Transactional Memory Evaluation using Apache Webserver

Haggai Eran

November 20, 2008

Outline

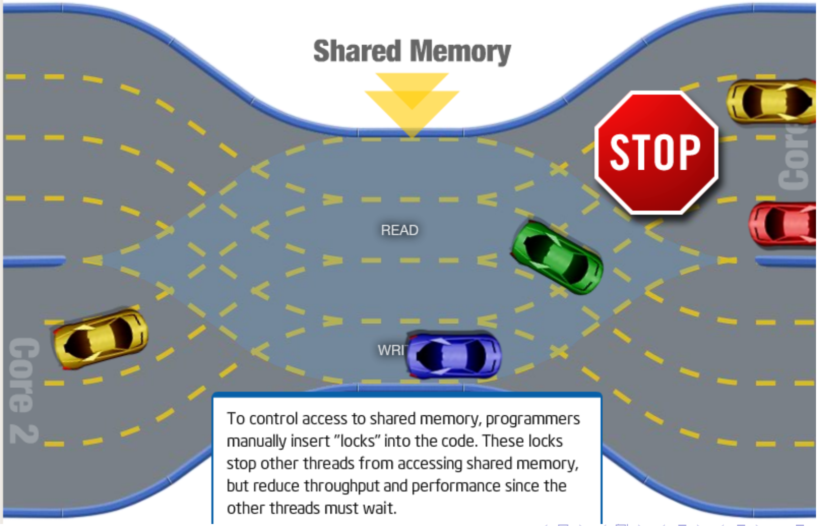
1. Transactional Memory
    - Lock based synchronization Limitations
    - Transactional Memory Introduction
2. TM Evaluation
    - Evaluation Strategy
    - Transactification Process
    - Evaluation

Traditional Synchronization

Example

```
void withdraw(account, amount) {
  accounts[account] -= amount;
}
```

Course-Grained Locks



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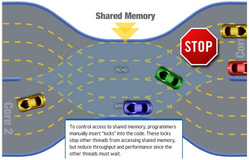

Example

```
void withdraw(account, amount) {
  lock(big_mutex);
  accounts[account] -= amount;
  release(big_mutex);
}
```

- Easy to program.
- Doesn't scale.

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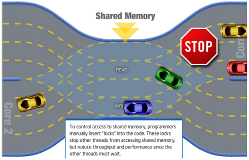

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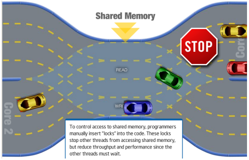

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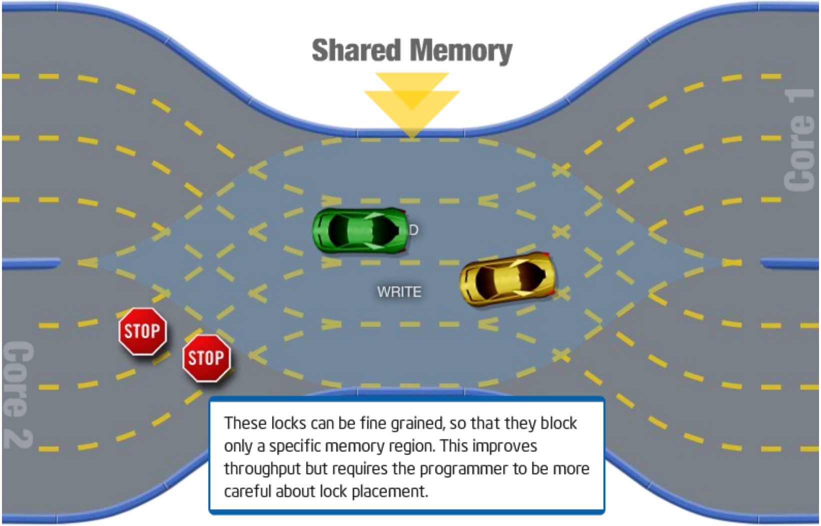

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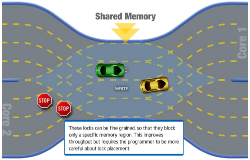

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void withdraw(account, amount) {
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- Can scale well.
- Difficult to program.

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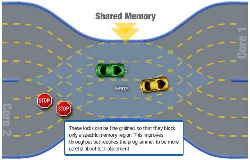

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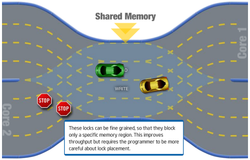

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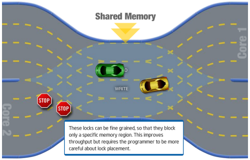
Fine-Grained Locks Difficulties

Composition



Example

```
void transfer(fromAccount, toAccount, amount) {
  withdraw(fromAccount, amount);
  deposit(toAcount, amount);
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- Locking both accounts from `transfer` - breaks encapsulation, deadlocks.
- Big lock - decreases performance

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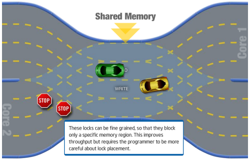

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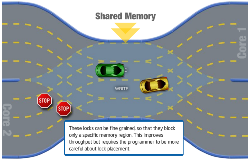

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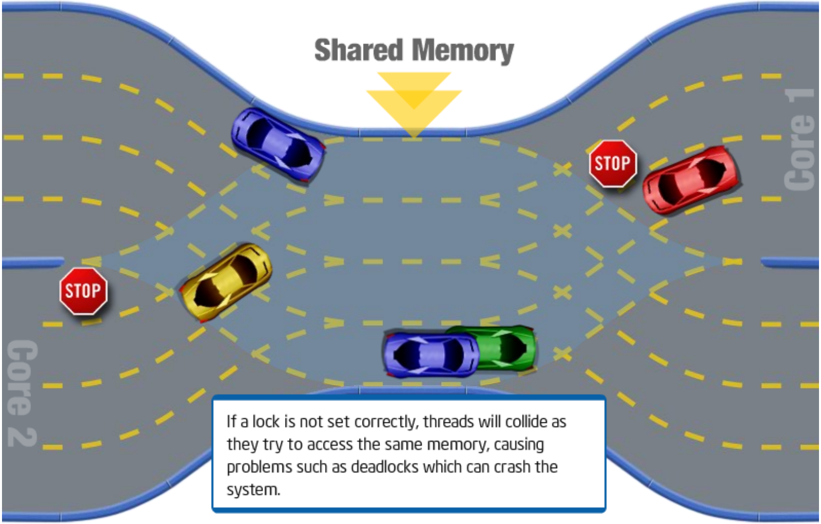
Fine-Grained Locks Difficulties

Locking Policies

Comment from the linux kernel

```
/*
 * When a locked buffer is visible to the I/O layer
 * BH_Launder is set. This means before unlocking
 * we must clear BH_Launder,mb() on alpha and then
 * clear BH_Lock, so no reader can see BH_Launder set
 * on an unlocked buffer and then risk to deadlock.
 */
```

Fine-Grained Locks Difficulties



Transactional Memory

- Provide a simple API for programmers.
- Offering fast implementations.

Transactional Memory
Simple API

Example

```
void withdraw(account, amount) {
  atomic {
    accounts[account] -= amount;
  }
}
```

Nested transactions

```
void transfer(fromAccount, toAccount, amount) {
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```

Transactional Memory
Simple API

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```
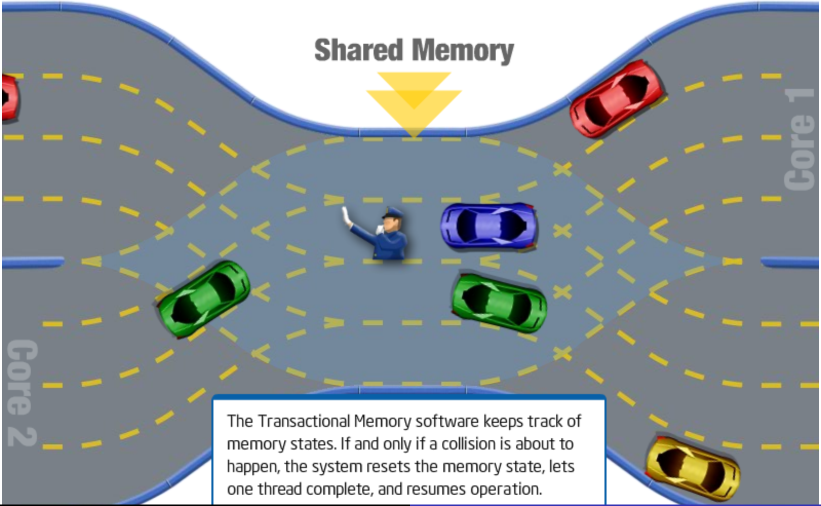

Transactional Memory
Implementation

- A transaction is run speculatively without taking any locks.
- Collisions are detected either at commit time or during the run.
- On collision, one of the transactions is aborted and its changes are rolled back.
- Later the aborted transaction is restarted.

Transactional Memory
Implementation



Transactional Memory

Implementation by software

- All global memory accesses are handled by a special library.
- The library detects collisions and handles commits and aborts.

Transactional Memory
Implementation by hardware

- Reuse the cache coherency mechanism in multicore/multiprocessor machines.
- Requires special hardware.
- Limitations: Size and duration of transactions, context switches.

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Existing Benchmarks

- Red-Black trees benchmarks
- STAMP benchmark suite.
  - Bayesian network learning
  - Gene sequencing
  - Network intrusion detection
  - K-means clustering
  - Maze routing
  - Graph kernels
  - Client/server travel reservation system
  - Delaunay mesh refinement

Our Project's Goal

Create a benchmark based on a real-world application for transactional memory.

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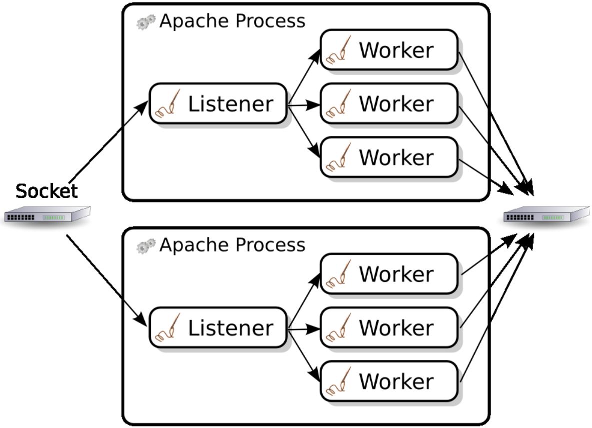
Our Project's Goal

Create a benchmark based on a Apache web-server for transactional memory.

Apache Web Server

- Written in C.
- Support many Multiprocessing Modules (MPMs): Parallel execution strategies.
- A mainly developed threaded MPM is the Worker MPM: Runs several processes, each running a fixed number of threads.

Apache Web Server
Worker MPM



Apache Cache Module - mod_mem_cache

- There isn't much interaction between the worker threads.
- The cache module enables worker threads of the same process to share cached pages in memory.
- Currently implemented with one big lock.

Software Transactional Memory in C/C++

Several STM implementations for C are available as libraries.

- Require accessing global variables through library functions / macros.

A few compiler based implementations:

- Tanger - An open-source academic LLVM-based STM compiler.
  - Support using any STM library through a known interface.
- ICC - Intel's experimental STM compiler
  - Works with Intel's own transactional memory manager.

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Transactifying Compiler

- Modifies code inside atomic blocks to access globals through the STM.
- Function calls.
- Indirect function calls.
- Library functions.

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Commit handlers

A common pattern we found, missing in both Tanger and ICC.

Example

```
atomic {
  if (--object.reference_count) {
    cache_remove(object);
    destroy(object);
  }
}
```

Commit handlers

Should be converted to:

Example

```
atomic {
  if (--object.reference_count == 0) {
    cache_remove(object);
  }
}
if (object.reference_count == 0)
  destroy(object);
```

Commit handlers

It would be nice to have:

Example

```
atomic {
  if (--object.reference_count == 0) {
    cache_remove(object);
    on_commit(destroy, object);
  }
}
```

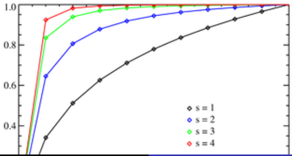
Evaluation

Evaluation of a web server requires:

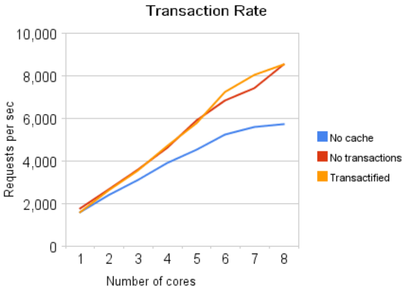
- A data set.
- Client strategy

We chose

- Data set of small files (man pages) so that the throughput of the NIC won't be the bottleneck.
- Running as many clients concurrently as possible to create contention on the server and its cache.
- Requesting pages according to Zipf distribution - to control locality.



Current Results



Theory

- The linux file cache contains the entire data set => Apache's cache just gets in the way.
- Dynamically generated content might give the cache an advantage.

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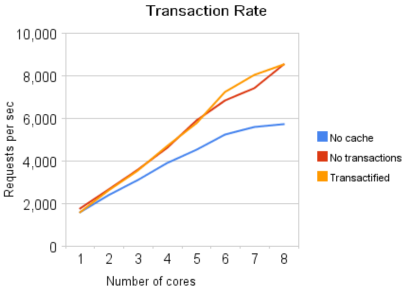

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Thank you

Questions

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