

Parallel Computing (PCO-730)

1. Introduction
 - Motivating Parallelism
 - Scope of Parallel Computing
 - Shared Objects and Synchronization
 - The Producer-Consumer Problem
 - The Readers-Writers Problem
 - The Harsh Realities of Parallelization
 - Parallel Programming
2. Mutual Exclusion
 - Thread Basics
 - Time
 - Critical Sections
 - 2-Thread Solutions
 - Fairness
 - Lamport's Bakery Algorithm
3. Concurrent Objects
 - Concurrency and Correctness
 - Sequential Objects
 - Quiescent Consistency
 - Sequential Consistency
 - Linearizability
 - Formal Definitions
 - Progress Conditions
4. Principles of Parallel Algorithm Design
 - Preliminaries
 - Decomposition Techniques
 - Characteristics of Tasks and Interactions
 - Mapping Techniques for Load Balancing
 - Methods for Containing Interaction Overheads
 - Parallel Algorithm Models
5. Intel Threading Building Blocks
 - Why Threading Building Blocks?
 - Algorithms
 - Containers
 - Scalable Memory Allocation
 - Mutual Exclusion
 - Timing
6. Scheduling, and Work Distribution
 - Analyzing Parallelism
 - Realistic Multiprocessor Scheduling
 - Work Distribution
 - Work-Stealing Dequeues
 - Overview of Barriers
7. Foundations of Shared Memory
 - The Space of Registers
 - Register Constructions
8. The Relative Power of Primitive Synchronization Operations
 - Consensus Numbers
 - Atomic Registers
 - Consensus Protocols
 - FIFO Queues
 - Multiple Assignment Objects
 - Read-Modify-Write Operations
 - Common2 RMW Operations
 - The compareAndSet() Operation
9. Parallel Programming Platforms
 - Implicit Parallelism
 - Limitations of Memory System Performance
 - Dichotomy of Parallel Computing Platforms
 - Physical Organization of Platforms
 - Communication Costs in Parallel Machines
 - Routing Mechanisms for Interconnection Networks
10. Basic Communication Operations
 - One-to-All Broadcast and All-to-One Reduction
 - All-to-All Broadcast and Reduction
 - All-Reduce and Prefix-Sum Operations
 - Scatter and Gather
11. Analytical Modeling of Parallel Programs
 - Sources of Overhead in Parallel Programs
 - Performance Metrics for Parallel Systems
12. Universality of Consensus
 - Universality
13. Spin Locks and Contention (2)
 - Welcome to the Real World
 - Test-And-Set Locks
 - TAS-Based Spin Locks Revisited
 - Exponential Backoff
 - Queue Locks
 - A Queue Lock with Timeouts
 - A Composite Lock
 - Hierarchical Locks
 - One Lock To Rule Them All
14. Monitors and Blocking Synchronization (1)
 - Monitor Locks and Conditions
 - Readers-Writers Locks
 - Our Own Reentrant Lock
 - Semaphores
15. Linked Lists: The Role of Locking (1)
 - List-Based Sets
 - Concurrent Reasoning
 - Coarse-Grained Synchronization
 - Fine-Grained Synchronization
 - Optimistic Synchronization
 - Lazy Synchronization
 - Non-Blocking Synchronization
16. Concurrent Queues and the ABA Problem (1)
 - Queues
 - A Bounded Partial Queue
 - An Unbounded Total Queue
 - An Unbounded Lock-Free Queue
 - Memory Reclamation and the ABA Problem
 - Dual Data Structures
17. Concurrent Stacks and Elimination (1)
 - An Unbounded Lock-Free Stack
 - Elimination
 - The Elimination Backoff Stack
18. Counting, Sorting, and Distributed Coordination (1)
 - Shared Counting
 - Software Combining
 - Quiescently Consistent Pools and Counters
 - Parallel Sorting
19. Concurrent Hashing and Natural Parallelism (1)
 - Closed-Address Hash Sets
 - A Lock-Free Hash Set
 - An Open-Addressed Hash Set
20. Graphs (10)
 - Storing graphs
 - Finding nodes and edges
 - Traversals
 - Sets, trees and forests
 - DFS and BFS
 - Shortest path
 - n-ary trees
21. Skiplists and Balanced Search (1)
 - Sequential Skiplists
 - A Lock-Based Concurrent Skiplist
 - A Lock-Free Concurrent Skiplist
 - Concurrent Skiplists
22. Priority Queues (1)
 - An Unbounded Heap-Based Priority Queue
23. Transactional Memory
 - Transactions and Atomicity
 - Software Transactional Memory
 - Hardware Transactional Memory