

Global-Local View Model

Scalable Consistency for Concurrent Data Types

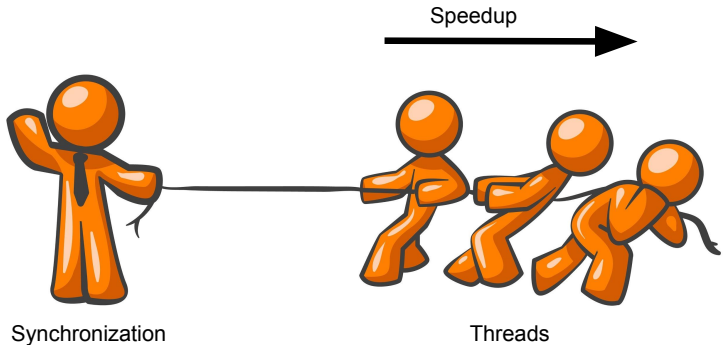
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Concurrent programs in multi-core



Overview

Distributed systems

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

Goal

- Relaxed consistency → Less synchronisation
- Speed up!

Overview

Distributed systems

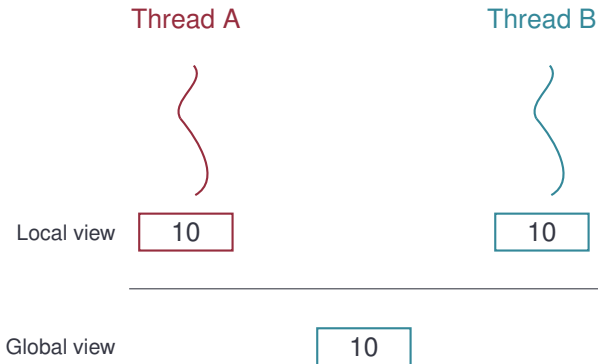
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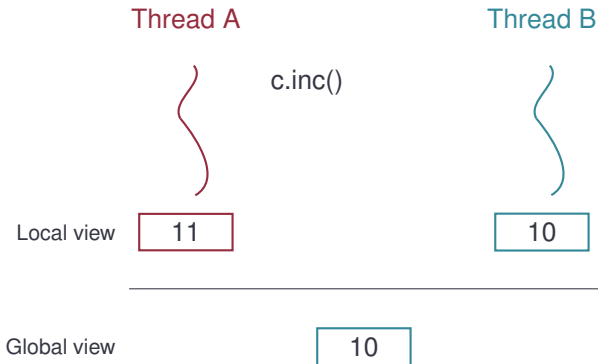
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Global-Local view model
Multi-view data types

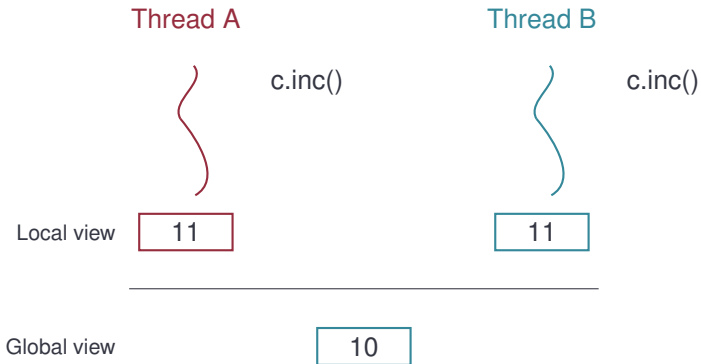
Global-local view model



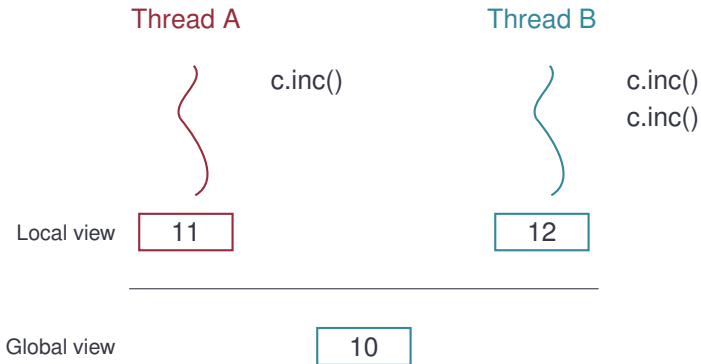
Global-local view model



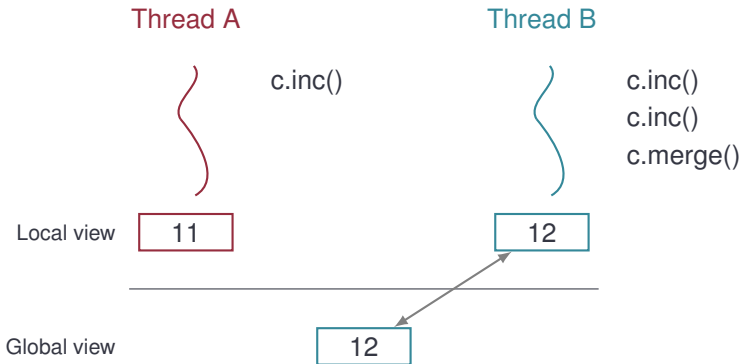
Global-local view model



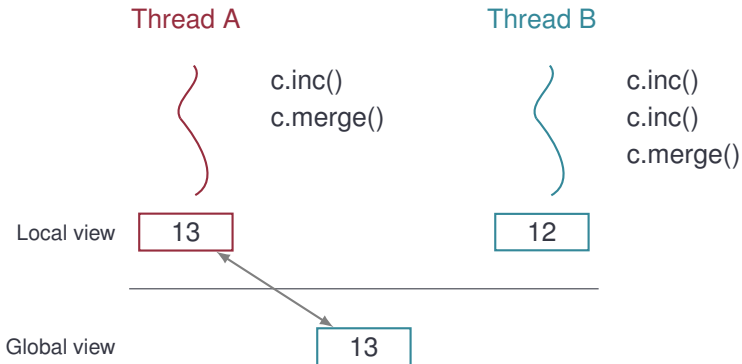
Global-local view model



Global-local view model



Global-local view model



Operations

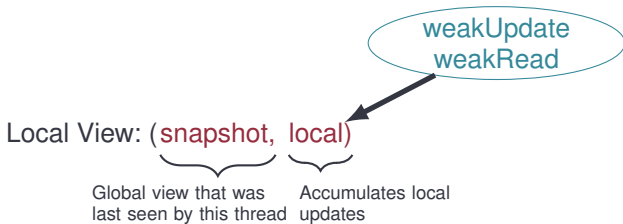
Local View: (**snapshot**, **local**)

Global view that was
last seen by this thread

Accumulates local
updates

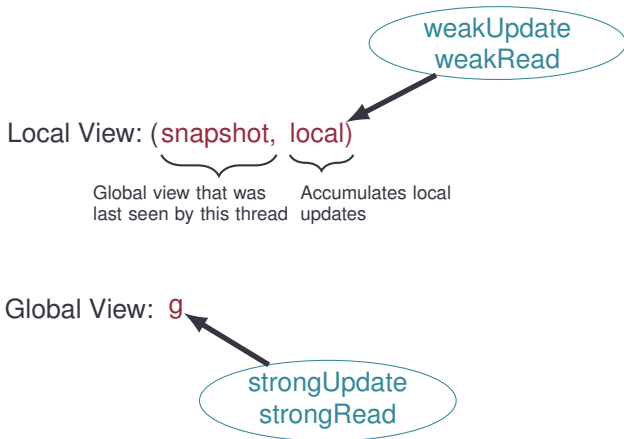
Global View: **g**

Operations

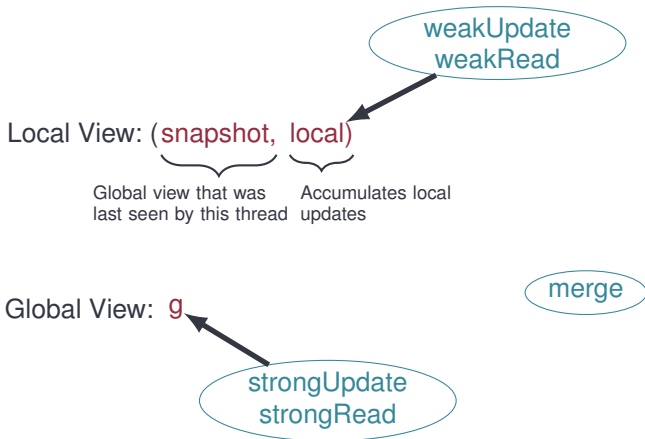


Global View: **g**

Operations



Operations



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

Applications

- Message queues
 - weakEnqueue
 - merge
- Work-stealing queue
 - `getTask` \implies `weakPopTop`
 - `addTask` \implies `weakPushTop`
 - `stealTask` \implies `strongPopBottom`
 - occasional merge

Implementation

Properties

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

Counter

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

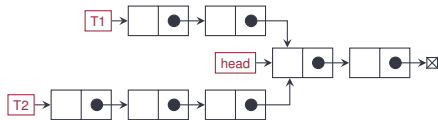
Thread-local copies

Exclusive access \Rightarrow no
synchronization

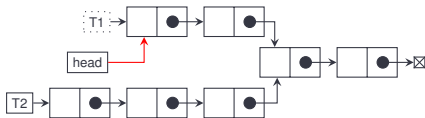
Synchronous merge

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

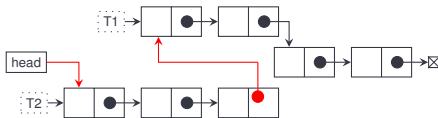
Multi-view list



After $T1$ merges:

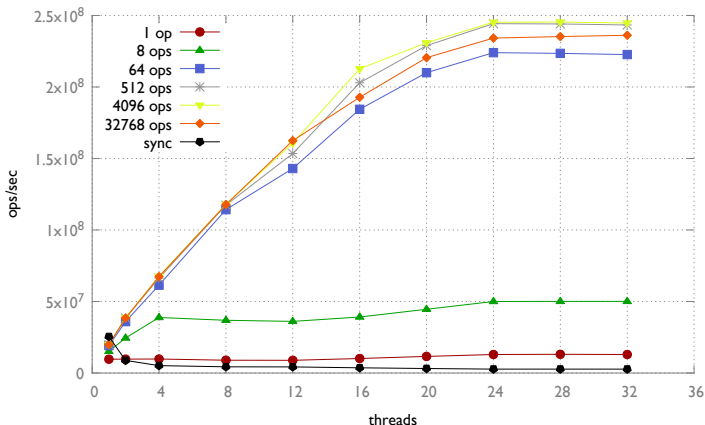


After $T2$ merges:



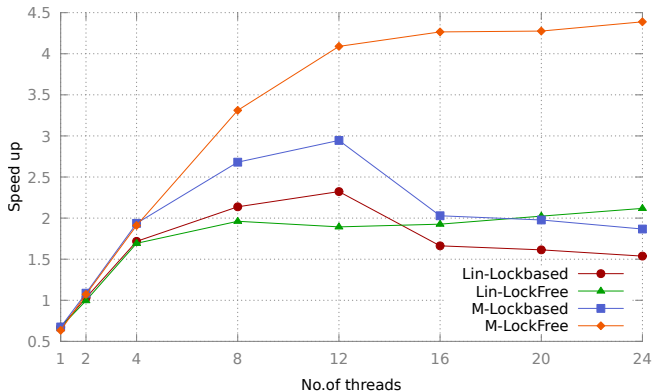
Evaluation: Hybrid Counter

Goal: increment until a target
Periodic merge \Rightarrow 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

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Thank you!

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References I



Afek, Y., Korland, G., and Yanovsky, E. (2010).

Quasi-linearizability: Relaxed consistency for improved concurrency.

In *Proceedings of the 14th International Conference on Principles of Distributed Systems*, OPODIS'10, pages 395–410, Berlin, Heidelberg. Springer-Verlag.



Aiyer, A., Alvisi, L., and Bazzi, R. A. (2005).

On the availability of non-strict quorum systems.

In *Proceedings of the 19th International Conference on Distributed Computing*, DISC'05, pages 48–62, Berlin, Heidelberg. Springer-Verlag.



Aspnes, J., Herlihy, M., and Shavit, N. (1994).

Counting networks.

J. ACM, 41(5):1020–1048.



Burckhardt, S., Baldassin, A., and Leijen, D. (2010).

Concurrent programming with revisions and isolation types.

In *Proceedings of the ACM International Conference on Object Oriented Programming Systems Languages and Applications*, OOPSLA '10, pages 691–707, New York, NY, USA. ACM.

References II



Kogan, A. and Herlihy, M. (2014).

The future(s) of shared data structures.

In *Proceedings of the 2014 ACM Symposium on Principles of Distributed Computing*, PODC '14, pages 30–39, New York, NY, USA. ACM.



Narula, N., Cutler, C., Kohler, E., and Morris, R. (2014).

Phase reconciliation for contended in-memory transactions.

In *Proceedings of the 11th USENIX Conference on Operating Systems Design and Implementation*, OSDI'14, pages 511–524, Berkeley, CA, USA. USENIX Association.