Crafty: Efficient, HTM-Compatible Persistent Transactions

Kaan Genç
The Ohio State University

Michael D. Bond
The Ohio State University

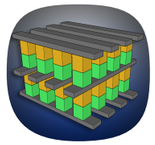
Guoqing Harry Xu
University of California, Los Angeles

Persistent transactions are a programming model where:

- Data is persistent, it survives power failures
- After recovering from a failure, transactions are atomic
- Concurrent transactions are isolated

The most effective ways to provide data persistency and isolation is through Non-volatile Memory and Hardware Transactional Memory, respectively.

Non-volatile Memory

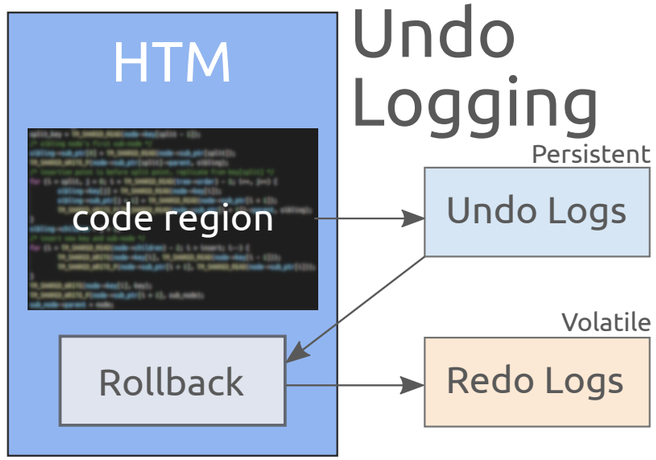


Non-volatile Memory (NVM), such as Intel Optane DC Memory, is a new class of memory that is persistent, byte-addressable and accessible using regular read and write instructions. Data in NVM survives power failures.

HTM and NVM are incompatible

Non-volatile Memory uses persist operations to write data from cache to memory. However, Hardware Transactional Memory prohibits data from being written back.

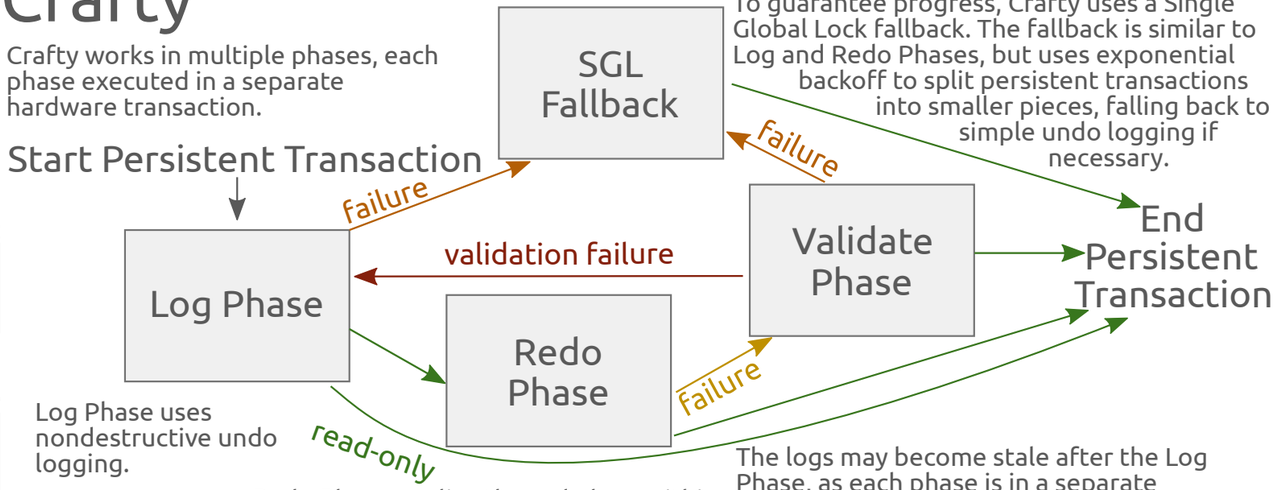
Nondestructive Undo Logging



Nondestructive undo logging creates logs without modifying program memory. Logs created when the code region is executing are rolled back at the end, which eliminates the need for persist operations and avoids the incompatibility between HTM and NVM.

Crafty

Crafty works in multiple phases, each phase executed in a separate hardware transaction.

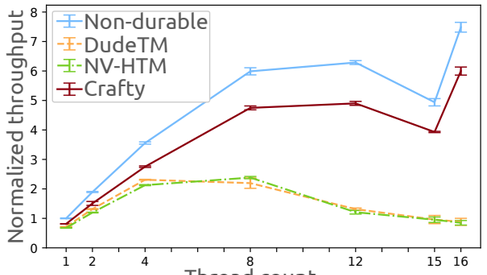


Log Phase uses nondestructive undo logging.

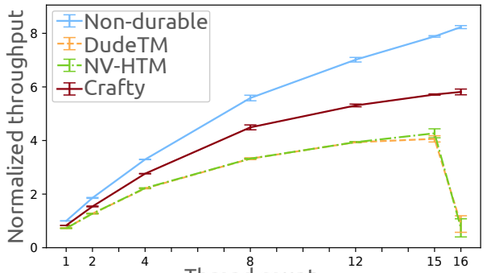
Redo Phase applies the redo logs within a hardware transaction. If it succeeds, the persistent transaction is complete. It can fail due to concurrency issues.

To guarantee progress, Crafty uses a Single Global Lock fallback. The fallback is similar to Log and Redo Phases, but uses exponential backoff to split persistent transactions into smaller pieces, falling back to simple undo logging if necessary.

The logs may become stale after the Log Phase, as each phase is in a separate hardware transaction. The Validate Phase checks that the logs are not stale, completing the persistent transaction if they are fresh. Otherwise, Crafty goes back to the Log Phase to get new logs.



B+ Tree insert only



vacation (low contention)

Crafty outperforms DudeTM [ASPLOS'17] and NV-HTM [IPDPS'18] under low contention, and performs similarly under high contention.