Multi-view data types

Scalable concurrency in the multi-core era

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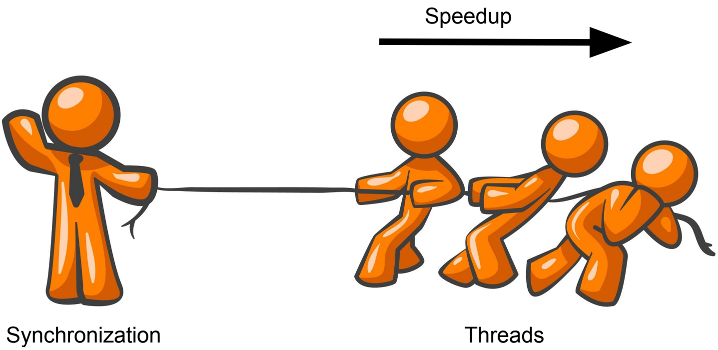
Concurrent programs in multi-core



Overview

Distributed systems

- Eventual consistency + CRDTs ➔ Synchronisation free
- Fast, Scalable, Available

Goal

- Weak consistency ➔ Less synchronisation
- Speed up!

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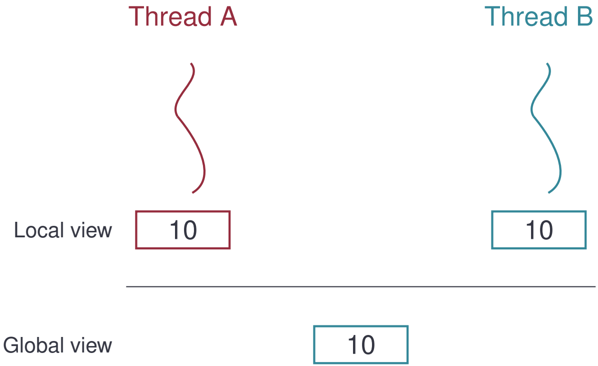
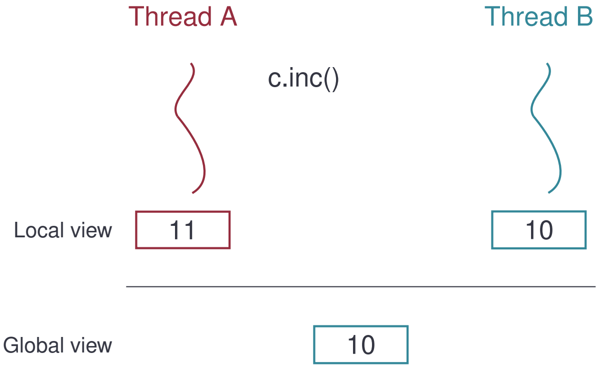
Global-Local view model
Multi-view data types

Global-local view model



Global-local view model



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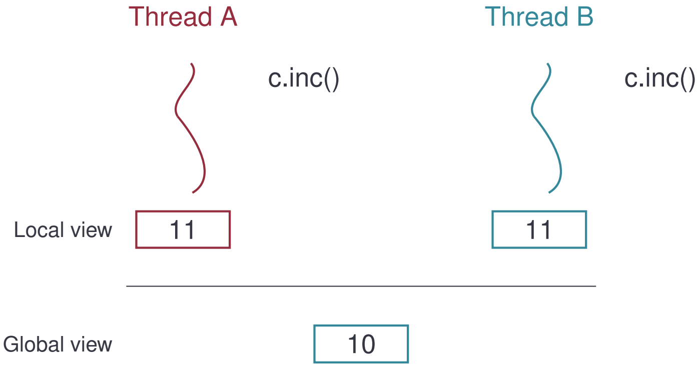
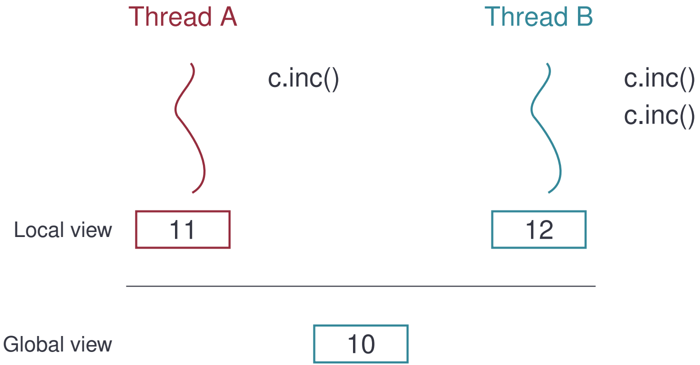
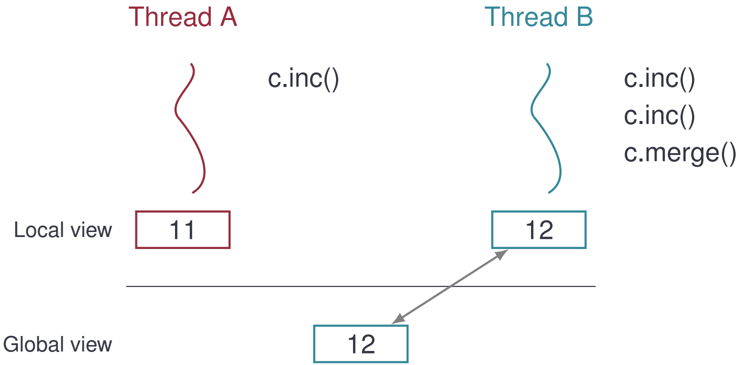


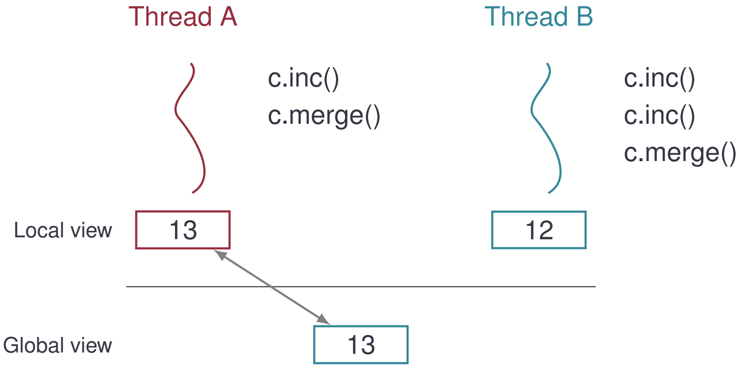
Global-local view model



Global-local view model



Global-local view model



Operations

Local View: (snapshot, local)

- snapshot: Global view that was last seen by this thread
- local: Accumulates local updates

Global View: g

Operations

weakUpdate
weakRead

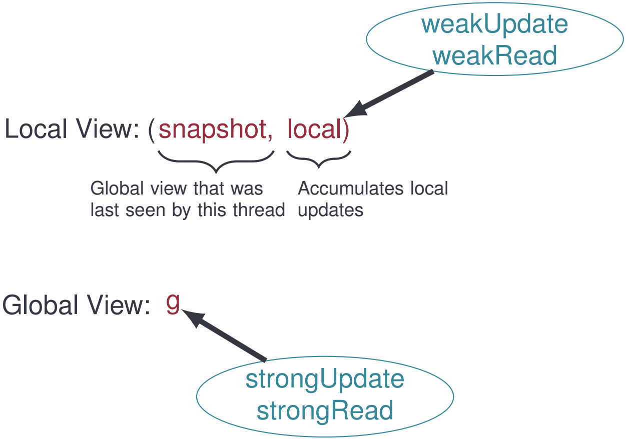
Local View: (snapshot, local)

Global view that was last seen by this thread

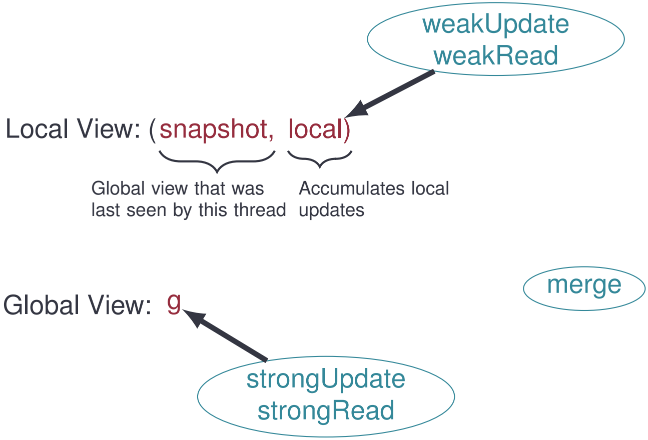
Accumulates local updates

Global View: g

Operations


weakUpdate
weakRead
Local View: (snapshot, local)
Global view that was last seen by this thread
Accumulates local updates
Global View: g
strongUpdate
strongRead

Operations



weakUpdate
weakRead
Local View: (snapshot, local)
Global view that was last seen by this thread
Accumulates local updates
merge
Global View: g
strongUpdate
strongRead

Multi-view data types

Mergeable types

- Implements weak operations and merge

Hybrid types

- Implements weak, strong and merge operations
- Hybrid counter
  synchronous increment when close to a target
- Hybrid queue
  weak enqueue and synchronous dequeue

CRDTs?

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- G-Set
  - merge = union of sets
- Counter
  - Map: id $\rightarrow$ int
  - merge = max of each elem

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Multi-view data types

- Multiple versions (view)
- Isolated access to each view
- Fast merge

Counter

- Global view: **int** g
- Local view :
  (**int** s, **int** l)

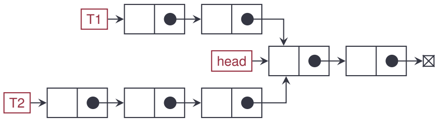
  Thread-local copies

  Exclusive access ⇒ no synchronization

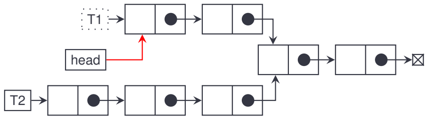
  Synchronous merge

```
weakInc() {
  l++;
}
weakValue(){
  return s+l;
}
merge(){
  atomic {g += l;
          s = g; l = 0;}
}
strongInc() {
        atomic {g++;}
}
```

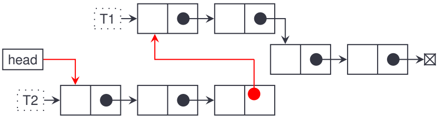
Multi-view list



After $T1$ commits:



After $T2$ commits:

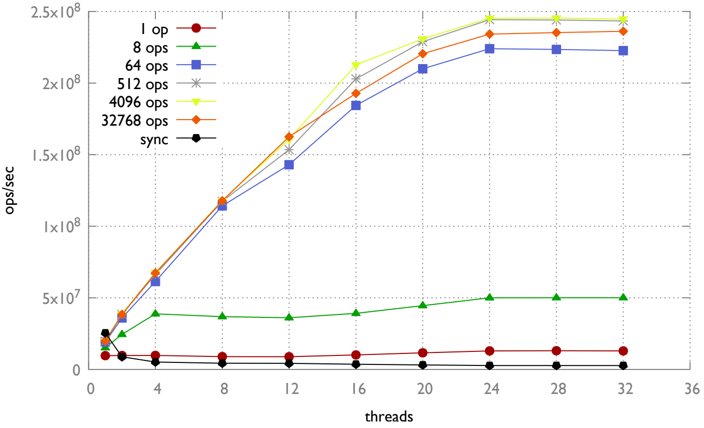


Evaluation: Hybrid Counter

Goal: increment until a target

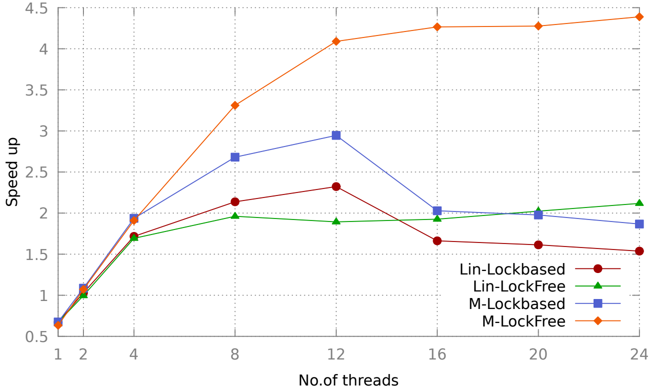
Periodic merge ⇒ Divergence from target

Switches to strong update after a threshold



Evaluation: Breadth first traversal

Using hybrid queue : weak enqueue and strong dequeue



Related work

Mergeable types

Doppel [Narula et al., 2014]

in-memory transactions

Concurrent revisions [Burckhardt et al., 2010]

fork join model

“mergeable” types

Weak consistency

Quasi linearizability [Afek et al., 2010]

Weak/medium future linearizability [Kogan and Herlihy, 2014]

K-linearizability [Aiyer et al., 2005]

Quiescent consistency [Aspnes et al., 1994]

Summary

Global-local view model

- fast local state, distant global state

Impact on underlying data structure design

- Multiple versions, Merge

Combination of weak and strong updates

- A spectrum of consistency

Thank you!

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