Mostly-Optimistic Concurrency Control

for Highly Contented Dynamic Workloads on 1000 cores

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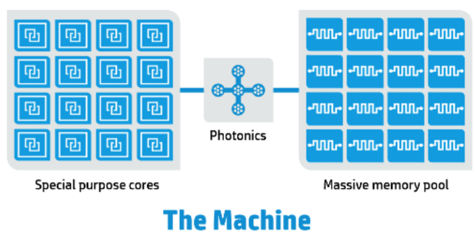
https://github.com/hewlettpackard/foedus_code

What? ***High-contention workloads*** are common, but not well supported under 1000 cores
Why? Optimistic concurrency control (OCC) ***doesn't protect reads***: extremely hard to commit
How? Hybrid approach: ***lock hot records upon access*** + OCC verification for serializability

OLTP on modern and future hardware

Multi-socket
Tens of cores

HPE Superdome X
16 sockets, 288 cores

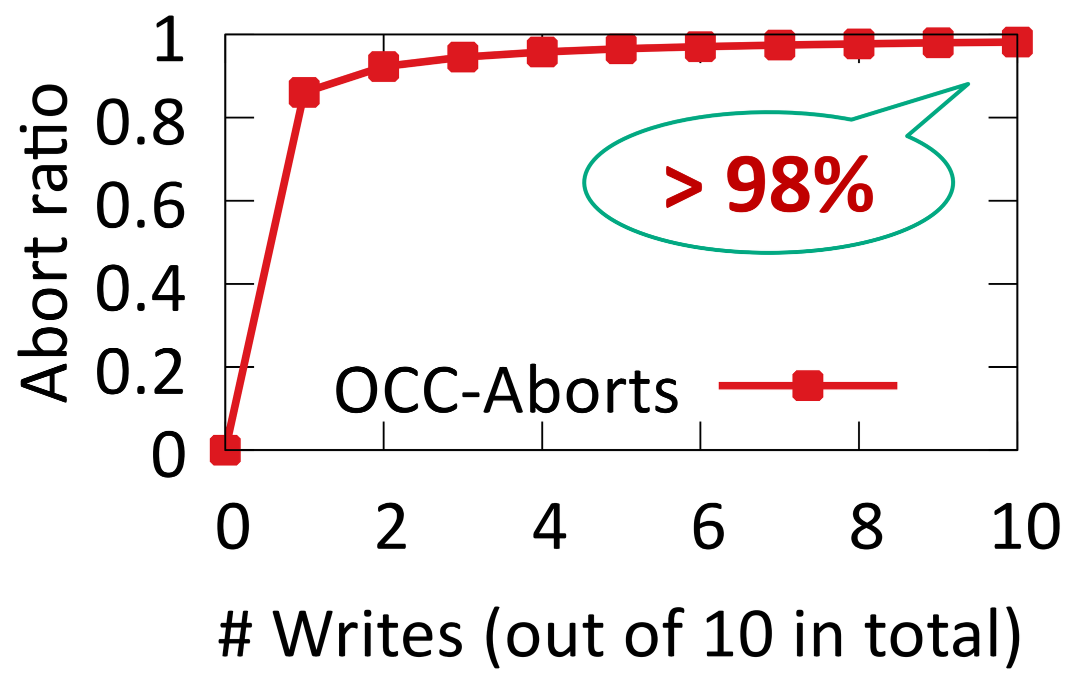


HPE The Machine
1000 cores

Very high parallelism ➔ favor lightweight, optimistic concurrency control (OCC)

OCC: high contention tx hardly commits

- 288-core, 16-socket, 50-record table, 10 ops per tx



Key reason:
reads not protected

Mostly-Optimistic Concurrency Control = best(2PL) + best(OCC)

Key idea: *protect hot accesses with pessimistic locks*

- Hot records under contention: lock ***upon*** access
  - Prevents clobbered reads ➔ more likely to succeed verification during pre-commit
- Cold records: same as in OCC

Challenges:

- Accurately and cheaply detect "real" hot records
- Lock-upon-access can lead to deadlocks
- Need an efficient cancellable, reader-writer lock

Must not revive all the overheads of traditional 2PL

Know the real hot: approximate counter*

Page
pTemp
A | B | ...

- Per-page (preferred) or per-record temperature field
- Real temperature **~= 2**^{pTemp}
- Increment upon abort with probability = 1/**2**^{pTemp}

- Larger ***pTemp*** ➔ harder to increment ➔ easy to tell "real" hot records
- Need not be accurate – no concurrency control needed ➔ less cacheline invalidation

* Robert Morris. Counting large numbers of events in small registers. *Commun. ACM* 21, 10 (October 1978), 840-842.

Canonical mode and retrospective locking

Reason for deadlock: **locks acquired out-of-order**

def: a transaction in **canonical mode** if all of its locks are acquired in order (so far)

1st run
Read set: {*A, C*}
Write set: {}
Locks held: {A, C}

Time ↓
Read A
Read C
Read B
...

Ways to recover:
Unlock C
Lock(B)

or **try-lock(B)**

Bottom line: verify upon commit

Retry
Read set: {*A, C, B*}
Write set: {}
Locks held: {}
RLL: {A, B, C}

Retrospective locking: a safety net

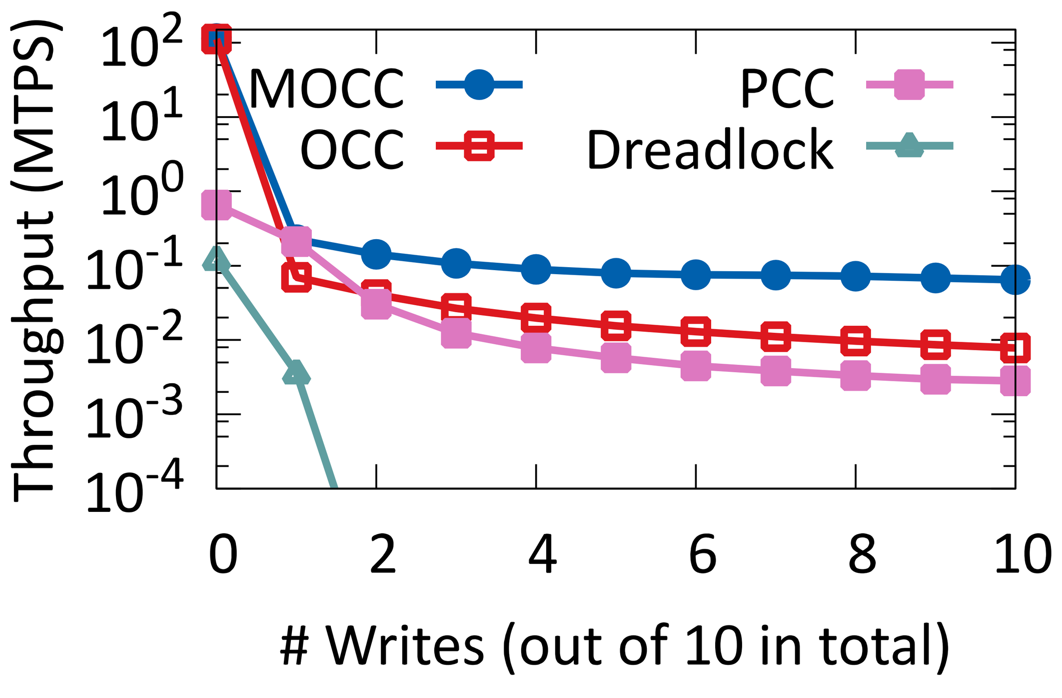
Time ↓
Read A – Lock (A)
Read C – Lock (B, C)
Read B – already locked

Efficient native locking

- **Desired properties**
  - ***Native locking***: synchronization primitives directly as database locks
  - ***Decentralized:*** co-locate locks with records
  - ***Scalable, cancellable, reader-writer locks***
    - Cancel a request in case of possible deadlock
- Solution: **MOCC queuing lock**
  = MCS Reader-Writer + MCS Timeout

Keeps OCC's best and keeps away its worst

HW: 288-core, 16-socket, Intel E7-8890, 12TB RAM



Read-write TPS:
MOCC: 65k, OCC: 7k
Pure locking (PCC): too many deadlocks
Dreadlock: too many interthread communications

Read-only
MOCC matches OCC:
No overhead for low contention
Pure locking (PCC):
too much physical contention