TECHNISCHE UNIVERSITÄT
KAISERSLAUTERN

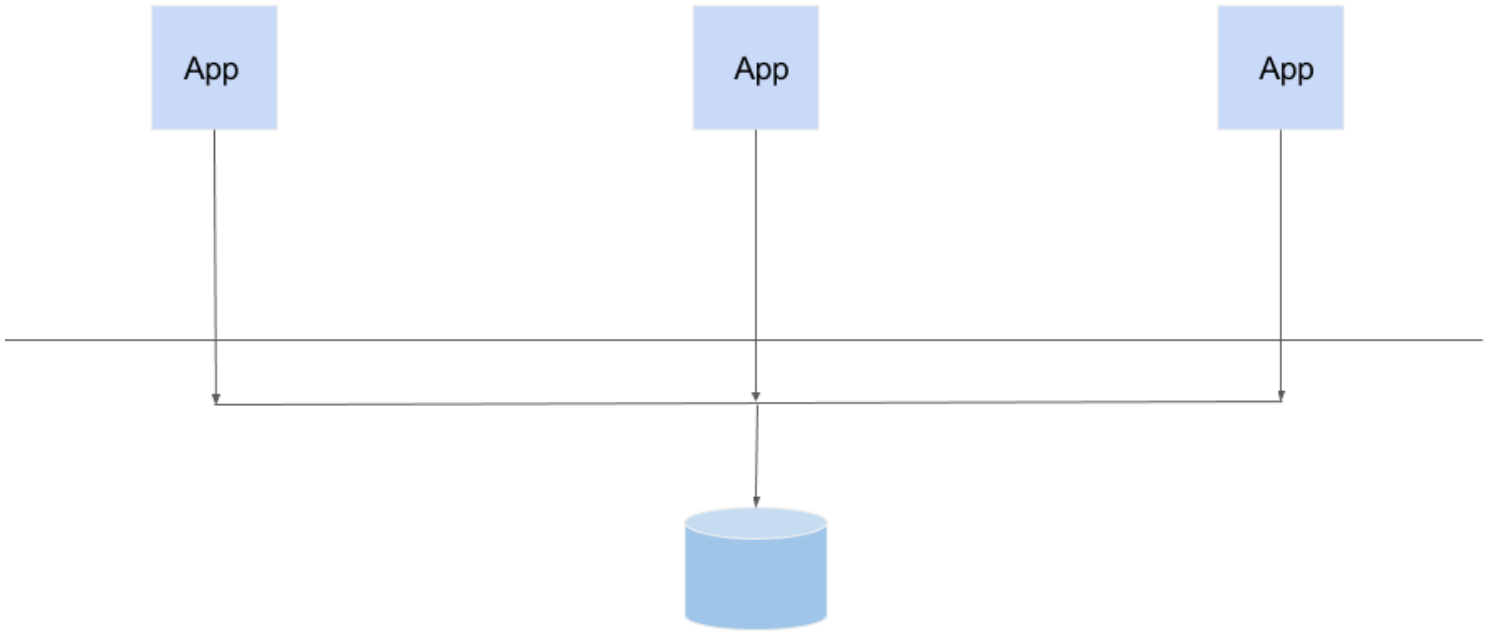
Highly-scalable Concurrent Objects

Deepthi Akkoorath[1] Annette Bieniusa[1]

[1]University of Kaiserslautern
AG Software Technology

18. Apr 2016

Concurrent Shared-Memory Systems

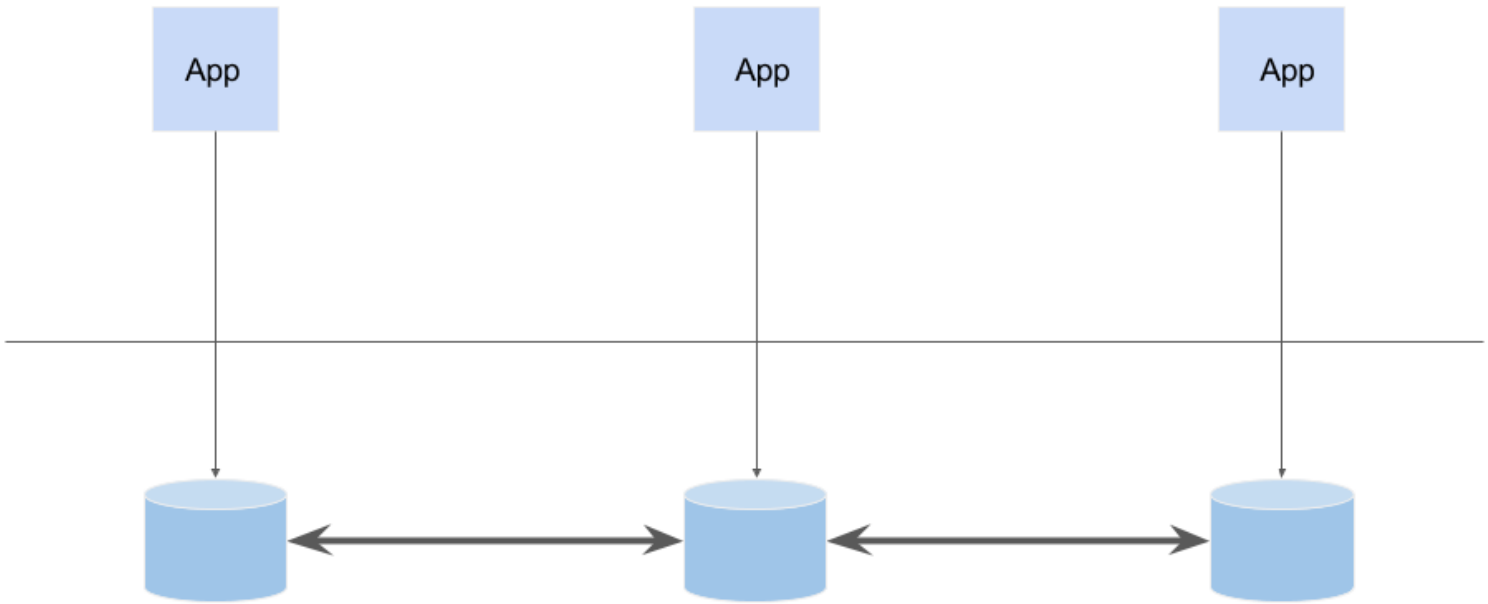


Correctness = Linearizability $\Longrightarrow$ Synchronization

Scalable?

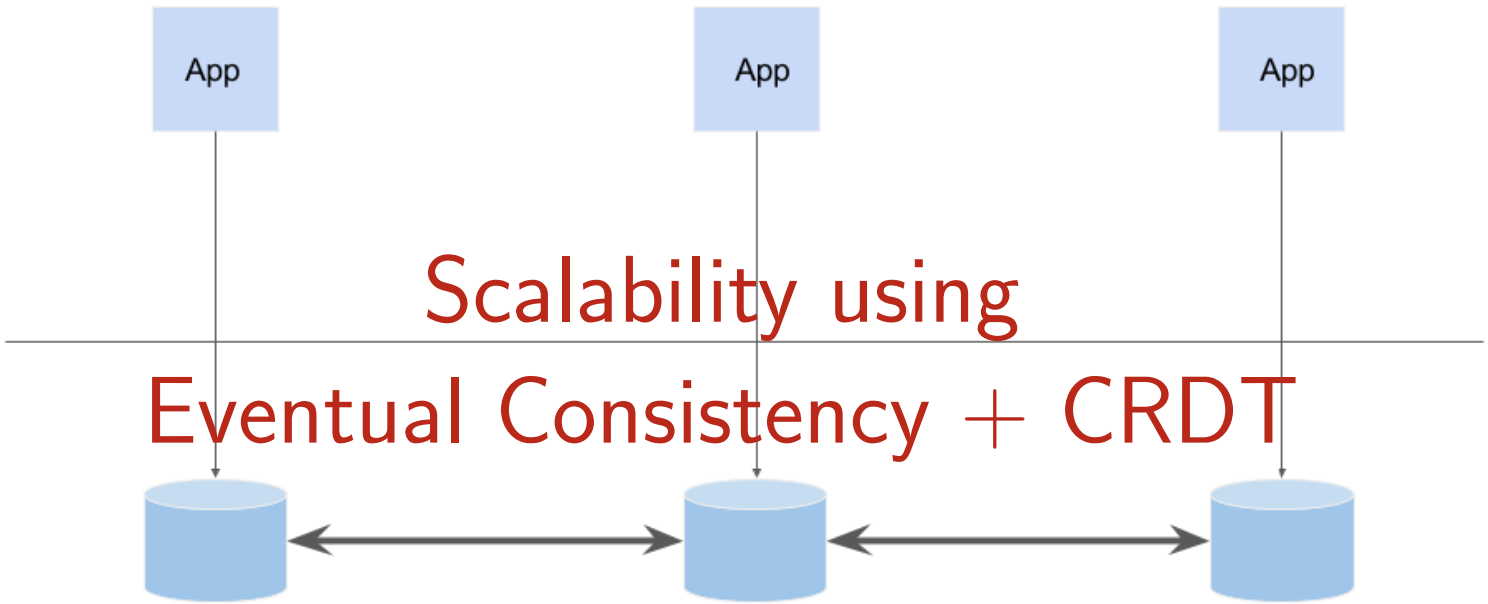
Shared Objects

Geo-Replicated Systems



Shared Objects

Geo-Replicated Systems



Shared Objects

Shared Memory Systems / Multi-core

- Many Scalable Data-structures exists
- Lock-free data-structures using Transactional Memory
- Scalable under contention?

Shared Objects

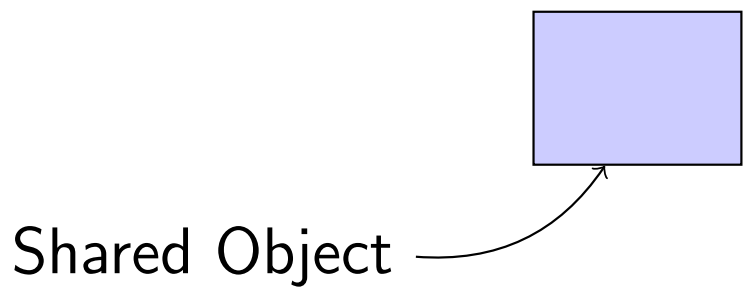
Shared Memory Systems / Multi-core

- Many Scalable Data-structures exists
- Lock-free data-structures using Transactional Memory
- Scalable under contention?

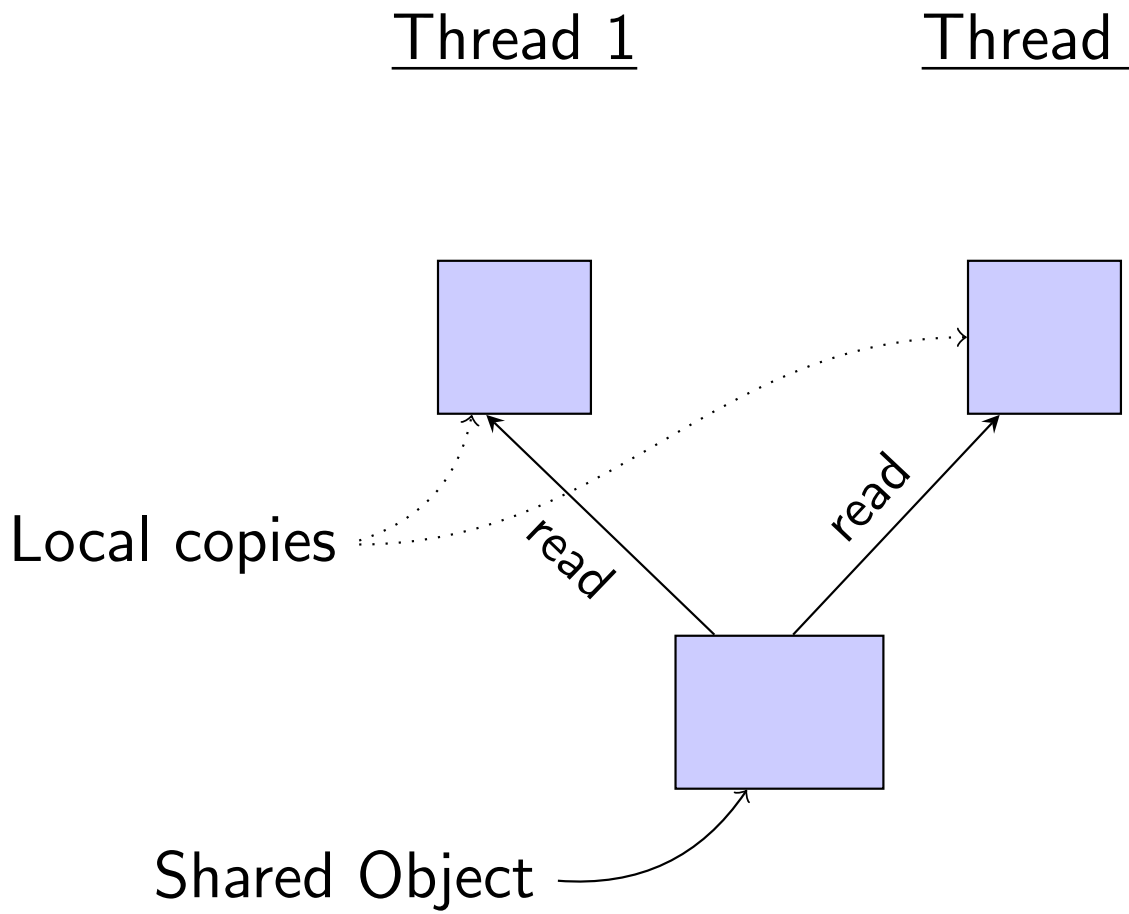
Weakening Linearizability $\Longrightarrow$ Scalability?

Mergeable Objects in Shared Memory Systems

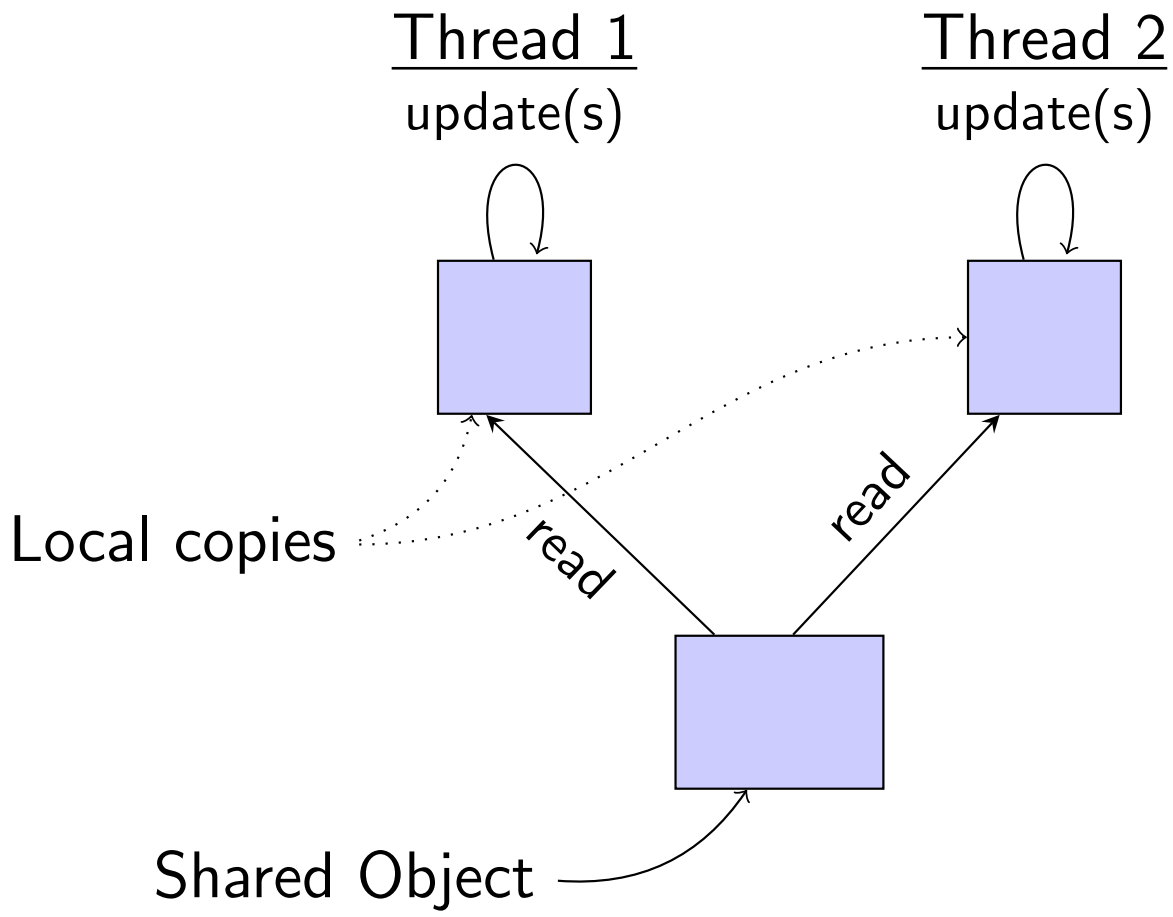
Thread 1 Thread 2



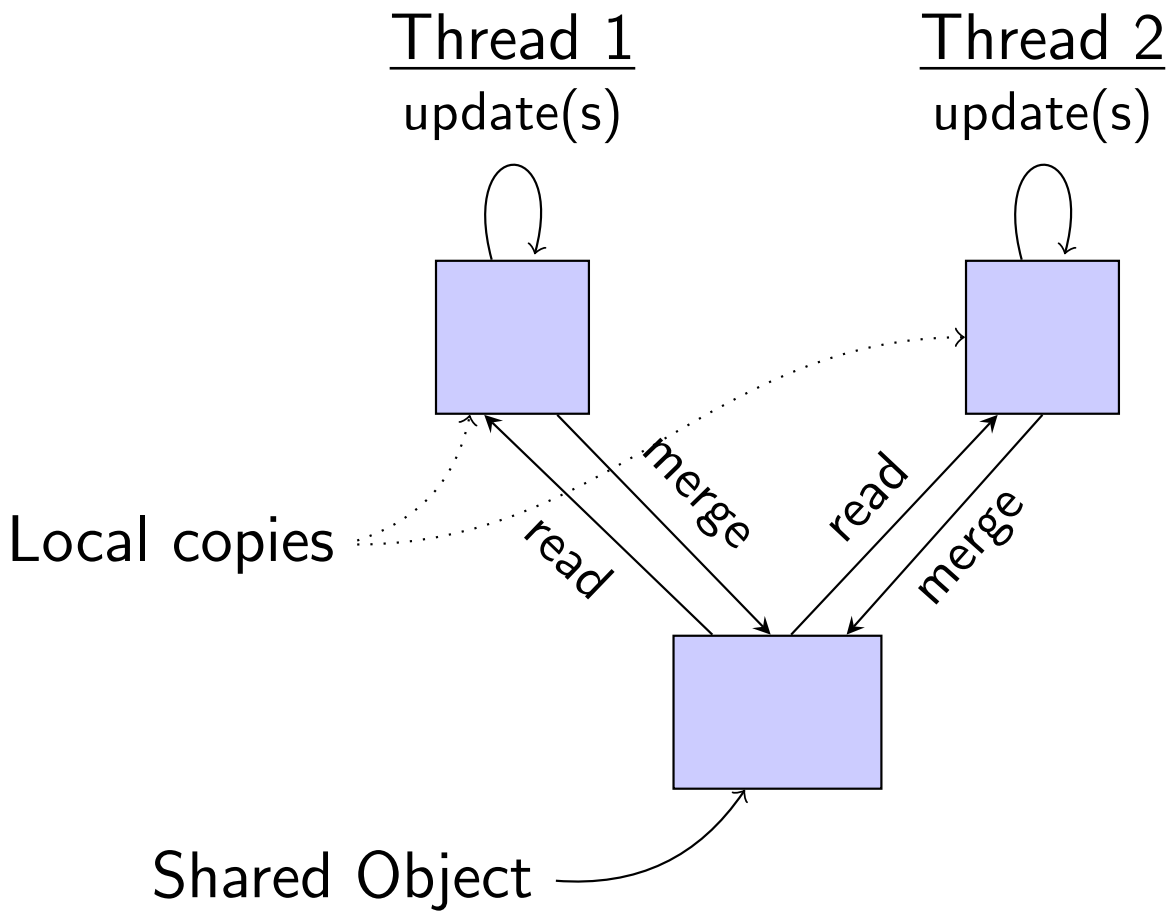
Mergeable Objects in Shared Memory Systems



Mergeable Objects in Shared Memory Systems

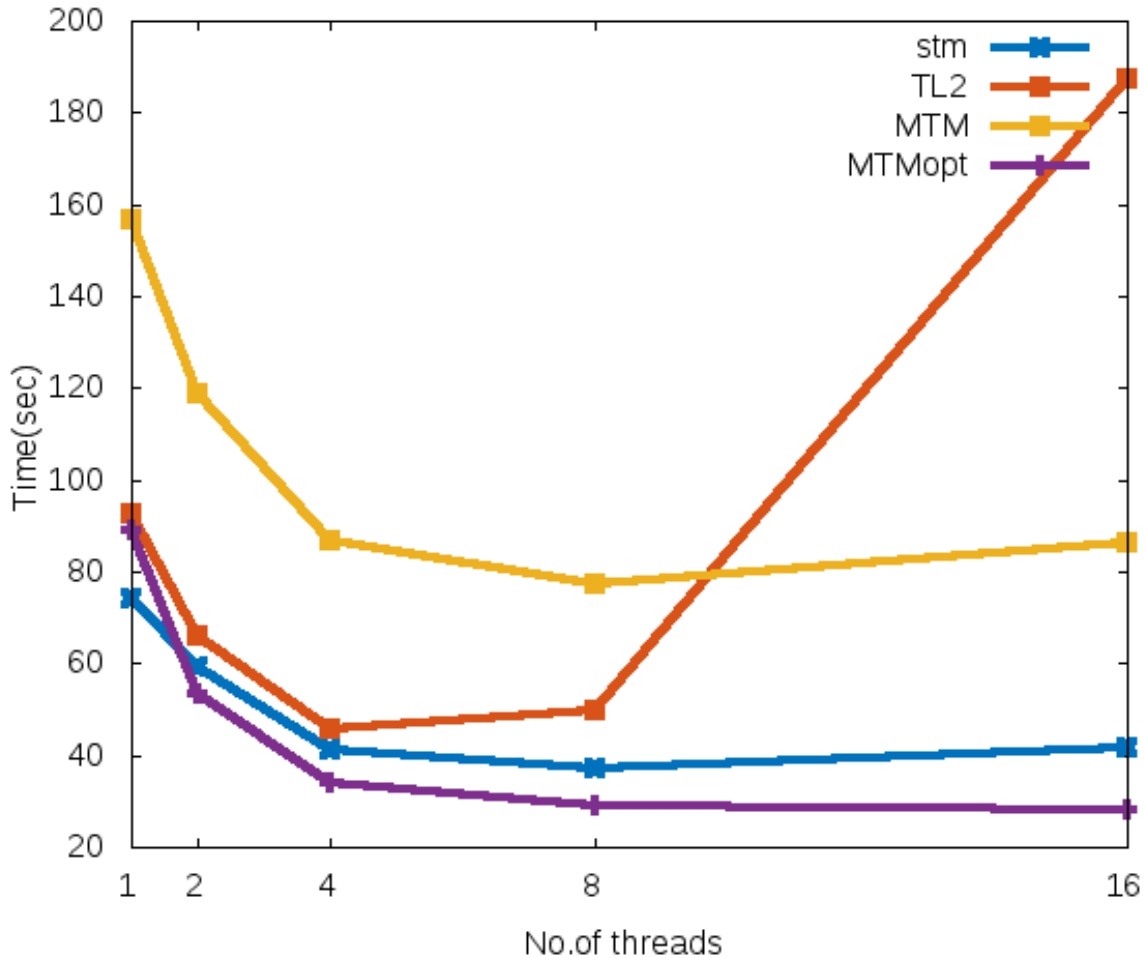


Mergeable Objects in Shared Memory Systems



Mergeable Transactions

Mergeable Objects in STM



CRDTs as Mergeable Objects

- Example: G-Set
  - a Set
  - Merge = union of two sets
- Example: G-Counter
  - A vector
  - Merge = max of each element in the vector

CRDTs as Mergeable Objects

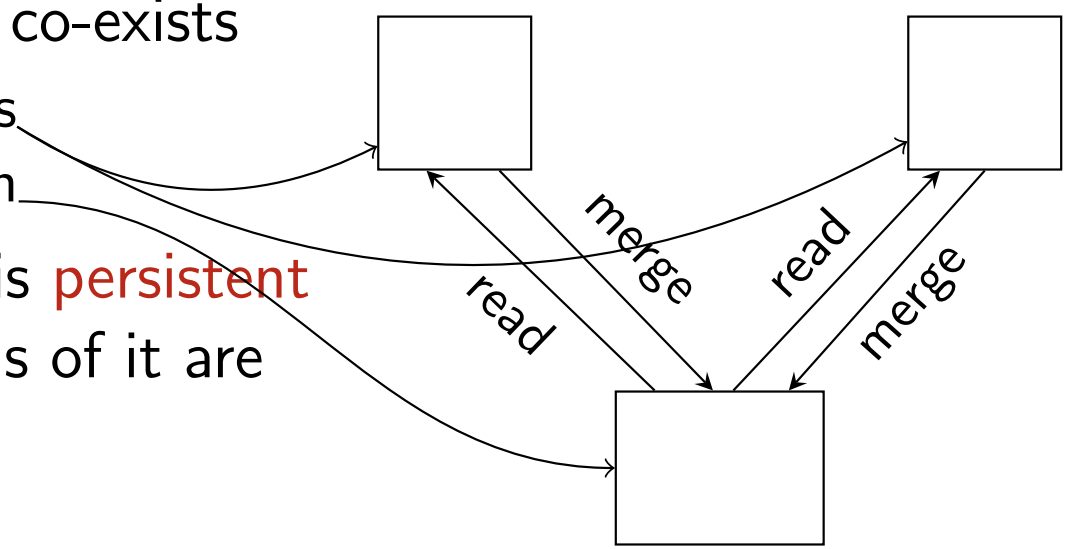
- Example: G-Set
  - a Set
  - Merge = union of two sets
- Example: G-Counter
  - A vector
  - Merge = max of each element in the vector

CRDT Merge is Expensive

Properties of Mergeable Objects

Persistence

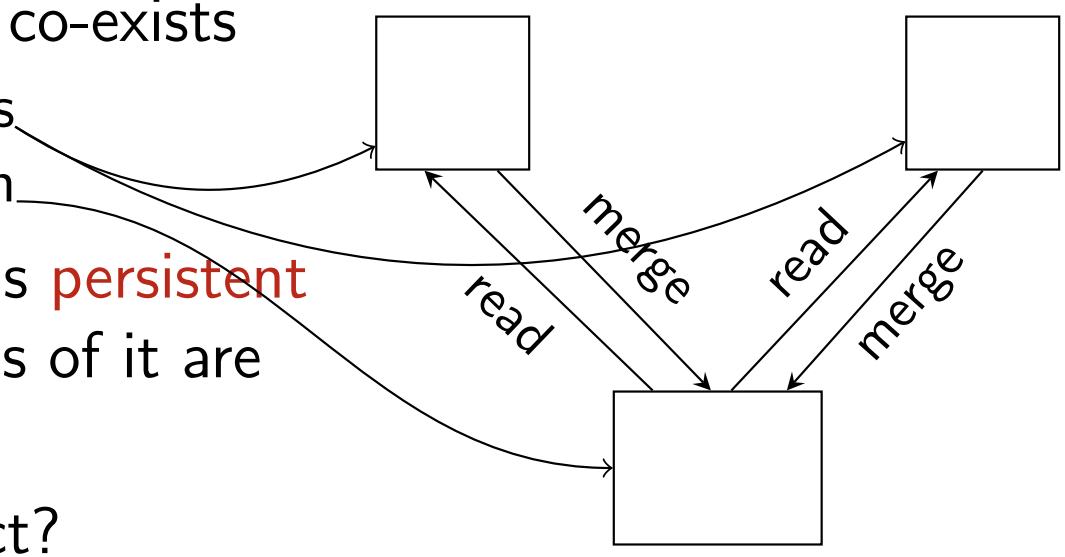
- Multiple Versions co-exists
  - Local Versions
  - Global Version
- A data structure is persistent if multiple versions of it are accessible



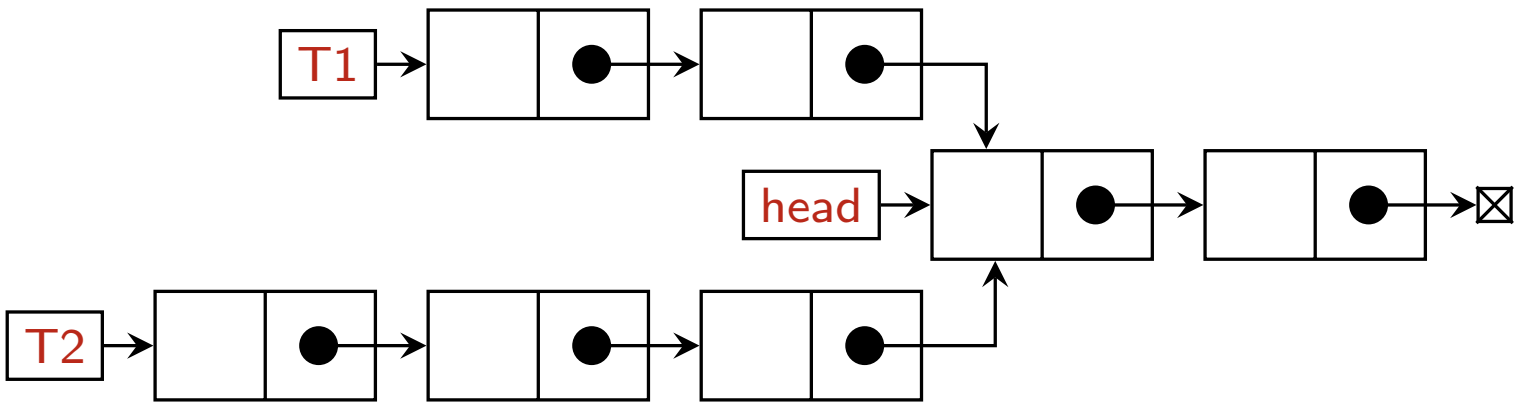
Properties of Mergeable Objects

Persistence

- Multiple Versions co-exists
  - Local Versions
  - Global Version
- A data structure is persistent if multiple versions of it are accessible
- Copy entire Object?



Persistence in List



Mergeability

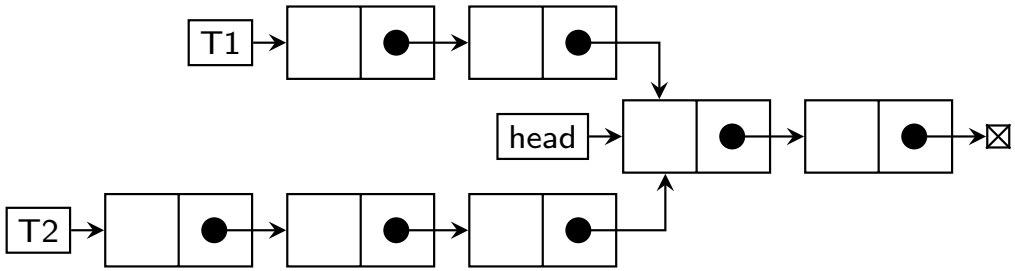
- Semantic Mergeability
  - Exploit object semantics (e.g. idempotence, commutativity) to obtain merge operation
  - Similar to CRDTs [Shapiro et. al '12]
- Structural Mergeability
  - How efficiently two versions can be merged
  - Share (parts of) the data structure between concurrent threads
  - Merge by modifying the data structure

Mergeable Counter

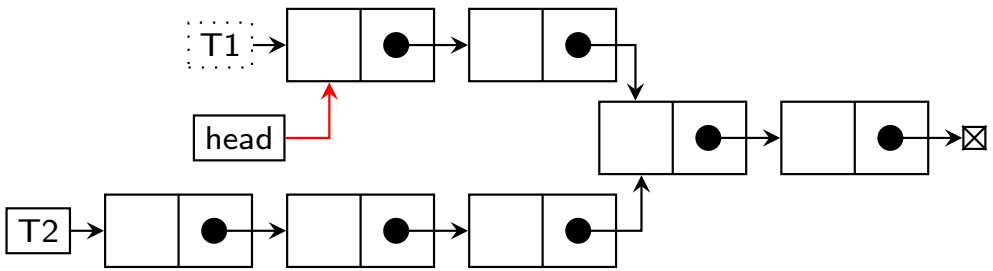
- 2 Integers: (G,L)
- increment = (G, L+1)
- merge (G,0) (G', L) = (G+L, 0)

- Persistence by "Copy object"
- Semantic Merge by arithmetic properties

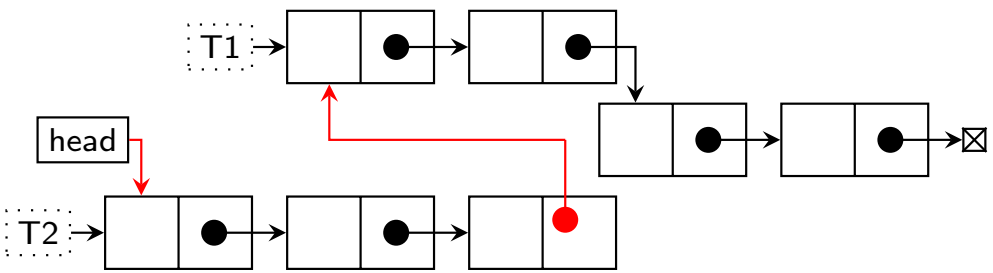
Add only Bag



After $T1$ commits:

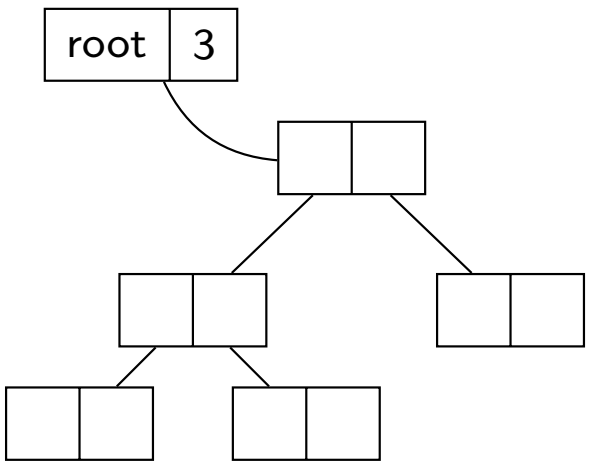


After $T2$ commits:



OR-Set

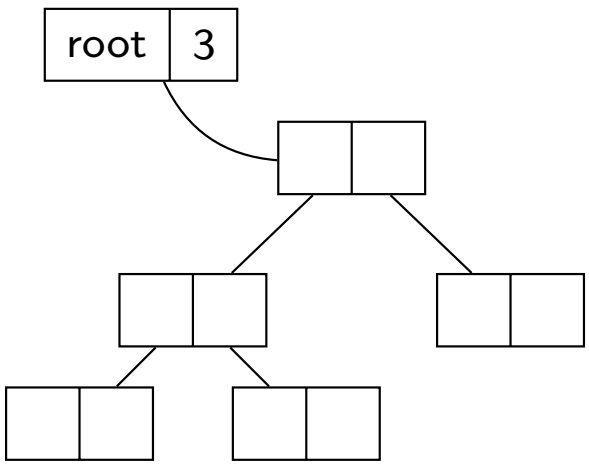
Binary Search Tree



- Node = (Val, Version info)
- Version info = $\langle first, last, removed \rangle$
-

OR-Set

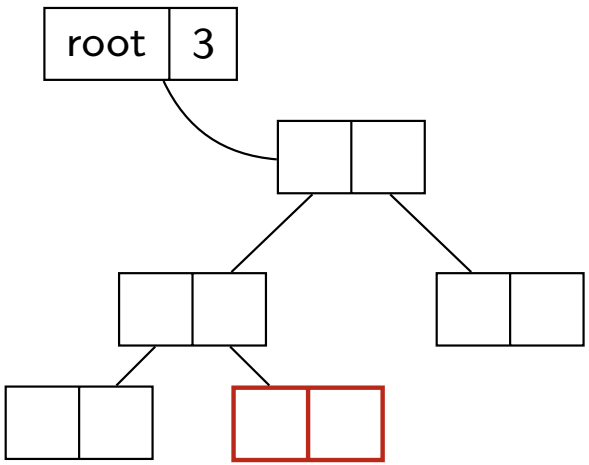
Binary Search Tree



- Node = (Val, Version info)
- Version info = $\langle first, last, removed \rangle$
- Lookup

OR-Set

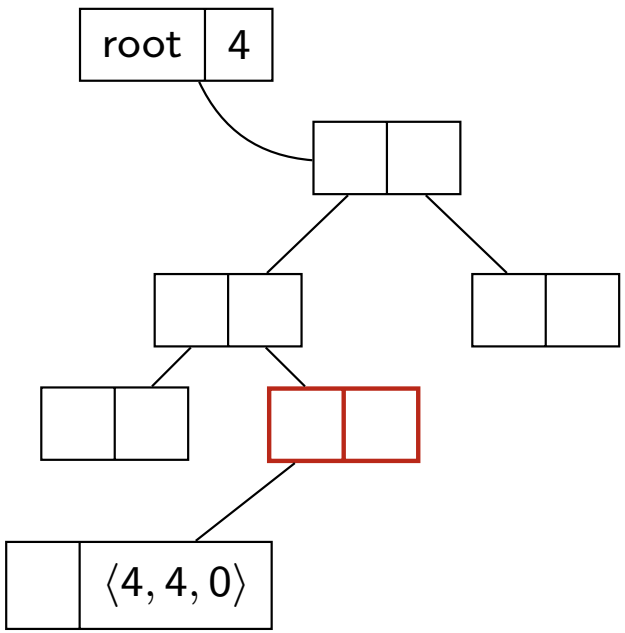
Binary Search Tree



- Node = (Val, Version info)
- Version info = $\langle first, last, removed \rangle$
- Add

OR-Set

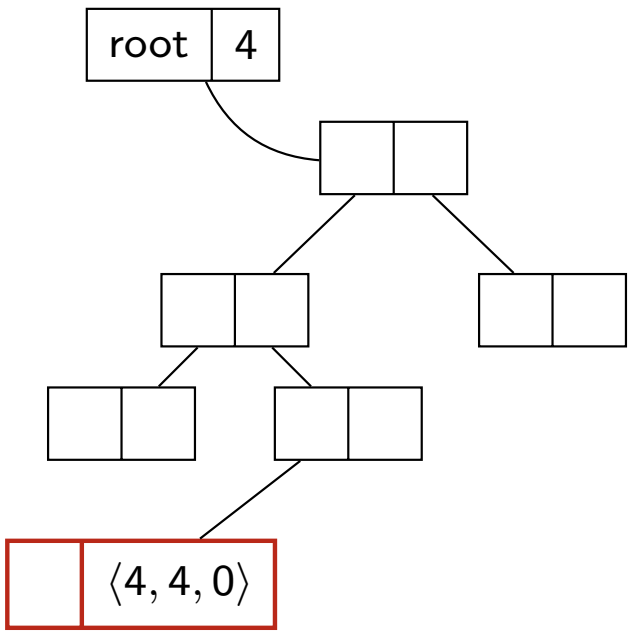
Binary Search Tree



- Node = (Val, Version info)
- Version info = $\langle first, last, removed \rangle$
- Merging Adds

OR-Set

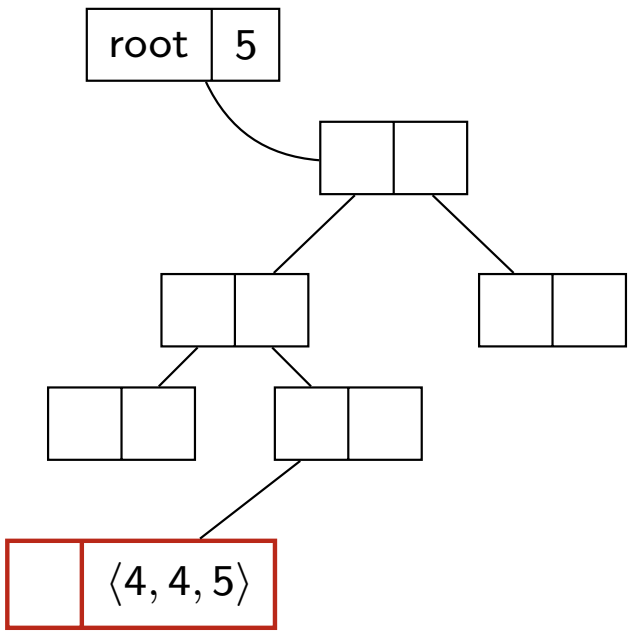
Binary Search Tree



- Node = (Val, Version info)
- Version info = $\langle first, last, removed \rangle$
- Remove

OR-Set

Binary Search Tree



- Node = (Val, Version info)
- Version info = $\langle first, last, removed \rangle$
- Merging Removes

Conclusion

- Mergeable Objects analogous to CRDTs
  - Non-linearizable
  - Meaningful merge semantics
- Properties for efficiency
  - Persistence
  - Mergeability
- Scalable?

akkoorath@cs.uni-kl.de