Enhancing Permissiveness of Transactional Memory via Time-Warp

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Transactional Memory

Simple API + guarantee of correctness criterion
Easy to use and reason

Introduction

To guarantee a given correctness level, a TM aborts transactions.

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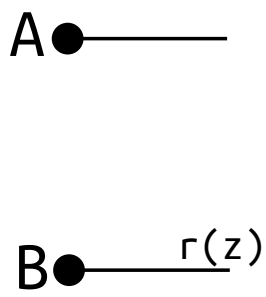

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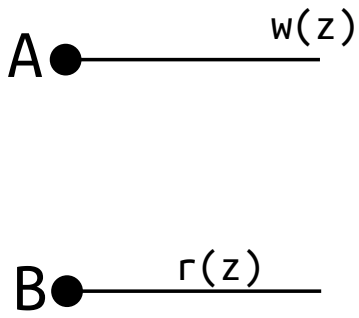

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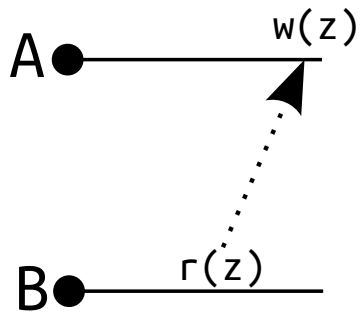

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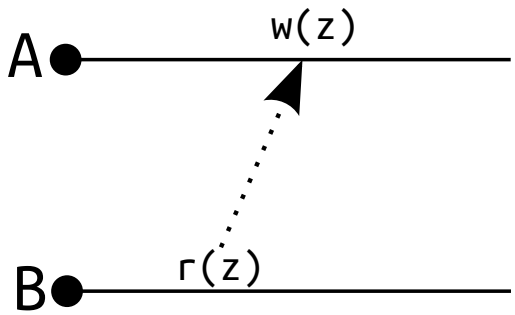

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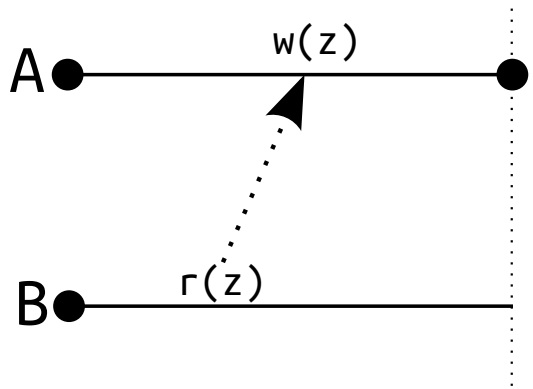

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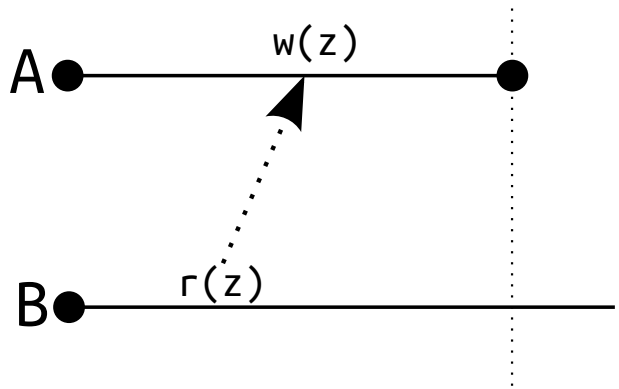

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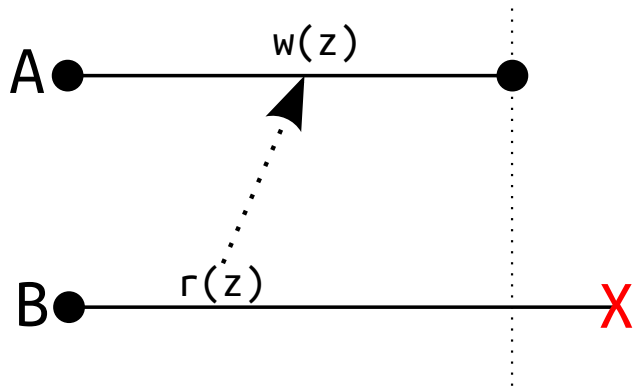

Problem at hands

But why are we aborting the transaction in the example?

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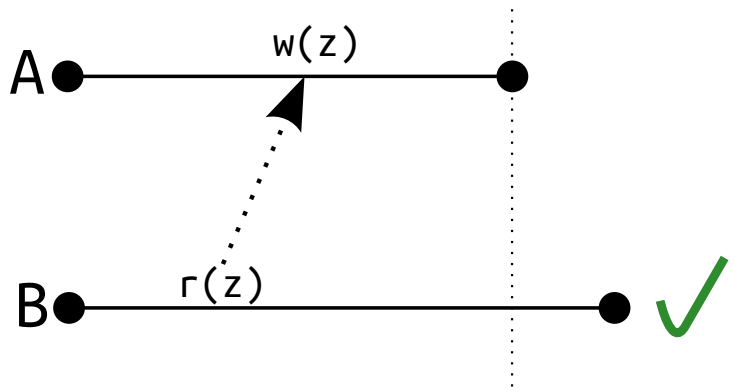
Instead, we could do the following:



Serialization order: B, A

Problem at hands

Condition:
Abort T if its reads are not up-to-date when it attempts to commit.

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Condition:
Abort T if its reads are not up-to-date when it attempts to commit.

Serializability:

- Necessary condition
- But **not** sufficient
- Deemed to be practical

Permissiveness

Notion of avoiding unnecessary aborts

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Notion of avoiding unnecessary aborts:

- If it only aborts a transaction when the resulting history (without the abort) does not respect some target correctness criterion

Permissiveness

State of the art TMs far from being permissive.

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What do we have to counter that?

- One way is to track the graph of dependencies — DATM
  - inconsistent reads and zombie transactions
- Maintain interval of possible serialization points — AVSTM
  - Moderate bookkeeping
  - Aborts read-only transactions

Goal

Enhance permissiveness without such costs

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Enhance permissiveness without such costs:

- More restrictive abort condition
- Always read consistently
- Wait-free read-only transactions (mv-permissiveness)

Time-warping

Allow transactions to commit in the past

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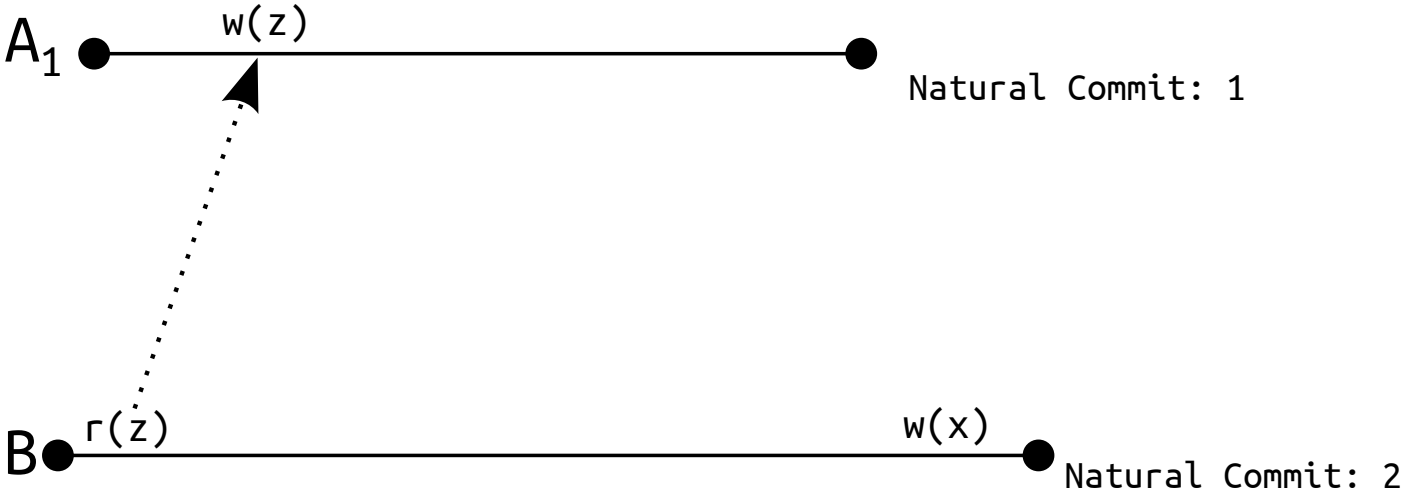
Allow transactions to commit in the past:

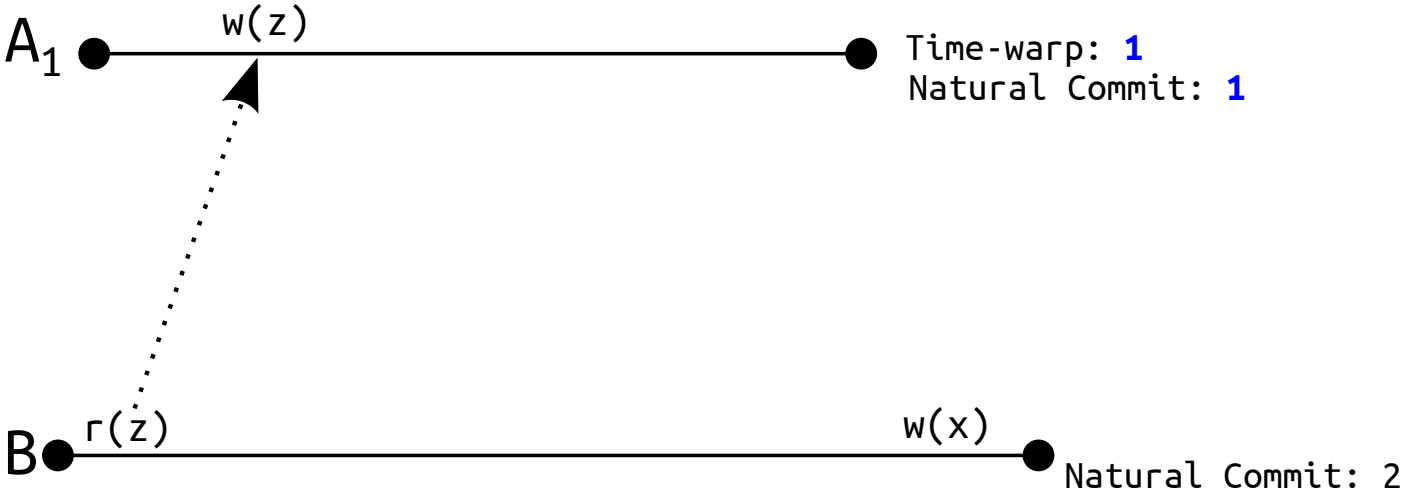
- Pick the condition defined previously
  - Abort T if its reads are not up-to-date when it attempts to commit.
- Commit T and serialize it before the writes it missed
  - Time-warp commit

Time-warp



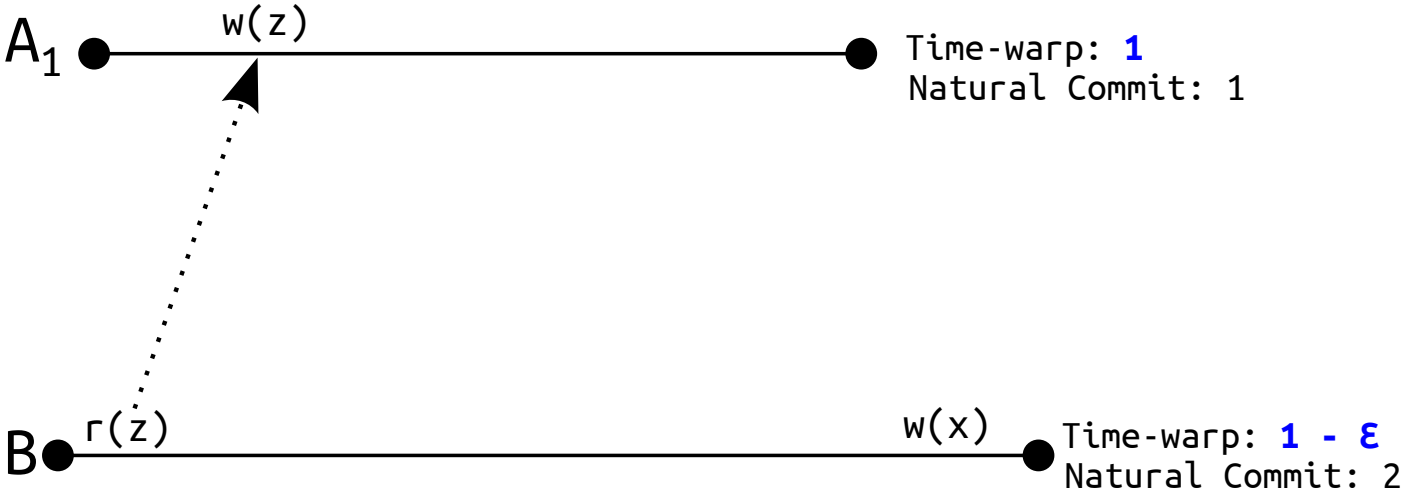
Same history as before

Time-warp



Time-warp order

Time-warp



B time-warp commits

Time-warp

When can we not apply this idea?

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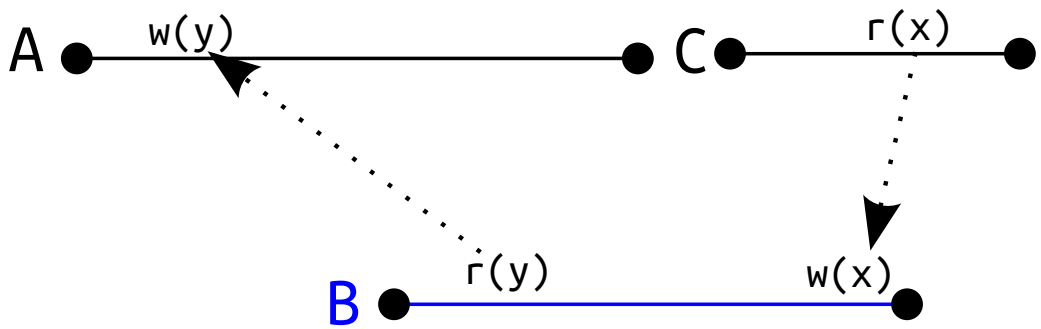
Look out for a specific structure:

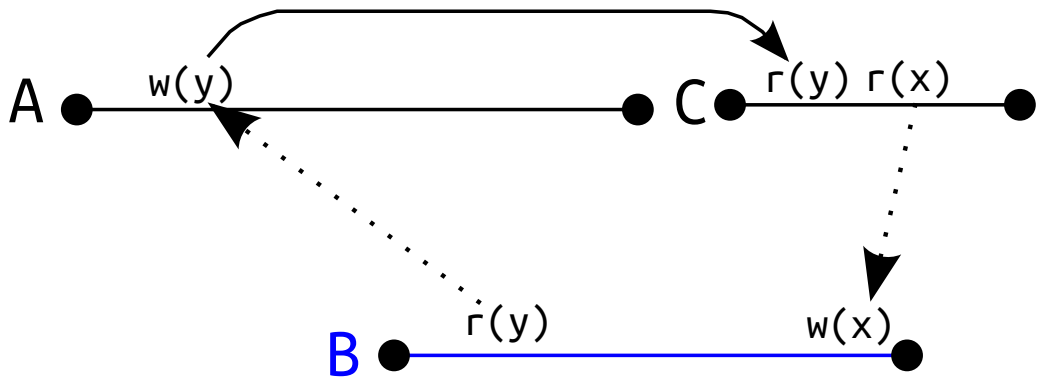
- Three transactions connected — a triad
- The link between all three — the pivot
- Abort T if:
  - Completes a triad
  - Whose pivot time-warp committed

Abort rule



C aborts here

Abort rule



(rather strict) necessary condition for a cycle

Theoretical and Practical results

- Serializability for committed transactions

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  - Prevent a range of phenomena to avoid sandboxing

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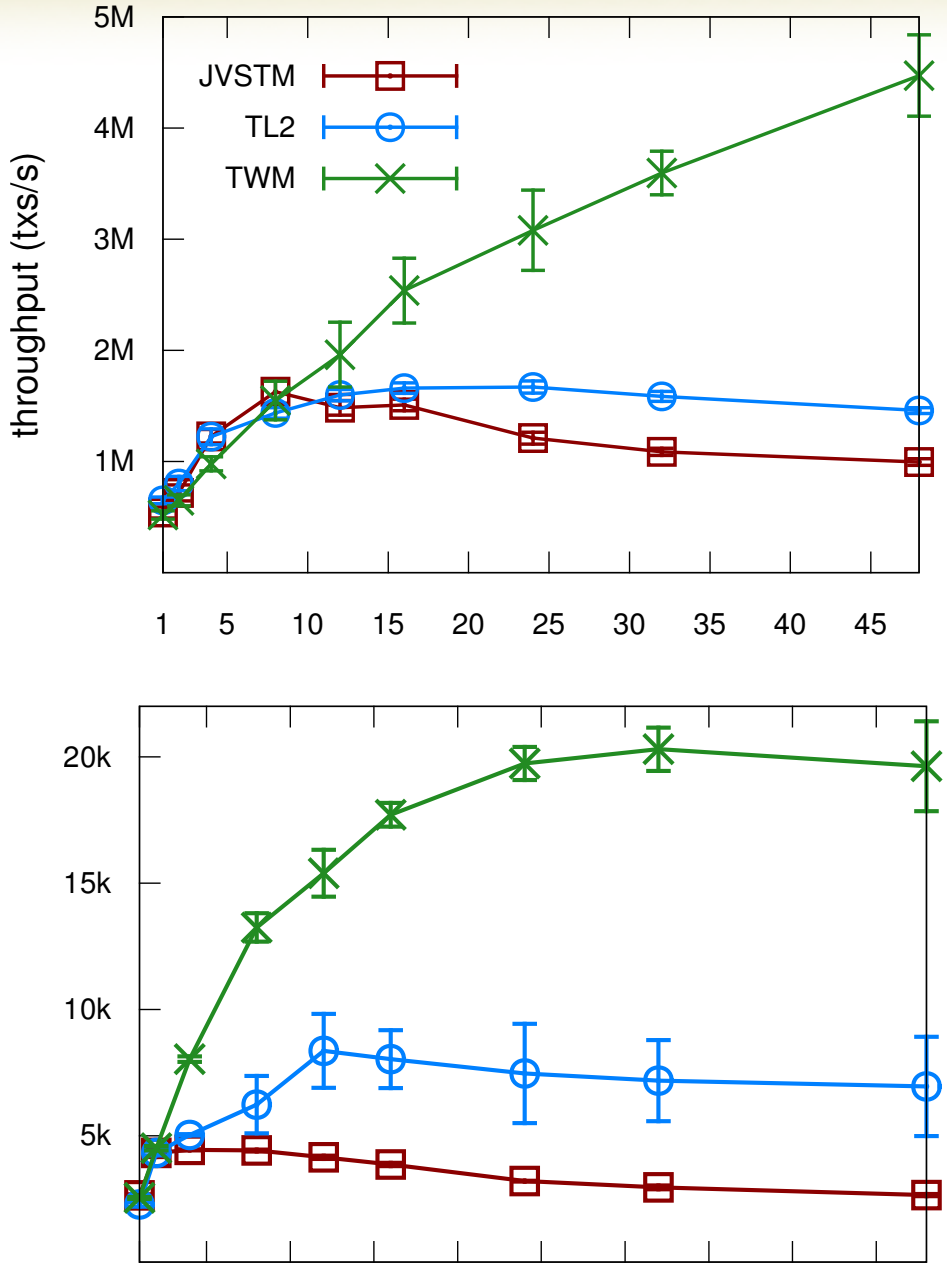
SkipList and Vacation from STAMP



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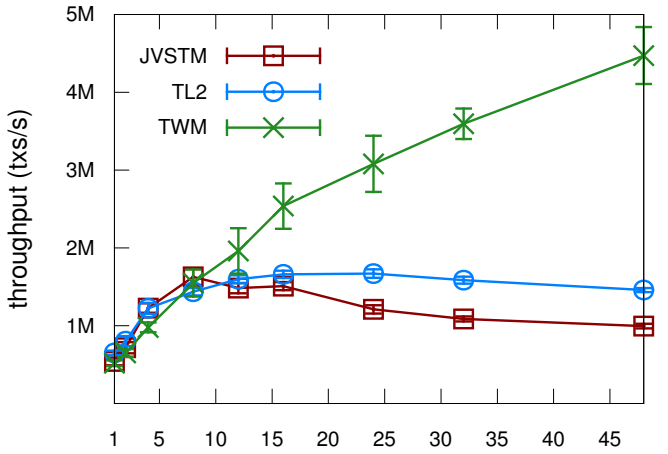

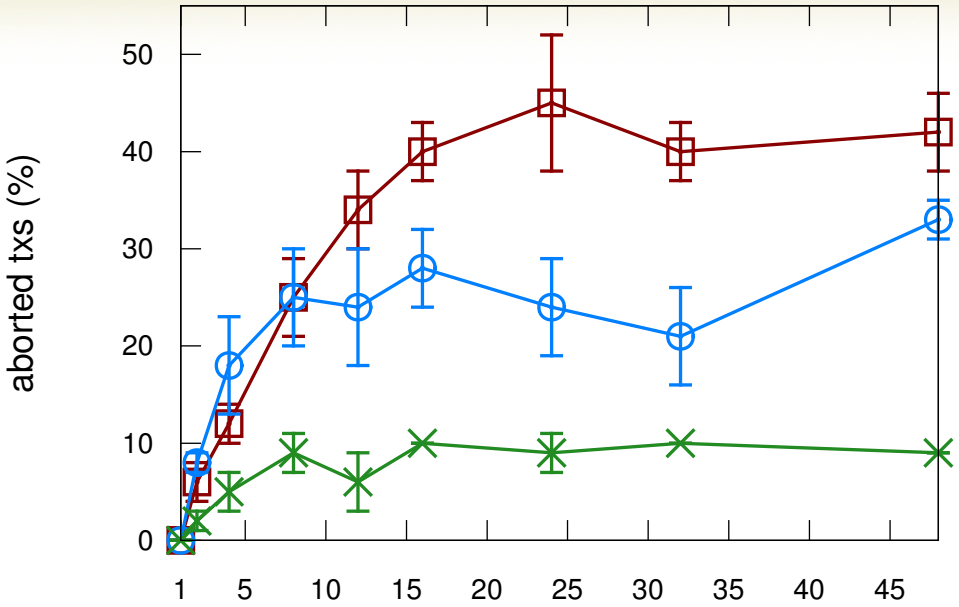

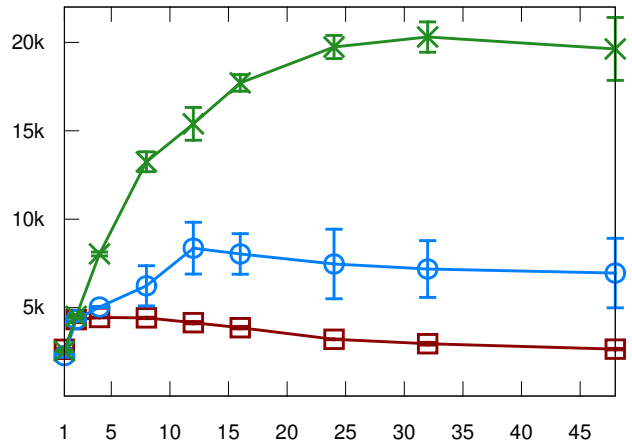

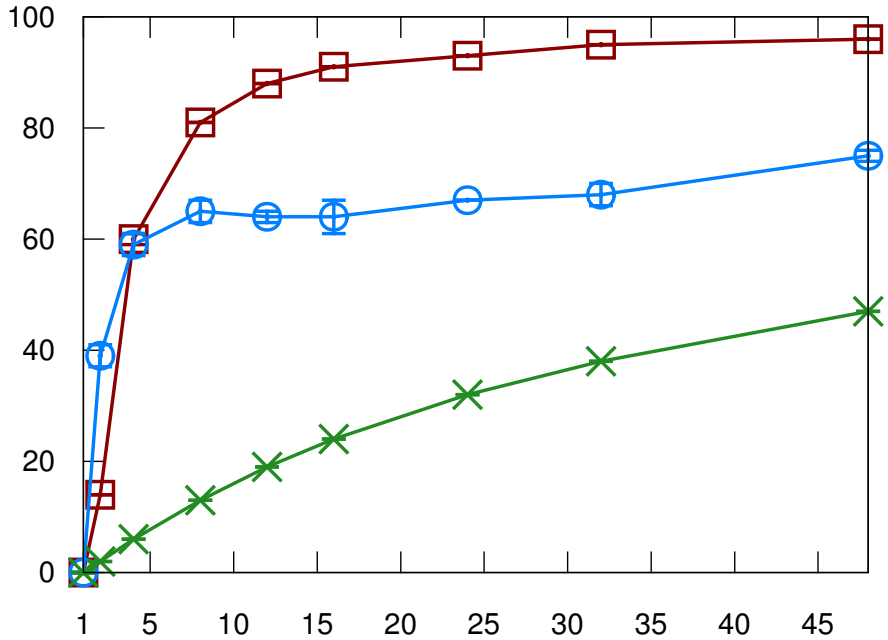

Ongoing work 1/2

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Time-warp in a distributed transactional setting

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- Generalizable to a variety of protocols

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Time-warp in a distributed transactional setting:

- Generalizable to a variety of protocols
- Partially replicated key-value store with transactions
- Scalable solution
  - Now also with update workloads

Ongoing work 2/2

Partially replicated large collections

- Scalable computations
- Transaction friendly despite structural conflicts

Thank you