On Transactional Memory Concurrency Control in Distributed Real-Time Programs

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Abstract

Distributed embedded software is inherently concurrent, as they monitor and control concurrent physical processes. Often, their computations need to concurrently access (i.e., read/write) shared data objects, which must be properly coordinated so that consistency properties (e.g., linearizability, serializability) can be ensured. Furthermore, they must satisfy application time constraints. The usual way for managing concurrency of different processes in a system is using locks, which inherently suffers from programmability, scalability, and composability challenges.

Main components of the proposed solution

Concurrency Control

- RT-TFA extends TFA (Transaction Forwarding Algorithm) to support transactions that execute under time constraints.
- Transactions inherit deadlines of their parent tasks.
- Objects are acquired at encounter time and object request carry deadline to remote node.
- Transactions are early-aborted if conflicts are detected at object access time.
- Locks are acquired at commit time and transactions resolve conflicts using the deadlines of subsuming tasks before getting locks over objects.

System Architecture

- The implementation consists of a stack of ChronOS Real-Time Linux kernel, JChronOS (a Java interface library), JVM, RT-TFA and application.
- ChronOS supports various scheduling algorithms (EDF, RMA, GEDE, DASA etc.).
- Time constraints are expressed using scheduling segments in a thread.
- Scheduling segments occur at regular intervals and have deadlines.
- JChronOS library extends scheduling interface of ChronOS for Java programs.

Experimental Evaluation

Configuration

- Private cluster of 14-nodes (AMD Opteron processor, 1.9GHz).
- Each node runs a set of periodic tasks constituting 70 distributed tasks.
- Implementation of concurrency control in Hyflow Java DTM framework.
- Benchmark: Bank
- Parameters tested: effects of variation in % of read transactions on throughput and deadline satisfaction ratio (DSR) of distributed tasks.

Results and Discussion

Bank Benchmark:

- A monetary application, which maintains a set of accounts distributed over bank branches and contains two transactions (transfer and total balance).
- Compared with three variations of classic two-phase-locking protocol.

Finally...

Our results revealed that RT-TFA yields comparable or better deadline satisfaction ratios to 2PL-based locking protocols. Additionally it allows programmers to reap benefits of DTM’s programmability and composability properties.

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