Versioned Boxes as the Basis for Memory Transactions

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Inesc-ID/Technical University of Lisbon

October 16, 2005

Abstract

Context

Optimistic Software Transactional Memory.

Problem

How can we reduce conflicts?

Proposals

- Use versioned boxes to hold the shared state.
- Delay reads for high-contention boxes.
- Use restartable nested transactions for high-contention sections of code.

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Outline

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Implemented as a Java library

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public class Transaction {
  public static void start();
  public static void abort();
  public static void commit();
}
```

```
public class VBox<E> {
  public VBox(E initial);
  public E get();
  public void put(E newE);
}
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```
public class Counter {
  private VBox<Long> count = new VBox<Long>(0L);

  public long getCount() {
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In Action

lastCommitted: 0
activeTxs: *empty*

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Counter counter = new Counter();
spawnThreads(counter);
```
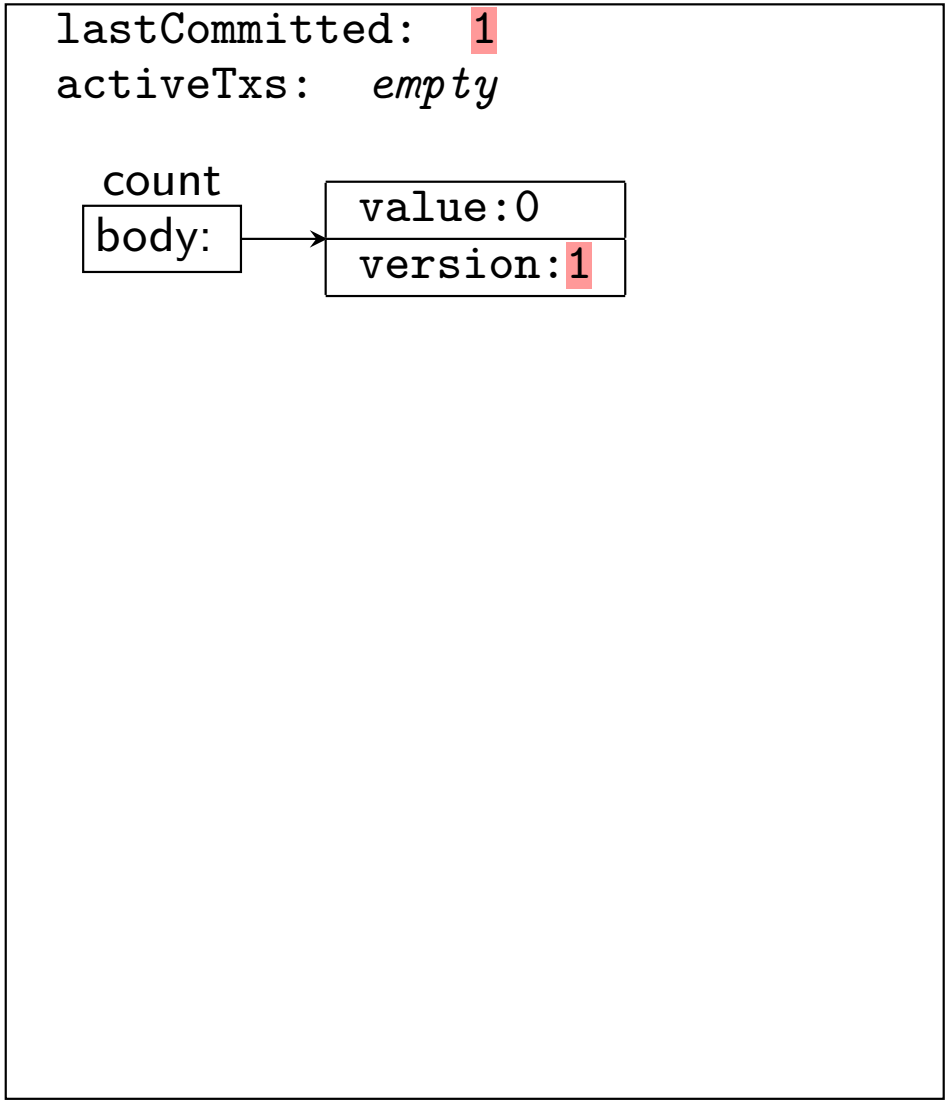

In Action

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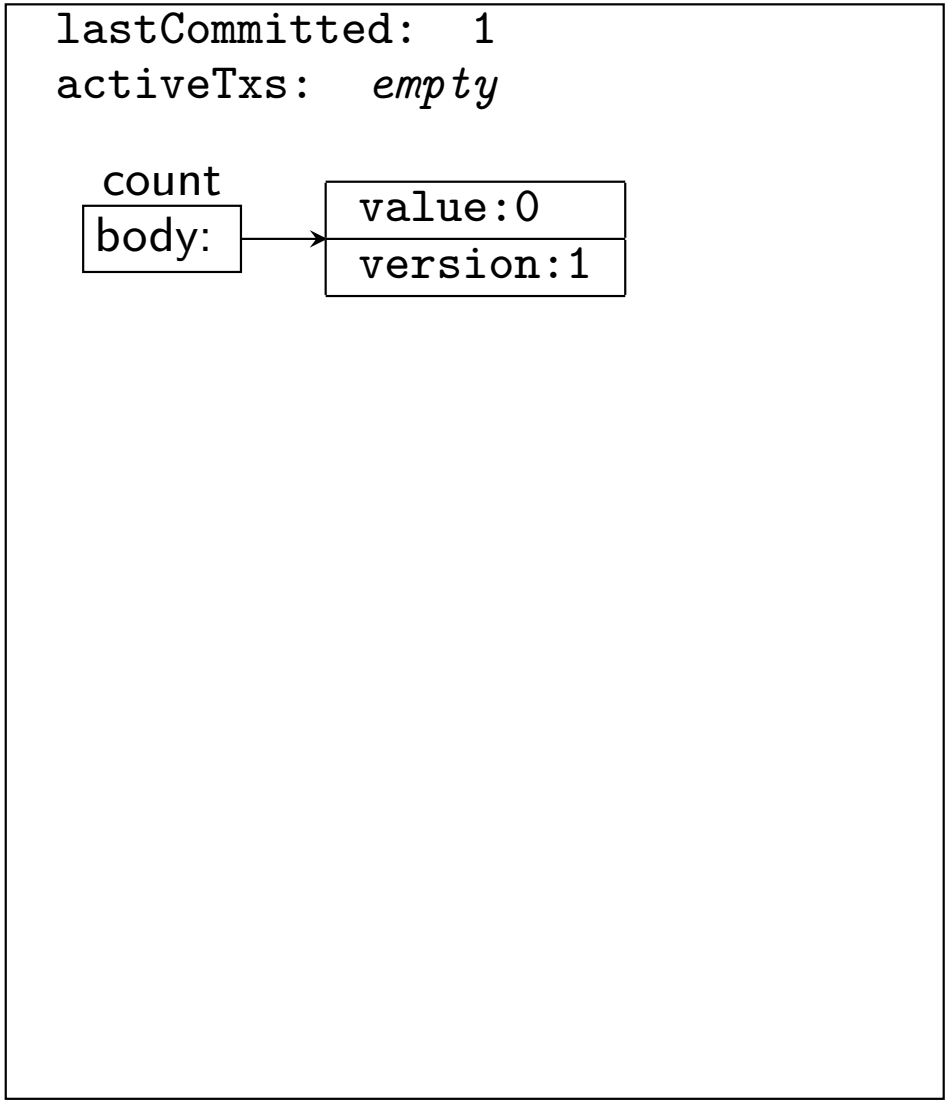


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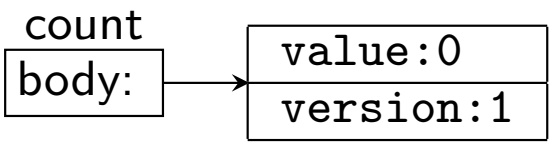

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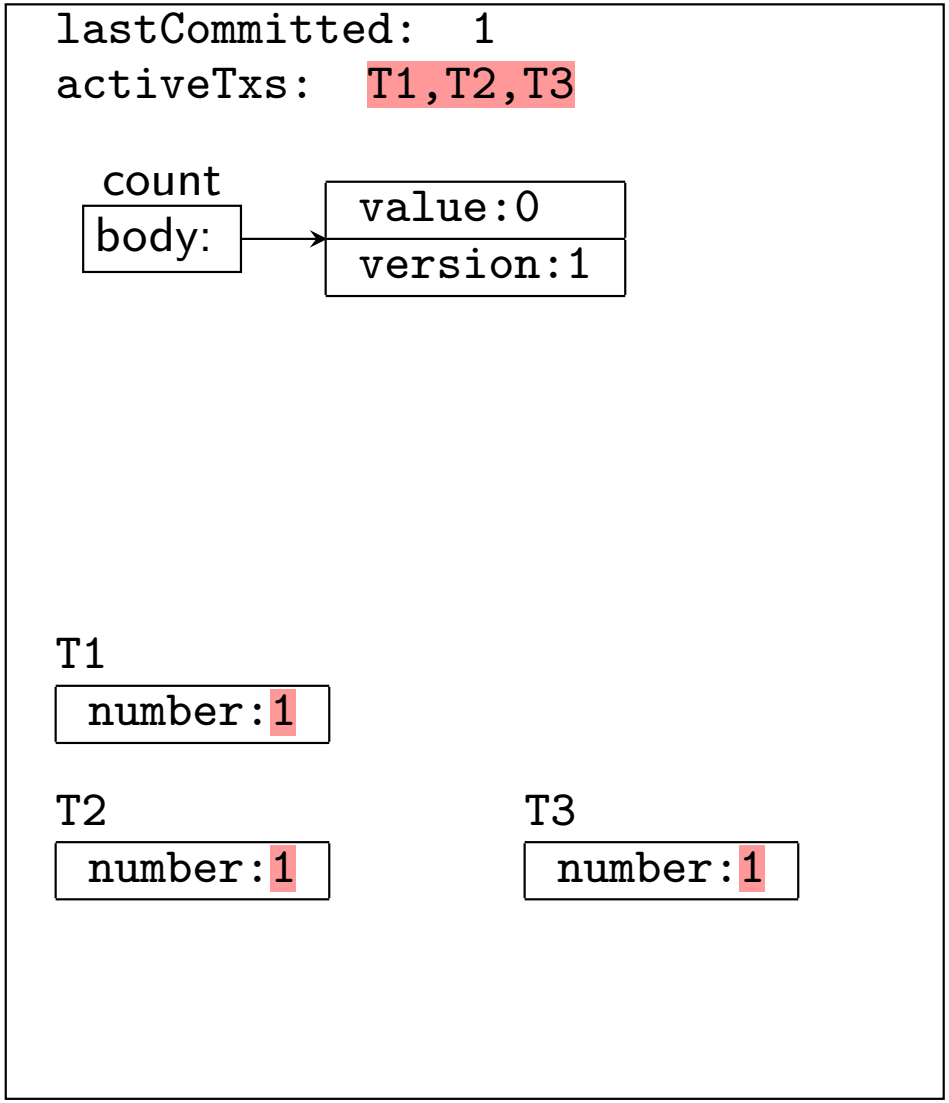

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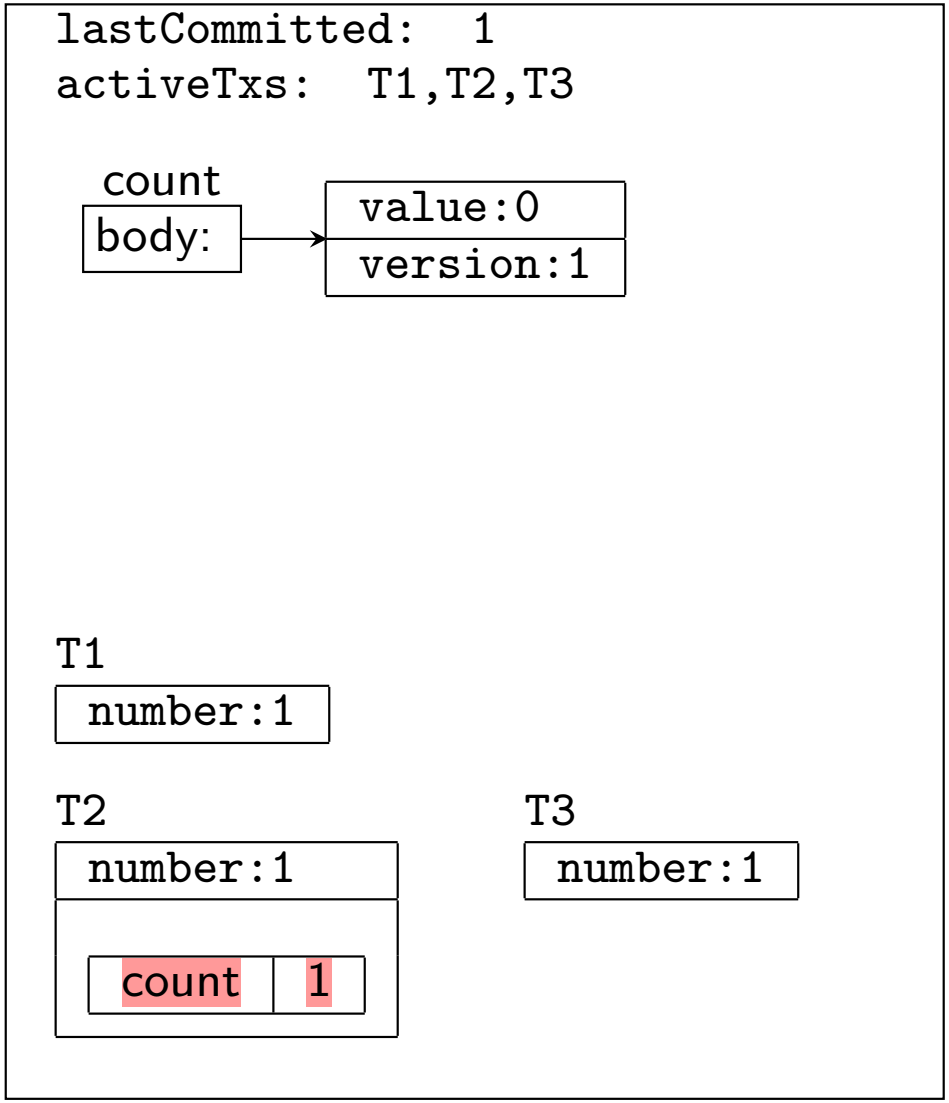

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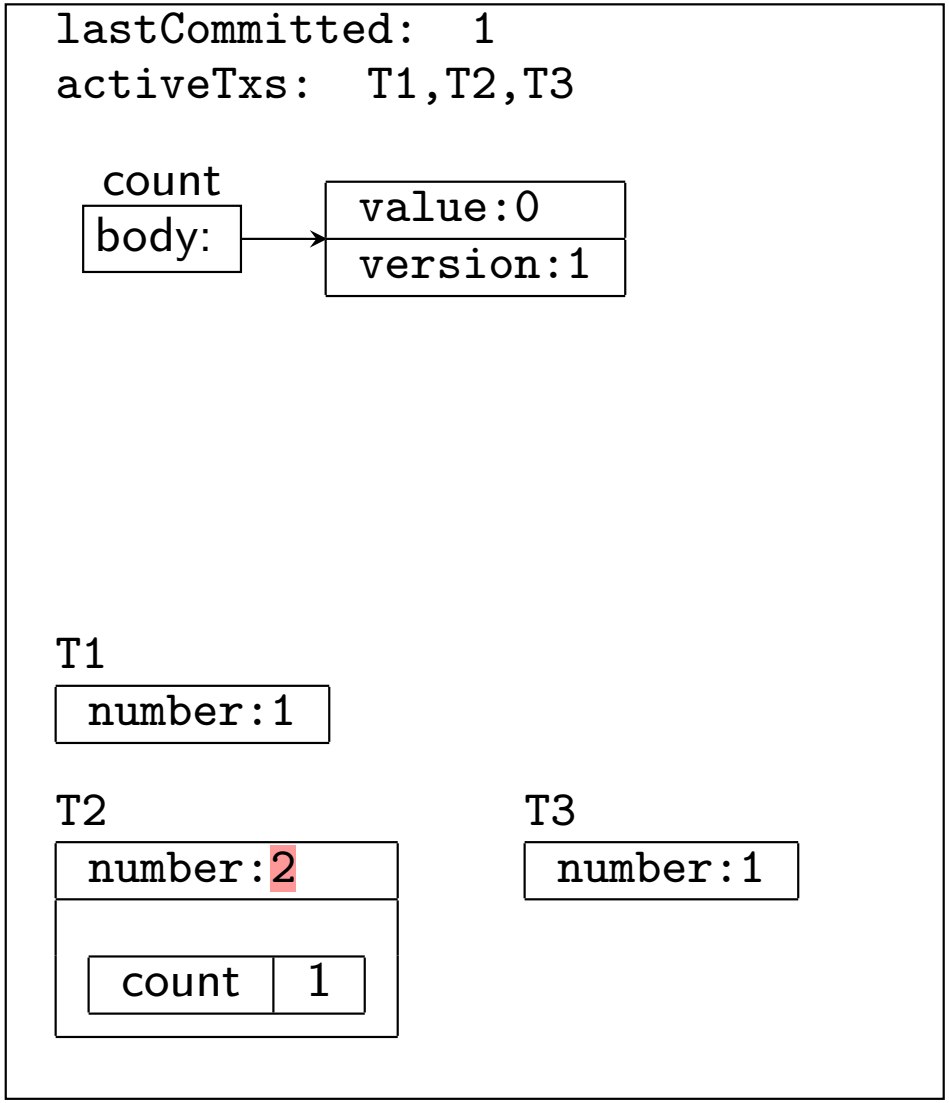

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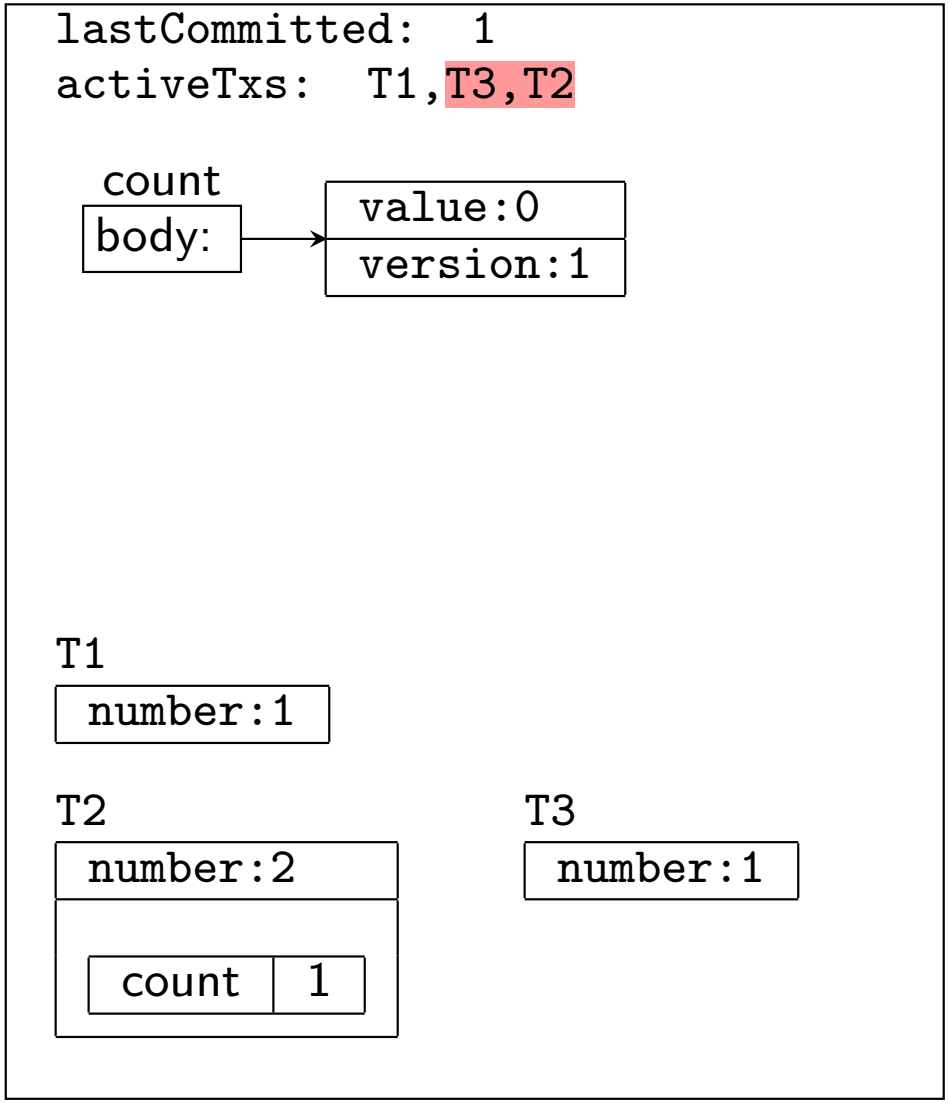

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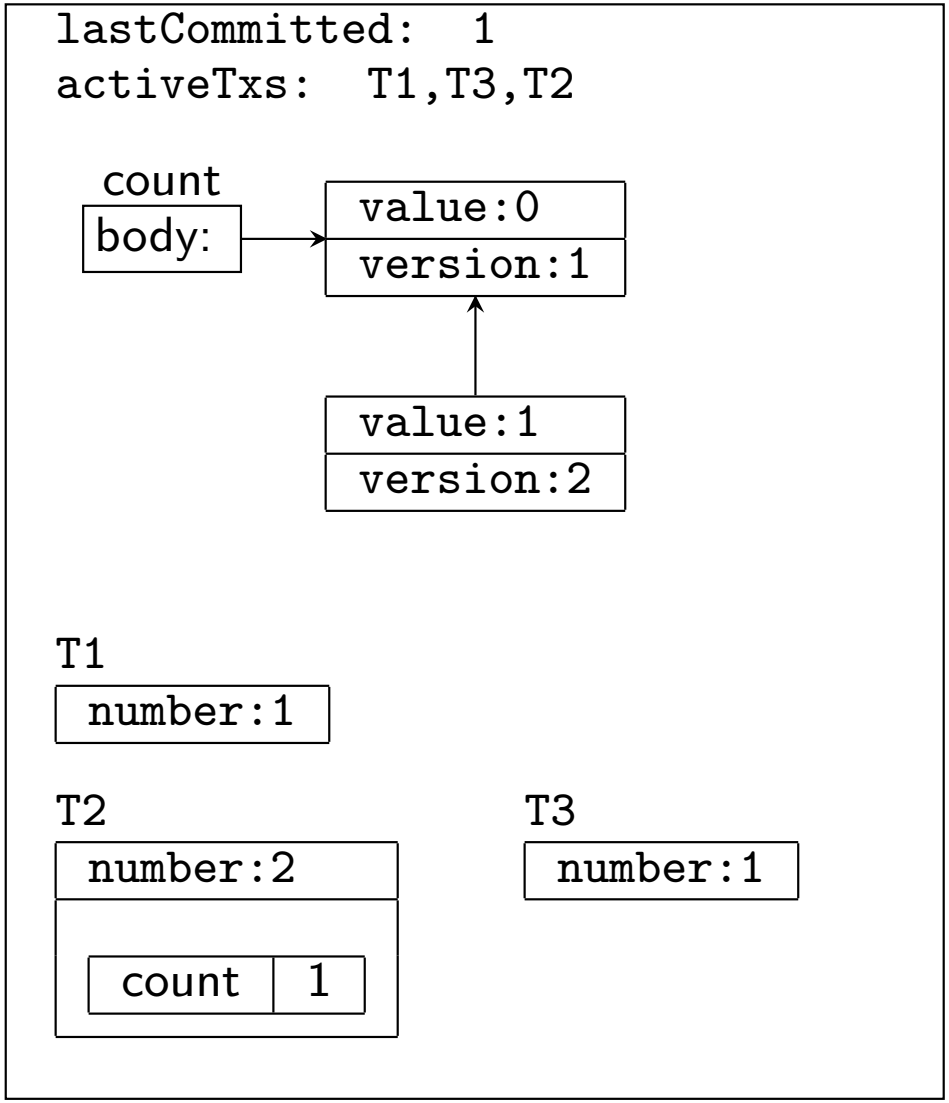

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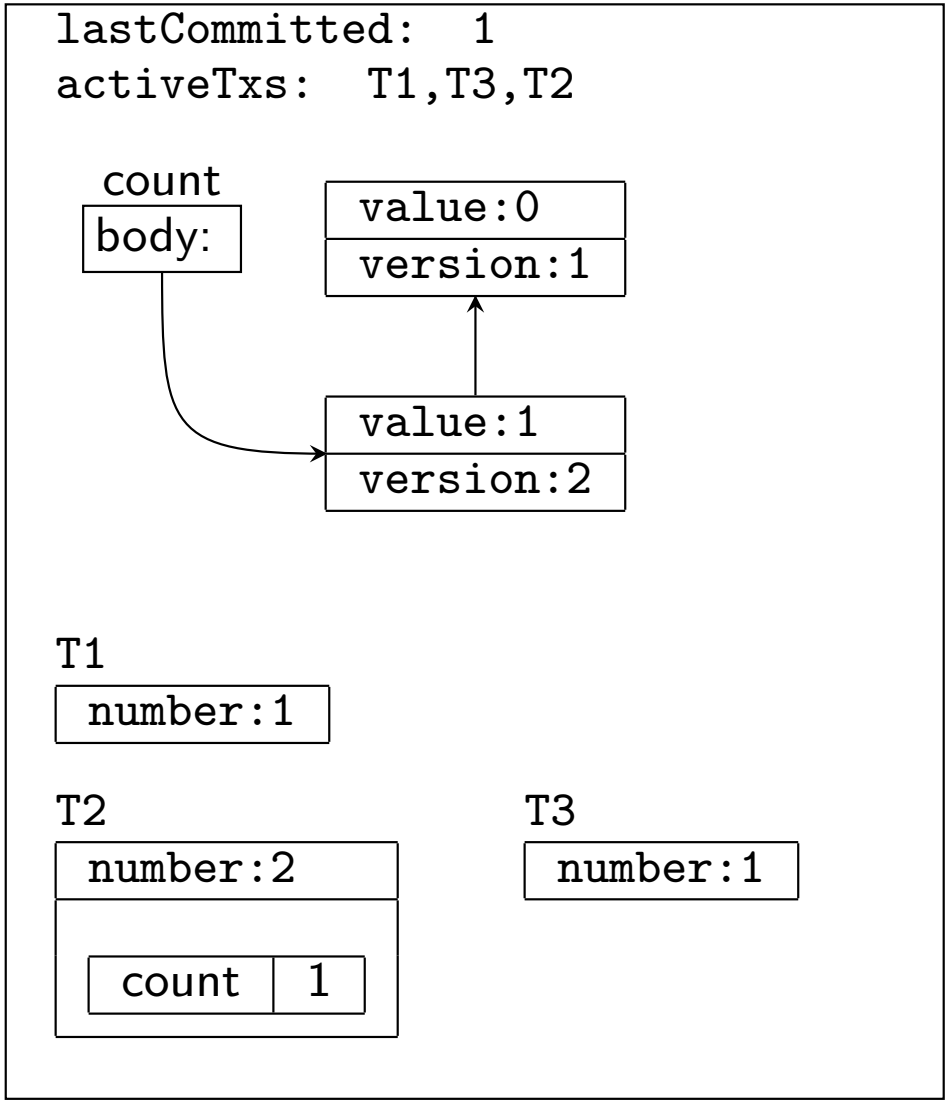

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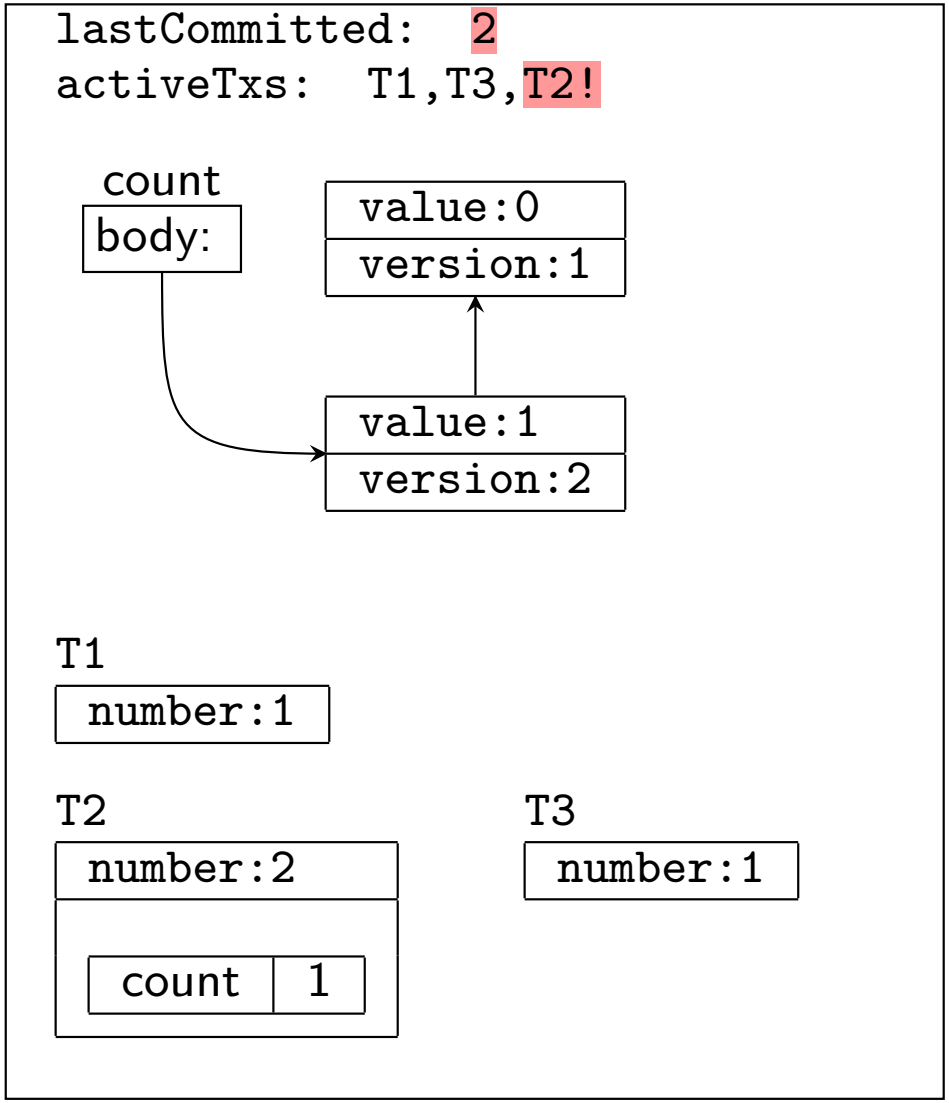

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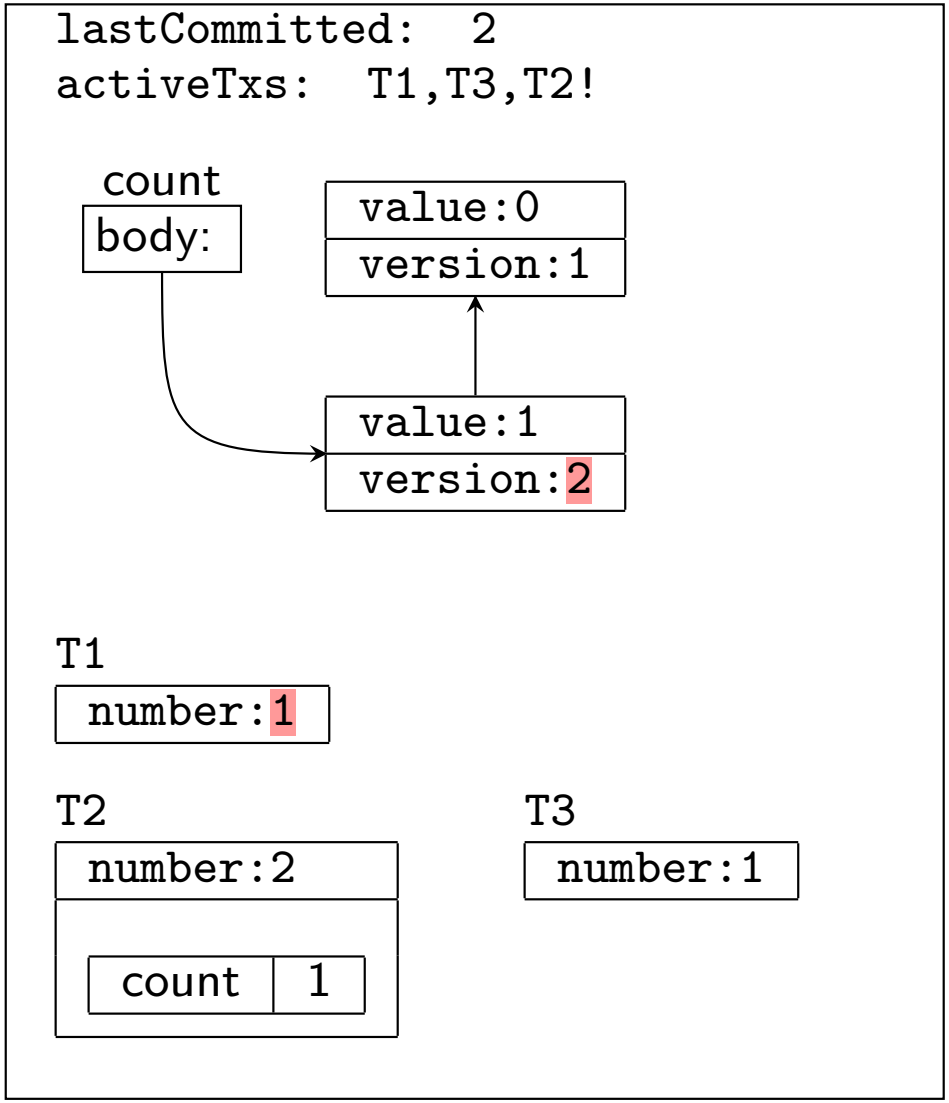

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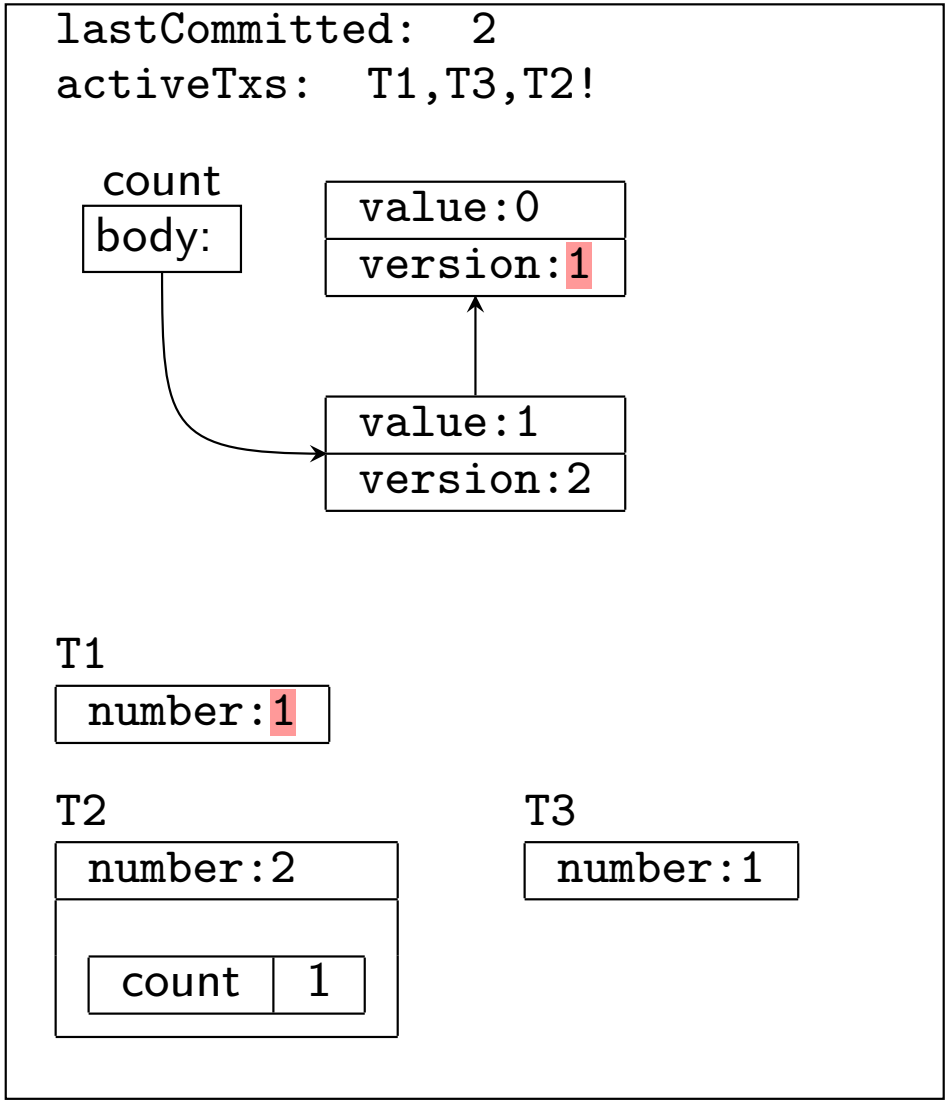

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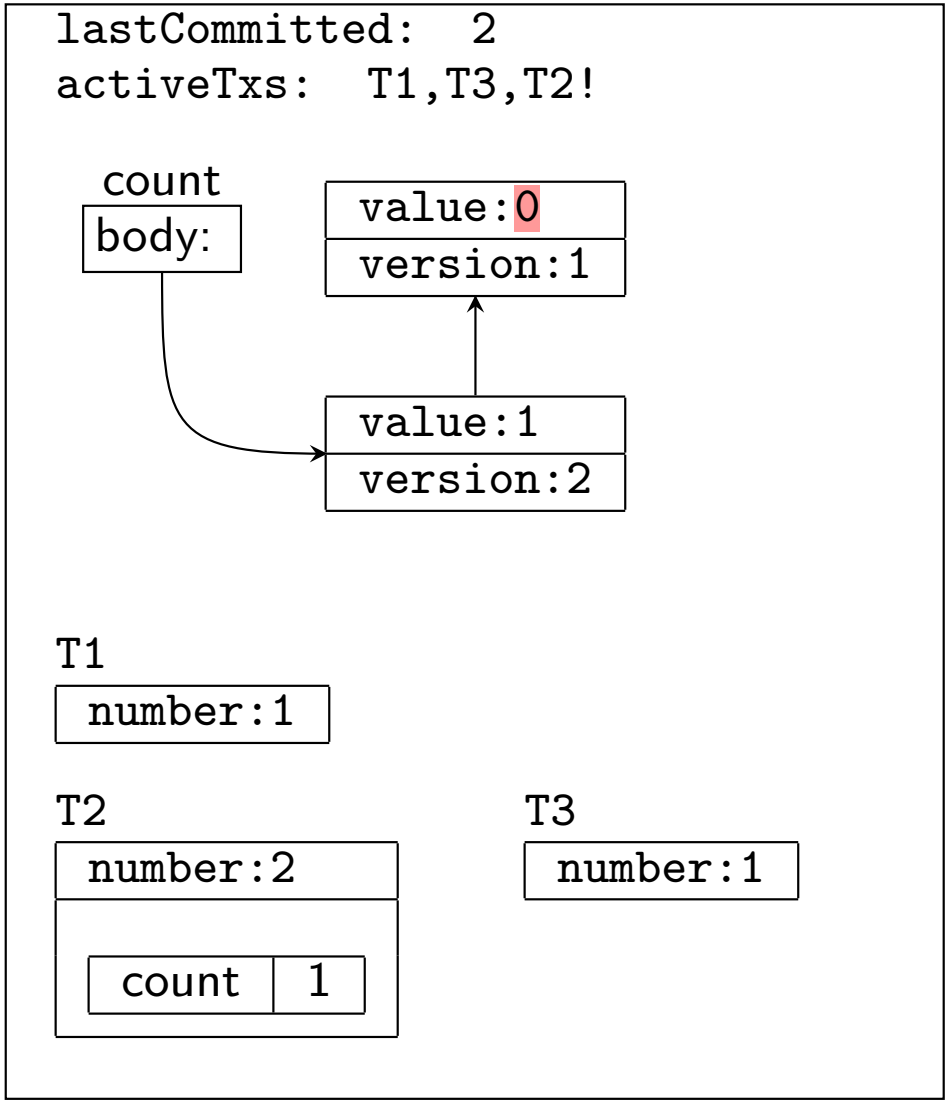

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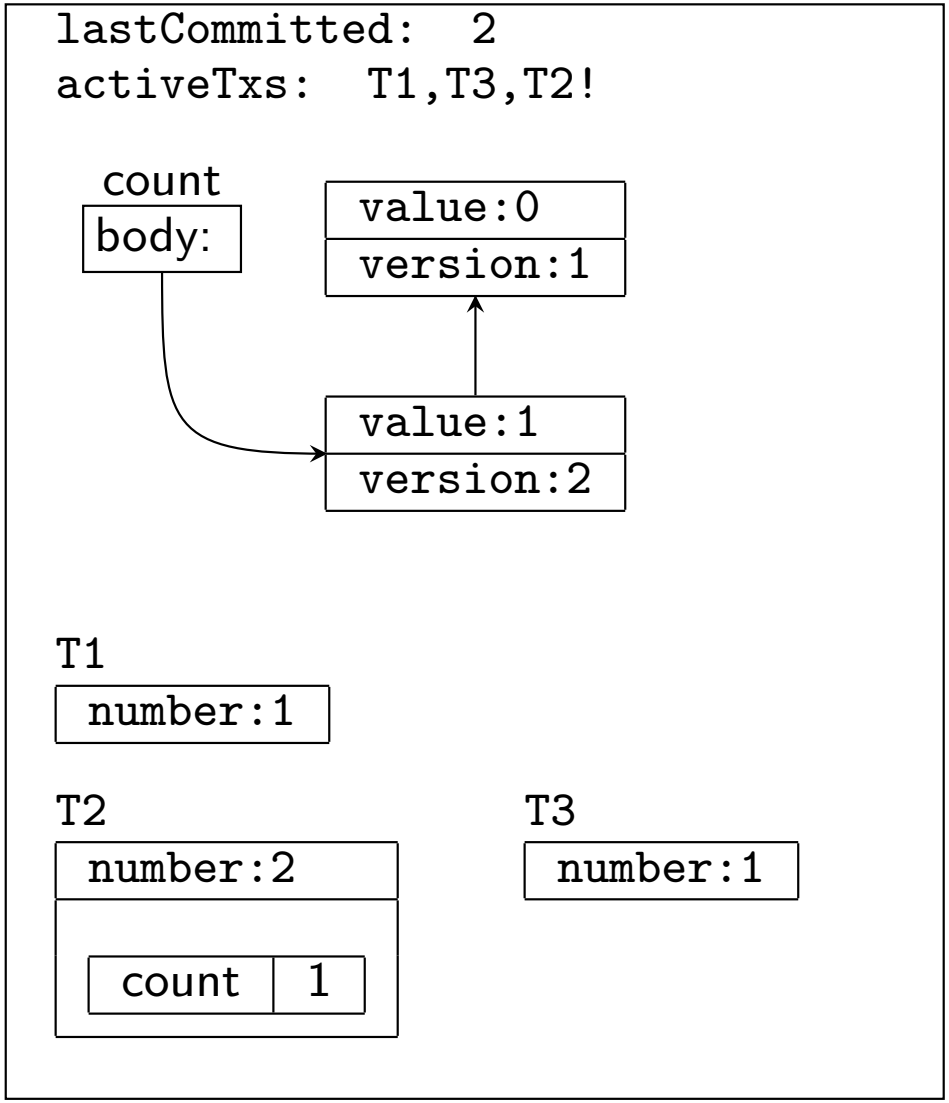

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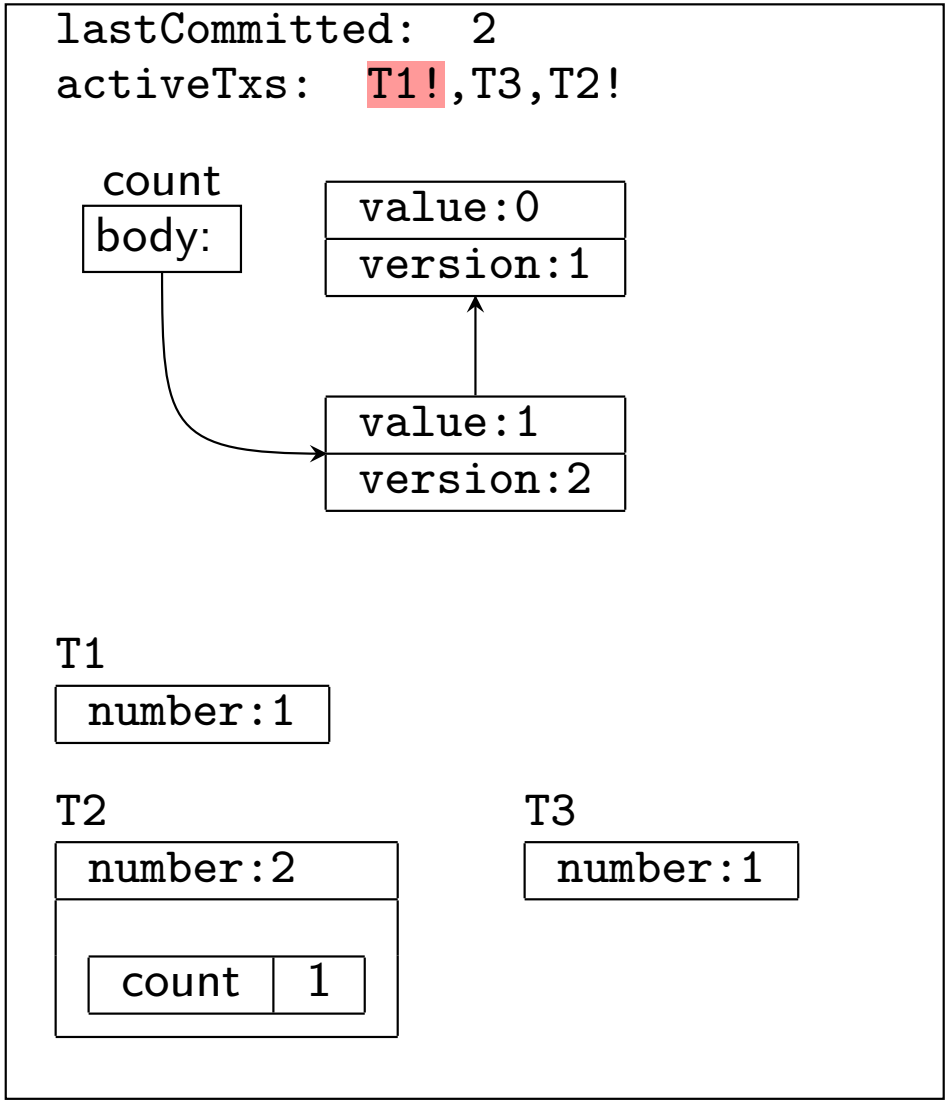

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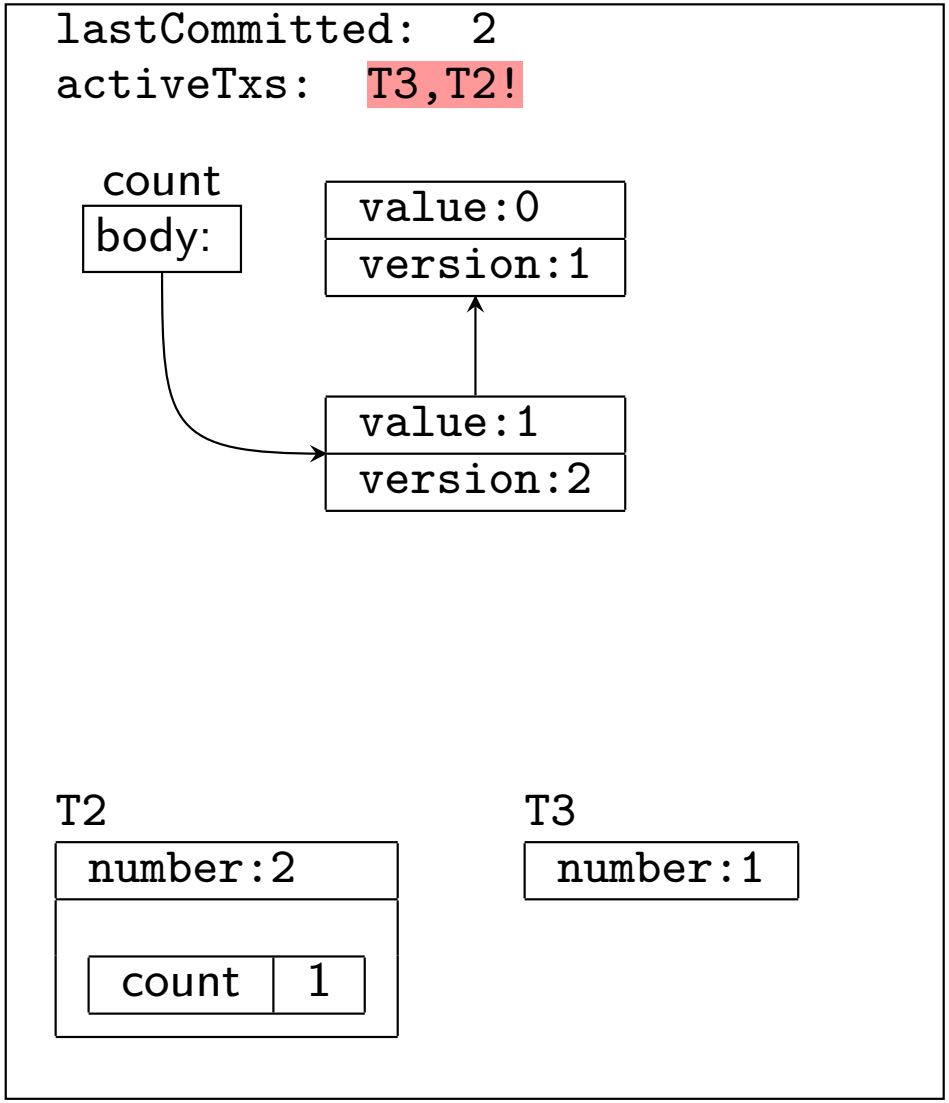

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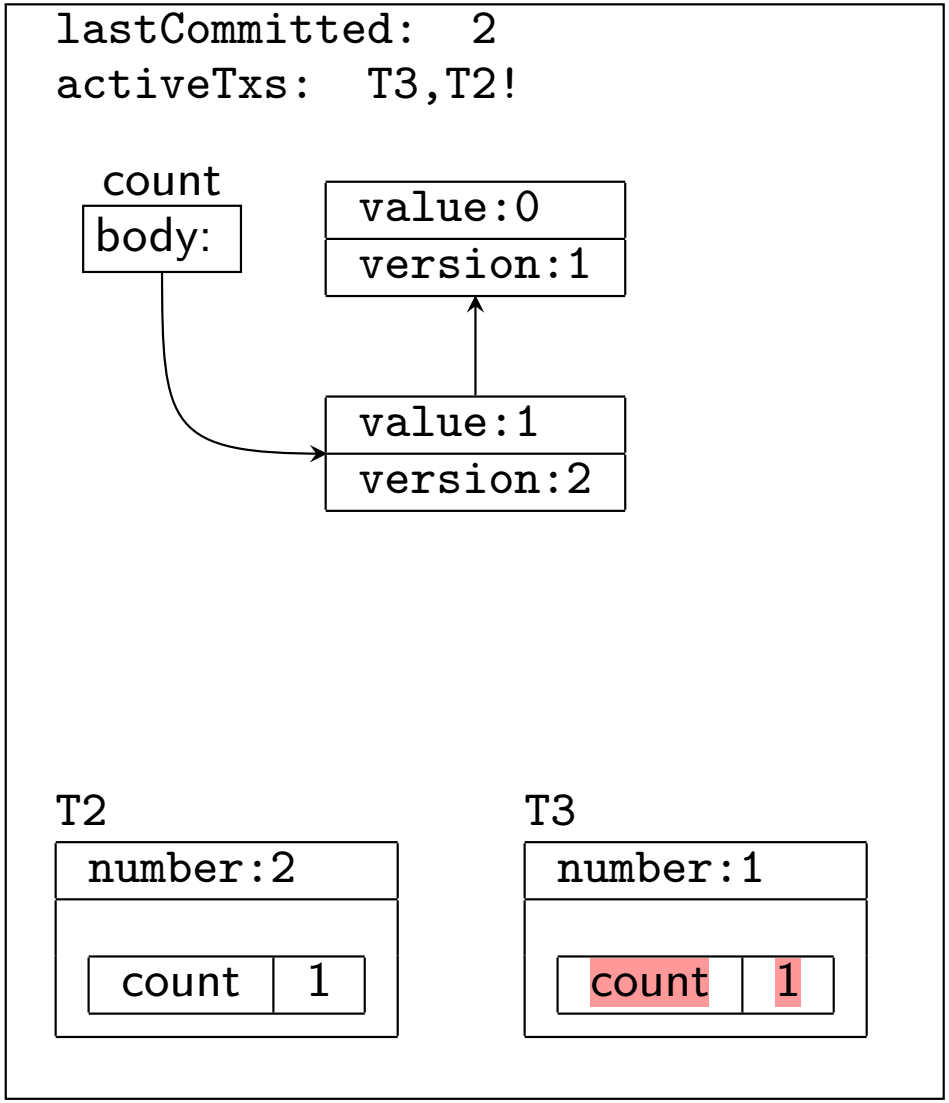

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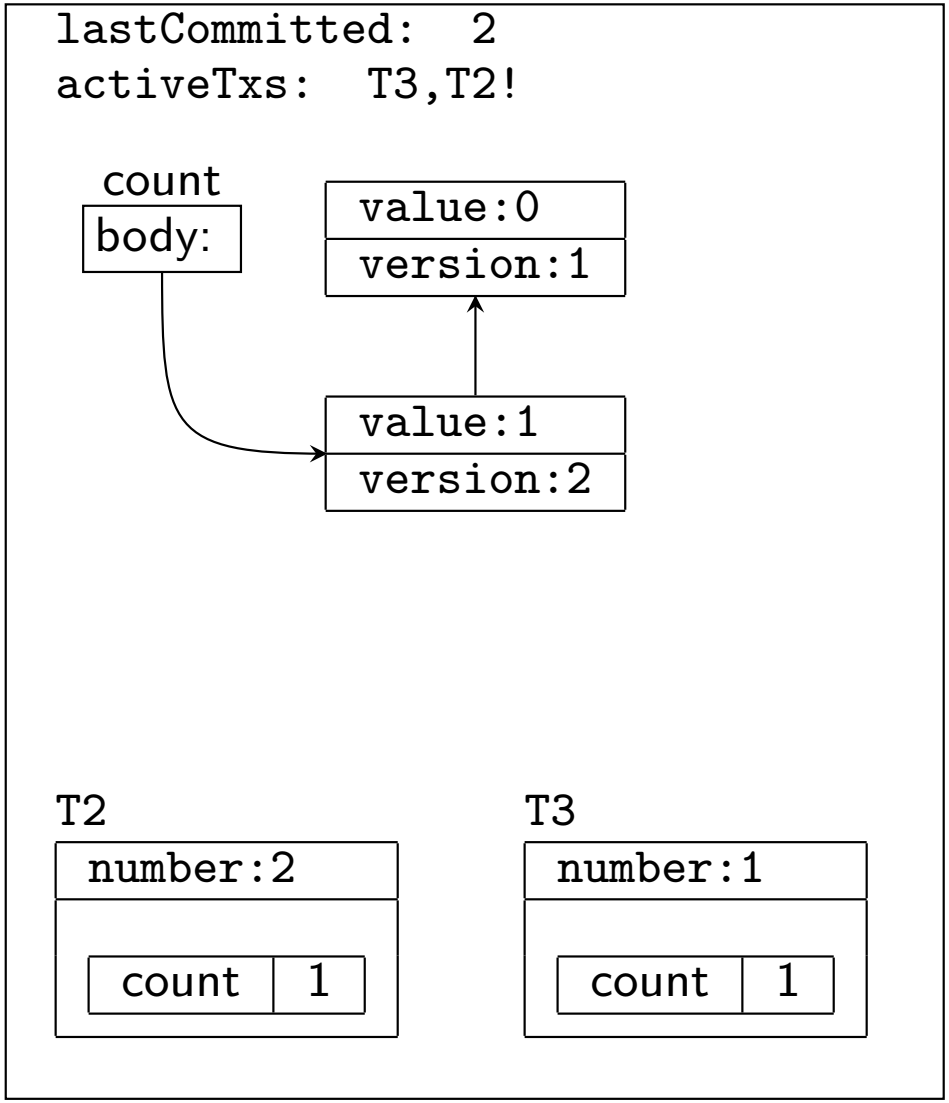

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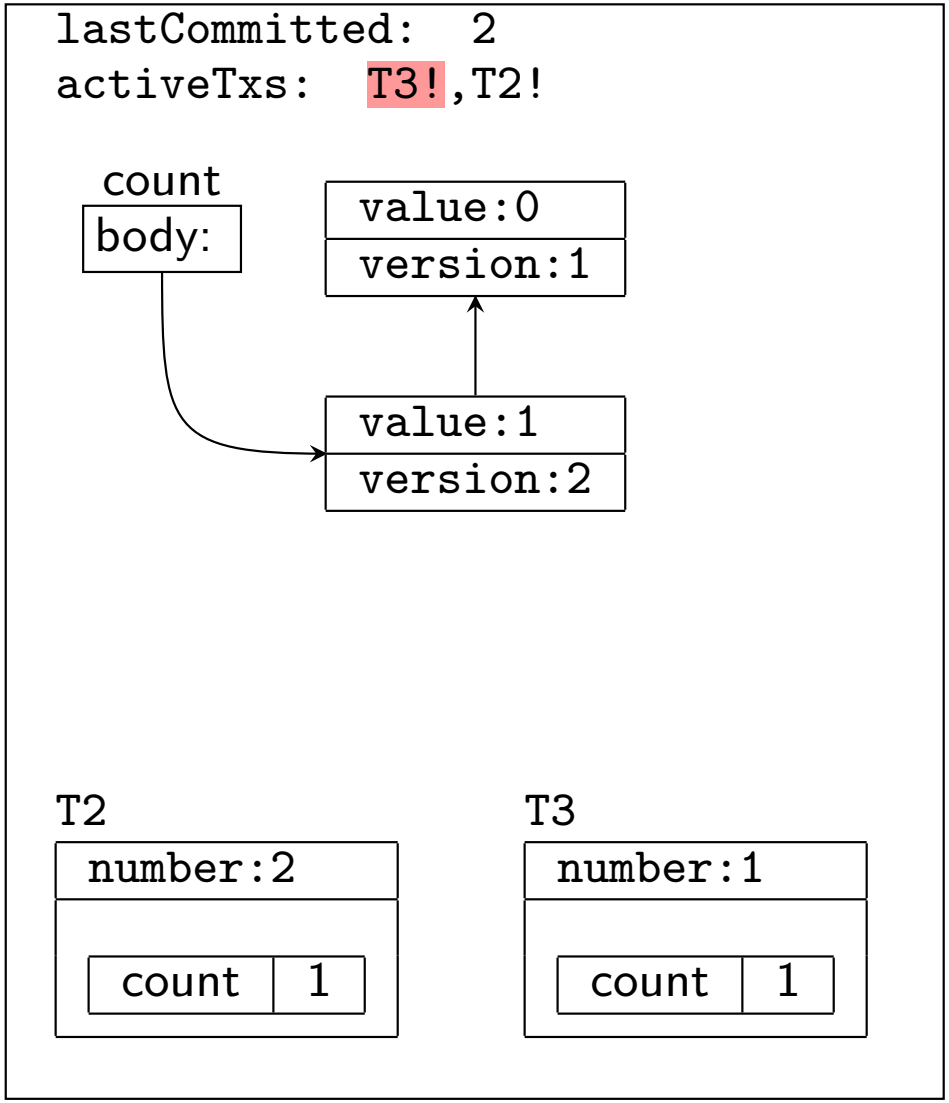

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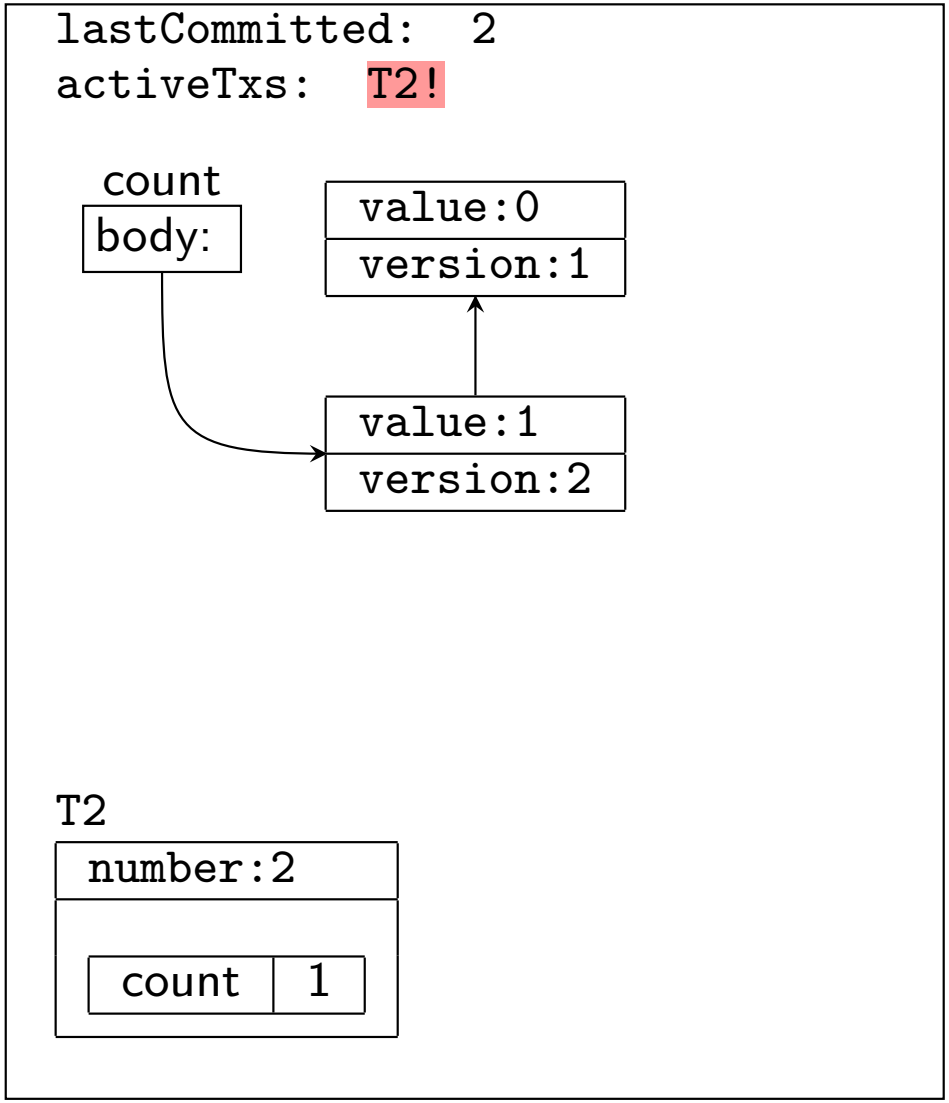

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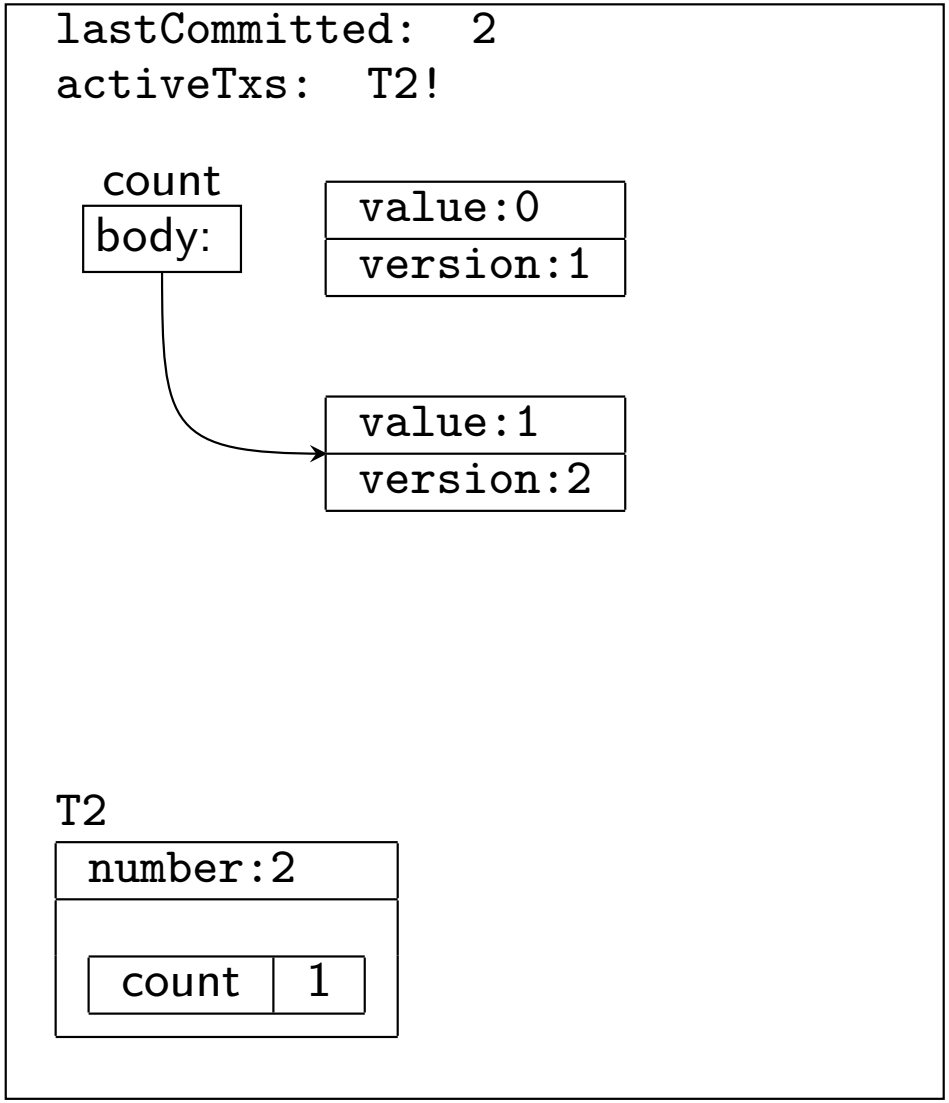

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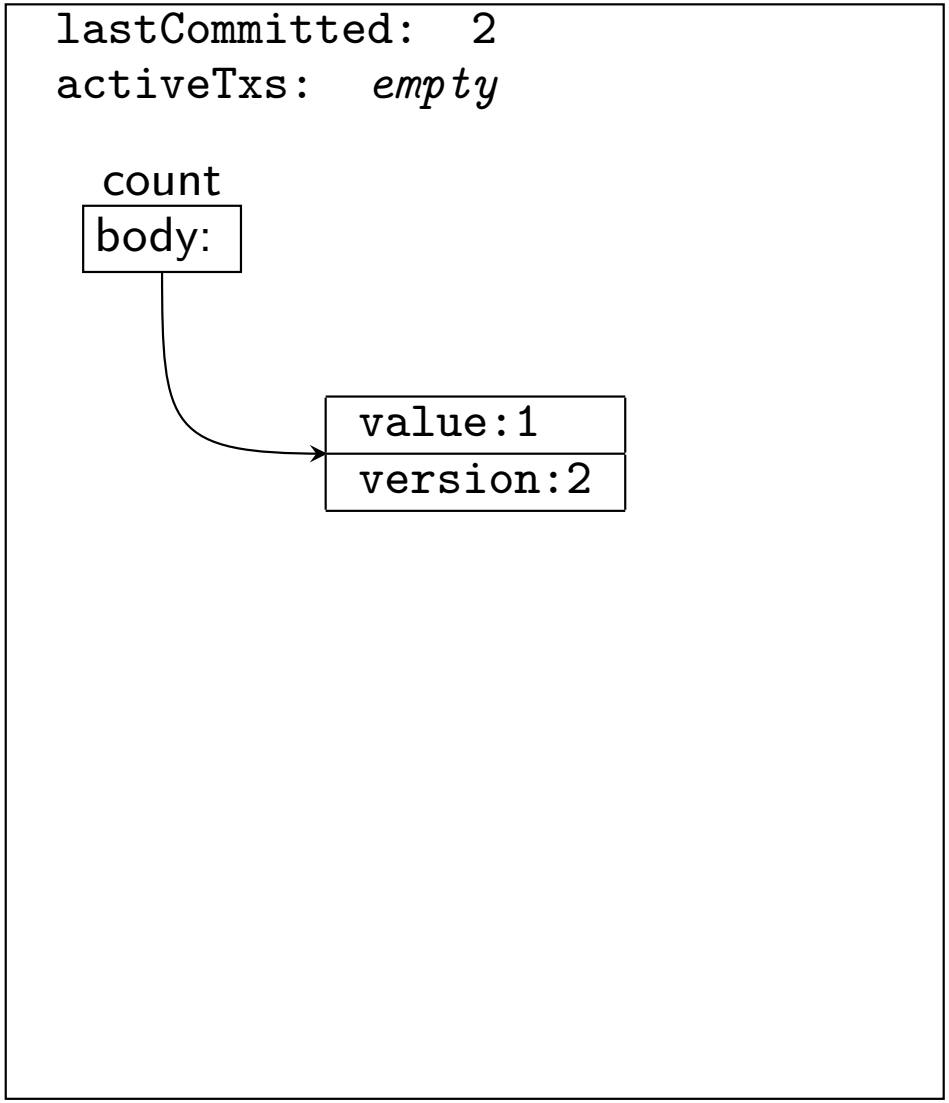

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Consider a shared `Counter` instance that is incremented in all transactions.

Then, all transactions conflict with each other if executed concurrently.

What can we do about it?

If the value of the counter is not used in the transaction, then we can delay the increment, thereby avoiding the read that causes the conflict.

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Using Per-Transaction Boxes to Delay Operations

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public class CFOCounter {
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  private PerTxBox<Long> toAdd =
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What if we cannot delay the reads?

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If the re-execution of the conflicting part, with the commit-time values, produces the same results, then it is safe to commit.

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Using Restartable Transactions

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class List {
  ...
  @Restartable boolean contains(Object obj) {
    ...contains body...
  }
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A transaction that uses the `List.contains` method can re-execute the contains method, if a conflict is on a box that was read only by this method.

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Unifying both Approaches

In both cases, we are moving for commit-time some computation.

However, in the `Counter` example, the operation also writes. . .
. . . and the result of the re-execution will not be the same.

Still, this different result does not interfere with the transaction execution flow.

A restartable transaction succeeds if:

- the read-set is still valid
- the read-set is not invalidated by the restarted transaction, but the read-set is still valid
- the read-set is invalidated by the restarted transaction, but the read-set is still valid and the read-set is equal

Unifying both Approaches

In both cases, we are moving for commit-time some computation.

However, in the `Counter` example, the operation also writes...
...and the result of the re-execution will not be the same.

Still, this different result does not interfere with the transaction execution flow.

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The main difficulties in the implementation of restartable transactions are:

- Freezing the execution context of each restartable transaction.
- Keeping track of dependencies between transactions that read and write the same boxes.

This is hard because the results of nested transactions are merged with their parents.

Fundamental change

Extend the versioned boxes model, so that nested transactions behave in the same way as top-level transactions.

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Extended Model

In this extended model:

- Transactions form a tree, where each node keeps the information of what was read and written.
- The execution context for a restartable transaction is the sub-tree that is to the left and above the transaction.
- The re-execution of a restartable transaction updates its local information only.
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Outline

Conclusions

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- We can avoid conflicts by delaying computations until commit-time.
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