RSTM: A Relaxed Consistency Software Transactional Memory System for Multicores

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STM - Overview

- ❑ Software Transactional Memory model
  - • For Non Blocking Synchronization
  - •"Transaction": Section of code that executes atomically.
- ❑ Implementation
  - • Keep track of versions of shared data.
  - • At commit time, detect read/write conflicts between concurrent transactions.
  - • Abort & retry if conflict detected.

STM Overheads

- ❑ Overheads due to STM implementation
  - • Bookkeeping, conflict resolution, state buffering..
- ❑ Overheads due to STM semantics
  - • Difficult to specify fine grained consistency requirements for shared data
  - • Unnecessary conflicts and aborts due to variables for which "stale" values are acceptable
  - • Large performance penalty esp. for long running transactions.

RSTM – Key Ideas

Sacrifice data consistency for performance

(carefully and where appropriate!)

- ❑ Group shared variables according to the type of synchronization they need
- ❑ Relax synchronization for variable groups that don't require strict STM semantics.
- ❑ **Result:** Fewer aborts due to shared variables for which strict read/write synchronization is unnecessary to produce acceptable results.

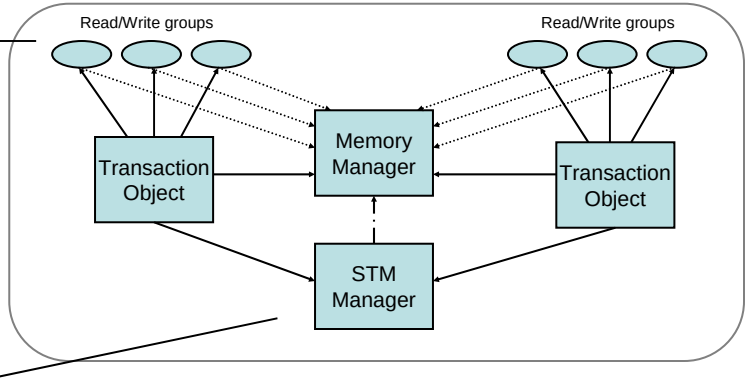
Applications: Games, Multimedia

- ❑ Distinct properties
  - • Large amount of shared state
  - • High-performance requirements (frame rates)
  - • STM overheads are sometimes unacceptable
  - • Large existing codebases
  - • Proving hard to scale using locks (programming complexity)
  - • Are "error-tolerant": Can sometimes tradeoff "accuracy" for performance
  - • Predominantly written in C/C++

Consistency Groups

- ❑ "Collection of named shared variables that a transaction reads/writes, on which a consistency policy is applied"
  - • Not all variables require strict read/write synchronization.
- ❑ Dynamic
  - • The same variable may be in different groups simultaneously or at different instants.

```
atomic T1 {
    openForRead(&a, sizeof(a), GROUP1)
    if(…) {
        openForRead(&a, sizeof(a), GROUP2);
    }
}
```



Consistency Modifiers

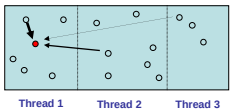
- ❑ Specifies the consistency policy to be applied to a group in a Transaction 'T'
- • **NONE** No read/write conflict check will be performed for this group when T is committing.
- • **SINGLE-SOURCE (T1, T2,..)** Exactly one of T1, T2… allowed to modify shared data in a group without causing a conflict with T.
- • **MULTI-SOURCE(T1, T2…)** Similar to SINGLE-SOURCE except any of T1, T2,… are allowed to modify data.

Bookkeeping

- ❑ Bookkeeping for memory regions instead of program objects.
  - • Vital for C/C++ programs with direct memory accesses.
- ❑ "Zone" : Basic unit of bookkeeping.
  - • A contiguous region of memory with the same metadata (version)
- ❑Smart Zone management
  - • Several strategies to minimize the number of zones to keep track of.

Case Study: Particle Simulation

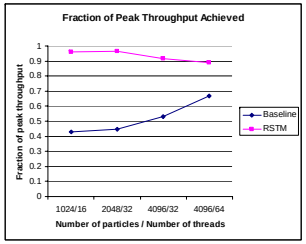
- ❑ Simulates particle interactions & motion (mutual gravity, external forces)
- • Influence of neighbors on a particle depends on the distance between them.

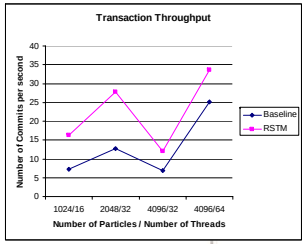


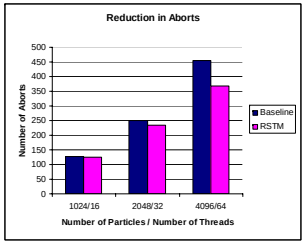
- ❑ Relaxation of STM semantics allows reading stale attributes of far away neighbor particles without aborting at commit.

Performance Results

(Baseline is standard STM with strict consistency)







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