भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

MICHIGAN STATE
UNIVERSITY

Achieving Starvation-Freedom with Greater Concurrency in Multi-Version Object-based Transactional Memory Systems

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21st International Symposium on Stabilization, Safety, and Security of Distributed Systems (SSS 2019)

Outline of Today's Presentation

Outline

Transaction

Sequence of instructions guaranteed to execute atomically.

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History

Concurrent execution of transactions.

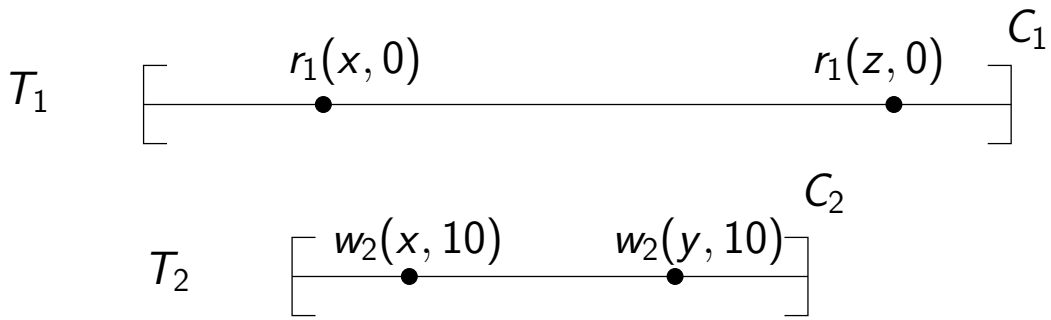

Figure 1: History of an STM

Introduction to STMs Cont'd..

Definition of STMs and its methods

- **Software Transaction Memory Systems (STMs)** are a convenient programming interface for a programmer to access shared memory using concurrent threads without worrying about concurrency issues.

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  - t_read()
  - t_write()
  - tryC() and tryA()

  We refer to these as Read-Write STMs (or RWSTMs).

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▸ Working of STMs

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Correctness of STMs: Opacity [a]

Opacity

1. It is a popular correctness-criteria for STMs which is stronger than serializability.
2. Opacity like serializability requires that the concurrent execution including the aborted transactions be equivalent to some serial execution.

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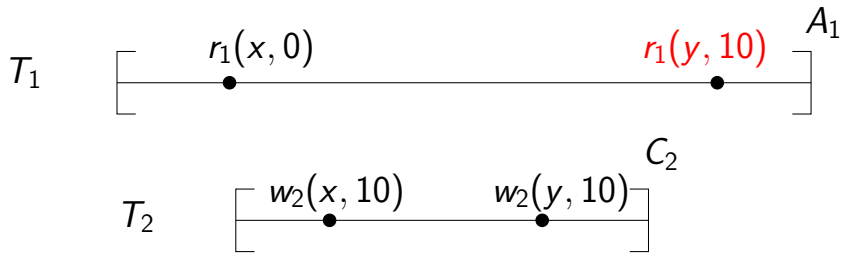

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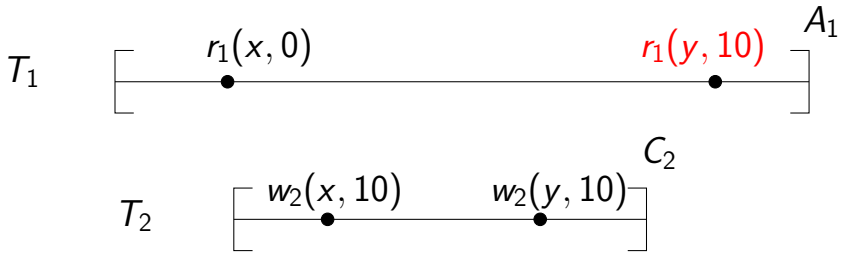

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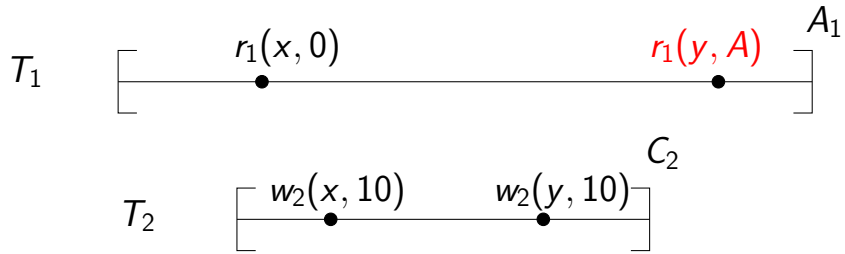

Figure 3: Opaque History H (T_1, T_2)

[a] Guerraoui, R., Kapalka, M.: On the Correctness of Transactional Memory. PPoPP, 2008

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Object-based STM (OSTM) [b] [c] [d]

Introduction

- **Object-based STMs (OSTM)** operate on higher level objects rather than primitive read and writes which act upon memory locations.

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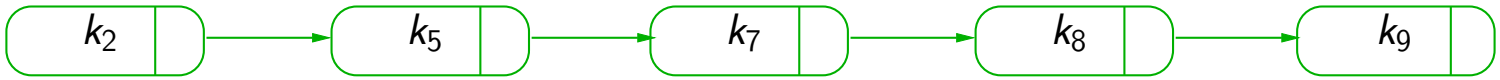
Motivation towards OSTMs

Problem with read-write STMs (RWSTMs)



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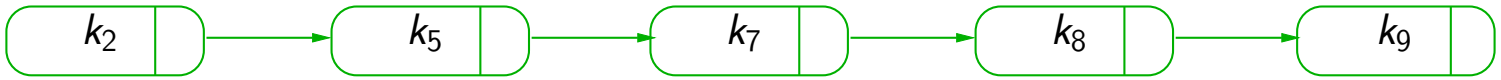

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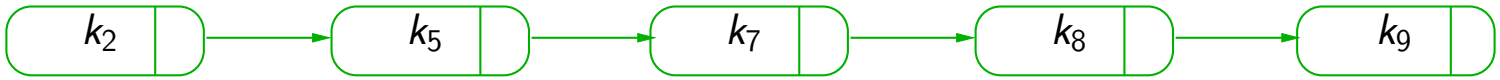
T_1: lookup(k_5), lookup(k_8) and T_2: delete(k_7)



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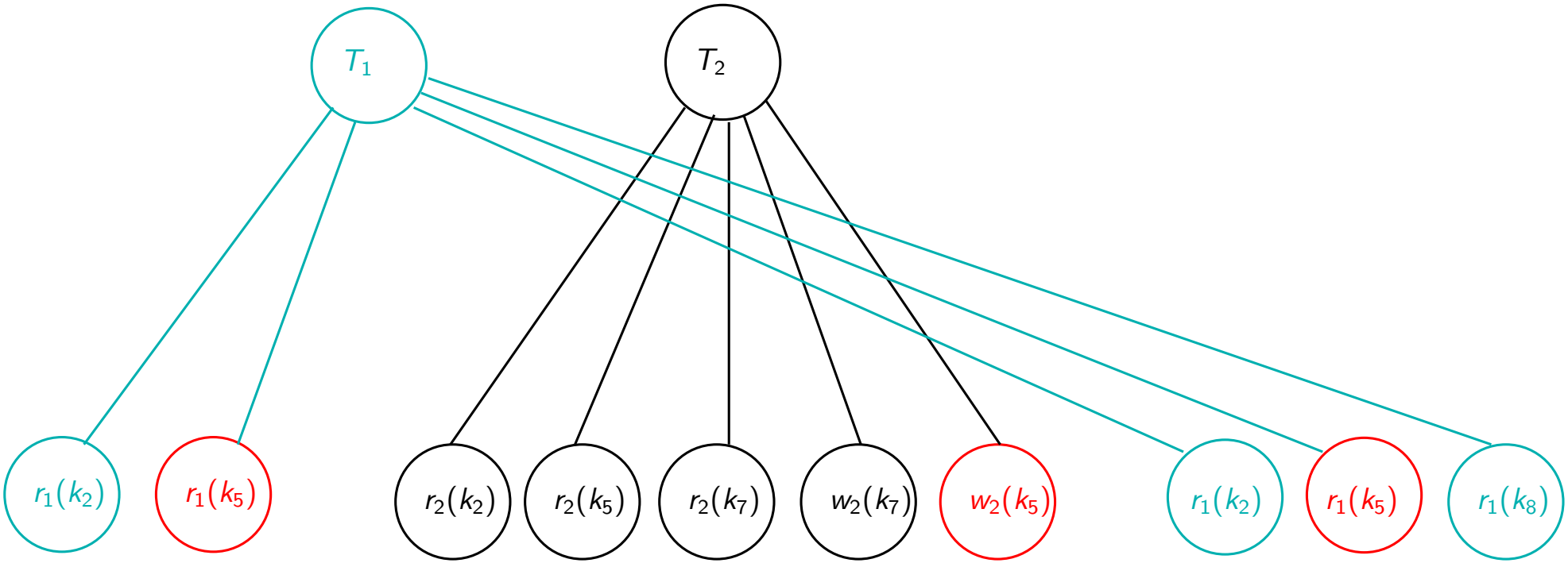

Figure 5: Tree Structure : conflicts are ($r_1(k_5)$, $w_2(k_5)$) and ($w_2(k_5)$, $r_1(k_5)$)

Motivation towards OSTMs Cont'd..

Problem with read-write STMs (RWSTMs)

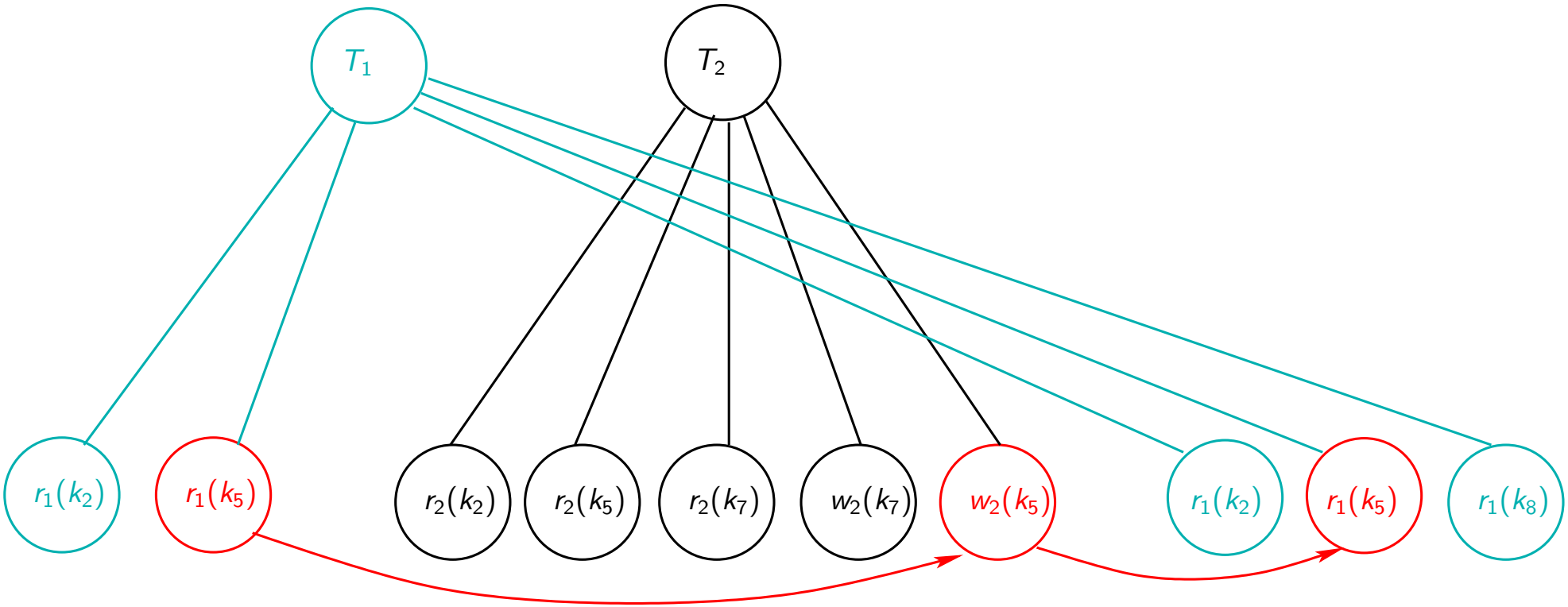

Figure 6: Tree Structure

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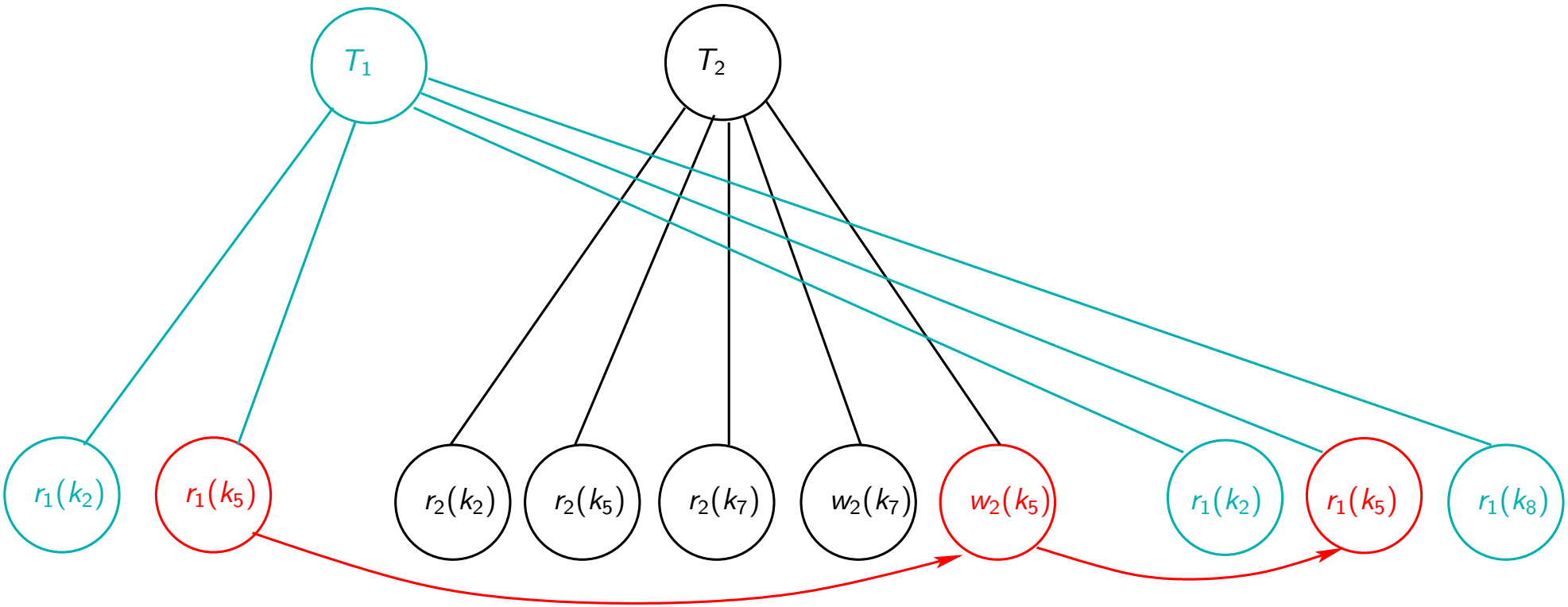

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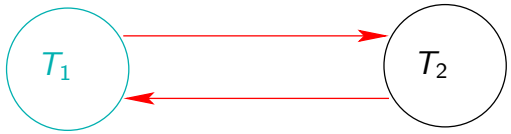

Figure 7: Cycle (Not Serial)

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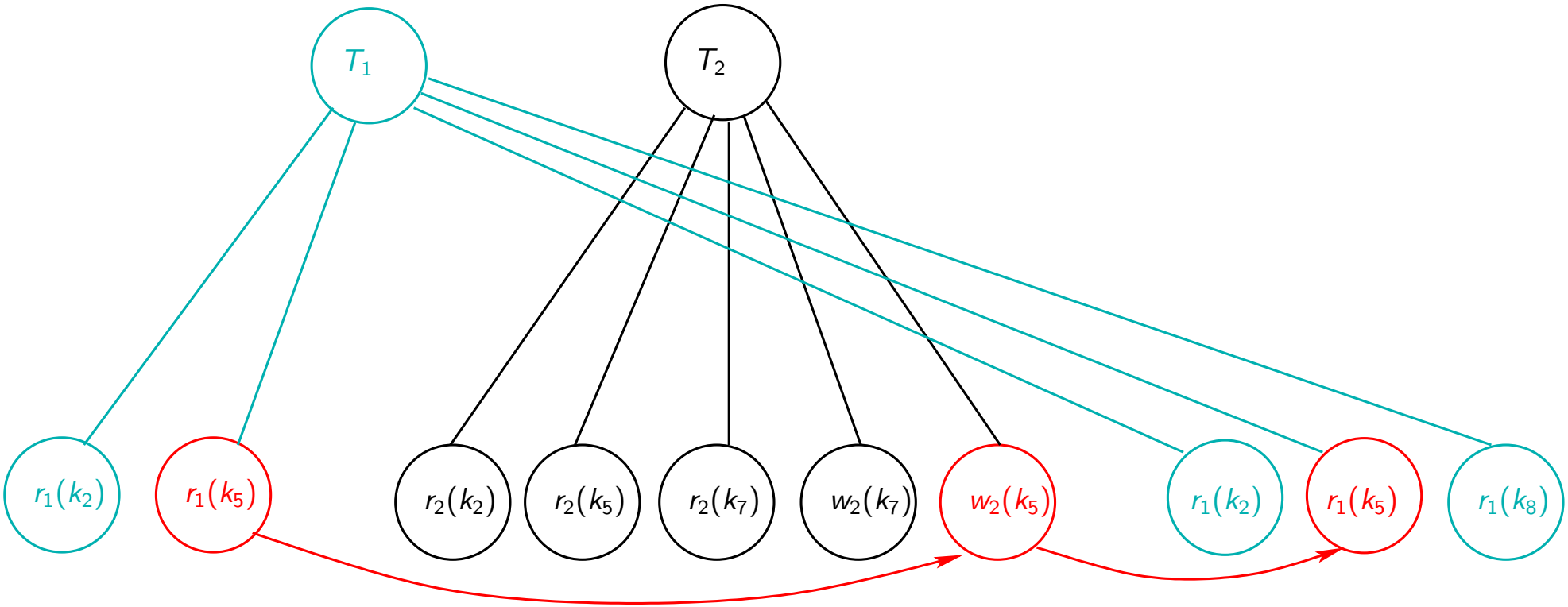

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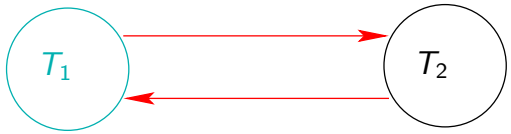

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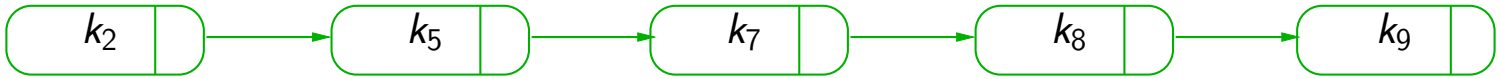
Schedule cannot be accepted by a RWSTM.

Motivation towards OSTMs Cont'd..

Execution at layer-1



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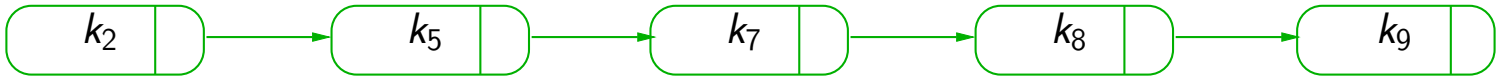

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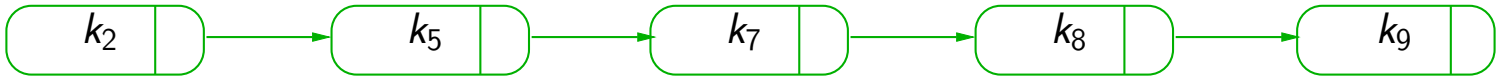

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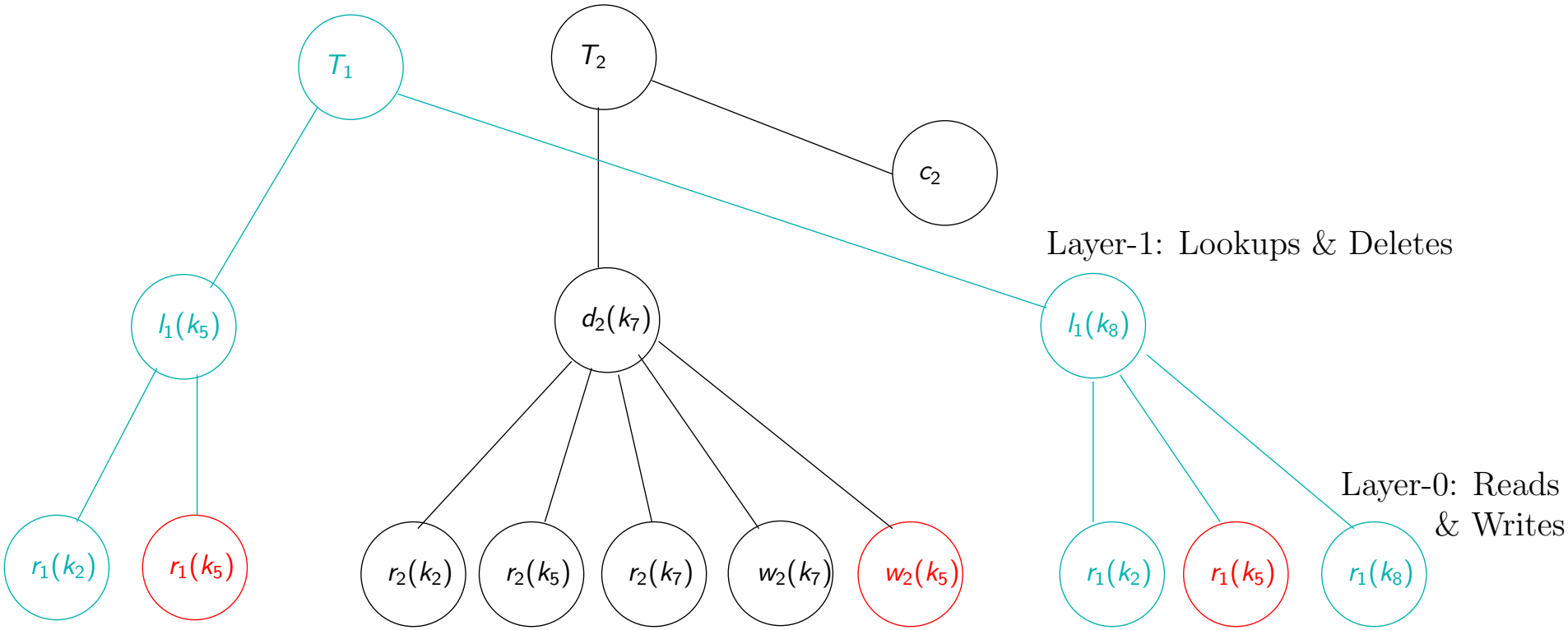

Figure 9: Tree Structure : no conflict at Layer-1[e]

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Motivation towards OSTMs Cont'd..

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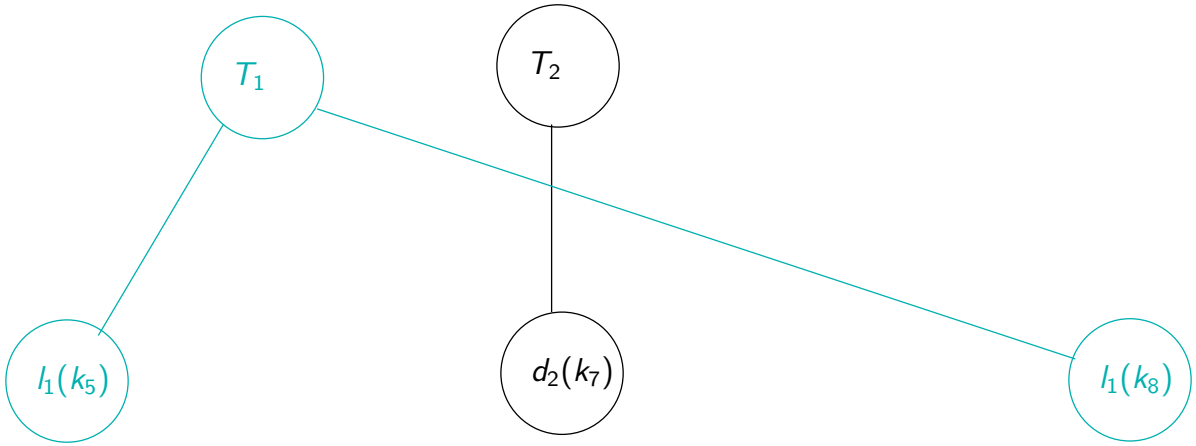
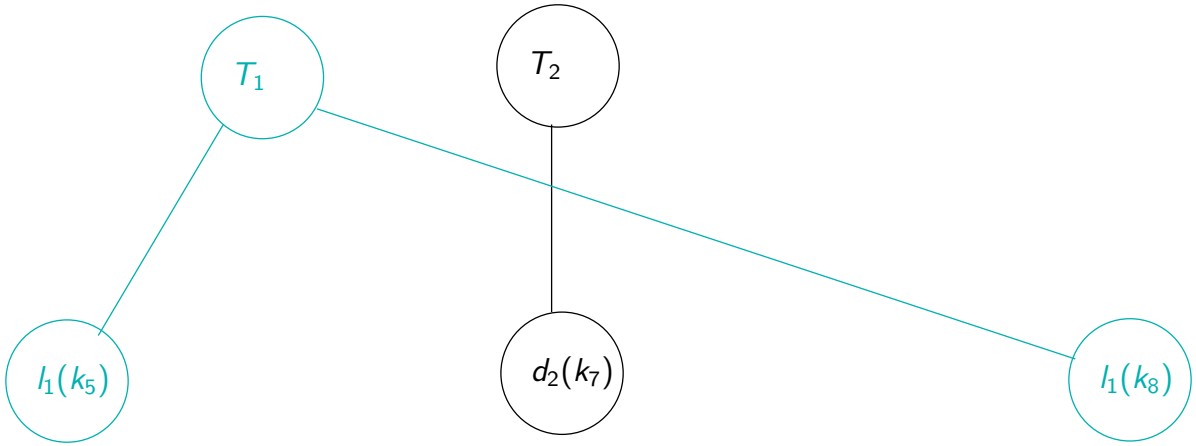


Figure 10: Pruned Tree

Motivation towards OSTMs Cont'd..

Execution at layer-1



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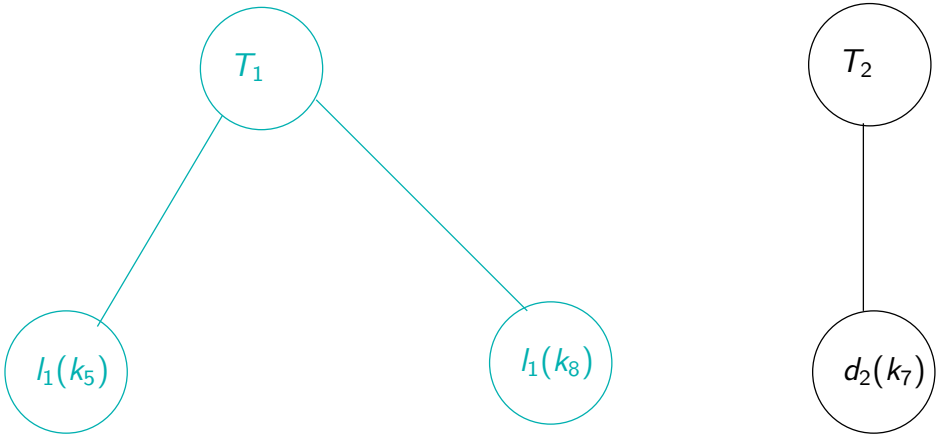

Figure 11: Sequential Schedule

Motivation towards OSTMs Cont'd..

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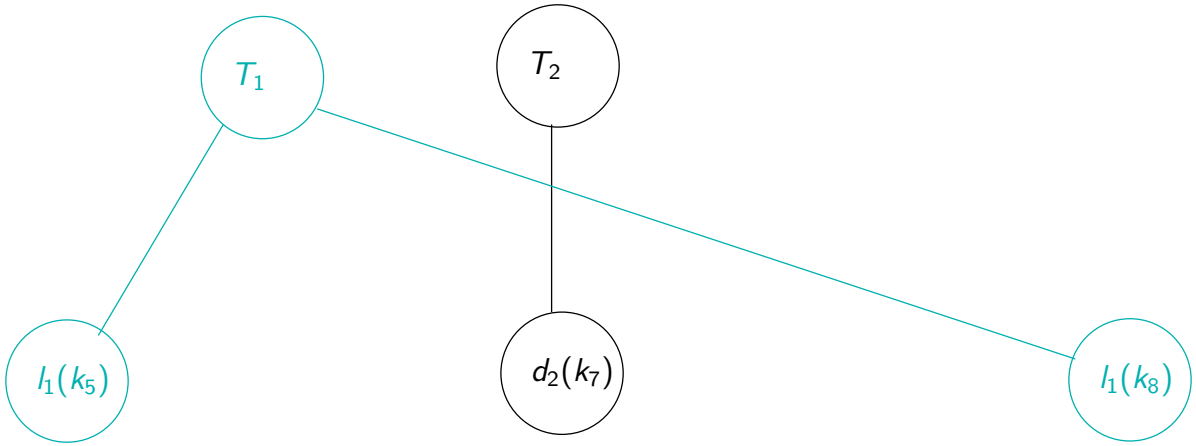

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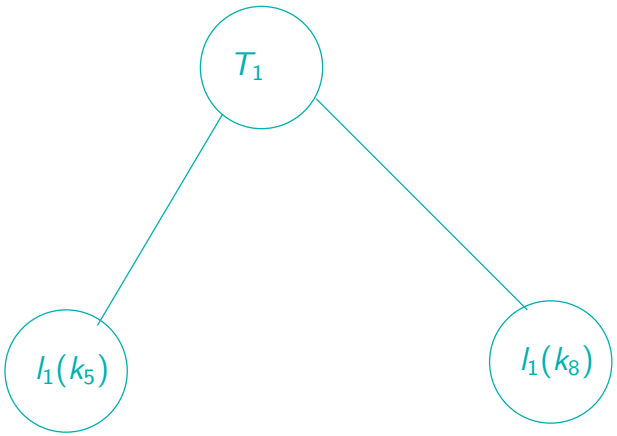

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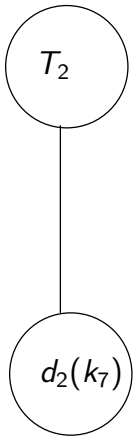

Figure 12: Serial History

Outline

Motivation towards Multi-Version OSTMs (MV-OSTMs)

Limitation of OSTMs

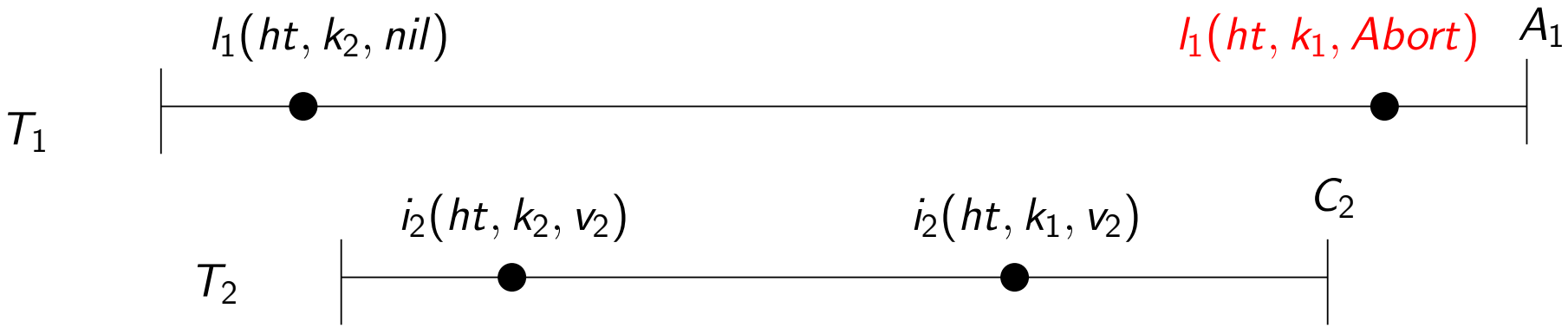

Figure 13: Single-version OSTM (SV-OSTM)

Motivation towards MV-OSTMs Cont'd..

Advantages of multi-version[f] over single-version RWSTMs

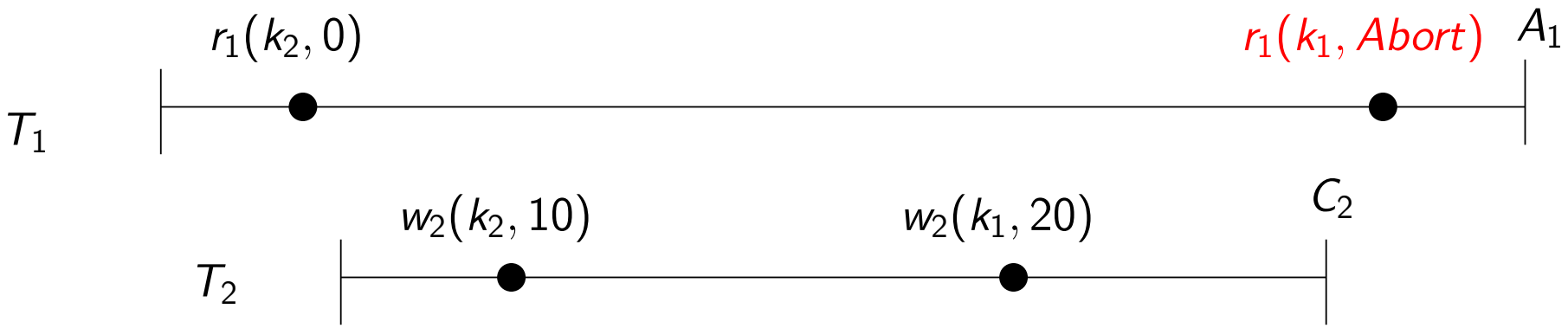

Figure 14: Single-version RWSTM (SV-RWSTM)

[f] Kumar P., Peri S., and K. Vidyasankar. A TimeStamp Based Multi-version STM Algorithm. ICDCN, 2014

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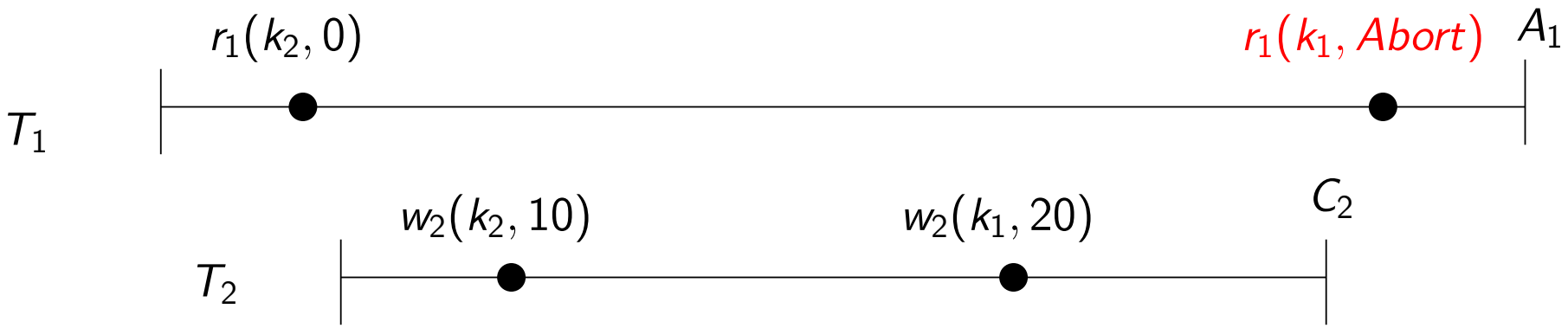

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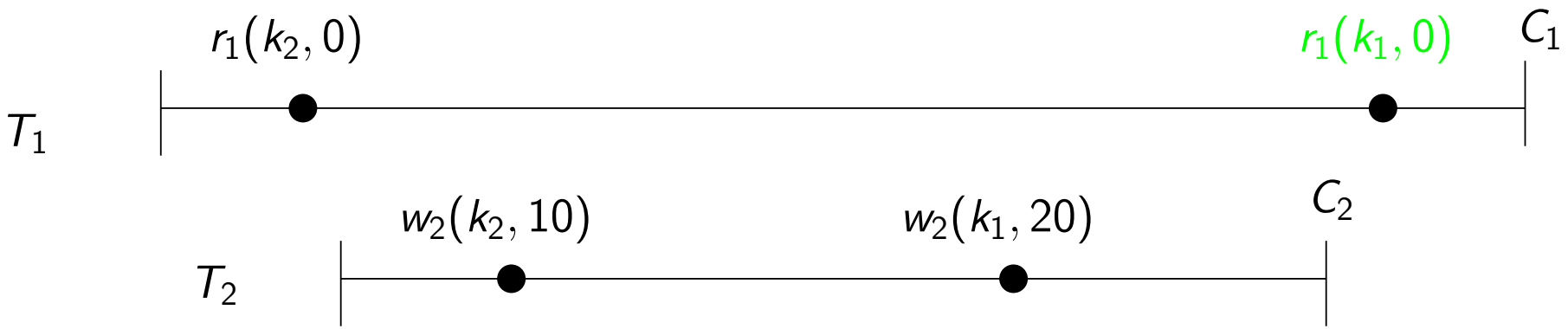

Figure 15: Multi-version RWSTM (MV-RWSTM) : (T_1, T_2)

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Advantages of multi-version[g] over single-version OSTM

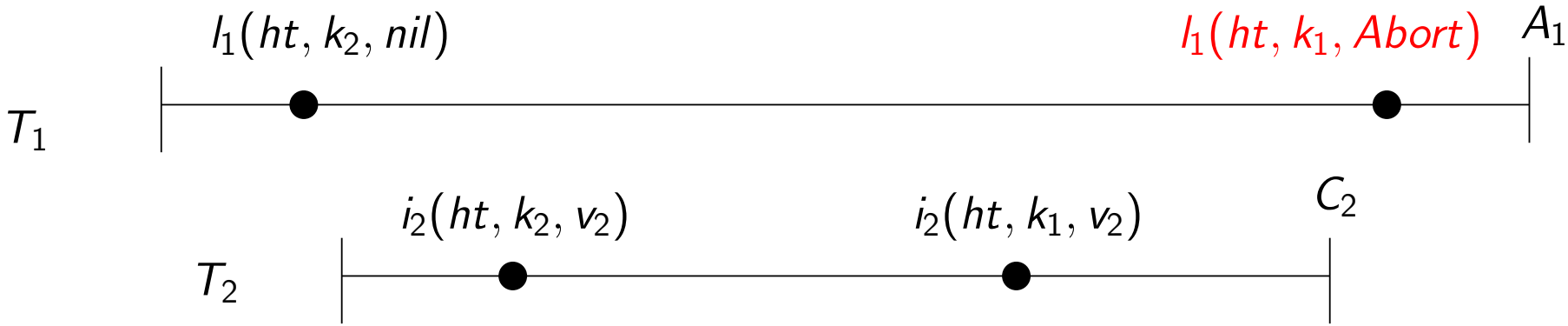

Figure 16: Single-version OSTM (SV-OSTM)

[g] Juyal, C., Kulkarni, S.S., Kumari, S., Peri, S., Somani, A., An innovative approach to achieve compositionality efficiently using multi-version object based transactional systems, SSS'18.

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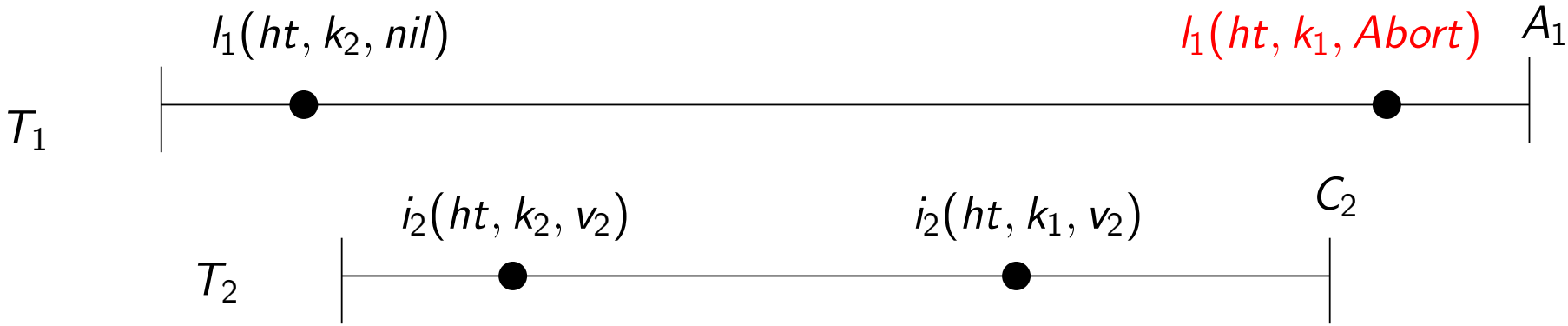

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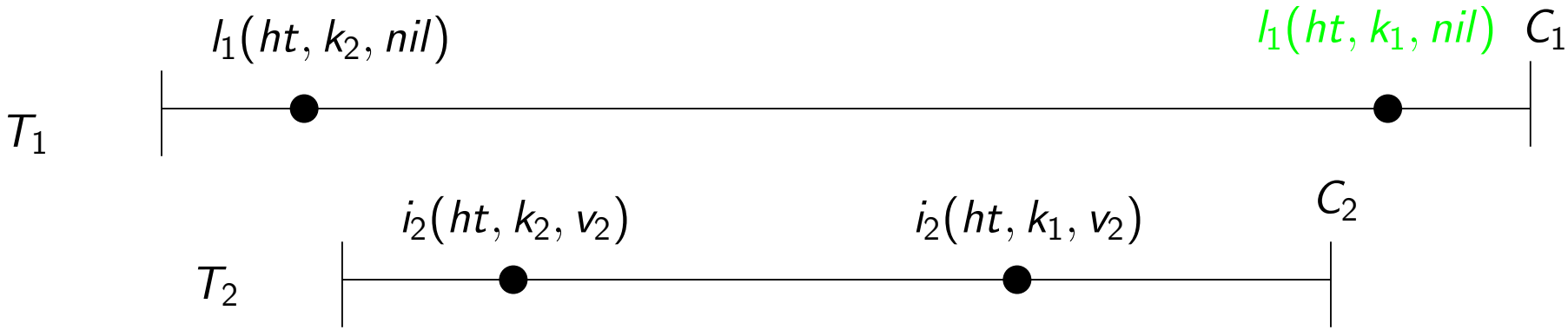

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Progress Guarantee in SV-OSTMs and MV-OSTMs

Starvation in STMs

- None of the Single and Multi-Version OSTMs provide starvation-freedom.

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Algorithm Insert(LL, v): Invoked by a thread to insert a value v into a linked-list LL. This method is implemented using transactions.

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1:  while (true) do
2:      id = t_begin();
3:      ...
4:      v = t_lookup(id, x);
5:      ...
6:      t_insert(id, x, v');
7:      ...
8:      ret = tryC(id);
9:      if (ret == success) then
10:         break;
11:     end if
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Issue: Starvation can occur.

Progress Guarantee in SV-OSTM and MV-OSTM Cont'd..

Definition of Starvation-Freedom in STMs

- **Definition of Starvation-Freedom:** An STM system is said to be *starvation-free* if a thread invoking a non-parasitic[h] transaction T_i gets opportunity to retry T_i on every abort, due to the presence of a fair scheduler, then T_i will eventually commit.

[h] Bushkov, V., Guerraoui, R., Kapalka, M.: On the liveness of transactional memory. In: PODC'12.Bushkov, V., Guerraoui, R., Kapalka, M.: On the liveness of transactional memory. In: PODC'12.

Progress Guarantee in SV-OSTM and MV-OSTM Cont'd..

Assumptions of our paper

Assumption (1)

We assume that in the absence of other concurrent conflicting transactions, every transaction will commit. In other words, (a) if a transaction T_i is executing in a system where other concurrent conflicting transactions are not present then T_i will not self-abort. (b) Transactions are not parasitic.

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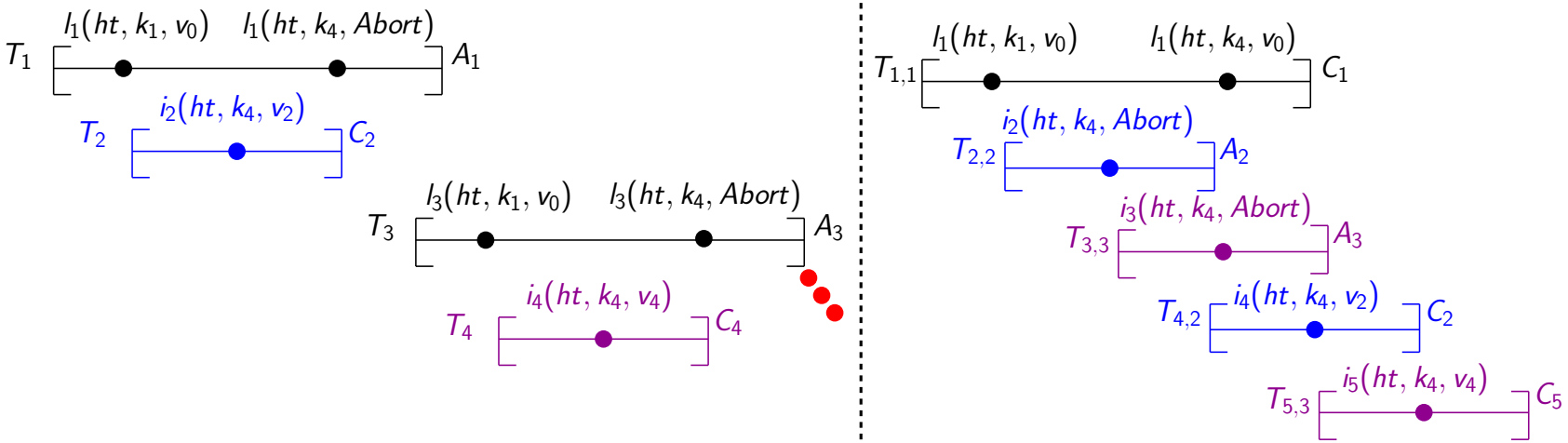
Assumption (2)

Bounded-Termination: *For any transaction T_i, invoked by a thread Th_x, the fair system scheduler ensures, in the absence of deadlocks, Th_x is given sufficient time on a CPU (and memory etc.) such that T_i terminates (either commits or aborts) in bounded time, L.*

Outline

Starvation-Freedom in Single-Version OSTMs

SF-SV-OSTMs



(a). T_1 is starving in SV-OSTMs

(b). Starvation-Free SV-OSTMs (SF-SV-OSTMs)

Figure 18: Advantage of SF-SV-OSTM over SV-OSTMs

- Each transaction T_i has two timestamps:

Starvation-Freedom in Single-Version OSTMs

SF-SV-OSTMs

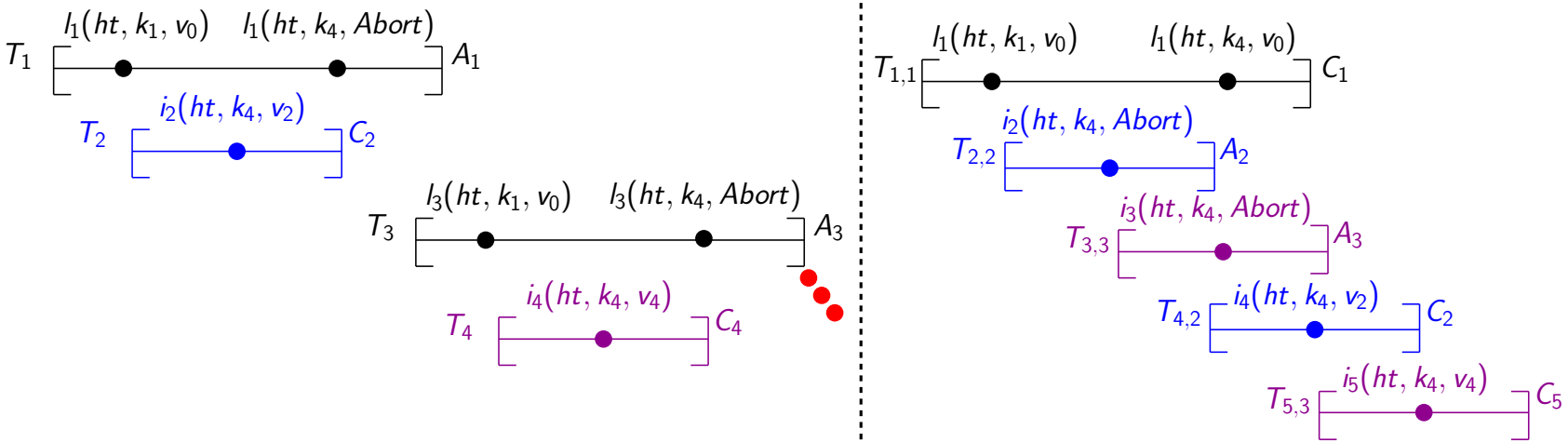


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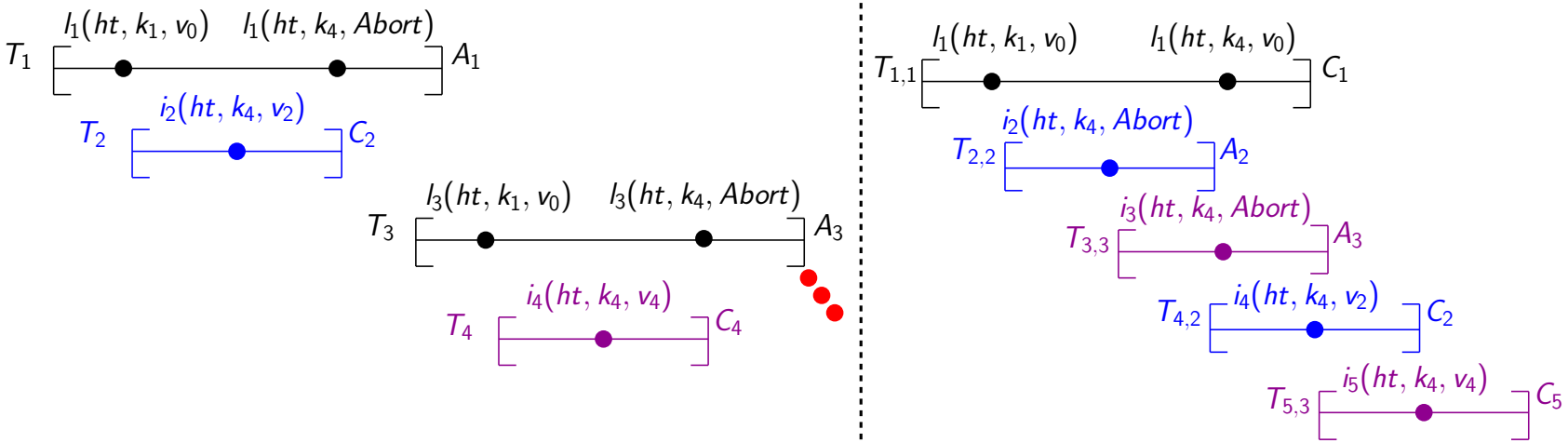
Figure 18: Advantage of SF-SV-OSTM over SV-OSTMs

- Each transaction T_i has two timestamps:
  1. *Current Timestamp (cts):* This is a unique timestamp alloted to T_i when it begins.

Starvation-Freedom in Single-Version OSTMs

SF-SV-OSTMs



(a). T_1 is starving in SV-OSTMs

(b). Starvation-Free SV-OSTMs (SF-SV-OSTMs)

Figure 18: Advantage of SF-SV-OSTM over SV-OSTMs

- Each transaction T_i has two timestamps:
  1. *Current Timestamp (cts):* This is a unique timestamp alloted to T_i when it begins.
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Starvation-Freedom in Single-Version OSTMs

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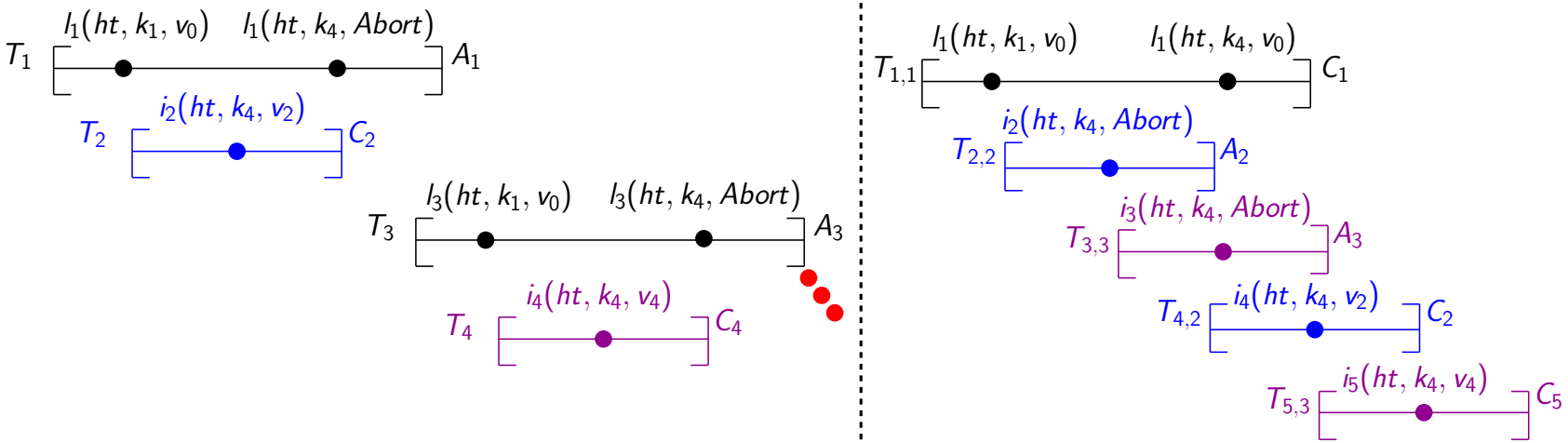

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Starvation-Freedom in Single-Version OSTMs

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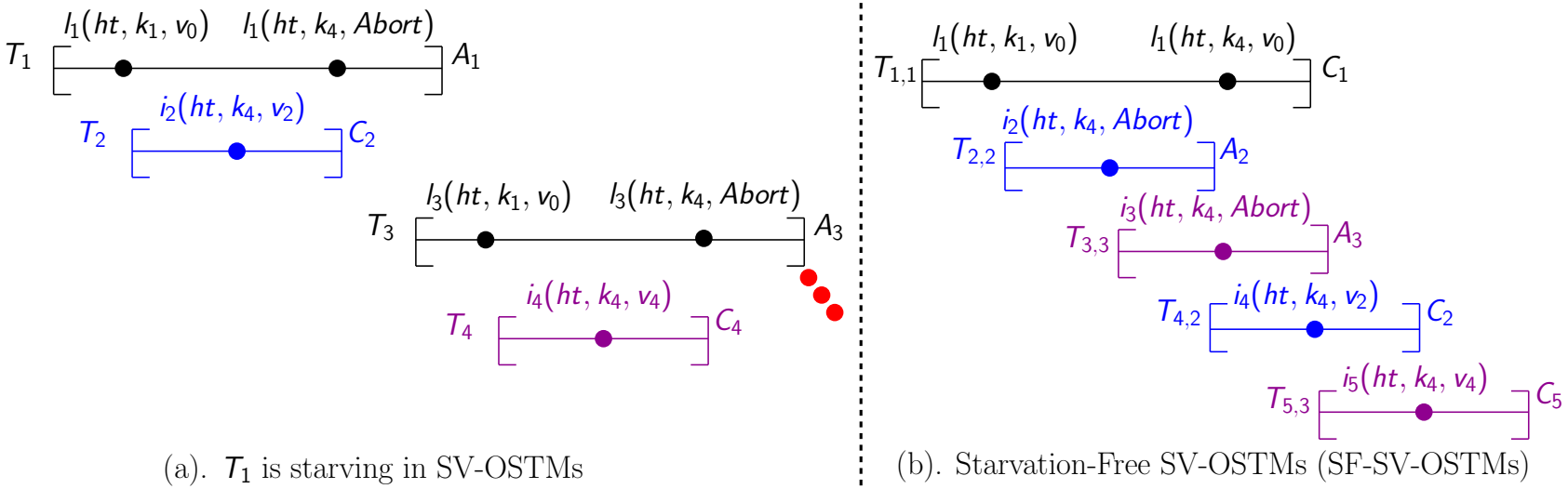

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Starvation-Freedom in Single-Version OSTMs

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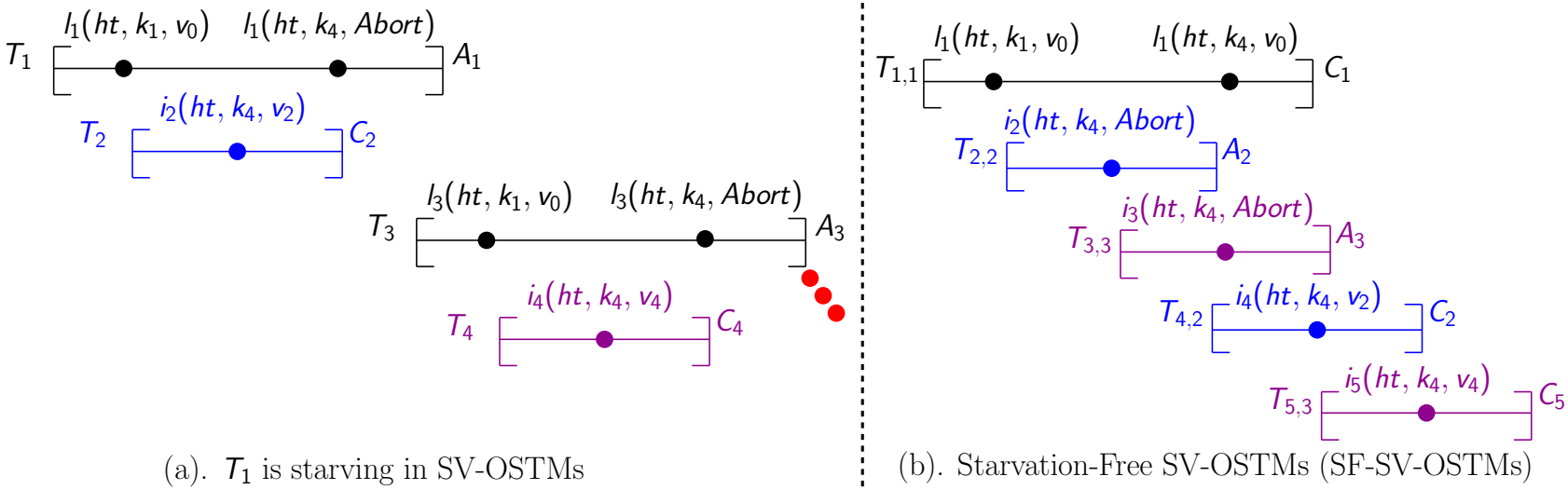

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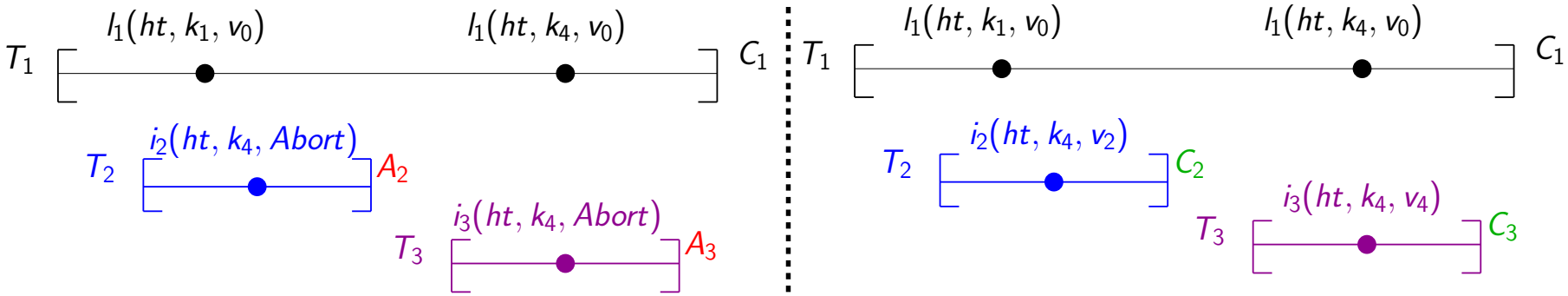
- When T_i aborts and restarts later, it gets a new *cts*.
- But it retains its original *cts* as *its*.
- The above procedure will repeat until T_i gets the lowest *its* when it will commit. Hence, achieves SF.

Outline

Starvation-Freedom in Multi-Version OSTMs

SF-MV-OSTMs

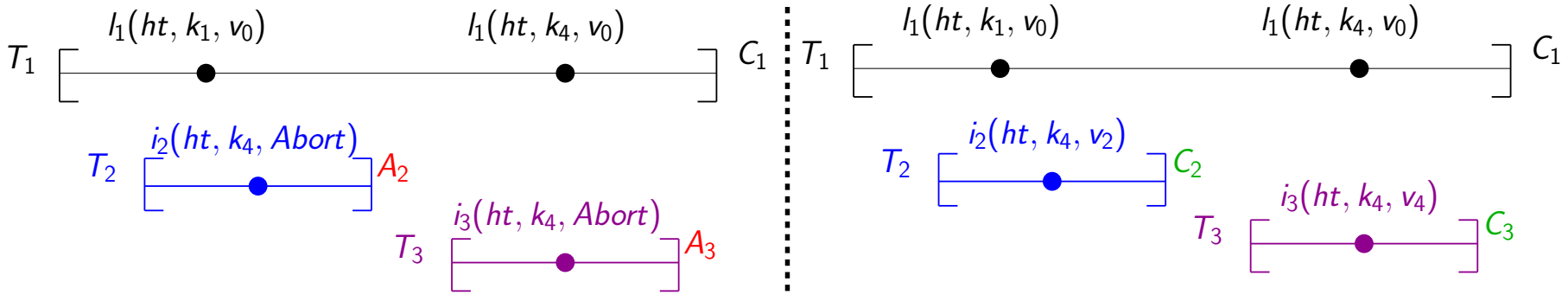


(a). Starvation-Free Single-Version OSTM (SF-SV-OSTM) (b). Starvation-Free Multi-Version OSTM (SF-MV-OSTM)

Figure 19: Benefits of Starvation-Free MV-OSTM over SF-SV-OSTM

Starvation-Freedom in Multi-Version OSTMs

SF-MV-OSTMs



(a). Starvation-Free Single-Version OSTM (SF-SV-OSTM) (b). Starvation-Free Multi-Version OSTM (SF-MV-OSTM)

Figure 19: Benefits of Starvation-Free MV-OSTM over SF-SV-OSTM

Takeaways

- Starvation-Free Multi-version OSTMs reduce number of aborts.
- Increase throughput.

Starvation-Freedom in Multi-Version OSTMs Cont'd..

Challenges for K-Version SF-MV-OSTMs

- Although multi-version OSTMs provide greater concurrency, they suffer from the cost of garbage collection.

Starvation-Freedom in Multi-Version OSTMs Cont'd..

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- Although multi-version OSTMs provide greater concurrency, they suffer from the cost of garbage collection.
  Solution: Maintaining bounded multi-version OSTMs.

Starvation-Freedom in Multi-Version OSTMs Cont'd..

Challenges for K-Version SF-MV-OSTMs

- Although multi-version OSTMs provide greater concurrency, they suffer from the cost of garbage collection.
  Solution: Maintaining bounded multi-version OSTMs.

- Achieving starvation-freedom while using only bounded versions is especially challenging given that a transaction may rely on the oldest version that has been removed.

Starvation-Freedom in Multi-Version OSTMs Cont'd..

Challenges for K-Version SF-MV-OSTMs

- Although multi-version OSTMs provide greater concurrency, they suffer from the cost of garbage collection.
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- Achieving starvation-freedom while using only bounded versions is especially challenging given that a transaction may rely on the oldest version that has been removed.
  Solution: So, we propose Starvation-Free K-Version OSTM (SF-K-OSTM).

Outline

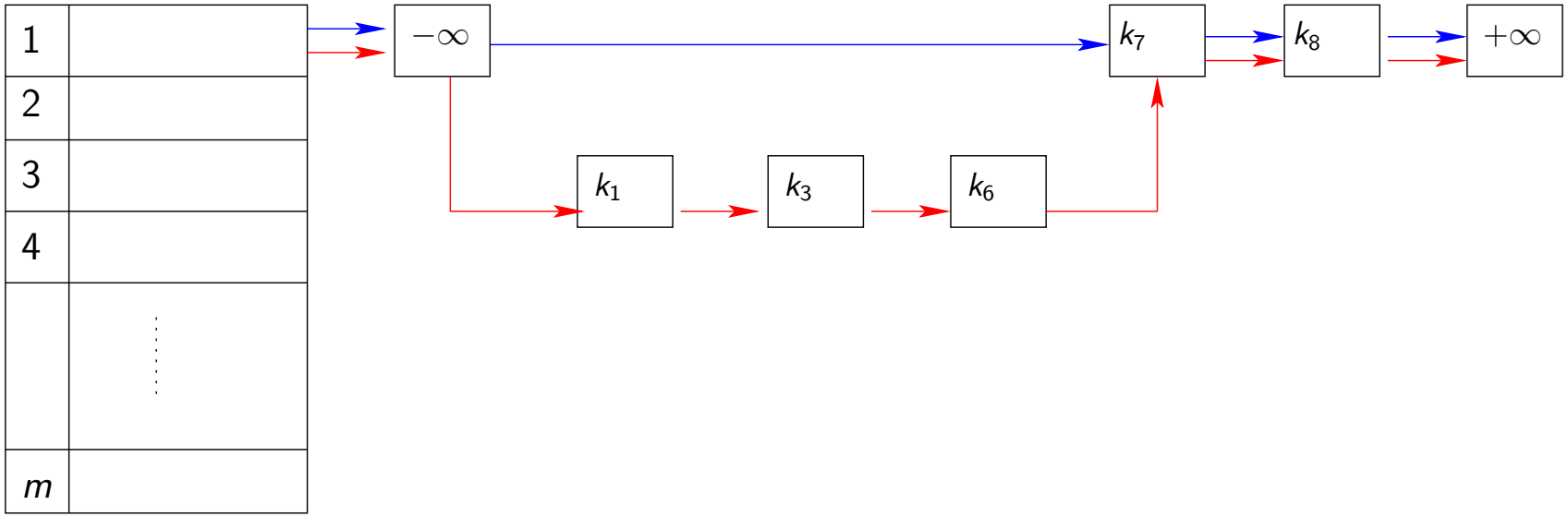
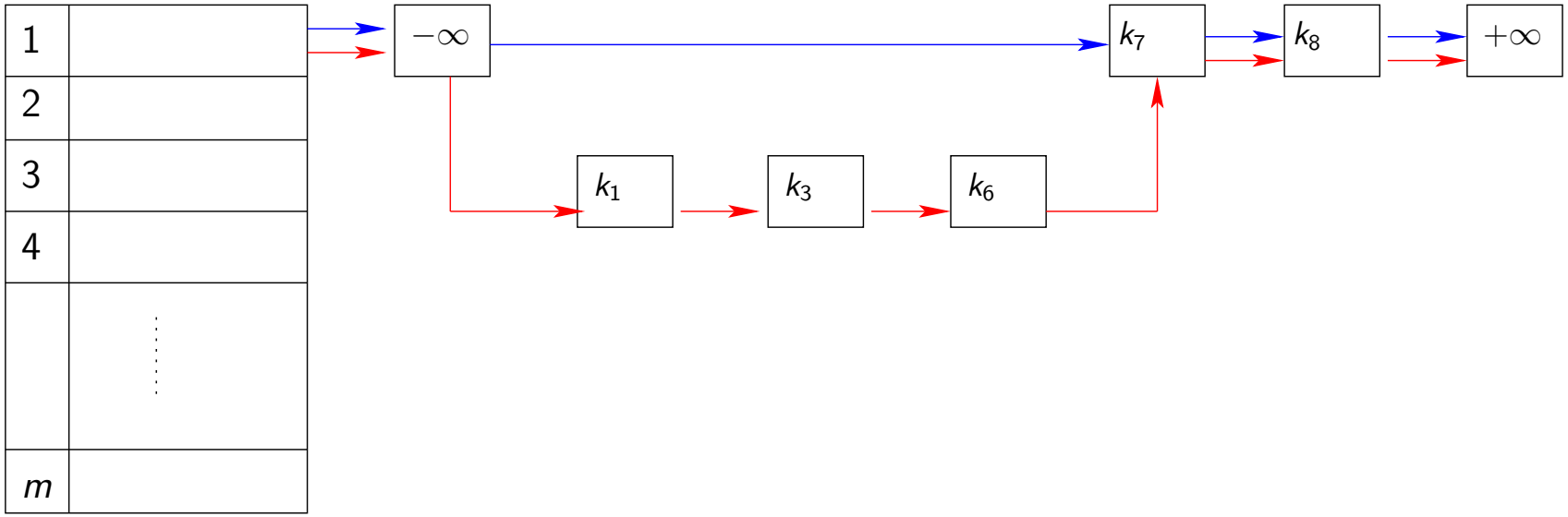


Figure 20: SF-K-OSTM design for Hash Table

Design and Data Structure of SF-K-OSTMs

High-level Design



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SF-K-OSTMs export following methods:

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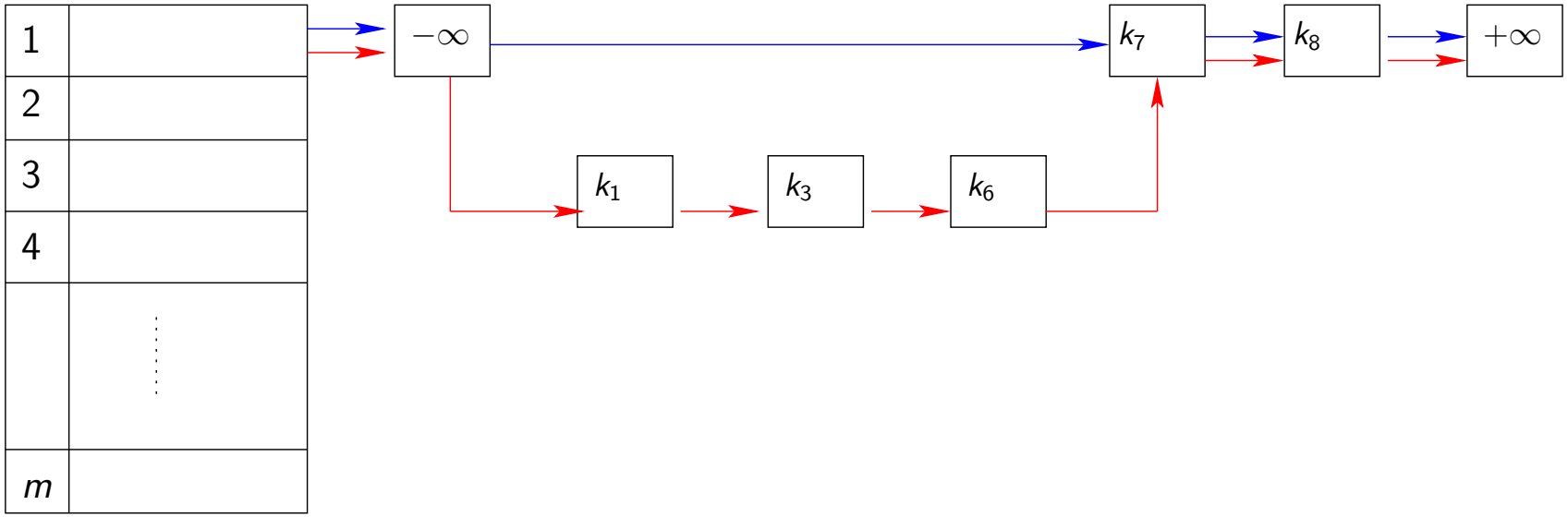

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SF-K-OSTMs export following methods:

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Design and Data Structure of SF-K-OSTMs Cont'd..

Maintains multiple version corresponding to each key

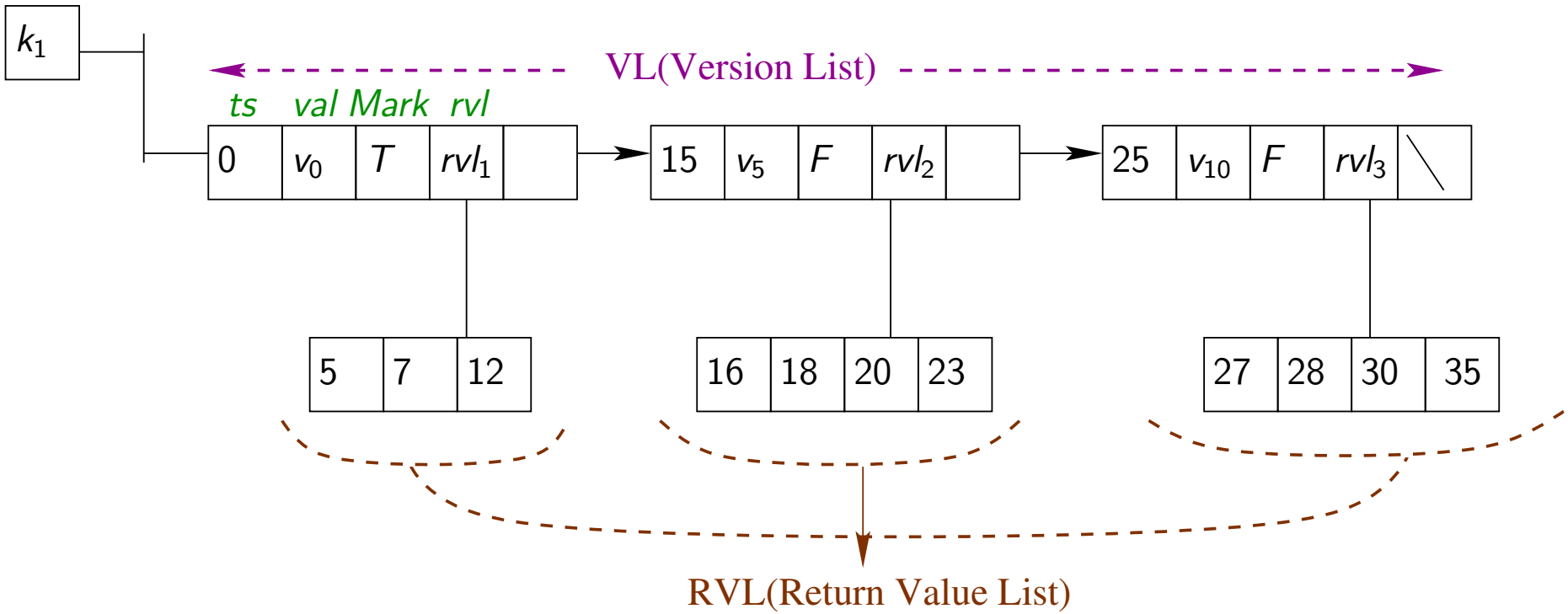

Figure 21: Data Structure for maintaining versions

Outline

Analysing K-MVOSTM

t_lookup() method

K-MVOSTM: K-Version Multi Version OSTM [i]

[i] Juyal, C., Kulkarni, S.S., Kumari, S., Peri, S., Somani, A.: An innovative approach to achieve compositionality efficiently using multi-version object based transactional systems. In: SSS'18.

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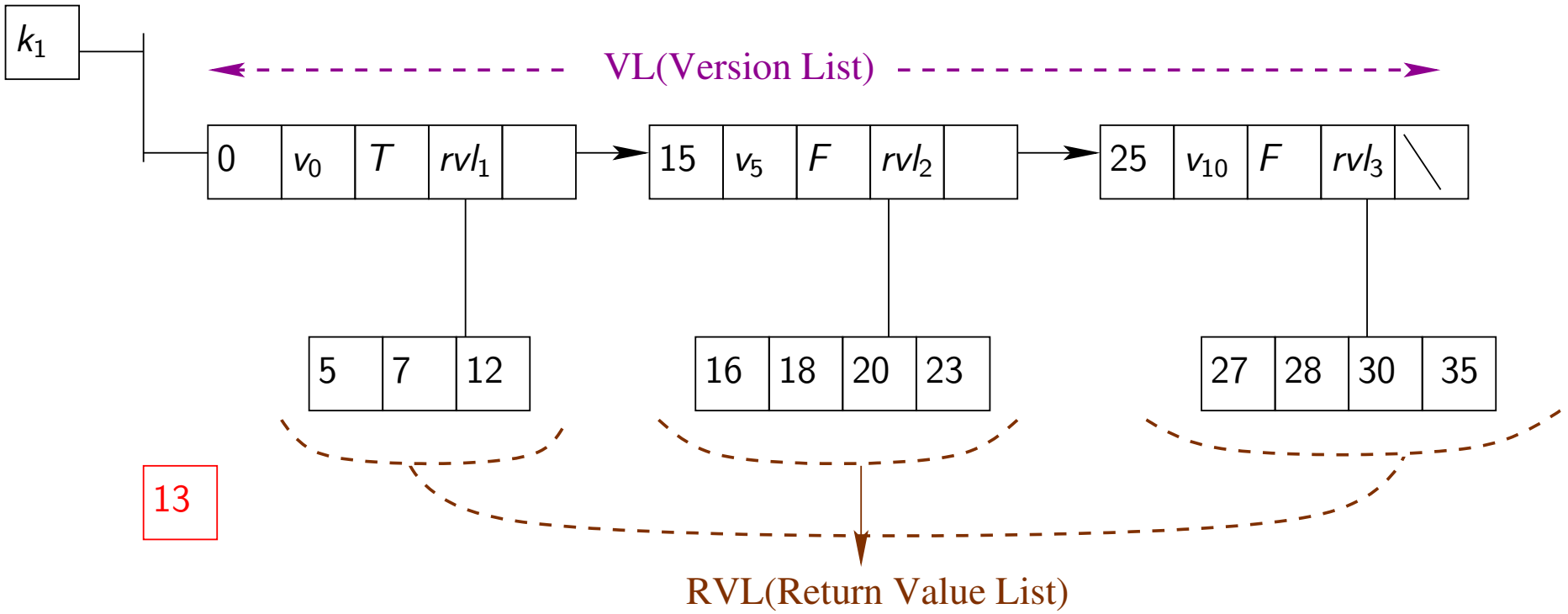

Figure 22: Lookup on key k_1 by T_{13}

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Analysing K-MVOSTM

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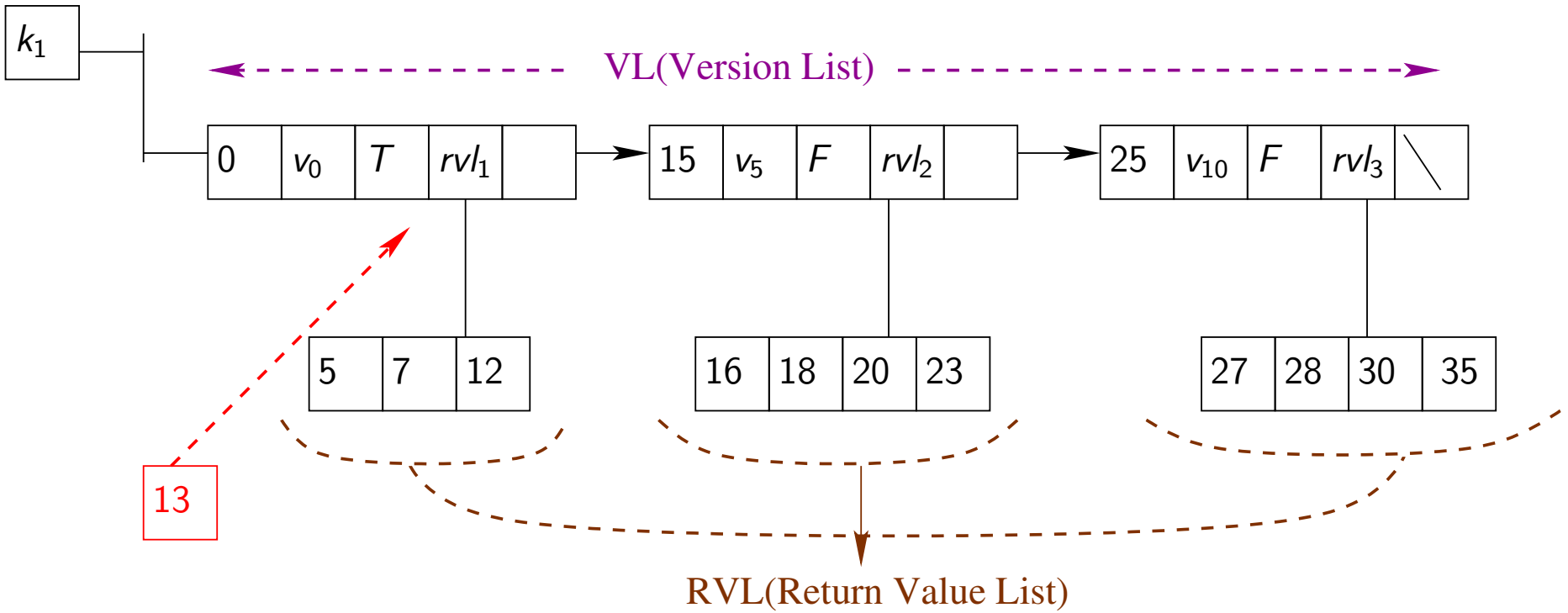

Figure 23: T_{13} searching appropriate place in version list of k_1

Analysing K-MVOSTM Cont'd...

t_lookup() method

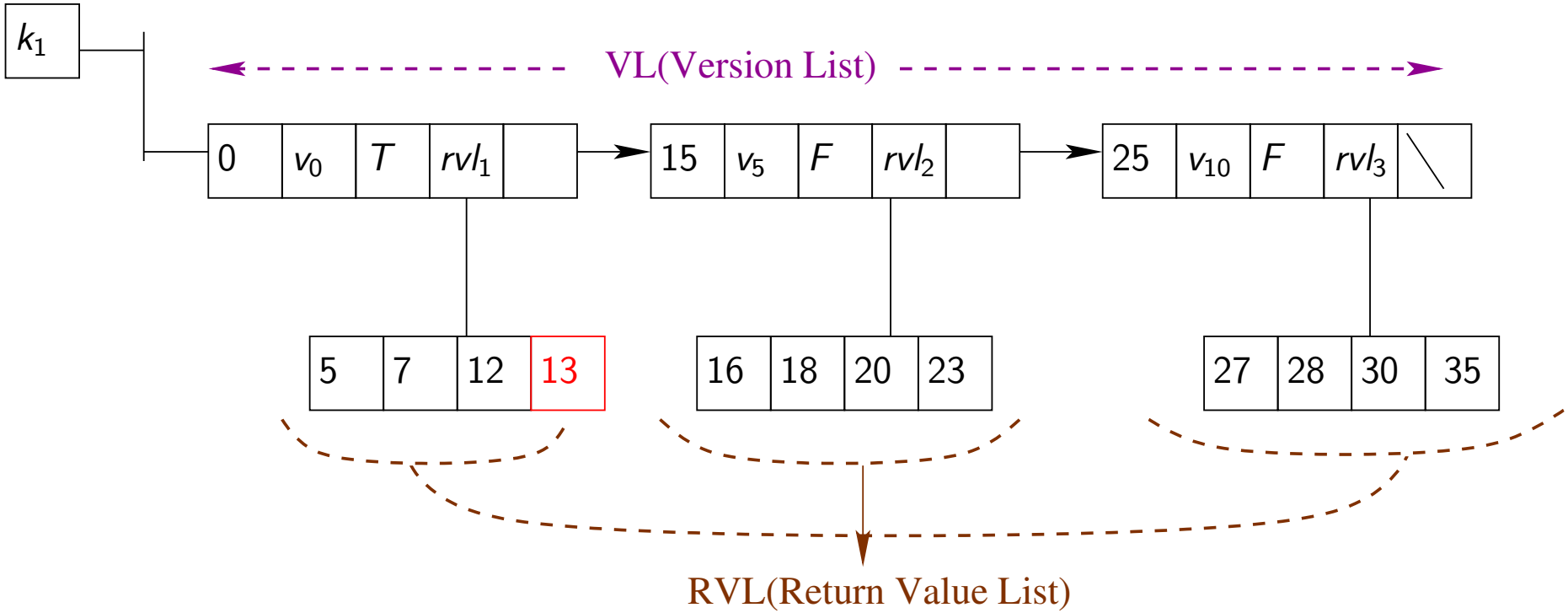

Figure 24: T_{13} successfully added into rvl_1

Analysing K-MVOSTM Cont'd..

tryC() : t_insert() method

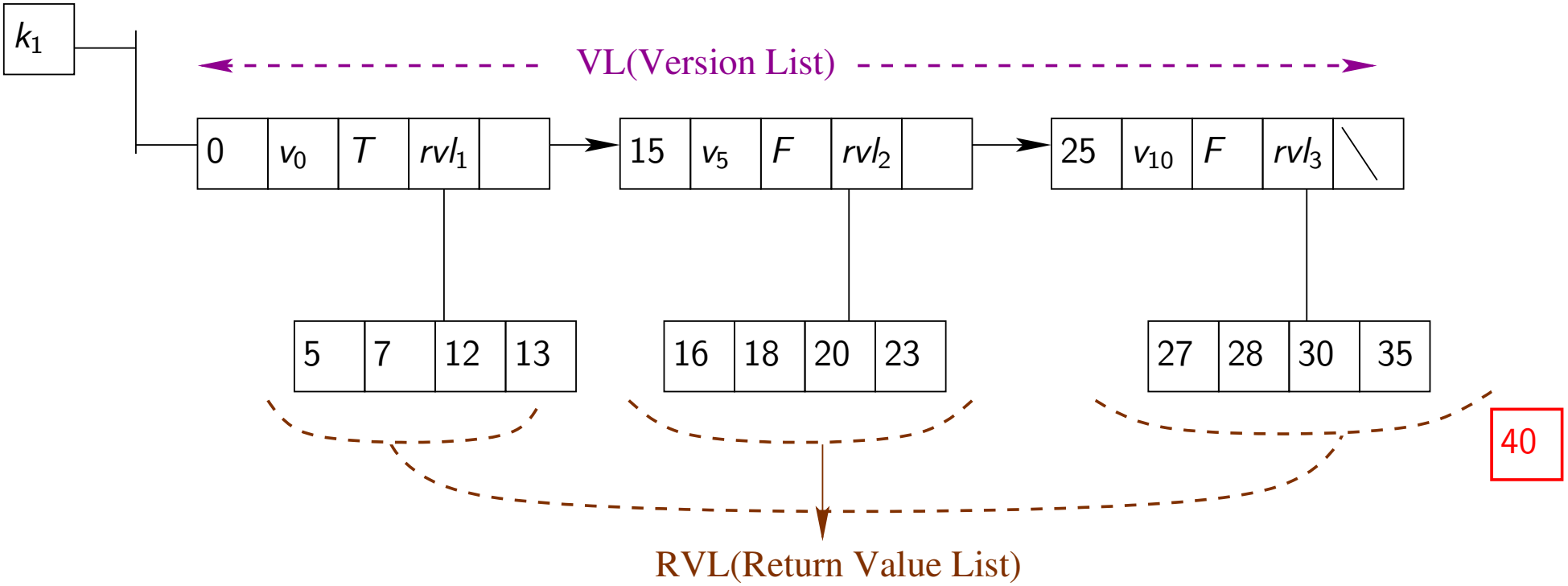

Figure 25: Insert a version of key k_1 by T_{40}

Analysing K-MVOSTM Cont'd..

tryC() : t_insert() method

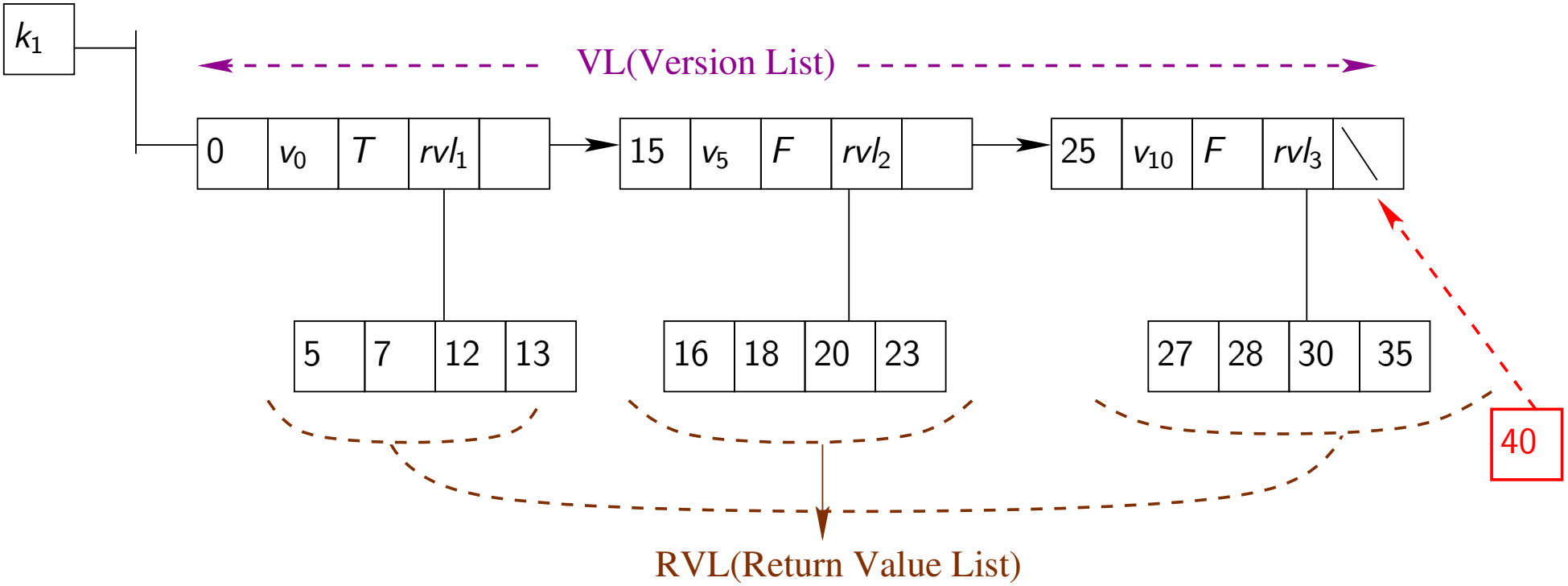

Figure 26: T_{40} searching appropriate place in version list of k_1

Analysing K-MVOSTM Cont'd..

tryC() : t_insert() method

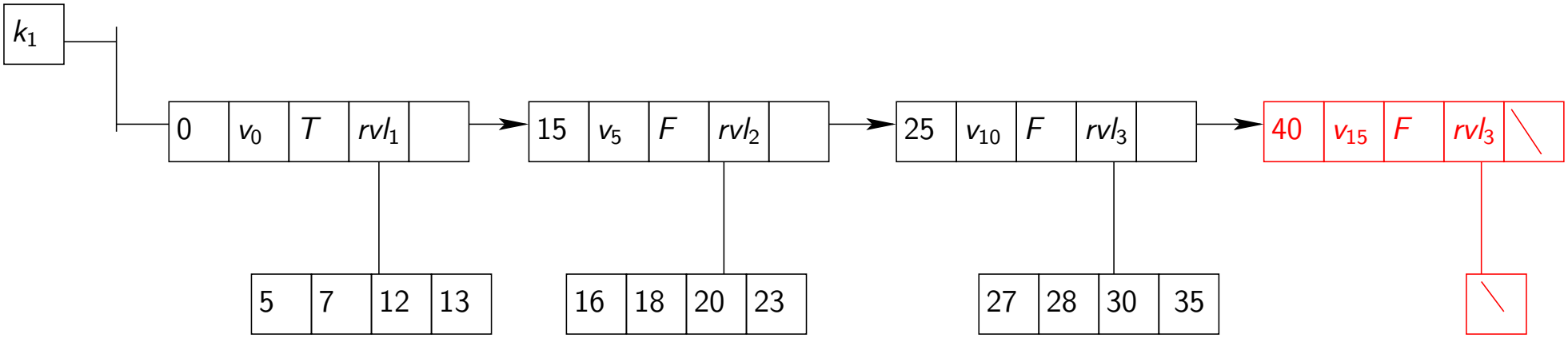

Figure 27: T_{40} successfully created a new version of k_1

Analysing K-MVOSTM Cont'd..

tryC() : t_insert() method

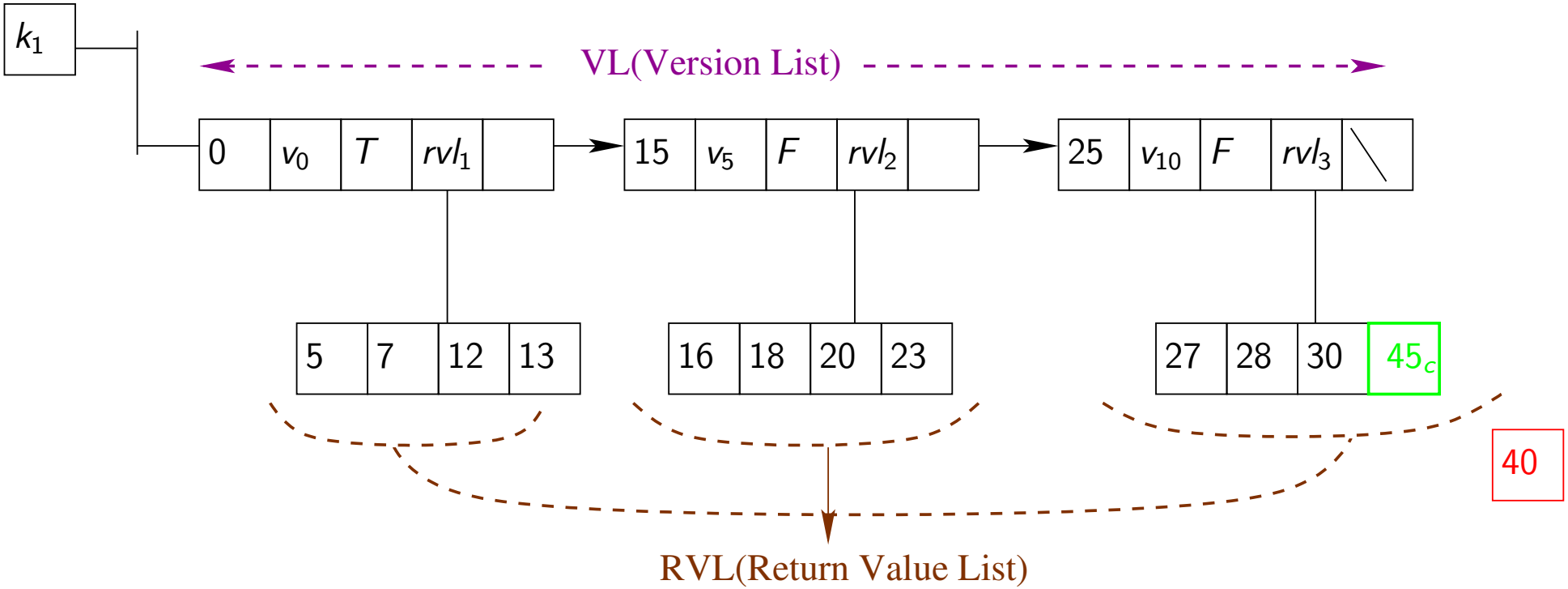

Figure 28: Insert a version of key k_1 by T_{40}

Analysing K-MVOSTM Cont'd..

tryC() : t_insert() method

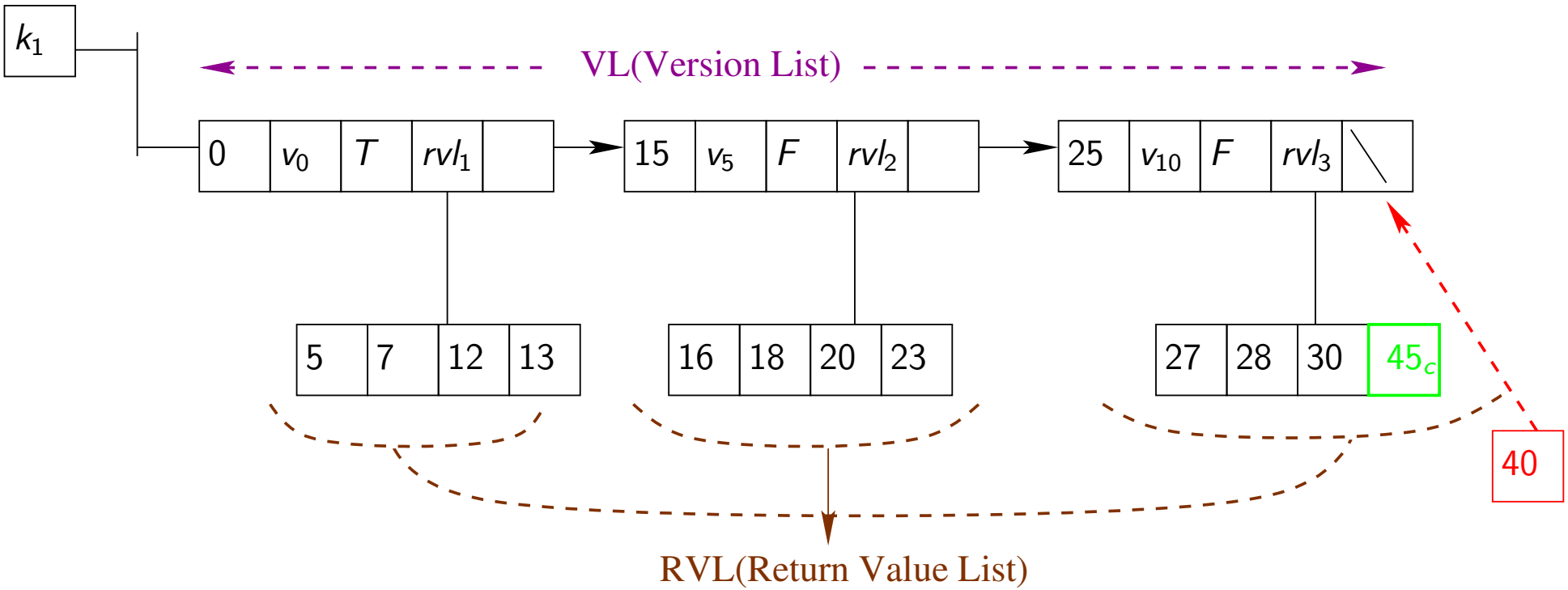

Figure 29: T_{40} searching appropriate place in version list of k_1

Analysing K-MVOSTM Cont'd..

tryC() : t_insert() method

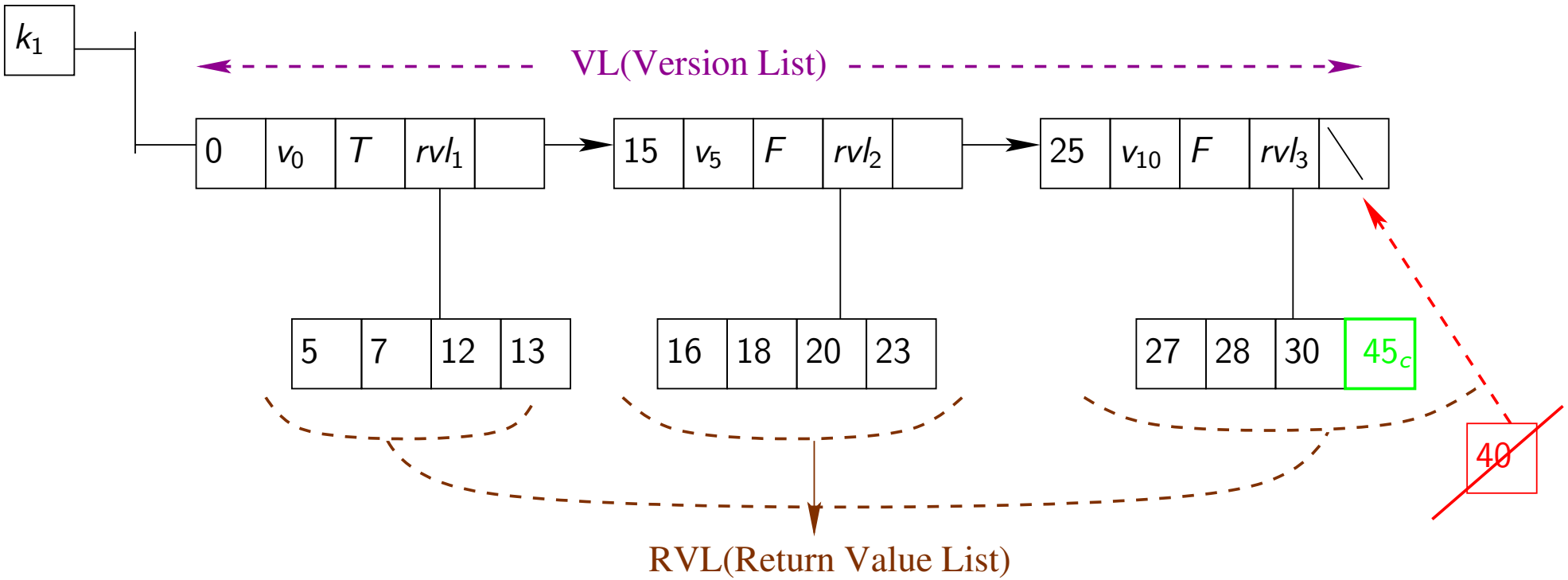

Figure 30: Abort T_{40} : T_{45} committed before T_{40}

Problem with K-MVOSTM

Drawback

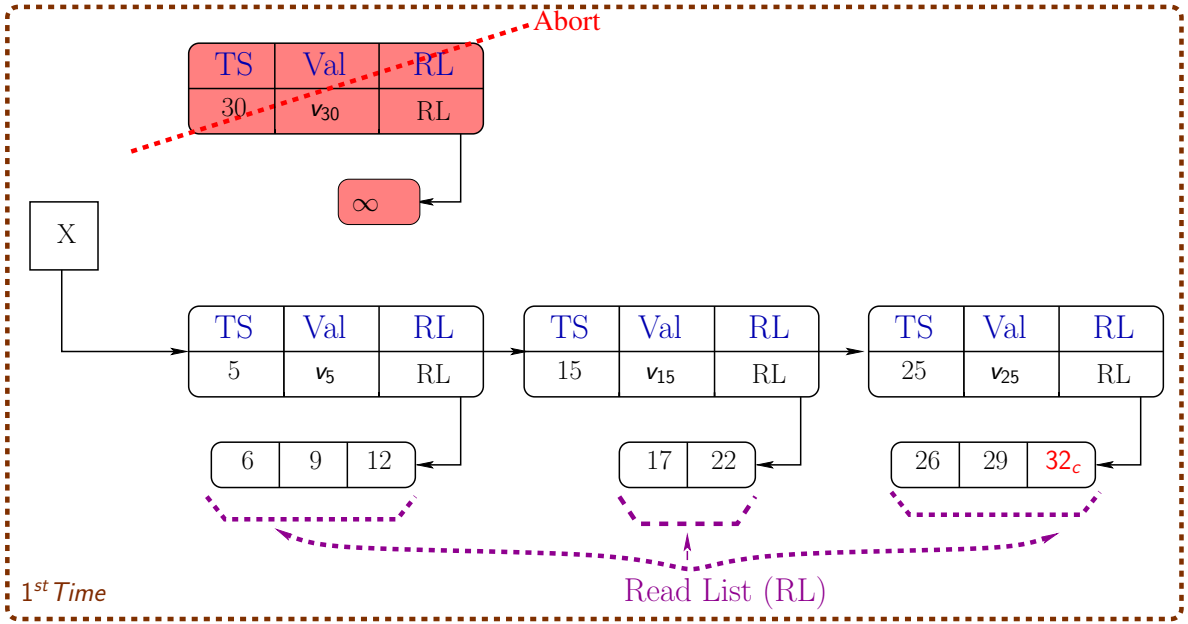

Figure 31: Starvation in K-MVOSTM

Problem with K-MVOSTM

Drawback

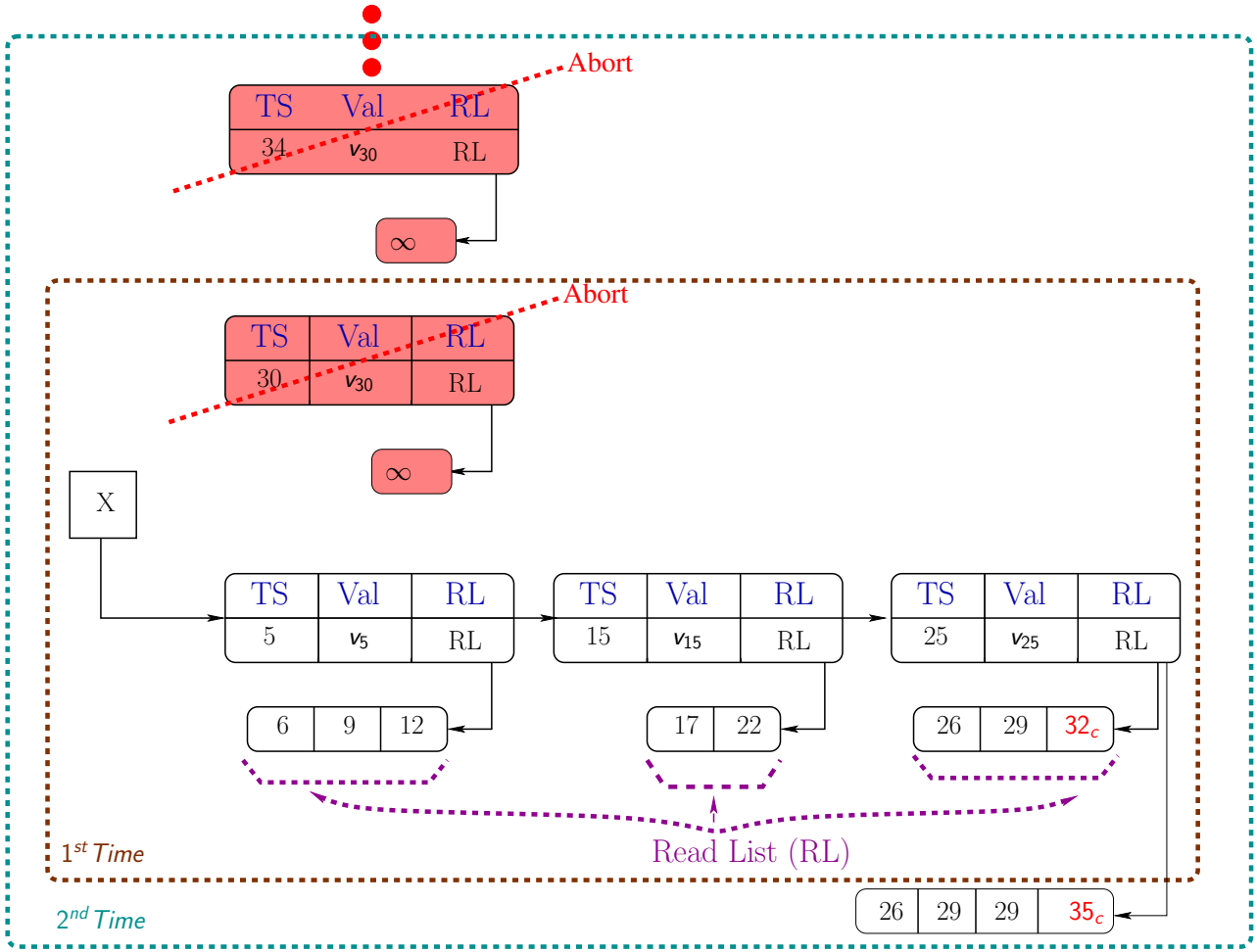

Figure 32: Starvation in K-MVOSTM

Adding ITS, CTS to K-MVOSTM

Solution Direction

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- We can add the notion of *its*, *cts* to K-MVOSTM algorithm.

Adding ITS, CTS to K-MVOSTM

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- We can add the notion of *its*, *cts* to K-MVOSTM algorithm.
- Key Observation: Any transaction with lowest *its* and highest *cts* will never abort. ▸ Detailed Description
- First observed in the context of RWSTMs by Chaudhary, V.P., Juyal, C., Kulkarni, S.S., Kumari, S., Peri, S.: Achieving starvation freedom in multi-version transactional memory systems. NETYS 2019.

Key Insight for Achieving Starvation

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- A transaction T_i instead of using the current time as cts_i, uses a potentially a unique higher timestamp, *Working Timestamp* - *wts* or wts_i.

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- Eventually, a transaction with lowest *its* will finally have the highest *wts*.

Starvation-Freedom in Multi-Version OSTMs Cont'd..

Drawback with *wts*

- As *wts* may be significantly larger than *cts* so it may not correspond to the real-time order.

[j] Papadimitriou, C.H.: The serializability of concurrent database updates. J. ACM 26(4) (1979).

[k] Kuznetsov, P., Peri, S.: Non-interference and local correctness in transactional memory. Theor. Comput. Sci. 2017

Starvation-Freedom in Multi-Version OSTMs Cont'd..

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- Hence, the history generated using *wts* ensures starvation-freedom but does not satisfies strict-serializability[j] and local opacity [k].

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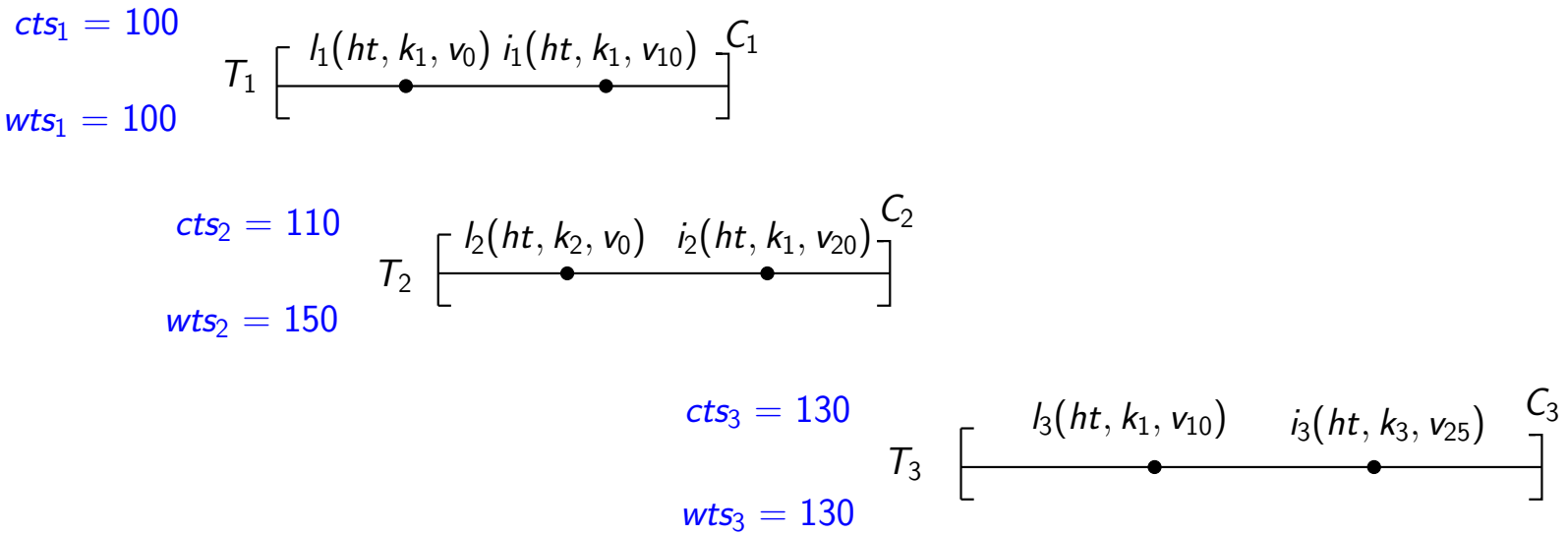

Figure 33: Violating the *real-time order* by *wts*

Starvation-Freedom in Multi-Version OSTMs Cont'd..

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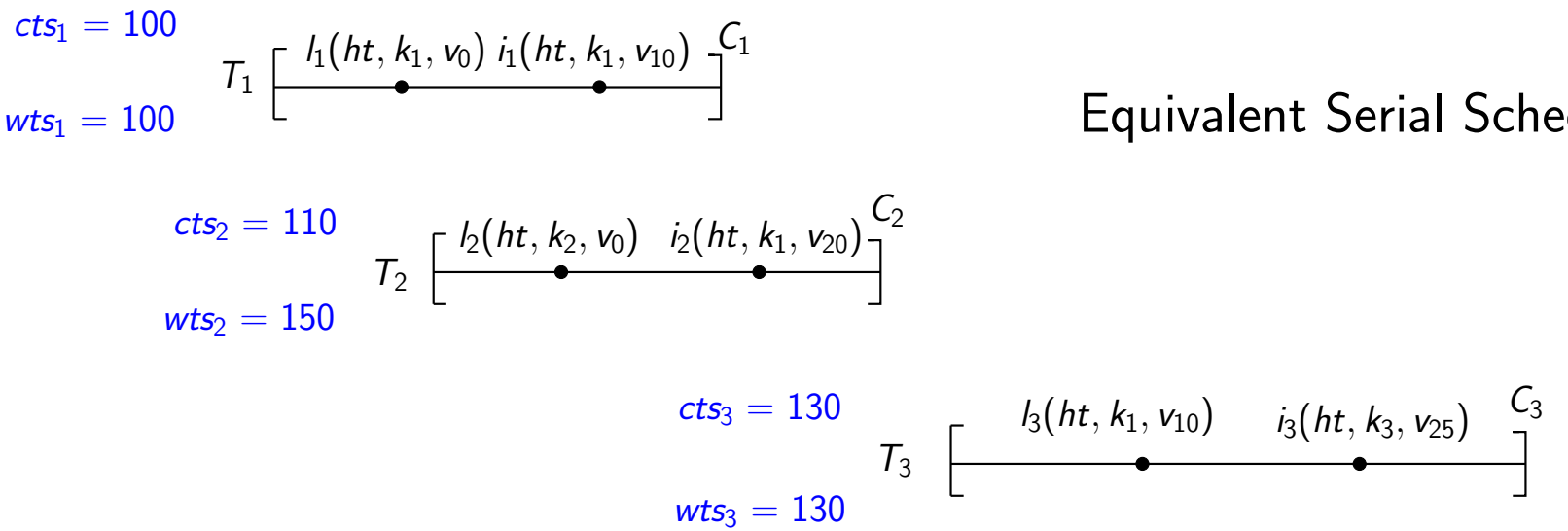

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Starvation-Freedom in Multi-Version OSTMs Cont'd..

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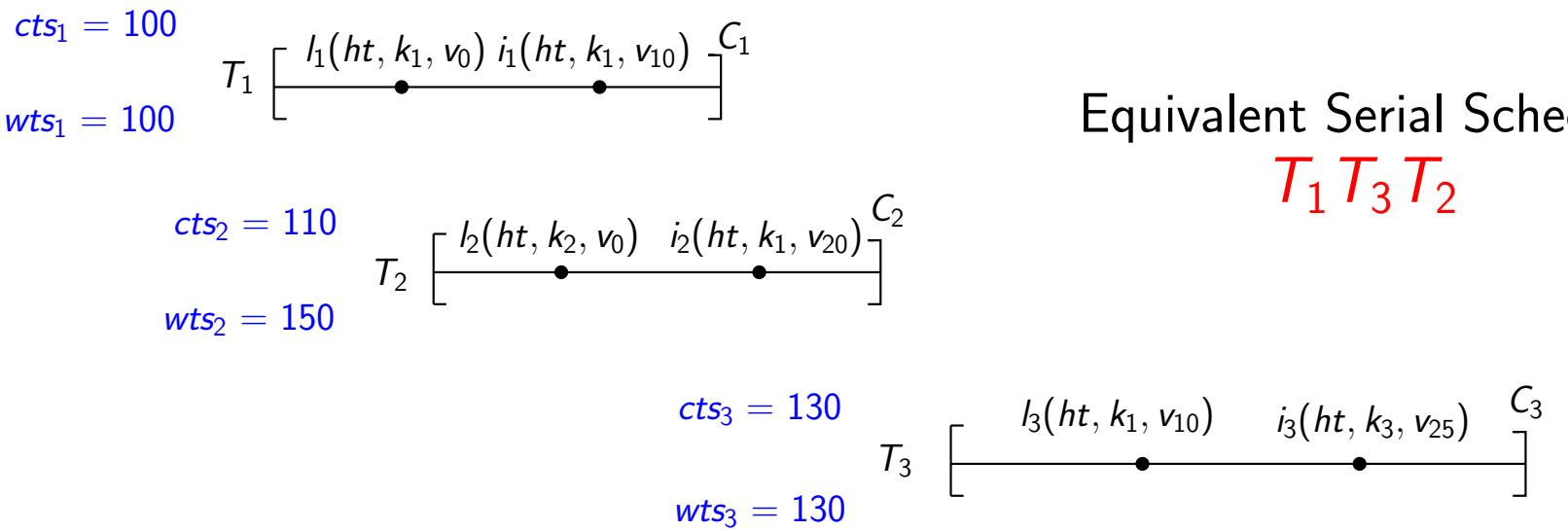

Equivalent Serial Schedule is $T_1 T_3 T_2$

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Starvation-Freedom in Multi-Version OSTMs Cont'd..

Regaining the real-time order

- We use the idea of timestamp ranges[1]: *Transaction Lower Timestamp Limit* or $tltl_i$, and *Transaction Upper Timestamp Limit* or $tutl_i$ to ensure real-time order.

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- A transaction T_i invokes the methods as follows:
  - *t_begin()*:
    1. Initialize $\langle its, wts, tltl \rangle$ = cts
    2. tutl $= \infty$
  - *t_lookup()* or *t_delete()* or *tryC()*:
    - Increments the tltl
    - Decrements the tutl
    - **If**(tltl $>$ tutl) **then** T_i returns abort.

[1] Riegel, T., Felber, P., Fetzer, C.: A lazy snapshot algorithm with eager validation. In: DISC 2006.

Starvation-Freedom in Multi-Version OSTMs Cont'd..

Correct Execution

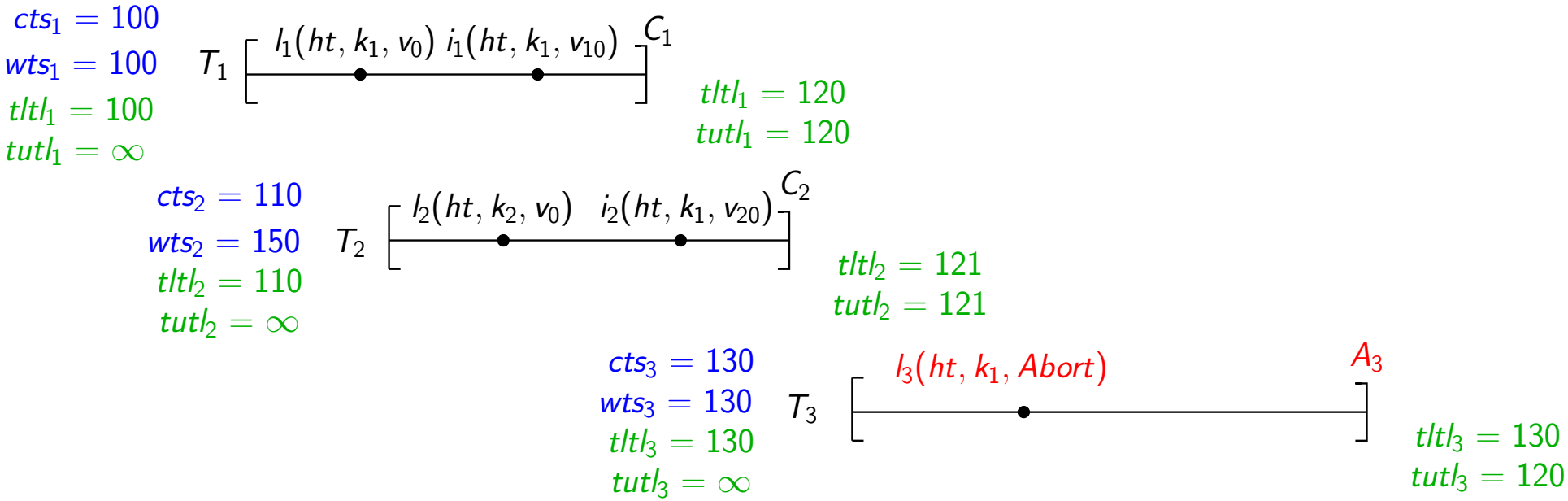

Figure 34: Regaining the *real-time order* using Timestamp Ranges along with *wts*

Starvation-Freedom in Multi-Version OSTMs Cont'd..

Correct Execution

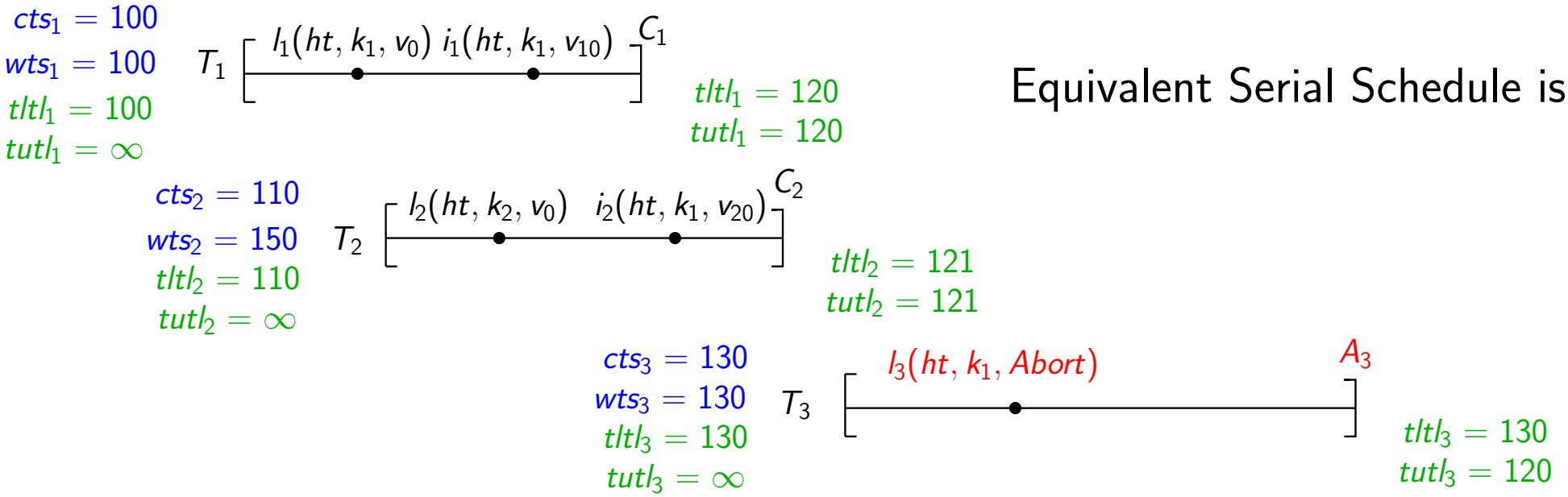

Figure 34: Regaining the *real-time order* using Timestamp Ranges along with *wts*

Starvation-Freedom in Multi-Version OSTMs Cont'd..

Correct Execution

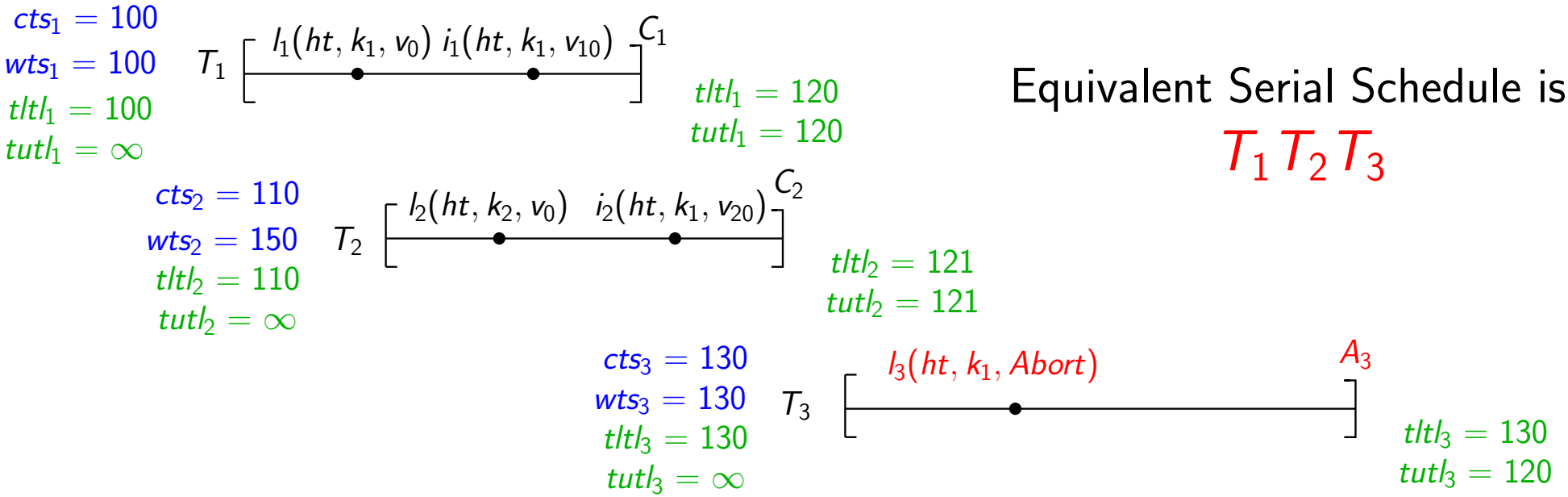

Figure 34: Regaining the *real-time order* using Timestamp Ranges along with *wts*

Outline

Proof Idea of SF-K-OSTMs

Safety and Liveness Proof

Theorem (1)

History generated by SF-K-OSTMs is strict-serializable and local-opaque.

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Theorem (1)

History generated by SF-K-OSTMs is strict-serializable and local-opaque.

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SF-K-OSTMs ensure starvation-freedom in presence of a fair scheduler that satisfies bounded-termination.

Proof.

Eventually, every transaction T_i of SF-K-OSTMs will get the lowest *its* and highest *wts*. Hence, T_i will never abort and SF-K-OSTMs ensures starvation-freedom. □

Outline

Experimental Evaluations

Experimental Setup

- The experimental system is a 2-socket Intel(R) Xeon(R) CPU E5-2690 v4 @ 2.60GHz with 14 cores per socket and 2 hyper-threads (HTs) per core, for a total of 56 threads.

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- We consider three workloads as follows:
  1. (W1) Lookup Intensive: lookup:90%, insert:5% & delete:5%
  2. (W2) Mid Intensive: lookup:50%, insert:25% & delete:25%
  3. (W3) Update Intensive: lookup:10%, insert:45% & delete:45%

Experimental Evaluations

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  2. (W2) Mid Intensive: lookup:50%, insert:25% & delete:25%
  3. (W3) Update Intensive: lookup:10%, insert:45% & delete:45%
- Shared data-items: 30 and Operations/transaction: 10

Experimental Evaluations Cont'd..

Comparison against State-of-the-art STMs

Hash Table based State-of-the-art STMs

- HT-SF-K-OSTM vs state-of-the-art STMs (HT-K-OSTM[a], HT-SV-OSTM[b], ESTM[c], RWSTM[d], and HT-MVTO[e]).

Experimental Evaluations Cont'd..

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[a] Juyal, C., Kulkarni, S.S., Kumari, S., Peri, S., Somani, A.: An innovative approach to achieve compositionality efficiently using multi-version object based transactional systems. In: SSS'18.

[b] Peri, S., Singh, A., Somani, A.: Efficient means of Achieving Composability using Transac- tional Memory. NETYS '18.

[c] Felber, P., Gramoli, V., Guerraoui, R.: Elastic Transactions. J. Parallel Distrib. Comput. 2017.

[d] Weikum, G., Vossen, G.: Transactional Information Systems: Theory, Algorithms, and the Practice of Concurrency Control and Recovery 2002.

[e] Kumar, P., Peri, S., Vidyasankar, K.: A TimeStamp Based Multi-version STM Algorithm. In: ICDCN'14.

List based State-of-the-art STMs

- list-SF-K-OSTM vs state-of-the-art STMs (list-K-OSTM, list-SV-OSTM, Trans-list[a], Boosting-list[b], NOrec-list[c], list-MVTO, and list-K-SFTM[d]).

Experimental Evaluations Cont'd..

Comparison against State-of-the-art STMs

Hash Table based State-of-the-art STMs

- HT-SF-K-OSTM vs state-of-the-art STMs (HT-K-OSTM[a], HT-SV-OSTM[b], ESTM[c], RWSTM[d], and HT-MVTO[e]).

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[a] Zhang, D., Dechev, D.: Lock-free transactions without rollbacks for linked data structures. SPAA'16.

[b] Herlihy, M., Koskinen, E.: Transactional boosting: a methodology for highly-concurrent transactional objects. PPoPP, 2008

[c] Dalessandro, L., Spear, M.F., Scott, M.L.: NOrec: streamlining stm by abolishing ownership records. PPOPP, 2010.

[d] Chaudhary, V.P., Juyal, C., Kulkarni, S.S., Kumari, S., Peri, S.: Achieving starvation freedom in multi-version transactional memory systems. NETYS 2019

Experimental Evaluations Cont'd..

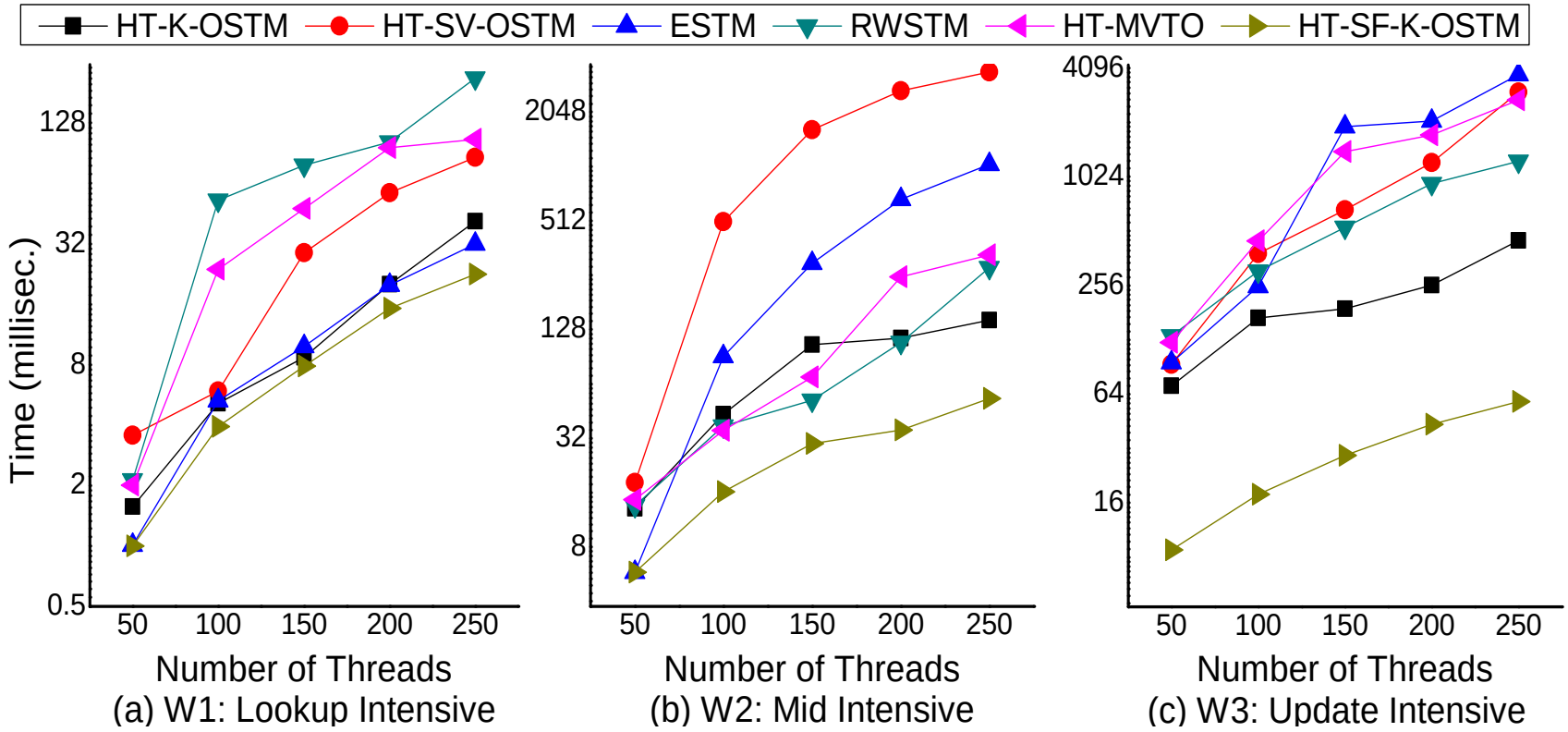


Figure 35: Performance analysis of SF-K-OSTM and State-of-the-art STMs on hash table

Experimental Evaluations Cont'd..

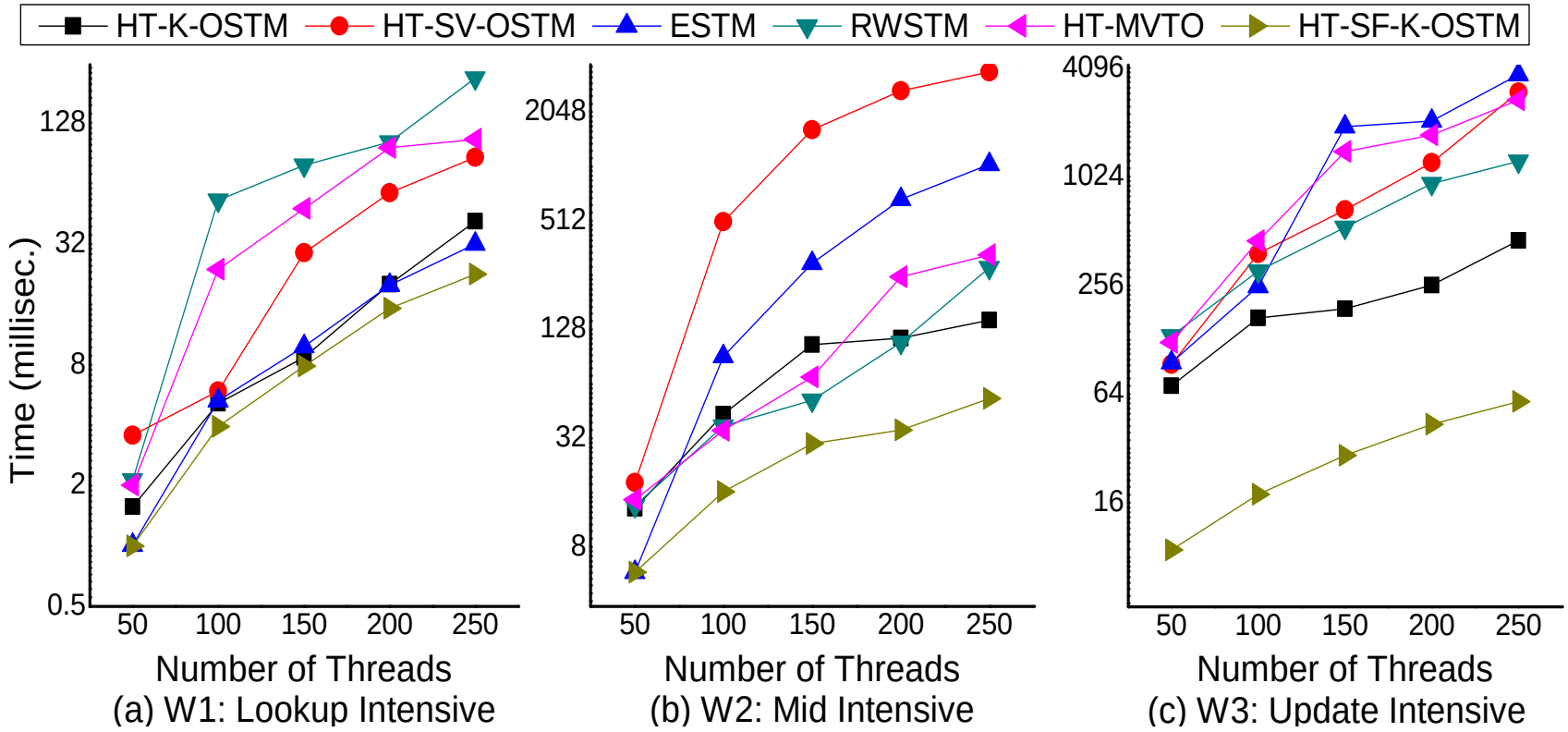


Figure 35: Performance analysis of SF-K-OSTM and State-of-the-art STMs on hash table

- Proposed hash table based SF-K-OSTM (HT-SF-K-OSTM) performs 3.9x, 32.18x, 22.67x, 10.8x, and 17.1x average speedup on *max-time* for a transaction to commit than state-of-the-art STMs (HT-K-OSTM, HT-SV-OSTM, ESTM, RWSTM, and HT-MVTO) respectively.

Experimental Evaluations Cont'd..

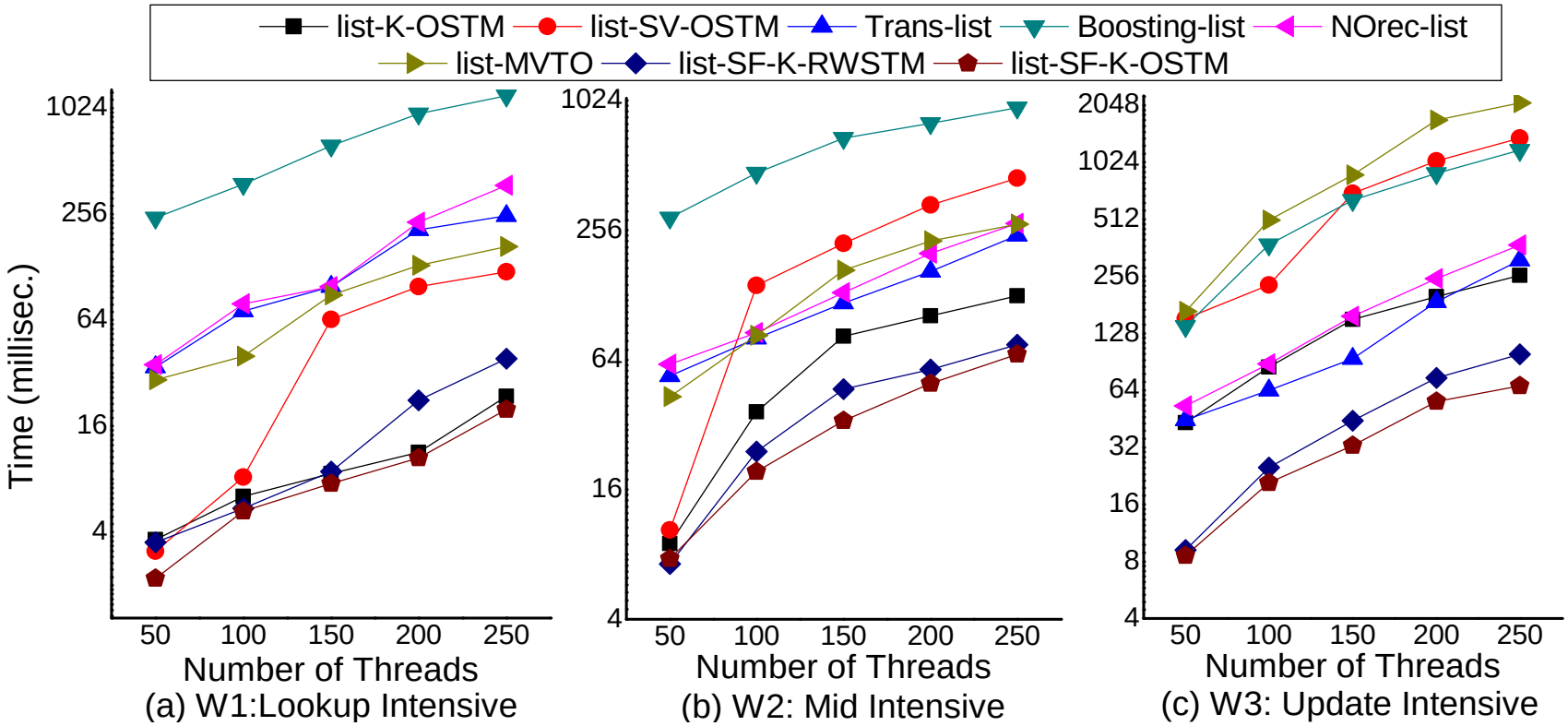


Figure 36: Performance analysis of SF-K-OSTM and State-of-the-art STMs on list

Experimental Evaluations Cont'd..

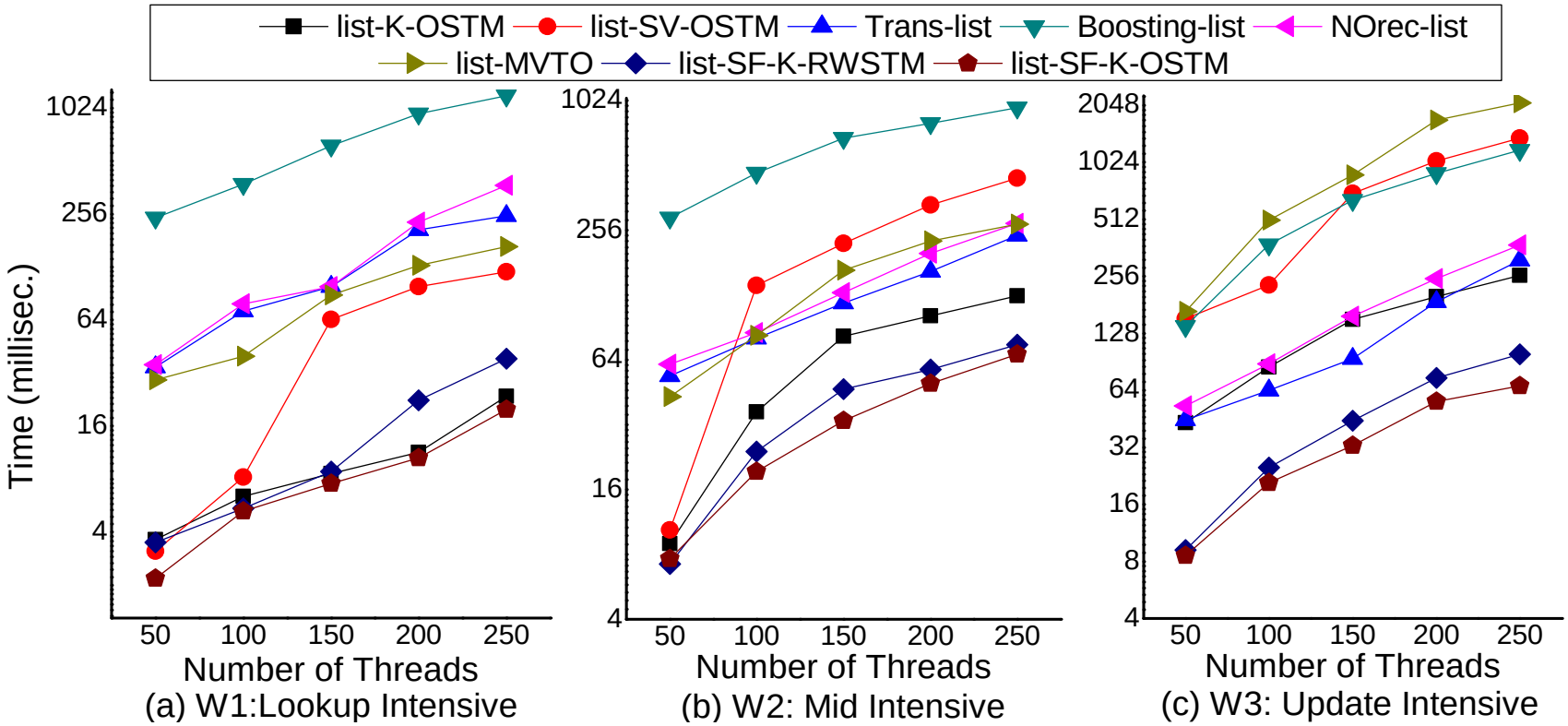
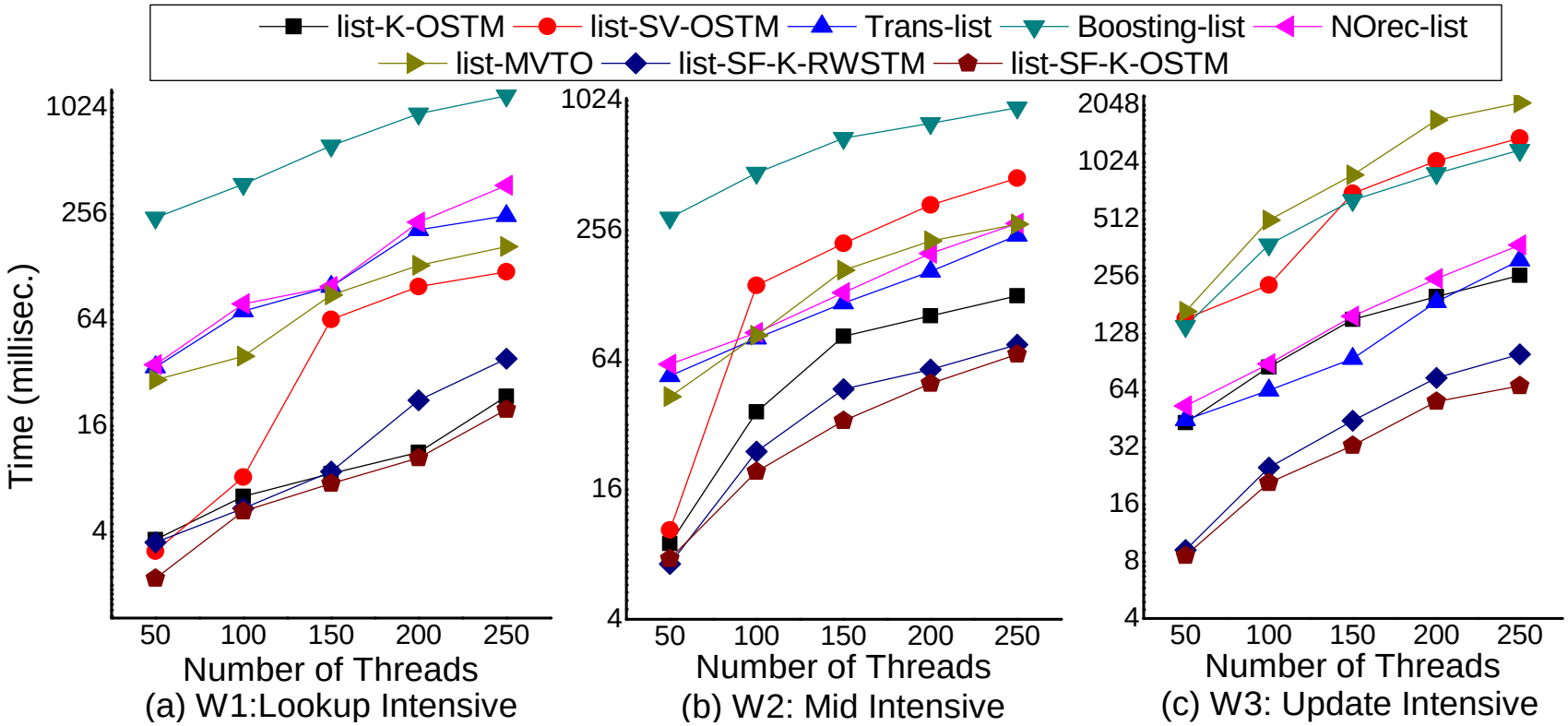


Figure 36: Performance analysis of SF-K-OSTM and State-of-the-art STMs on list

- Proposed list based SF-K-OSTM (list-SF-K-OSTM) performs 2.4x, 10.6x, 7.37x, 36.7x, 9.05x, 14.47x, and 1.43x average speedup on *max-time* for a transaction to commit than state-of-the-art STMs (list-K-OSTM, list-SV-OSTM, Trans-list, Boosting-list, NOrec-list, list-MVTO, and list-SF-K-RWSTM) respectively.

Experimental Evaluations Cont'd..



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▸ Additional Experiments

Outline

Conclusion and Future Direction

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- We proposed *SF-SV-OSTM* which ensures starvation-freedom along with the correctness-criteria as conflict-opacity.

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- For harnessing greater concurrency in STMs, we proposed a novel Starvation-Free *K-Version Object-based STM (SF-K-OSTM)*.

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- For harnessing greater concurrency in STMs, we proposed a novel Starvation-Free *K-Version Object-based STM (SF-K-OSTM)*.
- SF-K-OSTM ensures the starvation-freedom while maintaining the latest K-versions corresponding to each key and satisfies the correctness criteria as local-opacity.

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- We proposed the SF-SV-OSTM and SF-K-OSTM for hash-table and list but its generic for other data structures as well.

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- The results of SF-K-OSTM shows significant performance gain over state-of-the-art STMs and SF-SV-OSTM.

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Future Direction

- Exploring starvation-freedom in **Nested STMs**[a].

[a] Sathya Peri and K.Vidyasankar, Correctness of Concurrent Executions of Closed Nested Transactions in Transactional Memory Systems", Theoretical Computer Science, 2013

Thank You
&
Questions Please!!

Working of STMs

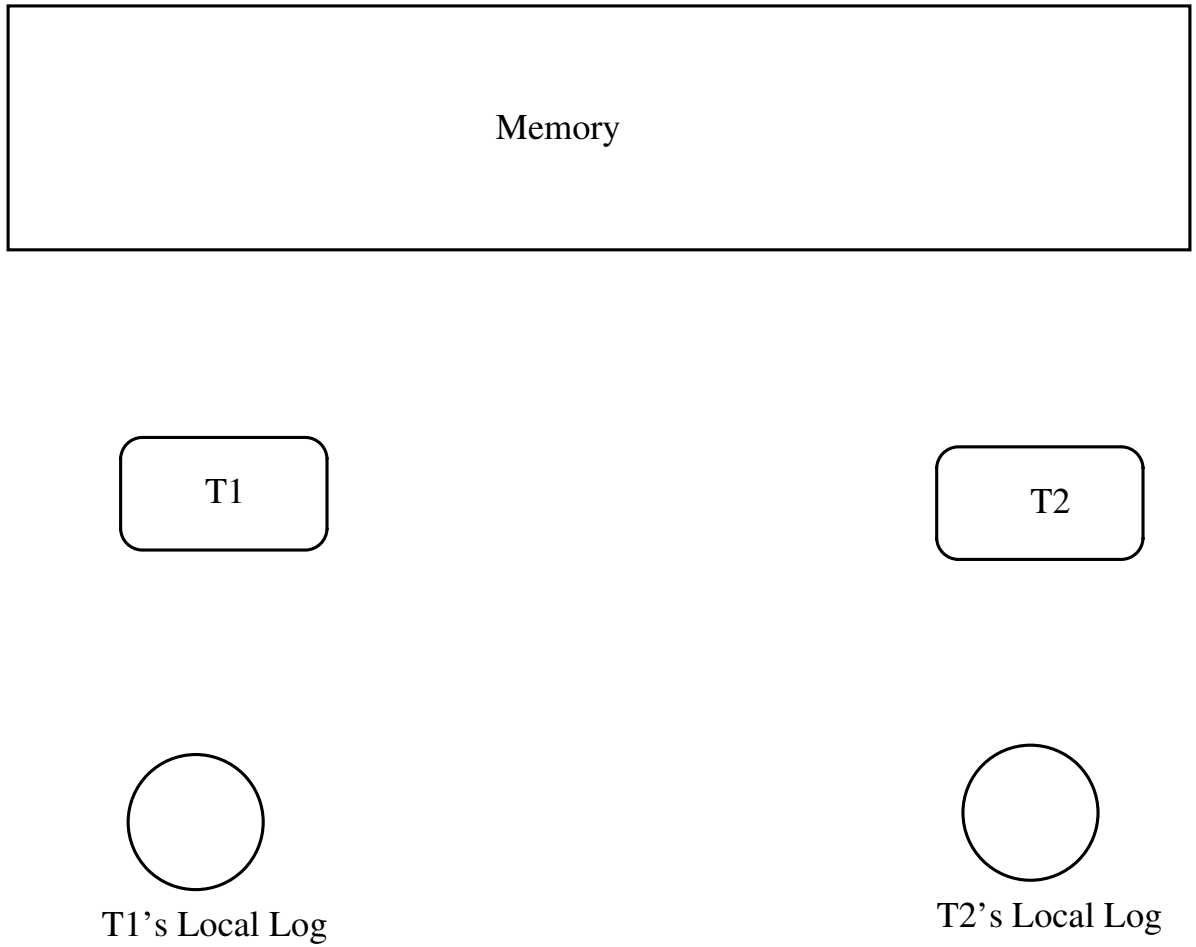
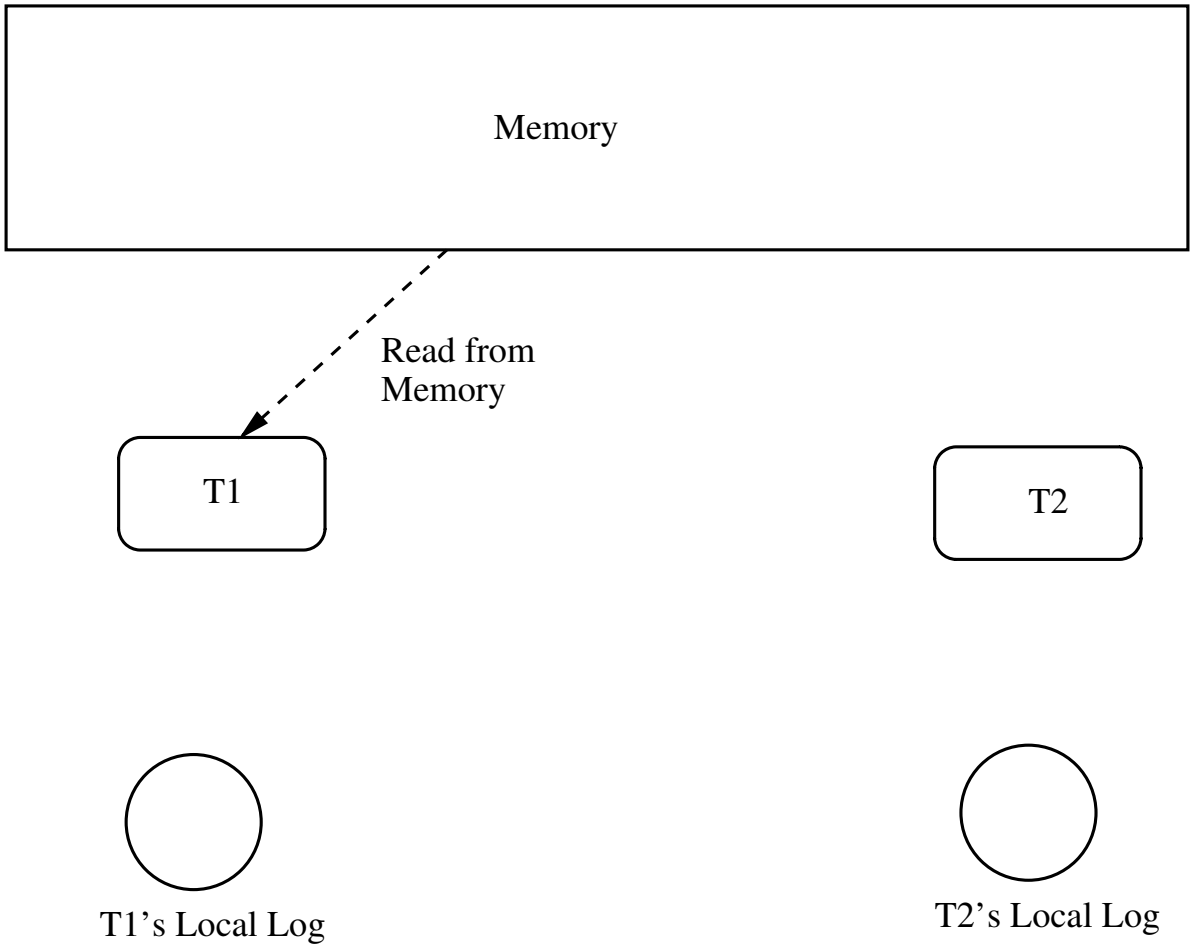


Figure 37: Working of STM System

return

Working of STMs



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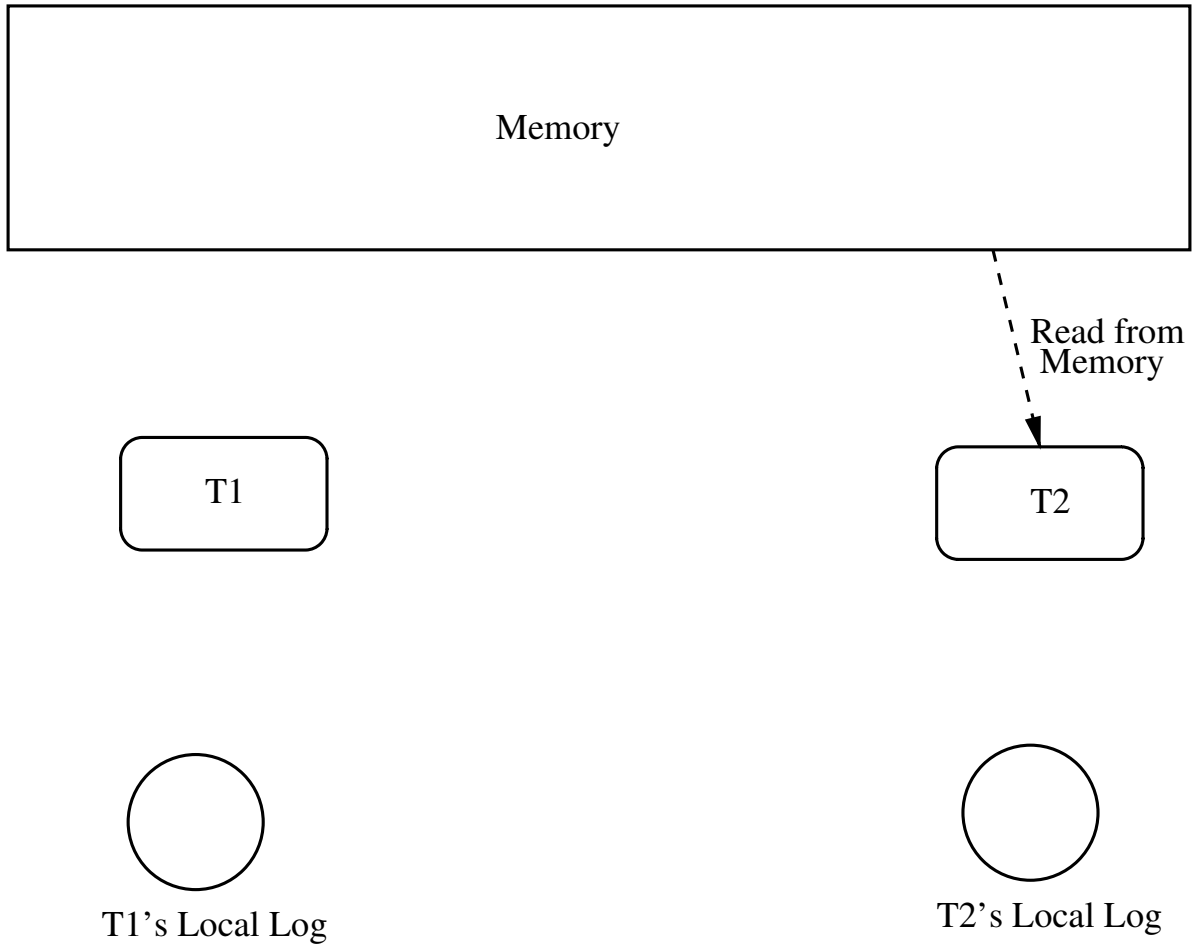

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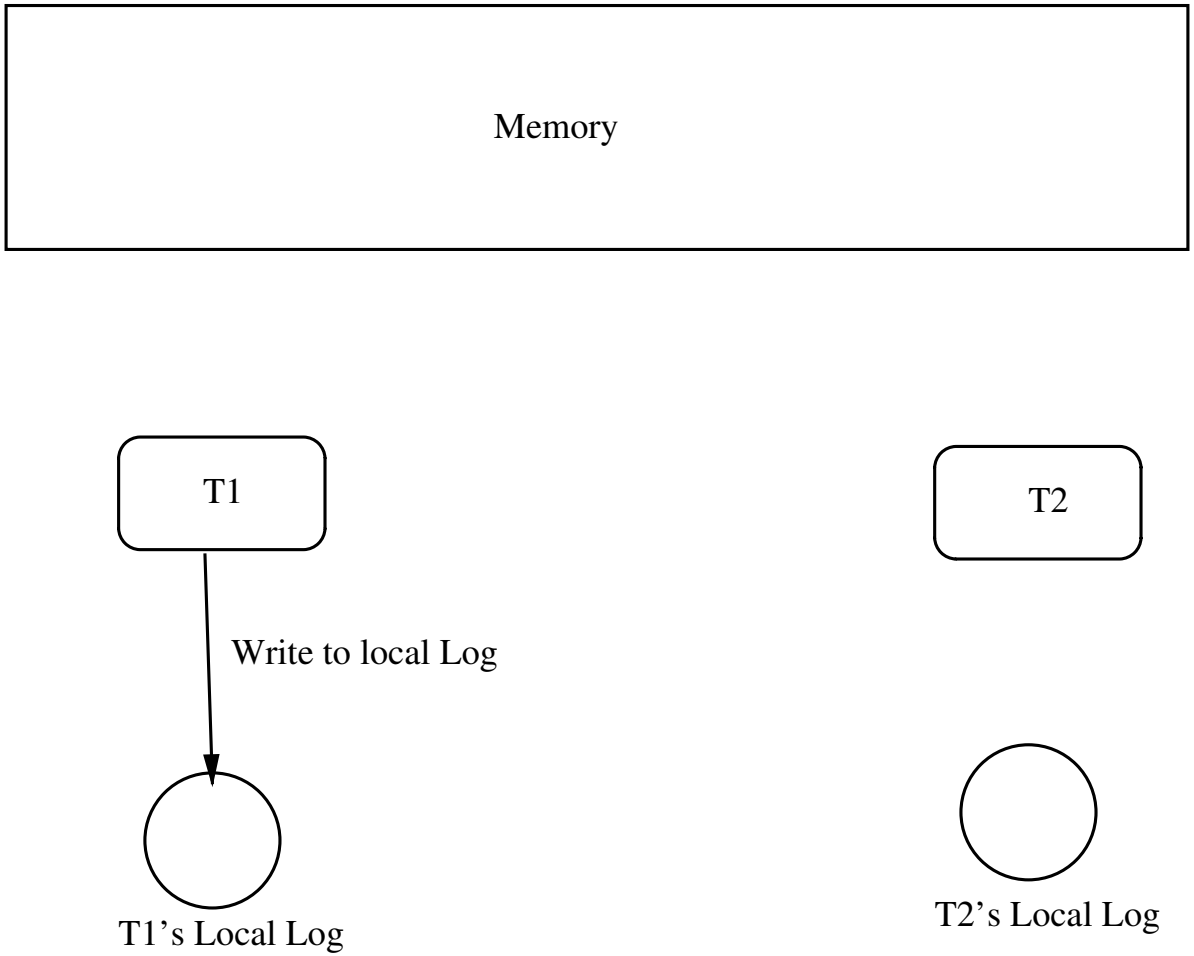

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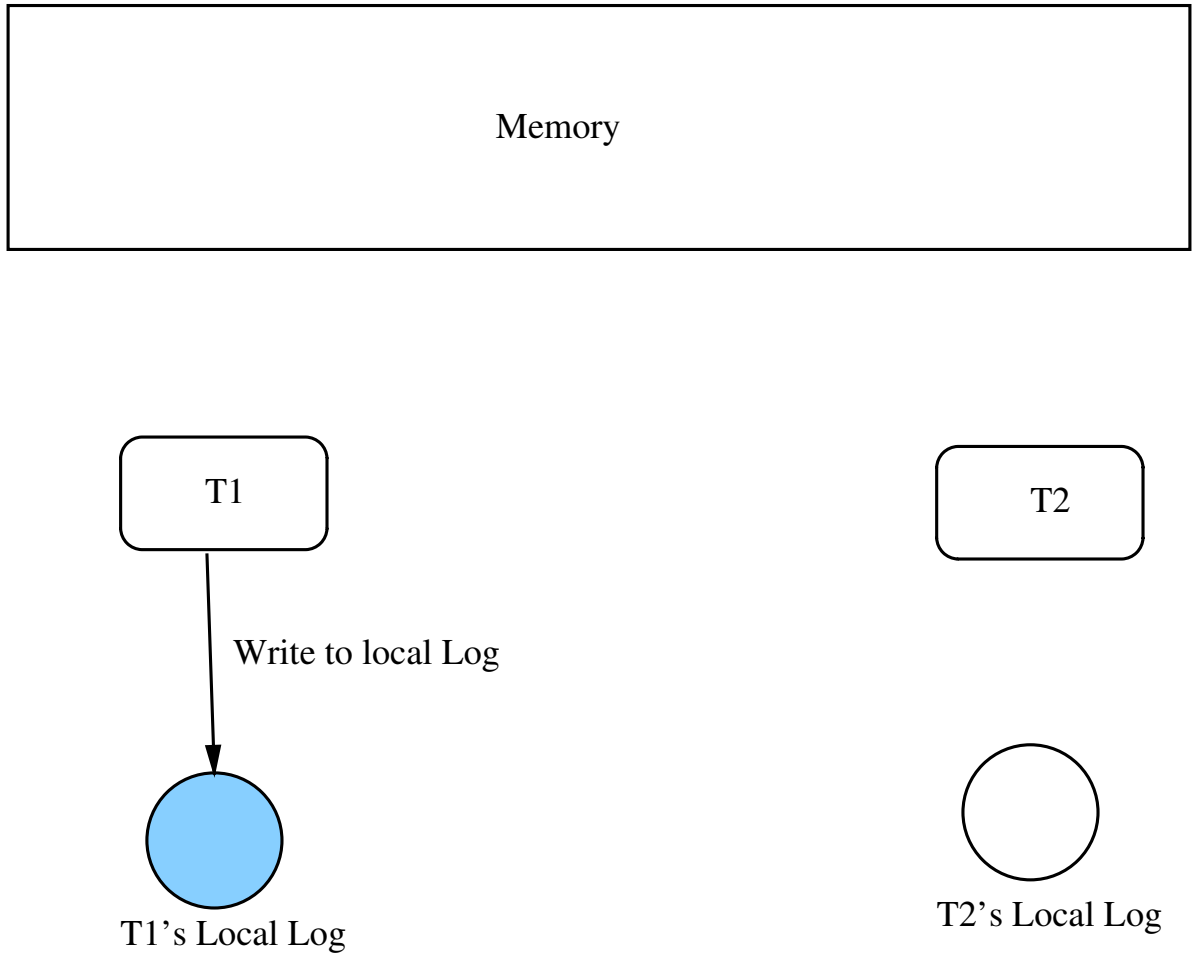

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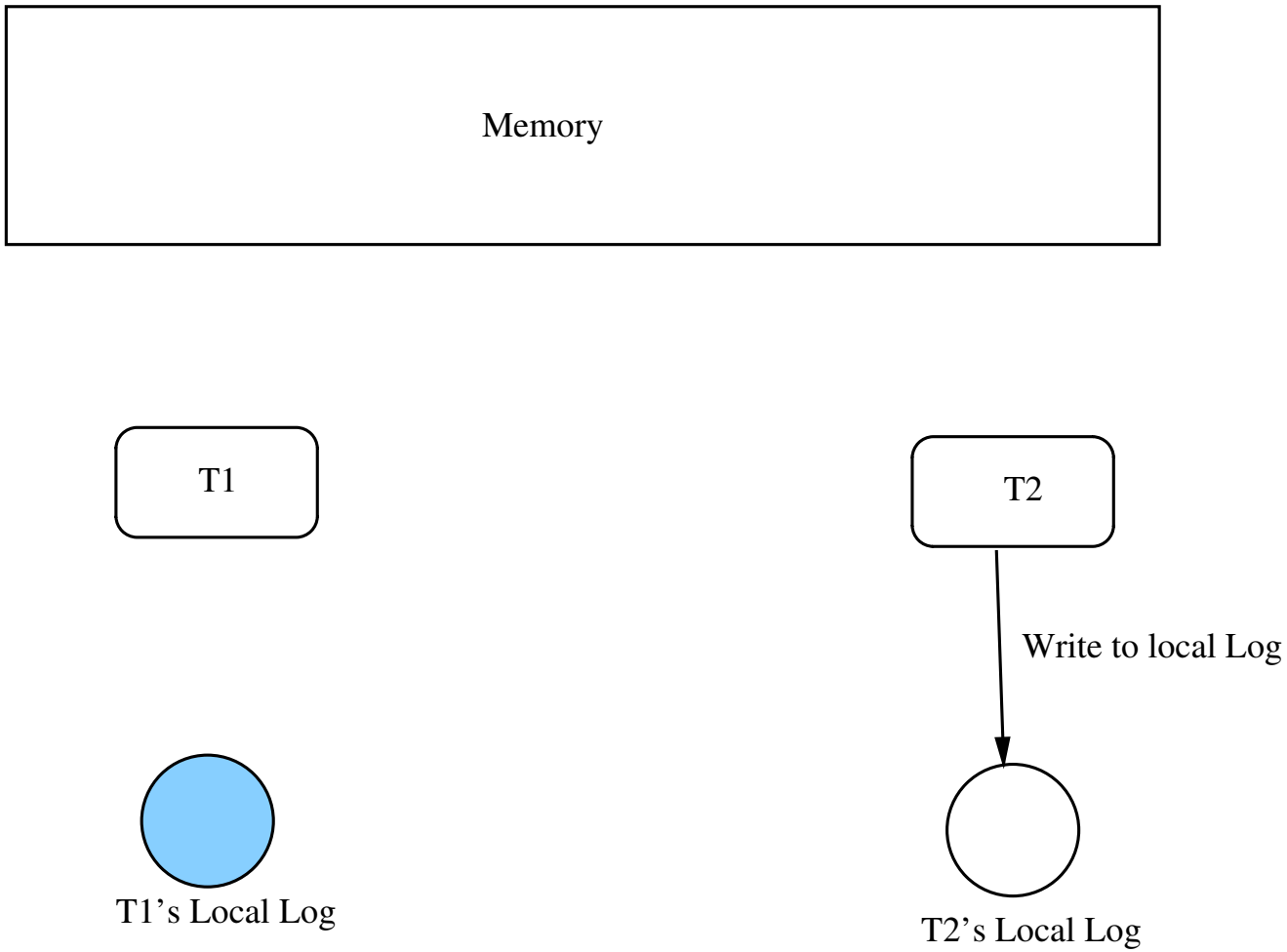

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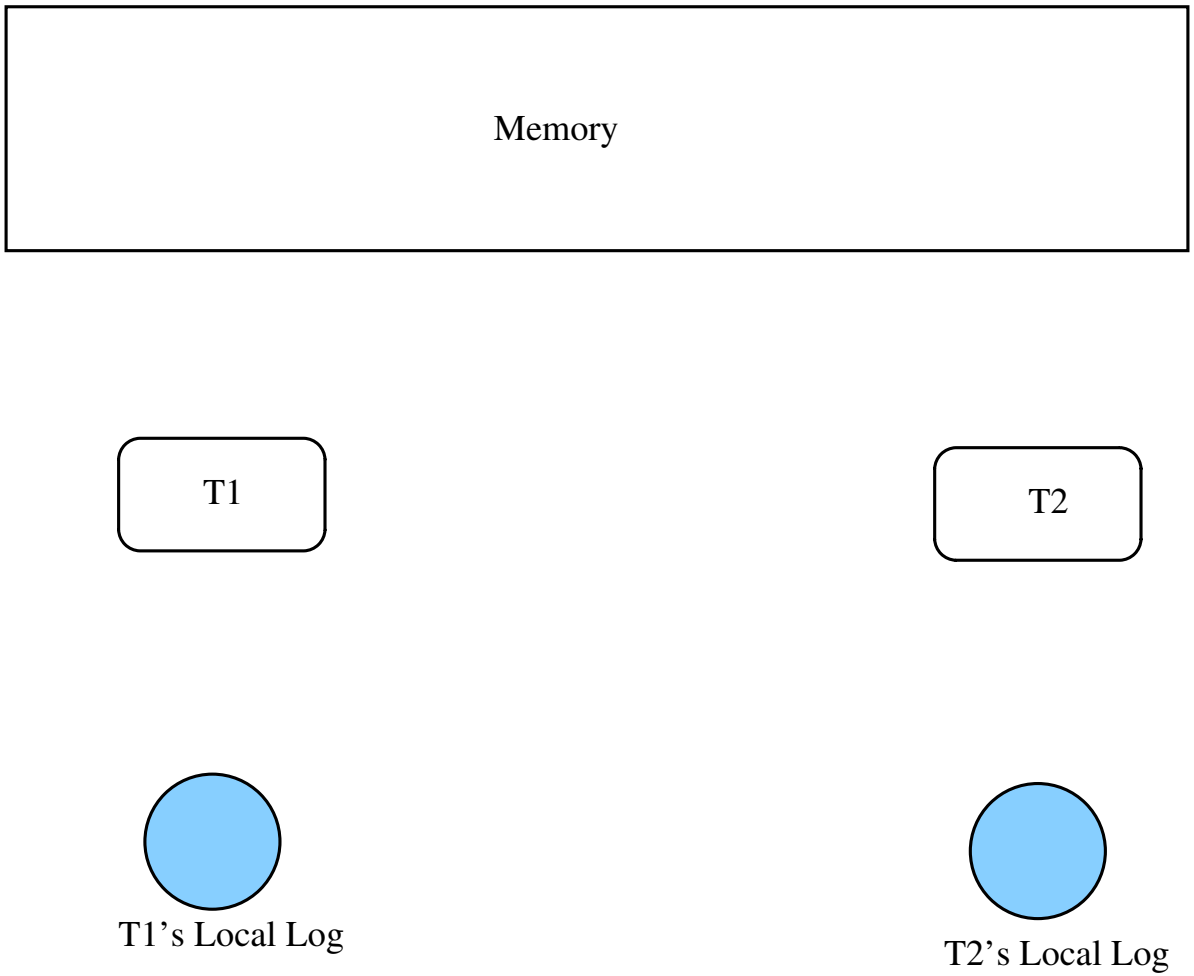

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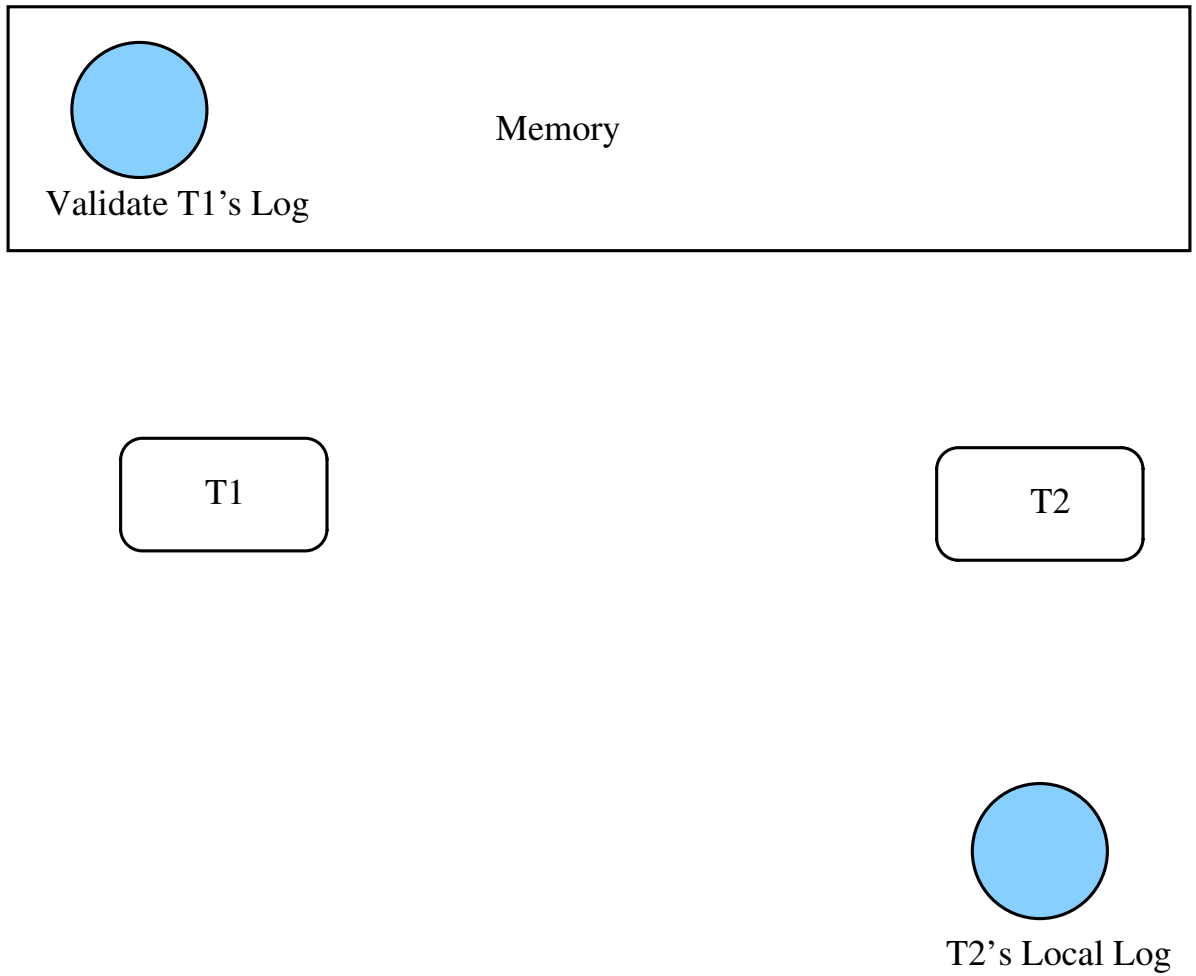

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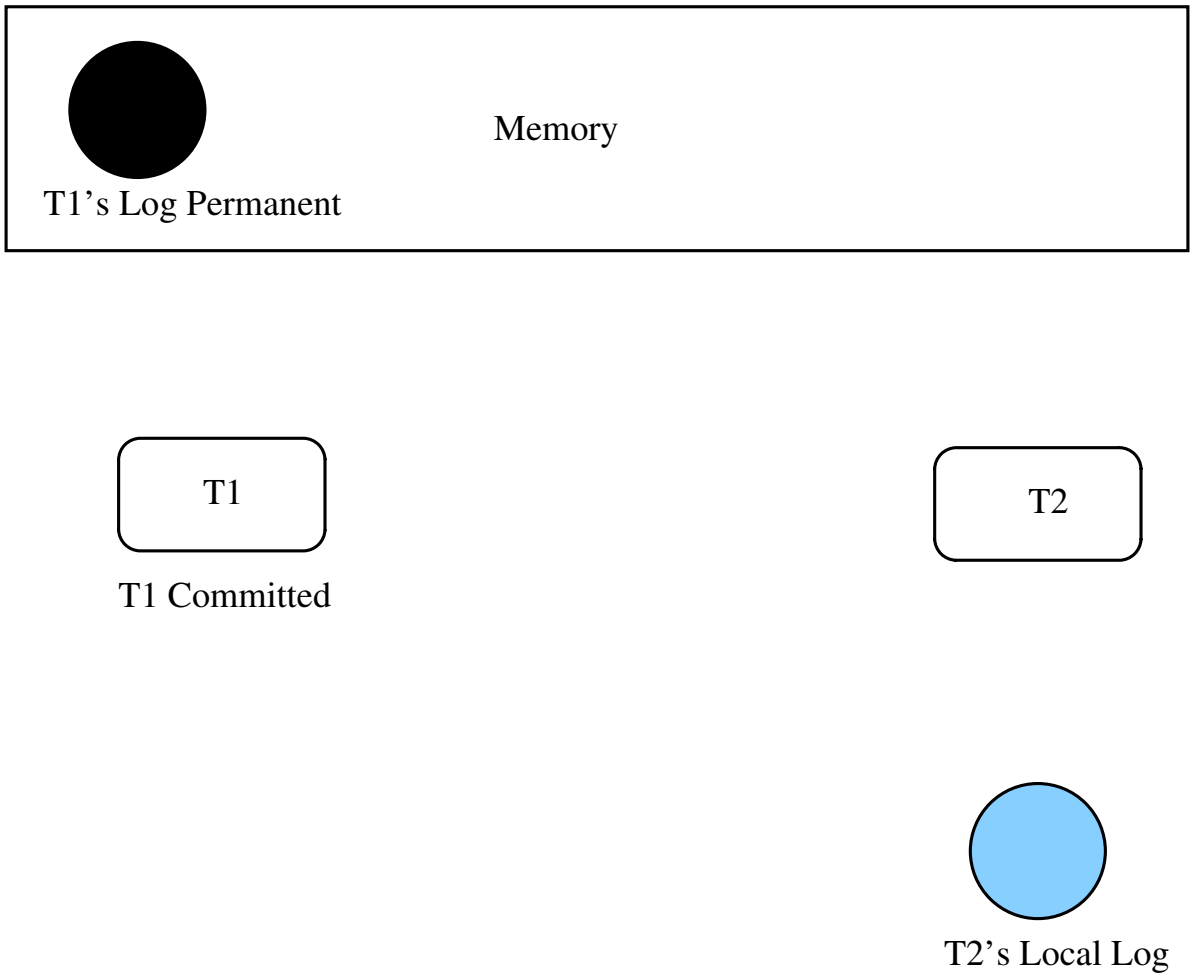
Working of STMs



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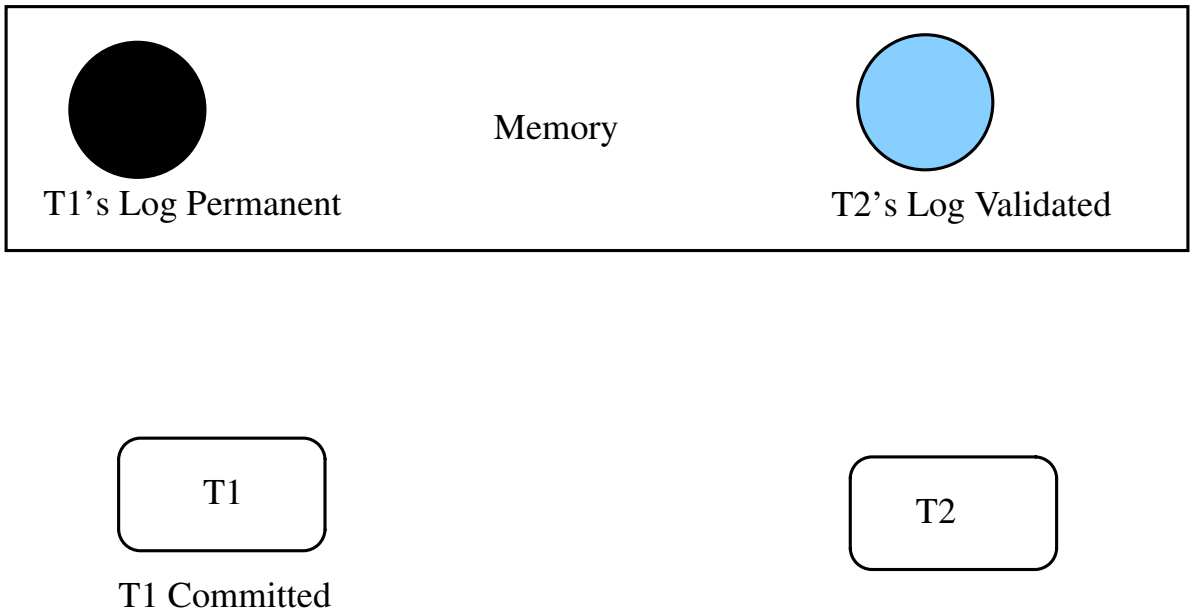

Figure 37: Working of STM System

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Working of STMs

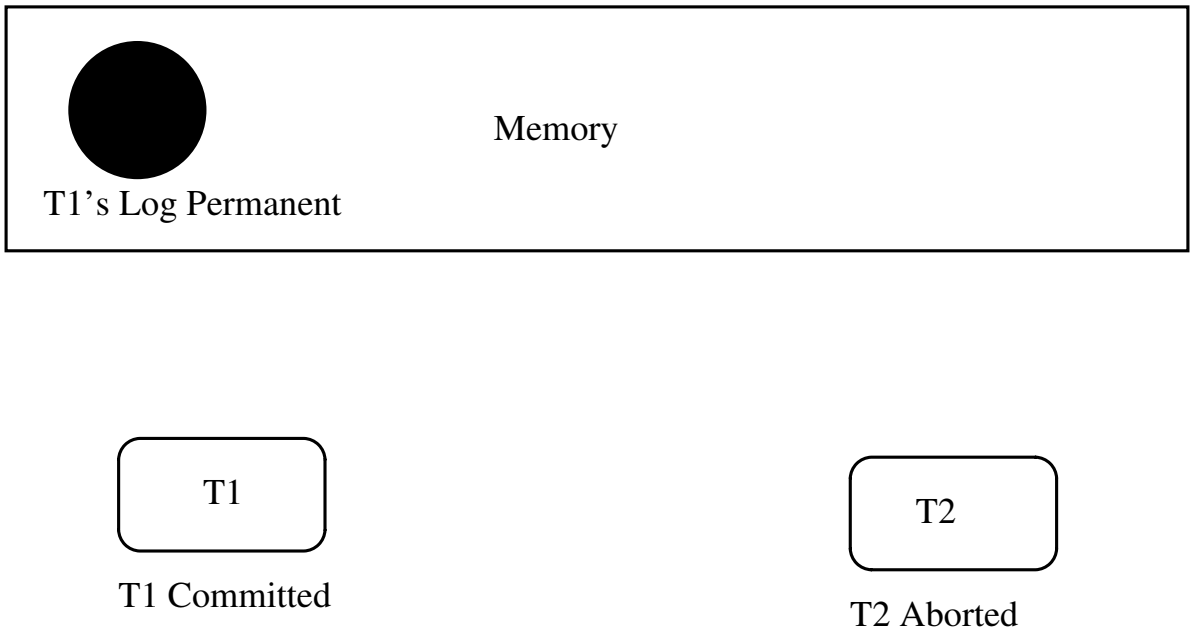


Figure 37: Working of STM System

return

Starvation-Freedom in Multi-Version OSTMs

Key Observation

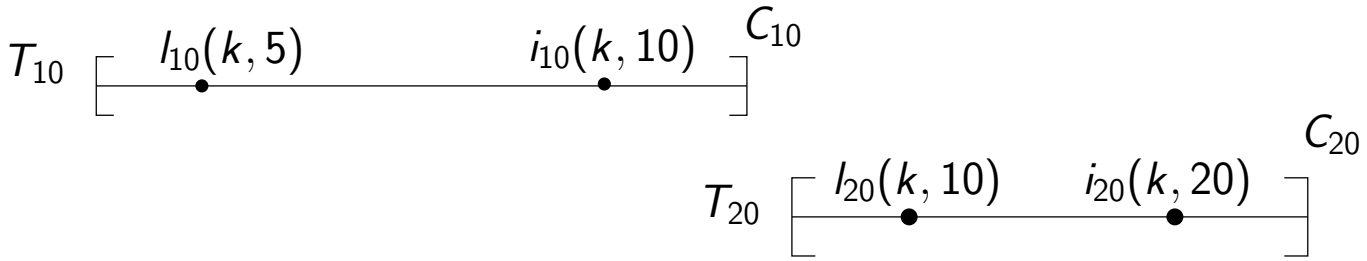


Figure 38: T_{20} looks up the version inserted by T_{10}. No conflict.

Starvation-Freedom in Multi-Version OSTMs

Key Observation

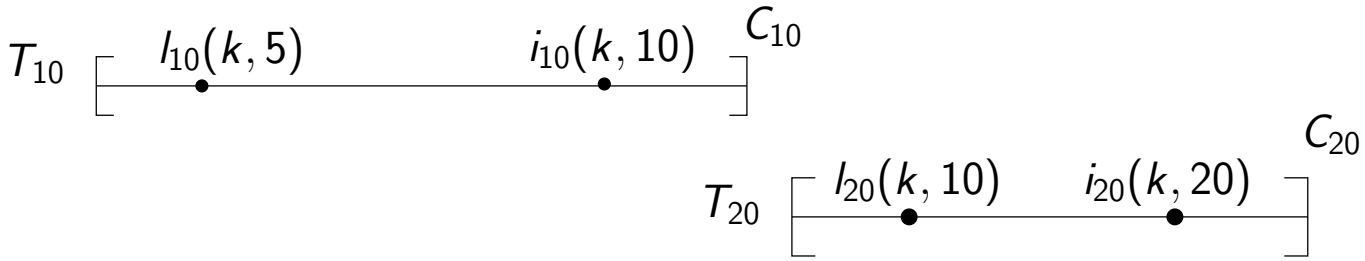


Figure 38: T_{20} looks up the version inserted by T_{10}. No conflict.

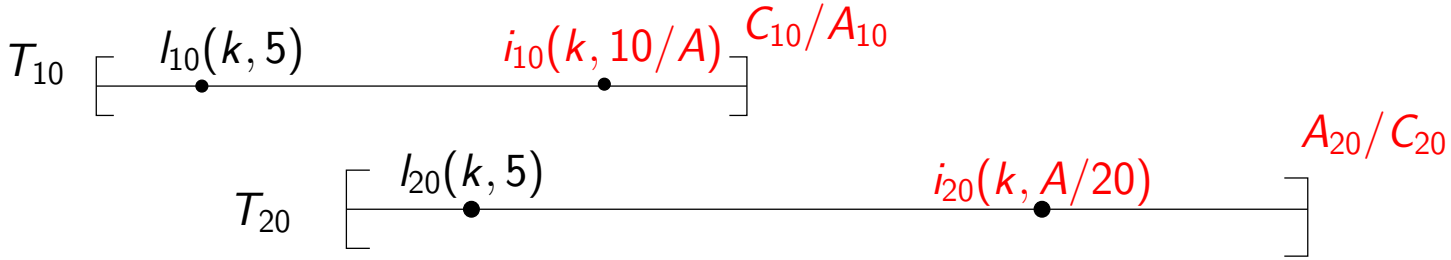


Figure 39: Conflict detected at i_{10}. Either abort T_{10} or T_{20}

Starvation-Freedom in Multi-Version OSTMs Cont'd..

Permutations of operations

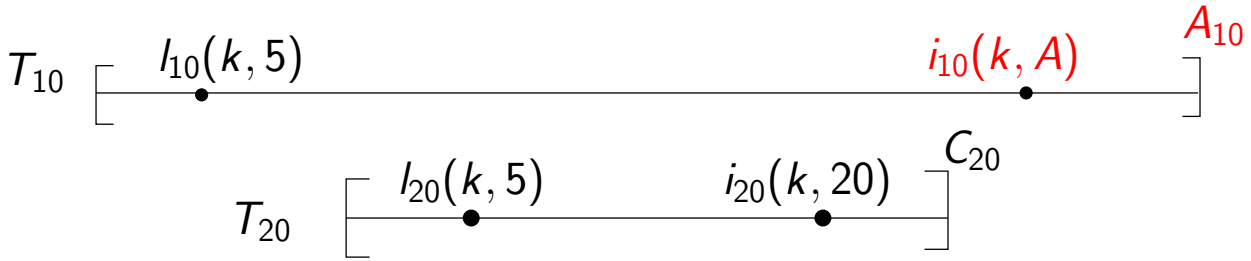
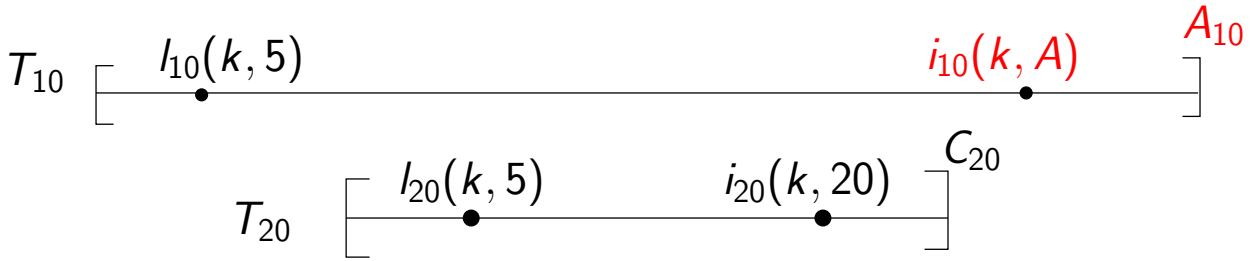


Figure 40: Conflict detected at i_{10}. Hence, abort T_{10}

Starvation-Freedom in Multi-Version OSTMs Cont'd..

Permutations of operations



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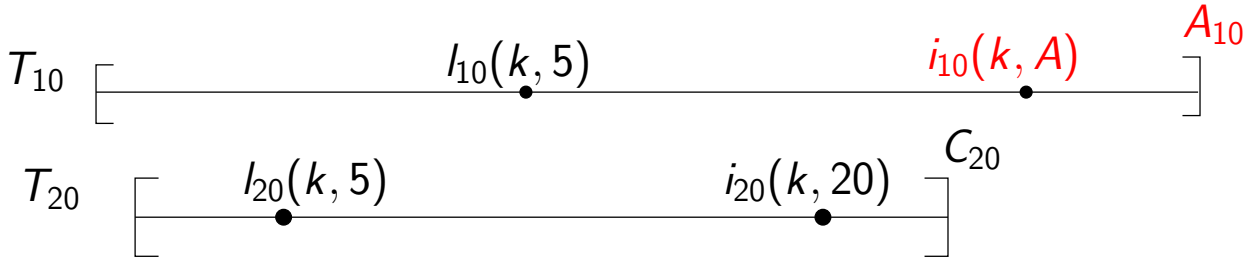


Figure 41: Conflict detected at i_{10}. Hence, abort T_{10}

Starvation-Freedom in Multi-Version OSTMs Cont'd..

Permutations of operations

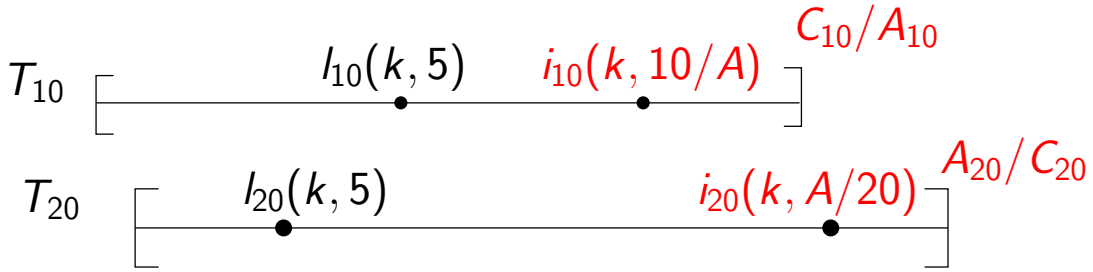


Figure 42: Conflict detected at i_{10}. Abort T_{10}

Starvation-Freedom in Multi-Version OSTMs Cont'd..

Permutations of operations

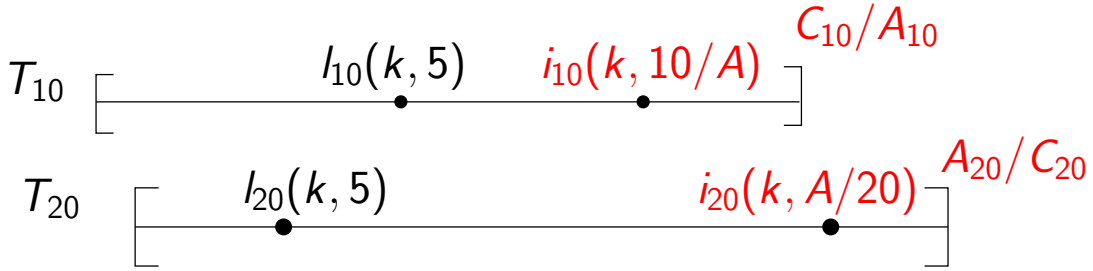


Figure 42: Conflict detected at i_{10}. Abort T_{10}

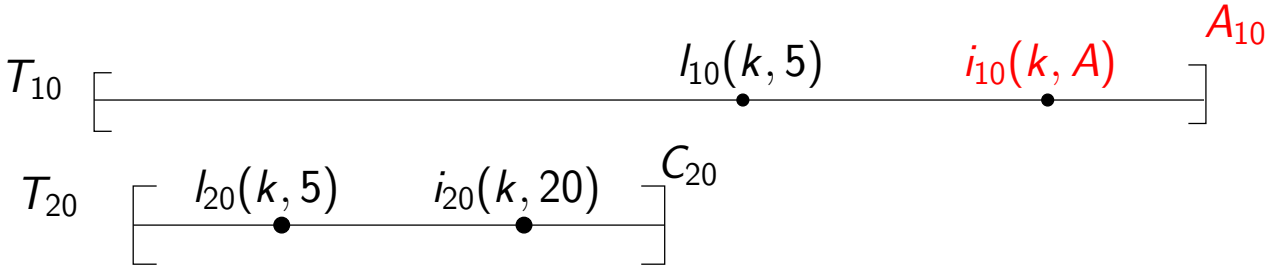


Figure 43: Conflict detected at i_{10}. Hence, abort T_{10}

Starvation-Freedom in Multi-Version OSTMs Cont'd..

Permutations of operations

S. No.	Execution Sequence	Possible actions by Transactions
1.	$l_{10}(k), i_{10}(k), l_{20}(k), i_{20}(k)$	$T_{20}(k)$ lookups the version inserted by T_{10}. No conflict.
2.	$l_{10}(k), l_{20}(k), i_{10}(k), i_{20}(k)$	Conflict detected at $i_{10}(k)$. Either abort T_{10} or T_{20}.
3.	$l_{10}(k), l_{20}(k), i_{20}(k), i_{10}(k)$	Conflict detected at $i_{10}(k)$. Hence, abort T_{10}.
4.	$l_{20}(k), l_{10}(k), i_{20}(k), i_{10}(k)$	Conflict detected at $i_{10}(k)$. Hence, abort T_{10}.
5.	$l_{20}(k), l_{10}(k), i_{10}(k), i_{20}(k)$	Conflict detected at $i_{10}(k)$. Either abort T_{10} or T_{20}.
6.	$l_{20}(k), i_{20}(k), l_{10}(k), i_{10}(k)$	Conflict detected at $i_{10}(k)$. Hence, abort T_{10}.

Table 1: Possible Permutations of Methods

Starvation-Freedom in Multi-Version OSTMs Cont'd..

Key Observation

Takeaway

A transaction cannot be aborted if

- It has the lowest *its*, i.e., it is the earliest transaction and
- It has the highest *cts*

return

Experimental Evaluations

Low Contention Environment: 1000 Shared data-items & 10 operations/transaction

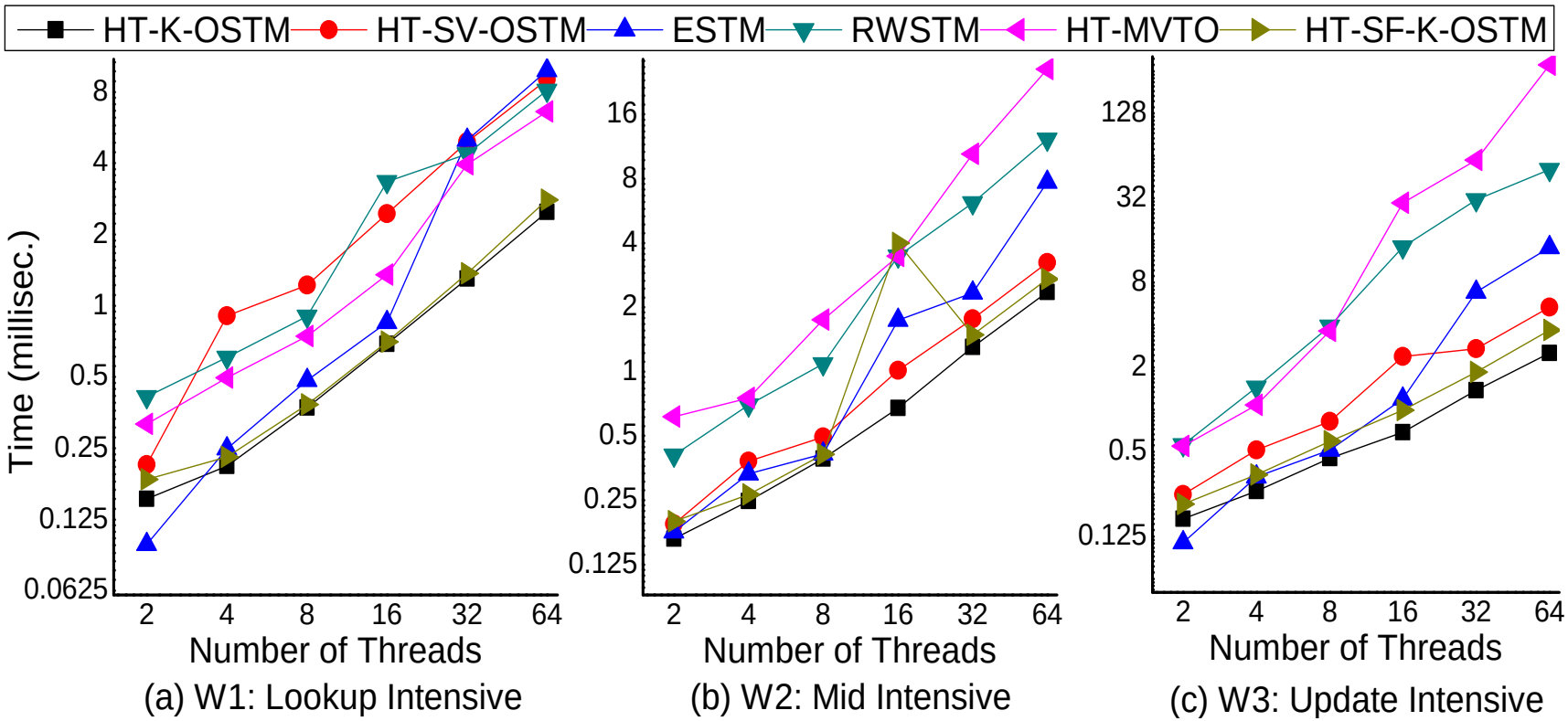
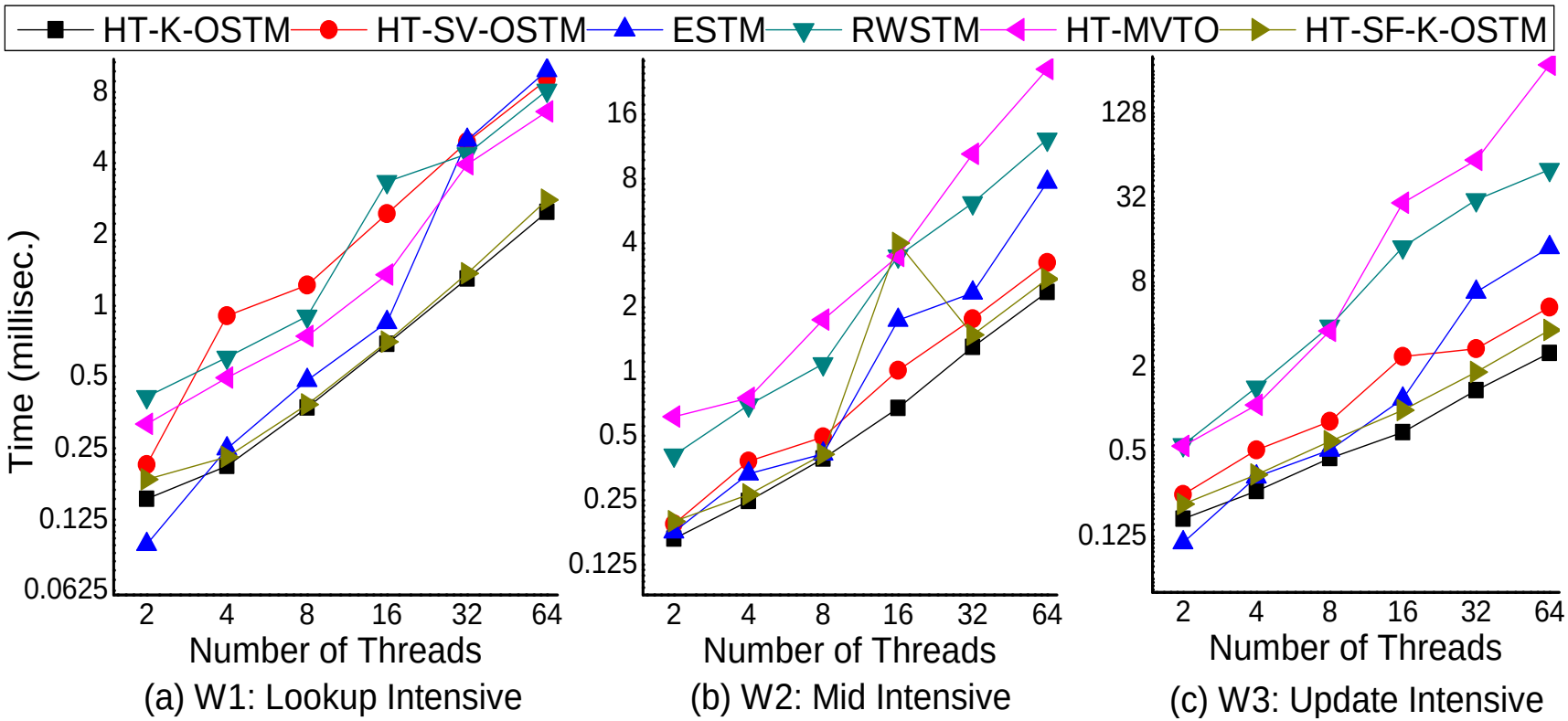


Figure 44: Time comparison of SF-K-OSTM and State-of-the-art STMs on hash table

Experimental Evaluations

Low Contention Environment: 1000 Shared data-items & 10 operations/transaction



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- Proposed hash table based SF-K-OSTM (HT-SF-K-OSTM) performs better than all other state-of-art-STMs algorithms but slightly lesser than the non starvation-free HT-K-OSTM.

Experimental Evaluations Cont'd..

Low Contention Environment: 1000 Shared data-items & 10 operations/transaction

Algorithm	W1	W2	W3
HT-SF-SV-OSTM	1.49	1.13	1.09
HT-SF-MV-OSTM	1.22	1.08	1.04
HT-SF-MV-OSTM-GC	1.13	1.03	1.02
HT-SV-OSTM	3.3	0.77	1.57
ESTM	2.92	1.4	3.03
RWSTM	3.13	2.65	13.36
HT-MVTO	2.37	4.74	49.39
HT-K-OSTM	0.91	0.7	0.8

Table 2: Speedup by HT-SF-K-OSTM

Experimental Evaluations Cont'd..

Low Contention Environment: 1000 Shared data-items & 10 operations/transaction

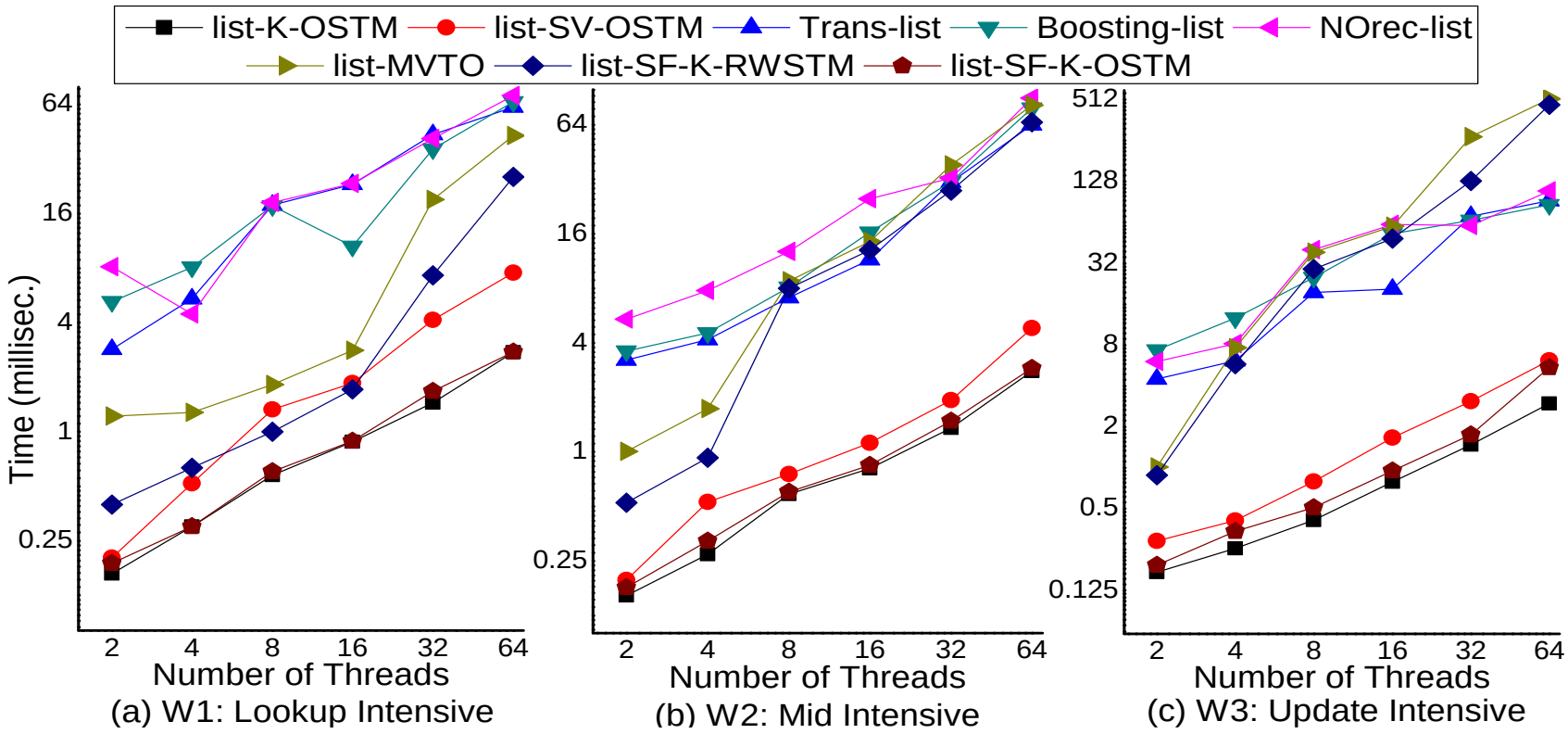

Figure 45: Time comparison of SF-K-OSTM and State-of-the-art STMs on list

Experimental Evaluations Cont'd..

Low Contention Environment: 1000 Shared data-items & 10 operations/transaction

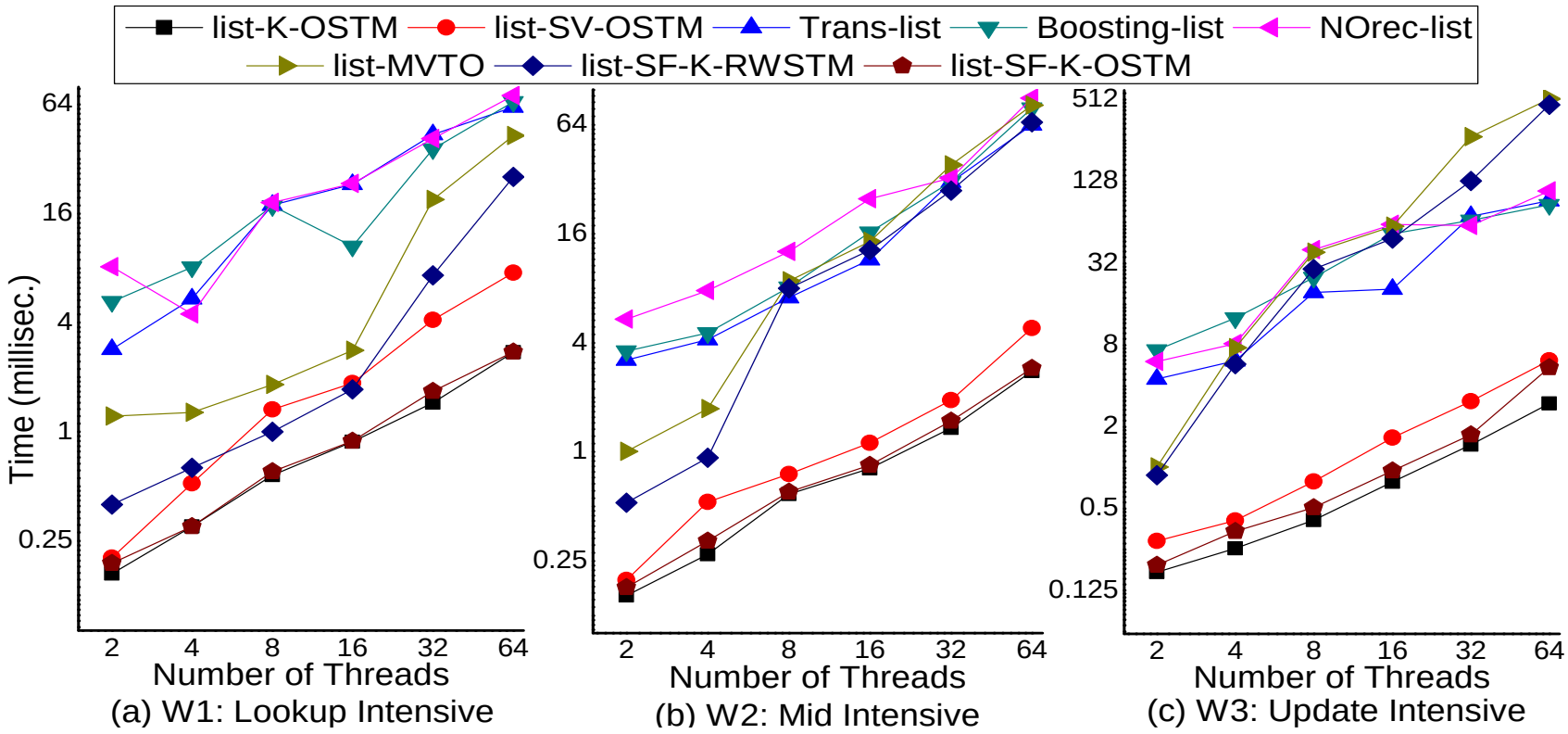

Figure 45: Time comparison of SF-K-OSTM and State-of-the-art STMs on list

- Proposed list based SF-K-OSTM (list-SF-K-OSTM) performs better than all other state-of-art-STMs algorithms but slightly lesser than the non starvation-free list-K-OSTM.

Experimental Evaluations Cont'd..

Low Contention Environment: 1000 Shared data-items & 10 operations/transaction

Algorithm	W1	W2	W3
list-SF-SV-OSTM	1.29	1.26	1.22
list-SF-MV-OSTM	1.25	1.29	1.12
list-SF-MV-OSTM-GC	1.14	1.5	1.13
list-SV-OSTM	2.4	1.5	1.4
Trans-list	24.15	19.06	23.26
Boosting-list	22.43	22.52	27.2
NOrec-list	26.12	27.33	31.05
list-MVTO	10.8	23.1	19.57
list-SF-K-RWSTM	5.7	18.4	74.20
list-K-OSTM	0.96	0.98	0.8

Table 3: Speedup by list-SF-K-OSTM

return