

Table of Contents

Synchronization 1

- Serialization 2
- The Trouble with Locks 2
- Transactions 3

Transactional Memory 4

- Transactions Facilitate Composition 4
- Limitations of Software Transactional Memory 5

Hardware Transactional Memory 6

- Implementing Hardware Transactional Memory 6
- Virtualizing HTM 6

LogTM 7**Multi-Threaded Programming 9****Transactional Programming 11**

- Transactional Memory 12

Concurrency Control 12

- Concurrency Control for Mutual Exclusion 13
- Lock-Based Concurrency Control in Database Systems 13
- Optimistic Concurrency Control in Database Systems 15

Transactional Memory Systems 16

- Hardware Support for Database Transactions 16
- Early HTM Systems 16
- Hardware Transactional Memory 18
- Recently Proposed HTMs 21

Eager Version Management 25

- The Transaction Log 25
- Example 26
- Discussion 26

Eager Conflict Detection 28

- Discussion 29

Conflict Resolution 30**LogTM API 30**

- Discussion 32

Implementing Eager Version Management 33

- Logging in Software 33
- Hardware Logging 34
- Hardware/Software Hybrid Logging 36
- Discussion 37

Implementing Eager Conflict Detection 38

- In-Cache Conflict Detection 38
- Out-of-Cache Conflict Detection 39
- LogTM Directory 40

LogTM-Bcast	45
Implementing Conflict Resolution	47
Processor Support	48
LogTM Enhancements	49
Write Set Prediction	49
Methods	51
SMP System Model	52
CMP System Model	52
Simulation Platform	53
Workloads	54
Microbenchmarks	54
Benchmarks	54
LogTM Performance	55
Implementation Tradeoffs	59
Write Set Prediction	59
Hardware Support for Logging	61
Conflict Detection and Resolution--INCOMPLETE	62
False Sharing	63
Nested Transactions	65
Closed Nested Transactions (with Partial Abort)	65
Open Nested Transactions	67
Virtualizing Conflict Detection	68
Detecting Conflicts with Signatures	69
Supporting Unbounded Nesting with Signatures	70
Hardware Transactional Memory	73
Unbounded Transactional Memory	73
Transactional Memory Coherence and Consistency (TCC)	75
Hardware-Software Hybrid Transactional Memory	76
Transactional Lock Removal	76
Hybrid Transactional Memory	78
Virtualizing Transactional Memory	79
Thread-Level Speculation	79
Using Software Logging to Support Multi-Version Buffering in Thread-Level Speculation, Garzaran et al, PACT 2003	79
Hardware for Speculative Run-Time Parallelization in Distributed Shared Memory Multiprocessors, Zhang et al, HPCA 1998.	79
Hardware for Speculative Parallelization of Partially-Parallel Loops in DSM Multiprocessors, Zhang et al, HPCA 1999.	80
Tradeoffs in Buffering Memory State for Thread-Level Speculation in Multiprocessors, Garzaran et al, HPCA 2003.	80
Speculative Versioning Cache, Gopal et al, HPCA 1998.	81