

# Parallel Programming

Q: So lets just all use multicore from now on!

A: Software must be written as parallel program

## Multicore difficulties

- Partitioning work
- **Coordination & synchronization**
- Communications overhead **HW**
- How do you write parallel programs?
  - ... without knowing exact underlying architecture?

SW  
Your  
career...

# Synchronization Of Parallel Programs

**Lingjun Ying**



## **Synchronization Of Parallel Programs:**

Cas075 Françoise André, Daniel Herman, J.-P. Verjus, 1985 This book proposes a method for expressing typical cooperation and competition problems as well as different synchronization and communication methods for implementing them

**Distributed Synchronization of Parallel Programs** Patrice Quinton, Jean-Pierre Verjus, 1986 *Distributed Synchronization of Parallel Programs: why and How?* Institut National de Recherche en Informatique et en Automatique, P. Quinton, Jean-Pierre Verjus, 1986 *Compiler Analysis to Implement Point-to-point Synchronization in Parallel Programs*

John Nguyen, 1993 Abstract The shared memory data parallel model presents an attractive interface for programming multiprocessors by allowing for easy management of parallel tasks while hiding details of the underlying machine architecture Unfortunately the shared memory abstraction requires synchronization in order to maintain data consistency Present compilers provide consistency between parallel code sections by enforcing a global point of synchrony with a barrier synchronization Such a simple mechanism possesses several disadvantages First the required global collection of information generates significant overhead which leads machine designers to employ special hardware to support barriers Second global synchronization reduces parallelism by requiring needless serialization of independent tasks This work aims to reduce the costs associated with these disadvantages by generating pairwise point to point synchronization between specific tasks Implementation of point to point synchronization demands extensive analysis of program dependences A compiler must perform flow analysis and dependence testing in order to compute lexical dependences between program statements In addition dynamic dependences between processors must be computed by examining array reference and statement contexts The final synchronization scheme must support any dependences that arise in the program while ensuring that no deadlock scenarios can occur This work proposes algorithms that satisfy such requirements and presents some encouraging results from a preliminary implementation

**Reducing Synchronization in Distributed Parallel Programs** Philip B. Miller, 2016 *Static Analyses and Optimizations for Parallel Programs with Synchronization*

Yuan Zhang, 2008 As parallel systems become dominant in computer architectures parallel programs that take the advantage of multiple threads of control are taking the place of conventional sequential programs Yet parallel programs have introduced new challenges to compiler static analyses and optimizations On one hand classical compiler analyses and optimizations need to be enhanced to handle the inter thread interference and synchronization enforced dependence relation in a parallel program On the other hand new analyses and optimizations need to be designed for new programming language features In this dissertation we propose the following compiler static analyses and optimizations for parallel programs with synchronization

- 1 An interprocedural multi valued expressions analysis for both distributed and shared memory programs based on program slicing An expression is multi valued if it evaluates differently in different threads For Single Program Multiple Data style programs multi valued expressions analysis is a key component to determine the concurrent paths which are executed by different threads

concurrently 2 An interprocedural barrier matching technique for both distributed and shared memory programs to detect synchronization errors caused by the misplacement of barriers or if the program is validated to determine the set of barrier statements that synchronize together 3 The first interprocedural concurrency analysis algorithm that can handle shared memory programs with textually unaligned barriers 4 A new framework of flow sensitive and synchronization sensitive data flow analyses for shared memory programs Pointer analysis is used as an example to demonstrate the effectiveness of this framework The most significant advantage of this framework is that inter thread interference and synchronization enforced dependence are modeled as concurrency relation thus it is easily extensible to new language features and compatible with different memory models 5 A lock assignment algorithm to optimize shared memory programs with atomic sections a high productivity synchronization construct that enforces atomicity and mutual exclusion Taking a program annotated with atomic sections the compiler automatically infers an assignment of the minimum number of locks to atomic sections so as to exploit the parallelism among atomic sections without violating their semantics Two additional lock optimization problems that are closely related to the lock assignment problem are presented

### **On Synchronization Patterns in Parallel Programs**

Jean-Loup Baer, Richard N. Zucker, 1991 Abstract Efficient synchronization is a key element in obtaining good speed up from parallel programs The overhead introduced by synchronization especially lock manipulation can sometimes remove any benefit from parallelizing programs Techniques to efficiently obtain locks under high contention have been studied in the literature using artificial programs We consider the impact of these techniques in a more realistic framework using a sample of real parallel programs running on a shared bus multiprocessor system Cycles lost to lock contention and the number of processors waiting to acquire a lock are the two principal metrics that we use Trace driven simulation experiments are performed for sequentially consistent and weakly consistent architectural models

### **Synchronization Costs in Parallel Programs and Concurrent Data Structures**

Vitalii Aksenov, 2018 To use the computational power of modern computing machines we have to deal with concurrent programs Writing efficient concurrent programs is notoriously difficult primarily due to the need of harnessing synchronization costs In this thesis we focus on synchronization costs in parallel programs and concurrent data structures First we present a novel granularity control technique for parallel programs designed for the dynamic multithreading environment Then in the context of concurrent data structures we consider the notion of concurrency optimality and propose the first implementation of a concurrency optimal binary search tree that intuitively accepts a concurrent schedule if and only if the schedule is correct Also we propose parallel combining a technique that enables efficient implementations of concurrent data structures from their parallel batched counterparts We validate the proposed techniques via experimental evaluations showing superior or comparable performance with respect to state of the art algorithms From a more formal perspective we consider the phenomenon of helping in concurrent data structures Intuitively helping is observed when the order of some operation in a linearization is fixed by a step of another process We

show that no wait free linearizable implementation of stack using read write compare swap and fetch add primitives can be help free correcting a mistake in an earlier proof by Censor Hillel et al Finally we propose a simple way to analytically predict the throughput of data structures based on coarse grained locking

**Modelling Communication and Synchronization in Parallel Programming Languages** Dennis Harold Freidel,1984 Verification of Sequential and Concurrent Programs Krzysztof R. Apt,Ernst-Rüdiger Olderog,2013-03-09 This book provides a structured introduction to the verification of sequential and concurrent programs It thus belongs to the area of programming languages but at the same time it is firmly based on mathematical logic In logic one usually studies fixed syntactic or semantic objects This is not necessarily the case in the area of program verification The objects studied here namely programs do not have a standard syntax their semantics can be defined in many different ways and several approaches to their verification can be contemplated These differences lead to various difficult design decisions Even though we restrict our attention here to one programming style imperative programming we are still confronted with a veritable cornucopia of programming constructs from which an appropriate selection has to be made Having studied some of these constructs separately does not yet imply that we understand their combined effect

**A New Construct for Synchronization of Parallel Logic Programs** University of Maryland at College Park. Computer Science Center,S. Kasif,1985 **Pro .NET 4 Parallel Programming in C#** Adam Freeman,2011-01-11 Parallel programming has been revolutionised in NET 4 providing for the first time a standardised and simplified method for creating robust scalable and reliable multi threaded applications The Parallel programming features of NET 4 allow the programmer to create applications that harness the power of multi core and multi processor machines Simpler to use and more powerful than classic NET threads parallel programming allows the developer to remain focused on the work an application needs to perform In Pro NET 4 Parallel Programming in C Adam Freeman presents expert advice that guides you through the process of creating concurrent C applications from the ground up You ll be introduced to NET s parallel programming features both old and new discover the key functionality that has been introduced in NET 4 and learn how you can take advantage of the power of multi core and multi processor machines with ease Pro NET4 Parallel Programming in C is a reliable companion that will remain with you as you explore the parallel programming universe elegantly and comprehensively explaining all aspects of parallel programming guiding you around potential pitfalls and providing clear cut solutions to the common problems that you will encounter

**Analysis of Synchronization in a Parallel Programming Environment** Rice University. Dept. of Computer Science,J. S. Subhlok,1990 *Event Synchronization Analysis for Debugging Parallel Programs* Perry Alan Emrath,Sanjoy Ghosh,David A. Padua,1988 We demonstrate an algorithm that solves this problem yielding a task graph upon which a race detection algorithm can be applied

**Synchronization Architecture in Parallel Programming Models** Arturo González Escribano,2003 Shared-Memory Synchronization Michael L. Scott,2013-06-01 From driving flying and swimming to digging for unknown

objects in space exploration autonomous robots take on varied shapes and sizes In part autonomous robots are designed to perform tasks that are too dirty dull or dangerous for humans With nontrivial autonomy and volition they may soon claim their own place in human society These robots will be our allies as we strive for understanding our natural and man made environments and build positive synergies around us Although we may never perfect replication of biological capabilities in robots we must harness the inevitable emergence of robots that synchronizes with our own capacities to live learn and grow This book is a snapshot of motivations and methodologies for our collective attempts to transform our lives and enable us to cohabit with robots that work with and for us It reviews and guides the reader to seminal and continual developments that are the foundations for successful paradigms It attempts to demystify the abilities and limitations of robots It is a progress report on the continuing work that will fuel future endeavors Table of Contents Part I Preliminaries Agency Motion and Anatomy Behaviors Architectures Affect Sensors Manipulators Part II Mobility Potential Fields Roadmaps Reactive Navigation Multi Robot Mapping Brick and Mortar Strategy Part III State of the Art Multi Robotics Phenomena Human Robot Interaction Fuzzy Control Decision Theory and Game Theory Part IV On the Horizon Applications Macro and Micro Robots References Author Biography Discussion *The Dependence Analysis and Synchronization of Parallel Programs* Samuel Pratt Midkiff,1992 **Synchronization Expressions in Parallel Programming Languages** Lifu Guo,1994 Scientific and Technical Aerospace Reports ,1991 Studies on Memory Consistency and Synchronization Failure Detection in Parallel Programs ,1998

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