**Crafty: Efficient, HTM-Compatible Persistent Transactions**

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**Persistent Transaction**

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

**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.

**Crafty**

- Crafty works in multiple phases, each phase executed in a separate hardware transaction.
- Start Persistent Transaction
  - Log Phase uses nondestructive undo logging.
  - Log Phase applies the redo logs within a hardware transaction. If it succeeds, the persistent transaction is complete. It can fail due to concurrency issues.
  - 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.
  - Validate Phase
  - 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.
  - End Persistent Transaction

**Non-destructive Undo Logging**

- Non-destructive 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 persistent operations and avoids the incompatibility between HTM and NVM.

**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.

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