

# Multi-view data types

Scalable concurrency in the multi-core era

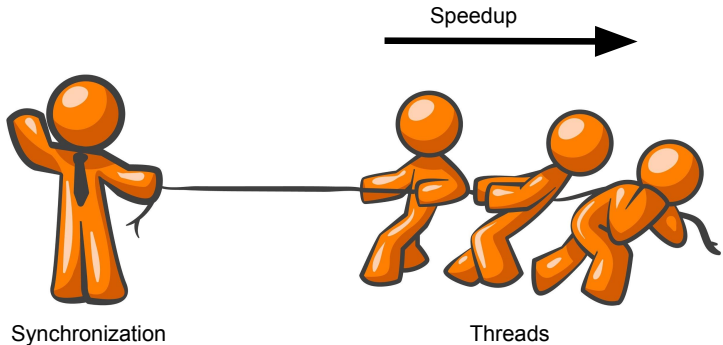
Deepthi Akkoorath<sup>1</sup>, José Brandão<sup>2</sup>, Annette Bieniusa<sup>1</sup>, Carlos Baquero<sup>3</sup>

<sup>1</sup>Technical University of Kaiserslautern  
Germany

<sup>2</sup>Universidade do Minho  
Braga, Portugal

<sup>3</sup>HASLab, Universidade do Minho & INESC TEC  
Braga, Portugal

# Concurrent programs in multi-core



# Overview

## Distributed systems

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

## Goal

- Weak consistency → Less synchronisation
- Speed up!

# Overview

## Distributed systems

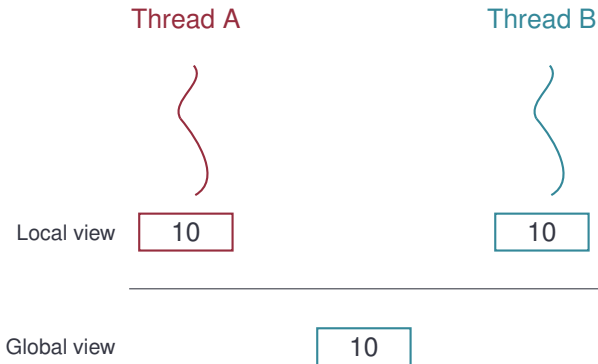
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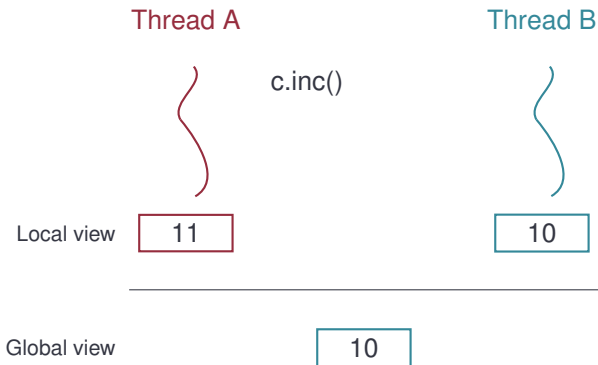
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Global-Local view model  
Multi-view data types

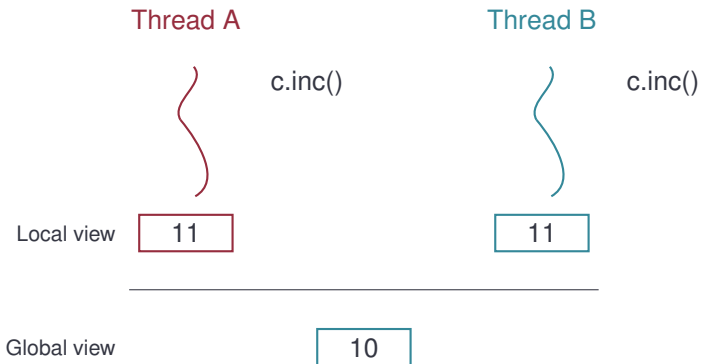
# Global-local view model



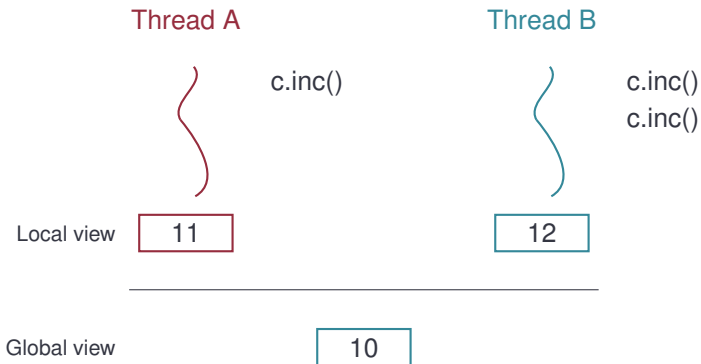
# Global-local view model



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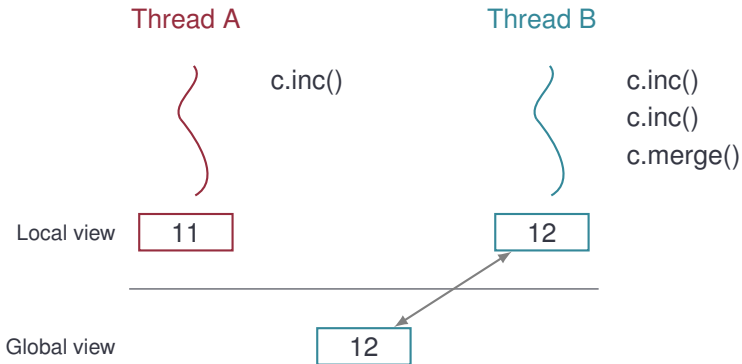


# Global-local view model

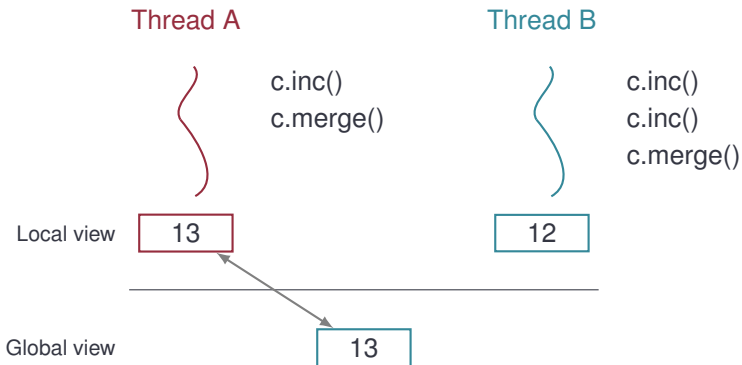




# Global-local view model



# Global-local view model



# Operations

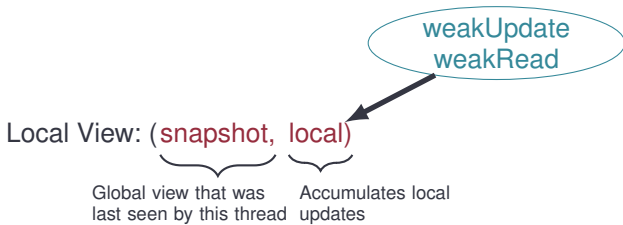
Local View: (snapshot, local)

Global view that was  
last seen by this thread

Accumulates local  
updates

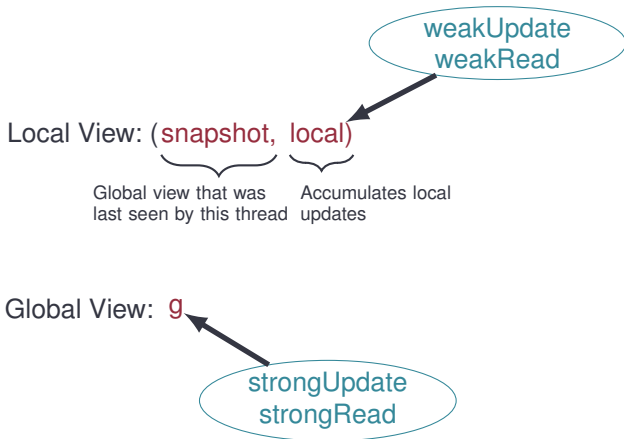
Global View: g

# Operations

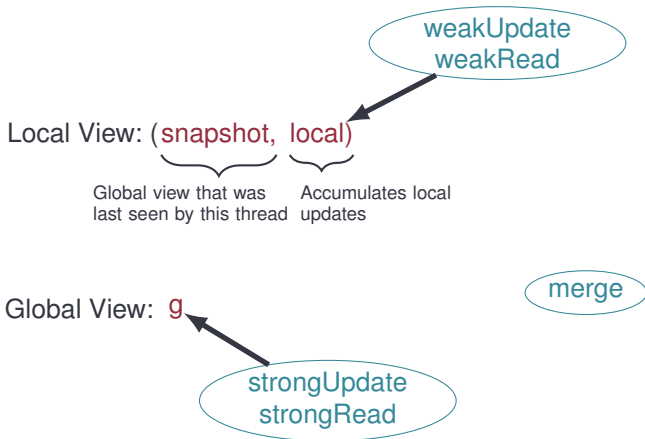


Global View: g

# 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

# CRDTs?



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- G-Set
  - merge = union of sets
- Counter
  - Map:  $\text{id} \rightarrow \text{int}$
  - 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)

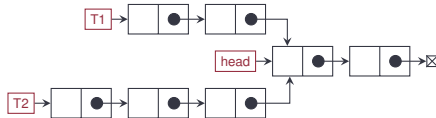
Thread-local copies

Exclusive access  $\Rightarrow$  no  
synchronization

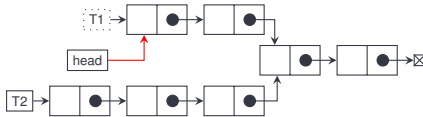
Synchronous merge

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

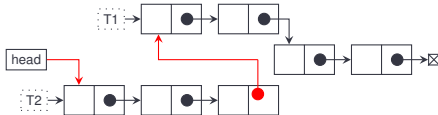
# Multi-view list



After  $T_1$  commits:

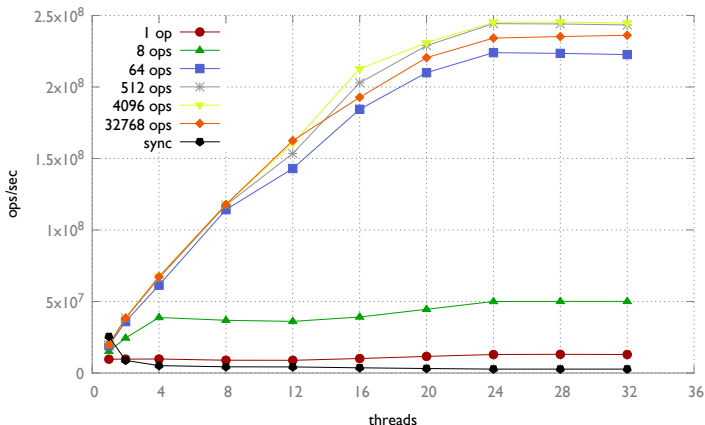


After  $T_2$  commits:



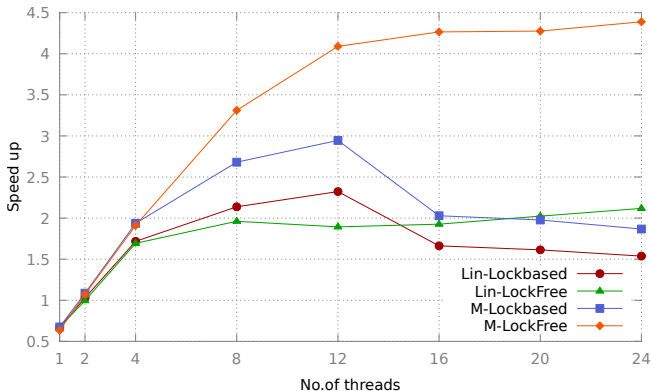
# Evaluation: Hybrid Counter

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

Thank you!

akkoorath@cs.uni-kl.de

# 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.