
 - Decomposition strategies
 - Load balancing
 - Synchronization and communication

Activities:

- Hands-on lab: Implementing a parallel algorithm using OpenMP.
- Coding exercise: Parallelizing a basic algorithm using MPI.

Module 4: Performance and Optimization

Duration: 5 Hours

Objectives:

- Understand how to measure and optimize the performance of parallel programs.
- Learn about common performance bottlenecks and how to address them.

Topics:

1. **Performance Metrics** (1.5 Hours)
 - Speedup
 - Efficiency
 - Amdahl's Law
2. **Optimization Techniques** (2 Hours)
 - Load balancing
 - Minimizing communication overhead
 - Memory optimization
3. **Profiling and Debugging** (1.5 Hours)
 - Tools and techniques for profiling parallel programs
 - Debugging strategies for parallel applications

Activities:

- Lab: Using profiling tools to analyze the performance of parallel applications.
- Group discussion on optimization challenges and strategies.

Module 5: Applications and Emerging Trends

Duration: 5 Hours

Objectives:

- Explore real-world applications of parallel computing.
- Stay updated with emerging trends and technologies.

Topics:

1. **Applications of Parallel Computing** (2 Hours)
 - Scientific computing
 - Big data and machine learning
 - Simulation and modeling
2. **Emerging Trends** (2 Hours)
 - Quantum computing and its relationship with parallel computing
 - Advances in hardware and software technologies
3. **Future Directions** (1 Hour)
 - Predictions and innovations in parallel computing

Activities:

- Case study analysis of parallel computing applications in different industries.
 - Group activity on brainstorming future applications and trends.
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Module 6: Review and Capstone Project

Duration: 4 Hours

Objectives:

- Review key concepts and apply them in a practical project.
- Evaluate and present findings from a capstone project.

Topics:

1. **Course Review and Q&A** (1 Hour)
 - Recap of key concepts
 - Open discussion and clarification
2. **Capstone Project Presentation** (3 Hours)
 - Group presentations of parallel computing projects
 - Peer review and feedback

Activities:

- Capstone project: Develop and present a parallel computing solution for a specific problem.
 - Final review session and course feedback.
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Total Duration: 30 Hours