Towards Concurrent Stateful Stream Processing on Multicore Processors

Shuhao Zhang

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Xtra Computing Group

lead by Prof. Bingsheng He

NUS National University of Singapore

Data Stream Processing Systems

1. *BriskStream: Scaling Data Stream Processing on Shared-Memory Multicore Architectures, SIGMOD'19*
2. *StreamBox: Modern Stream Processing on a Multicore Machine, ATC'19*
3. *Grizzly: Efficient Stream Processing Through Adaptive Query Compilation, SIGMOD'20*

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Data Stream Processing Systems

- [Available] Fast stream processing on large-scale multicore architectures
  - E.g., BriskStream[1], StreamBox[2], Grizzly[3]
- [Inadequate] Support of *consistent stateful stream processing*

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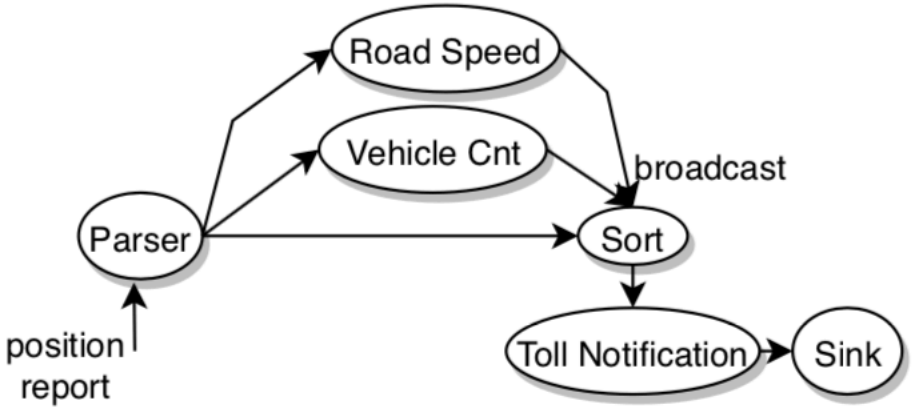
Outline

- **Motivation**
- **State-of-the-art**
- **Our Approach**
- **Experimental Results**

Motivation Example



Toll Processing: computes toll based on the road congestion status

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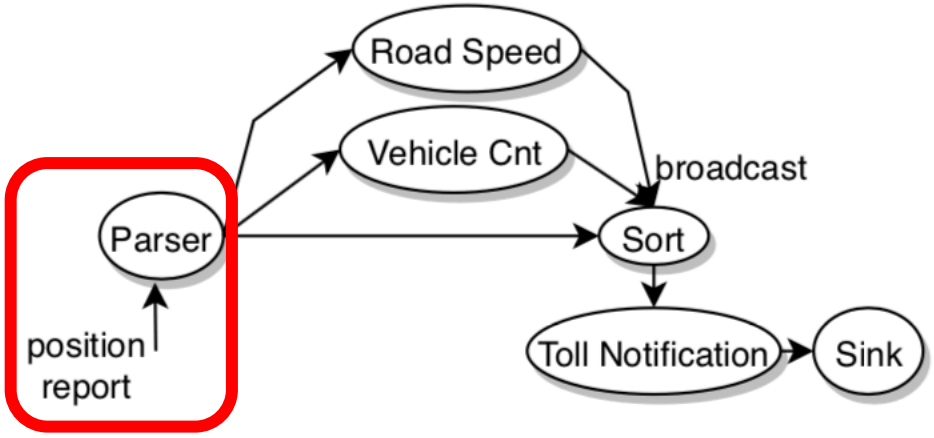

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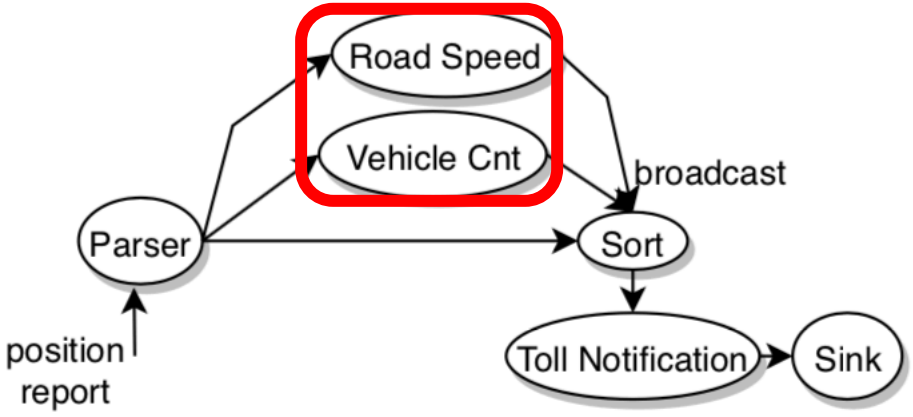

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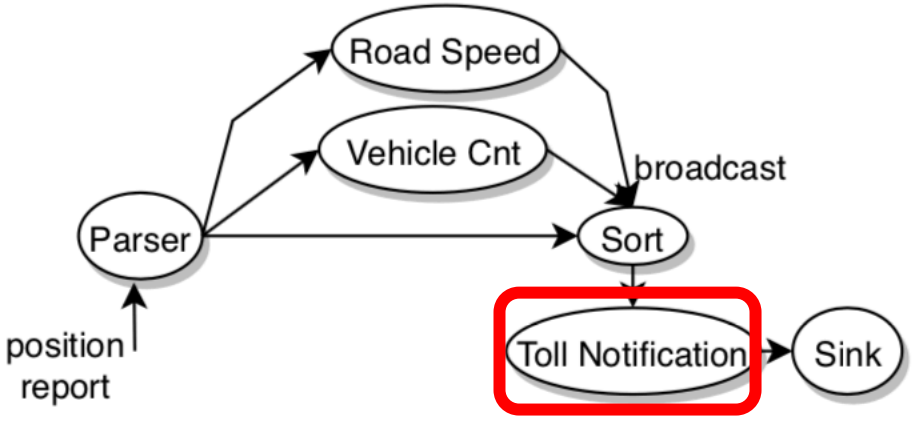

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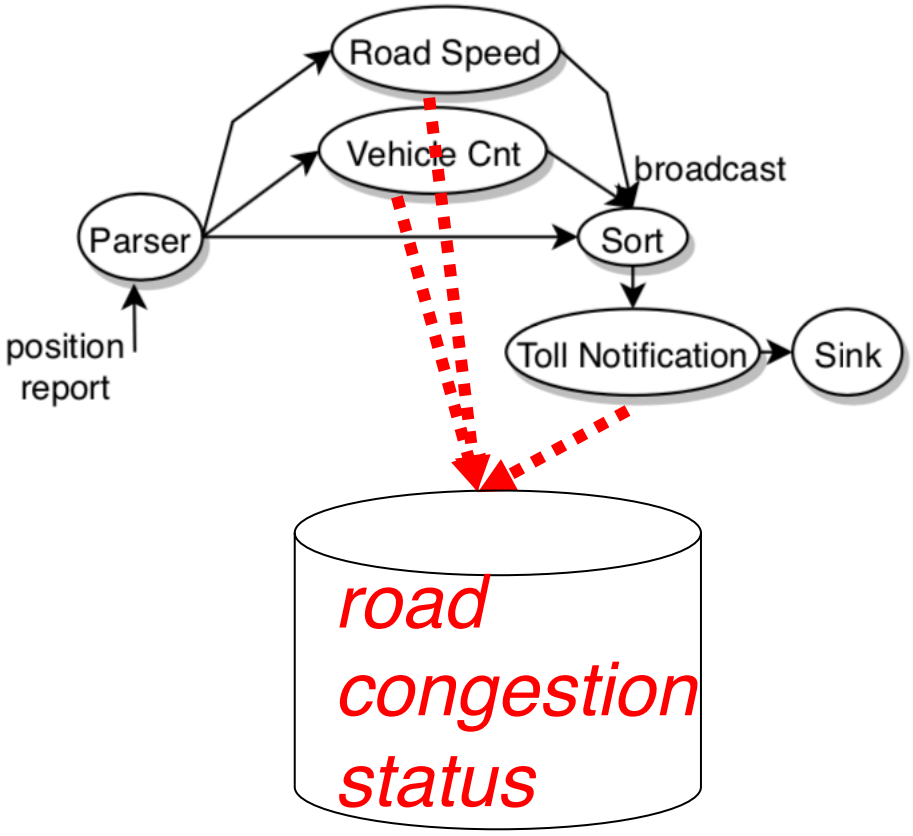

- *Road congestion status is shared among different streaming operators*
- *Its consistency needs to be preserved*

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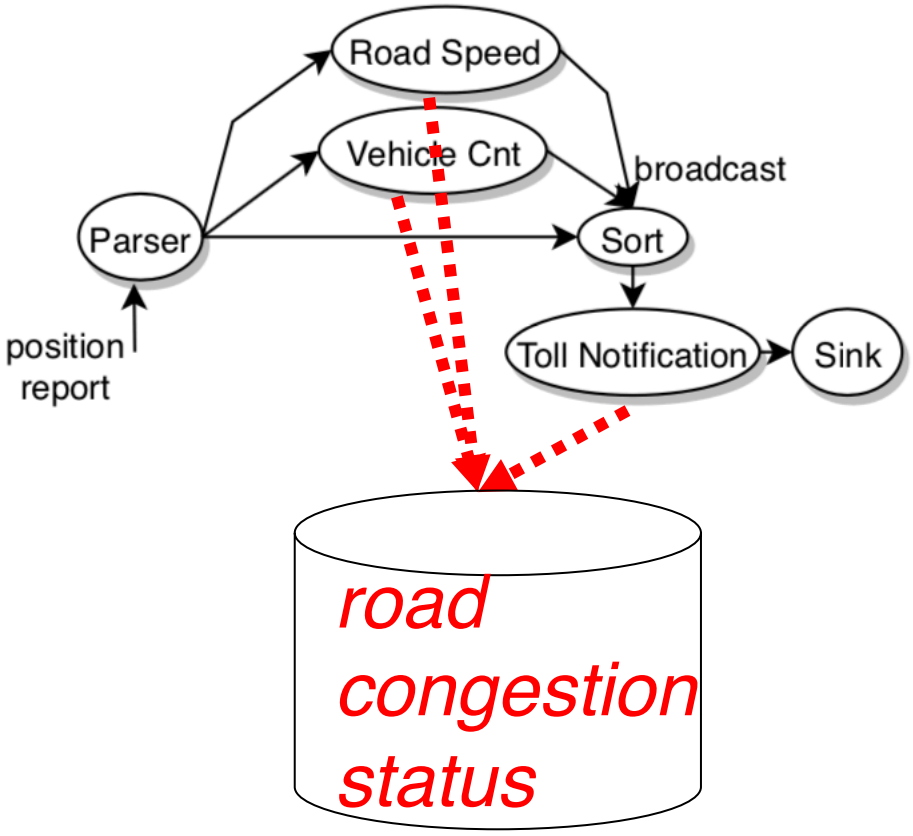

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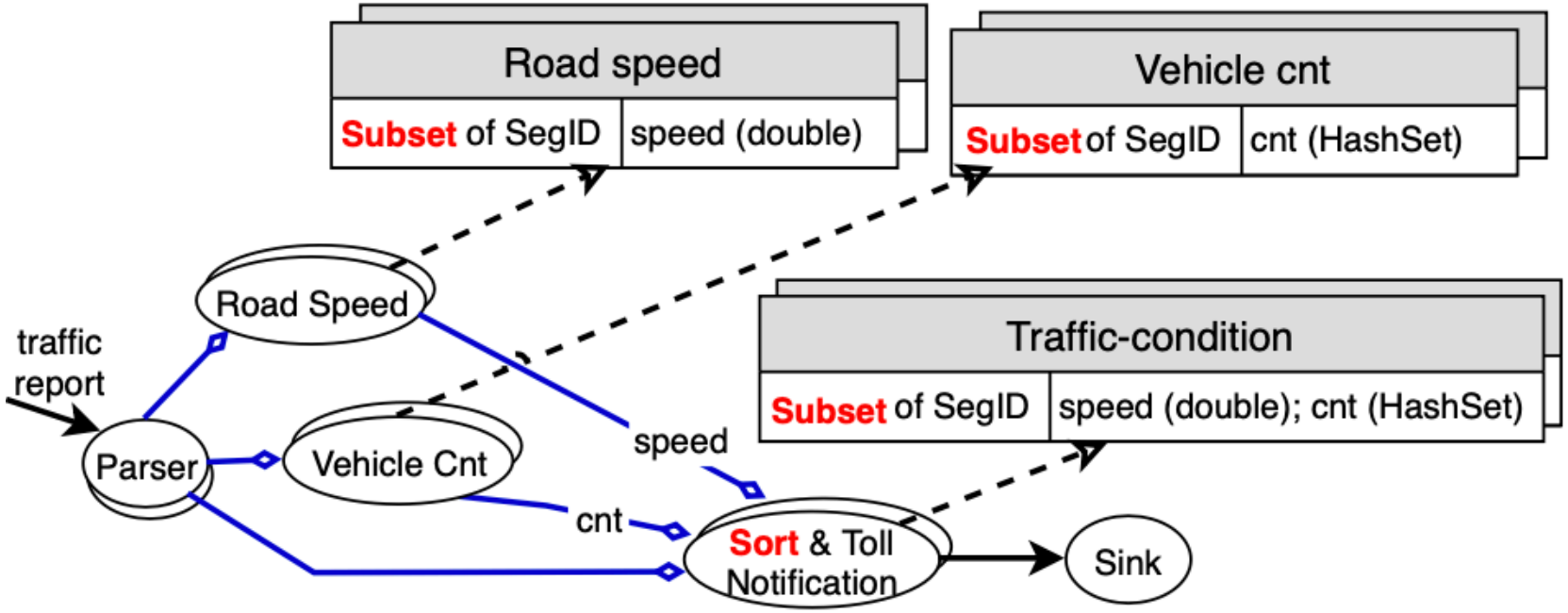
-- consistent stateful stream processing

The Current Common System Design



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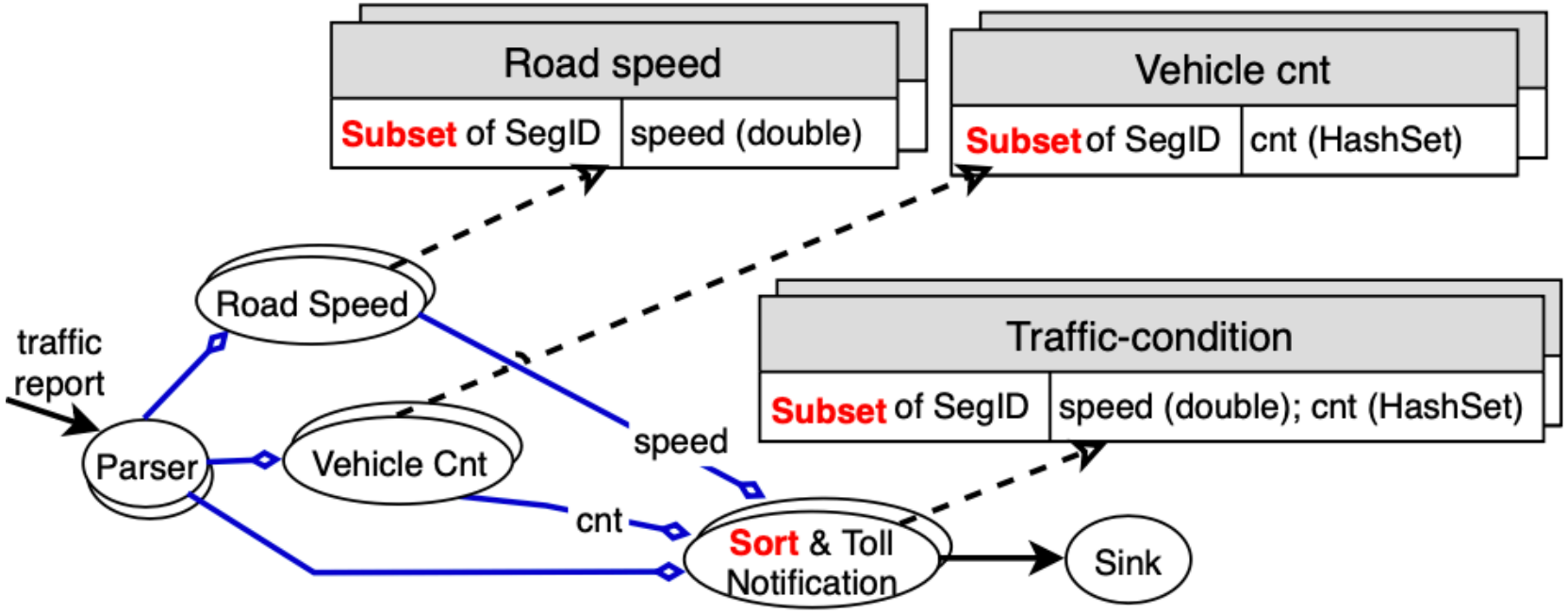

Common designs:

a) Pipelined processing with message passing

b) On-demand data parallelism

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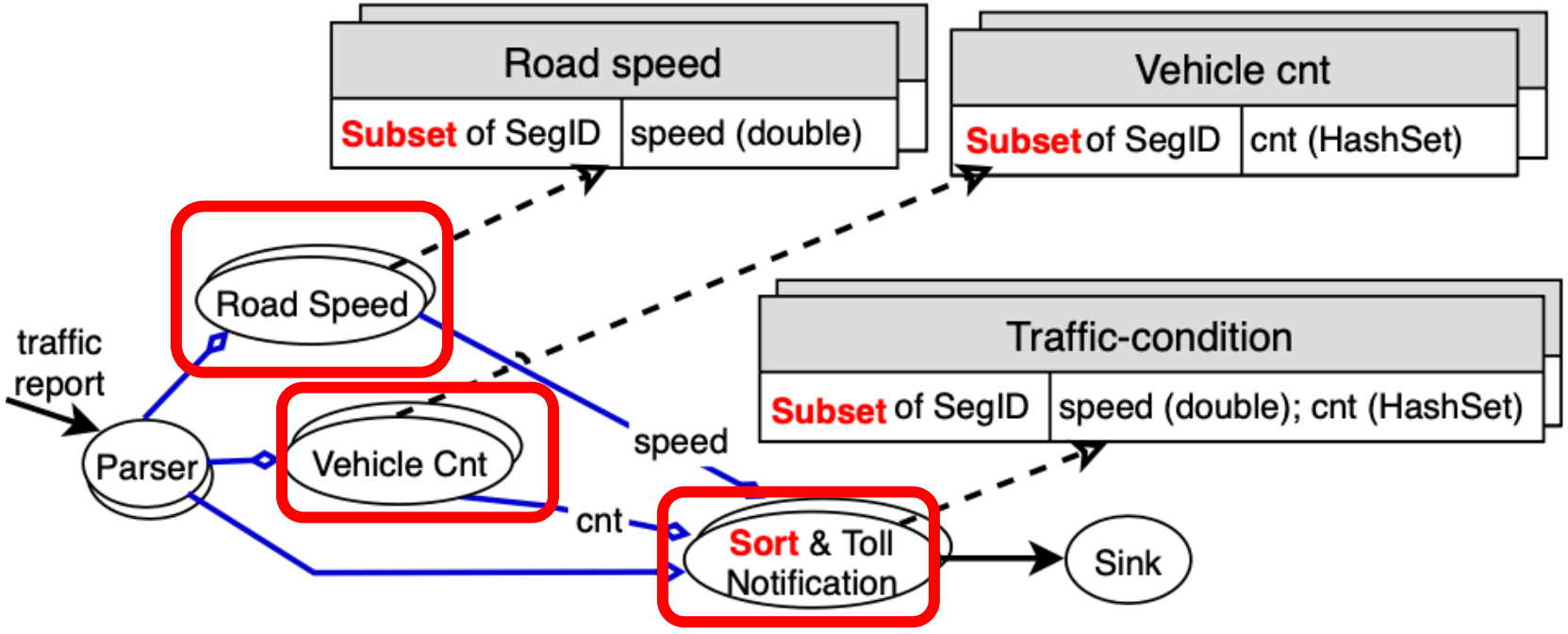

operator parallelism

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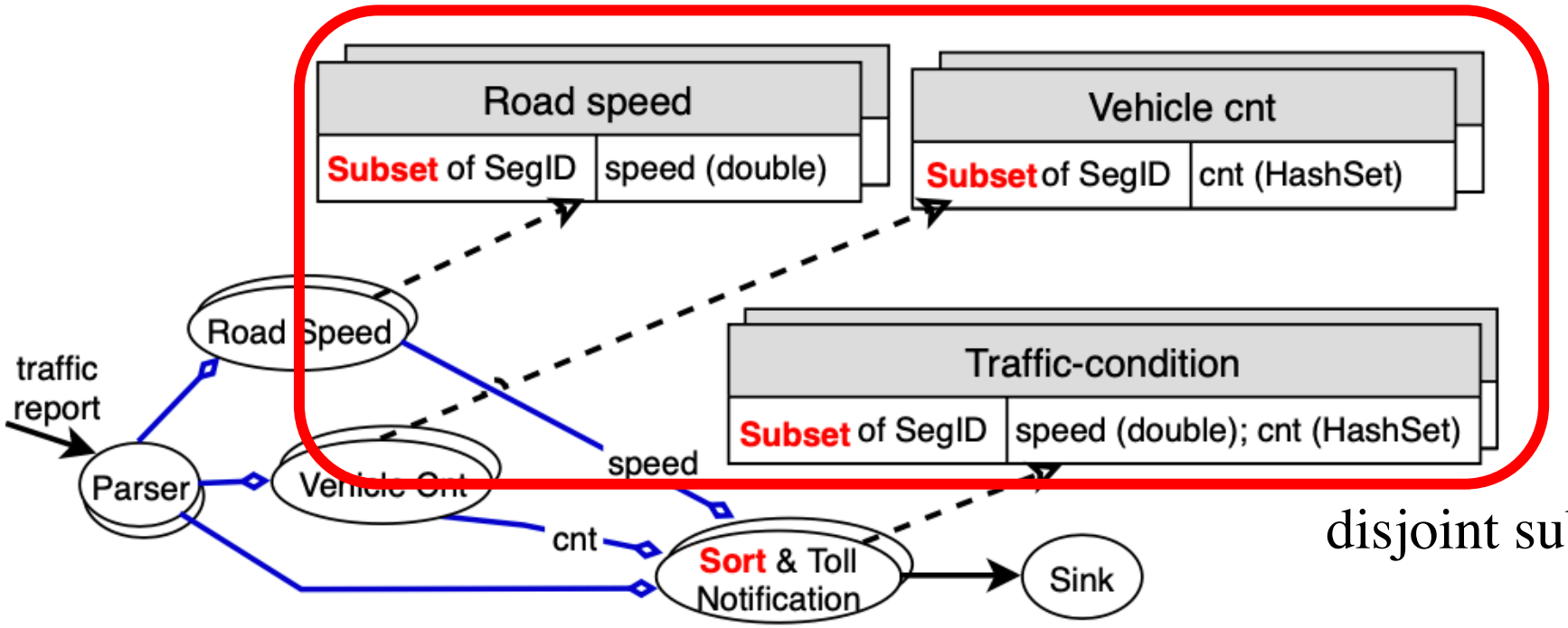

disjoint subset

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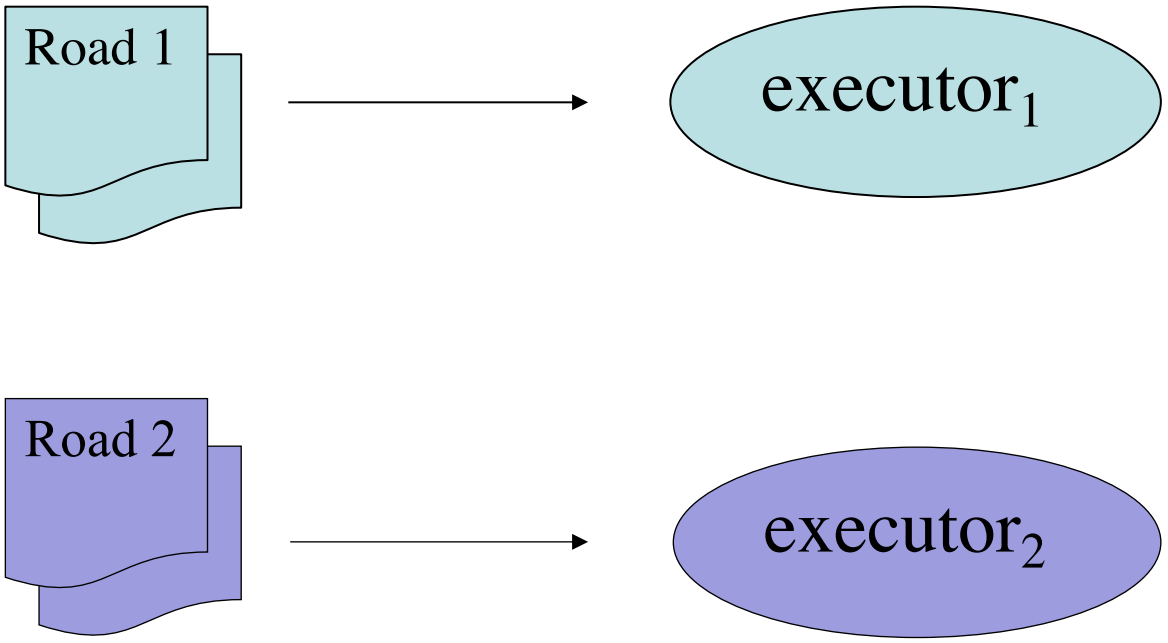
Key-based Stream Partition



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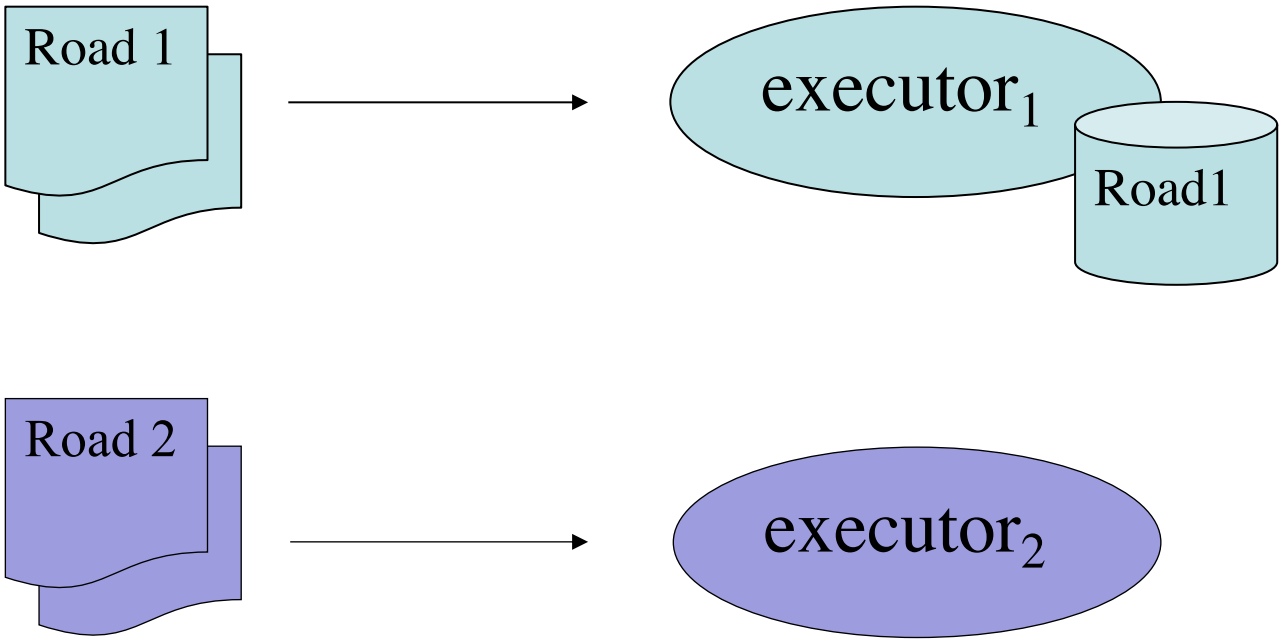

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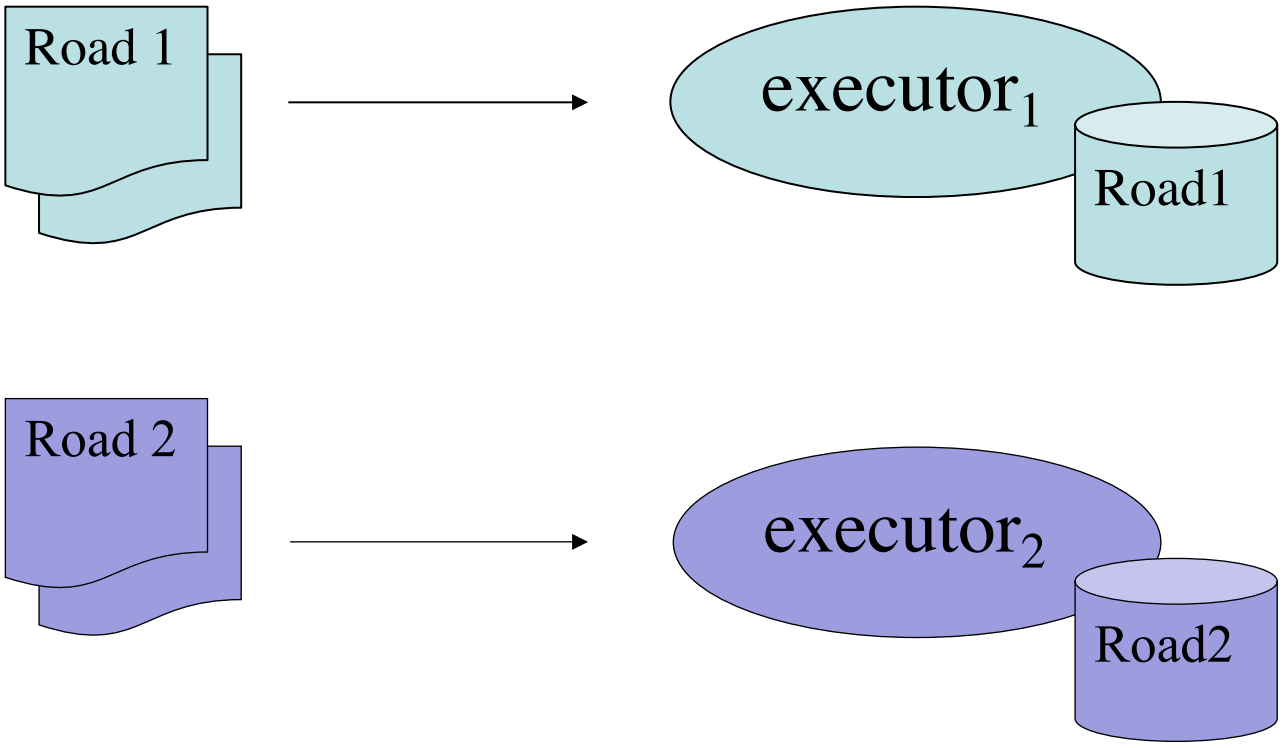

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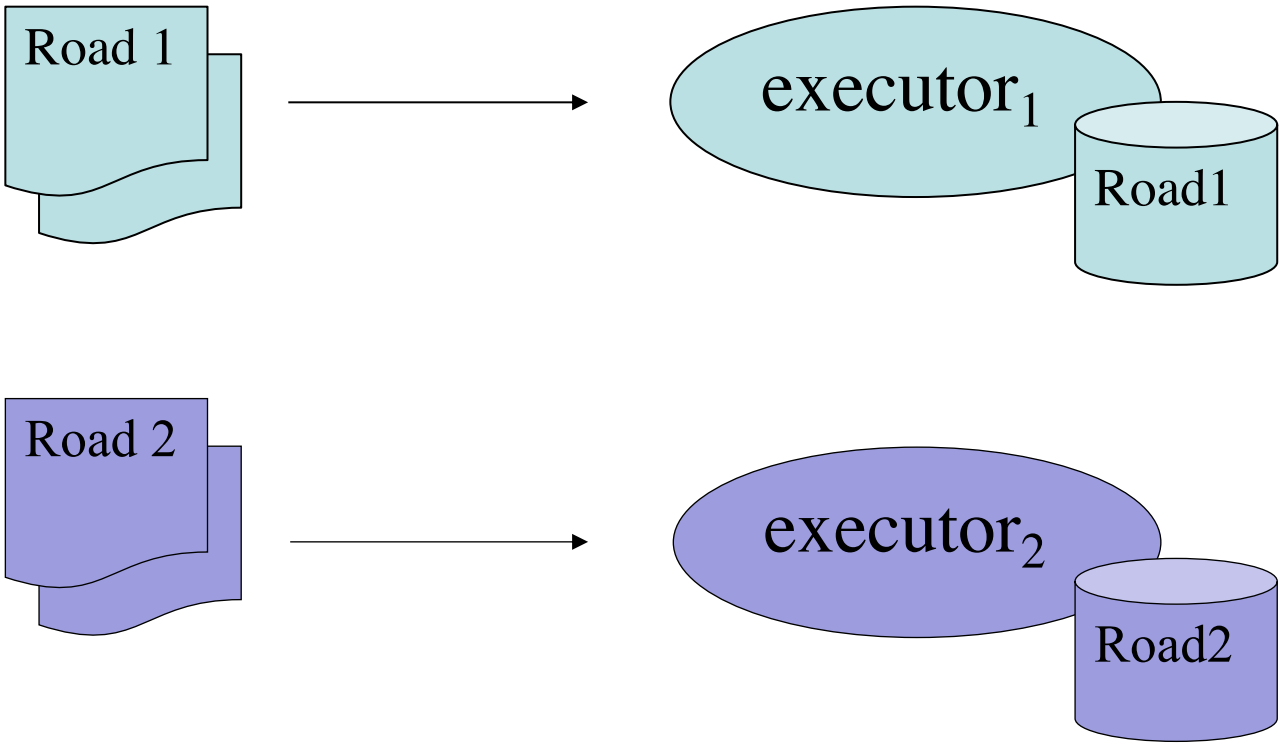
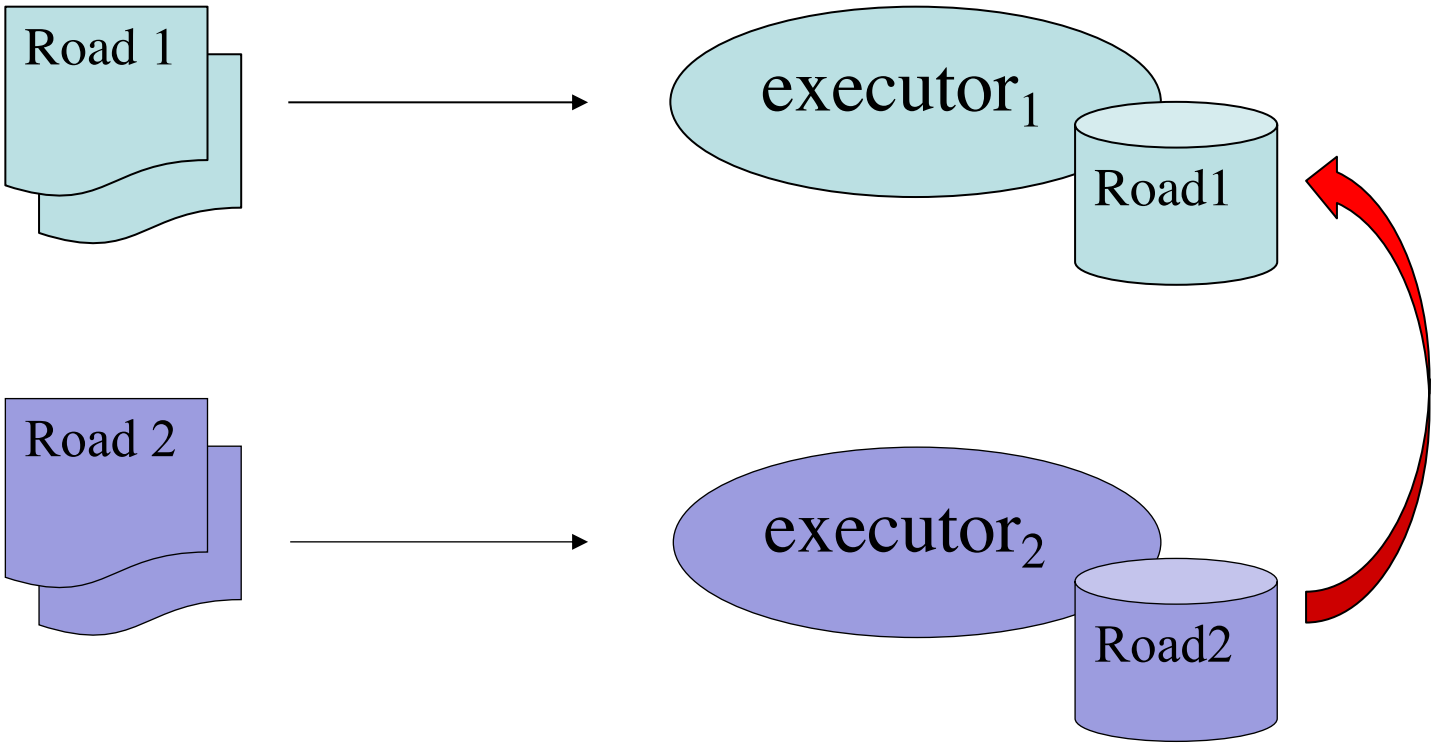


No Conflict!☺

Key-based Stream Partition



Pay extra penalty if road1 is empty!

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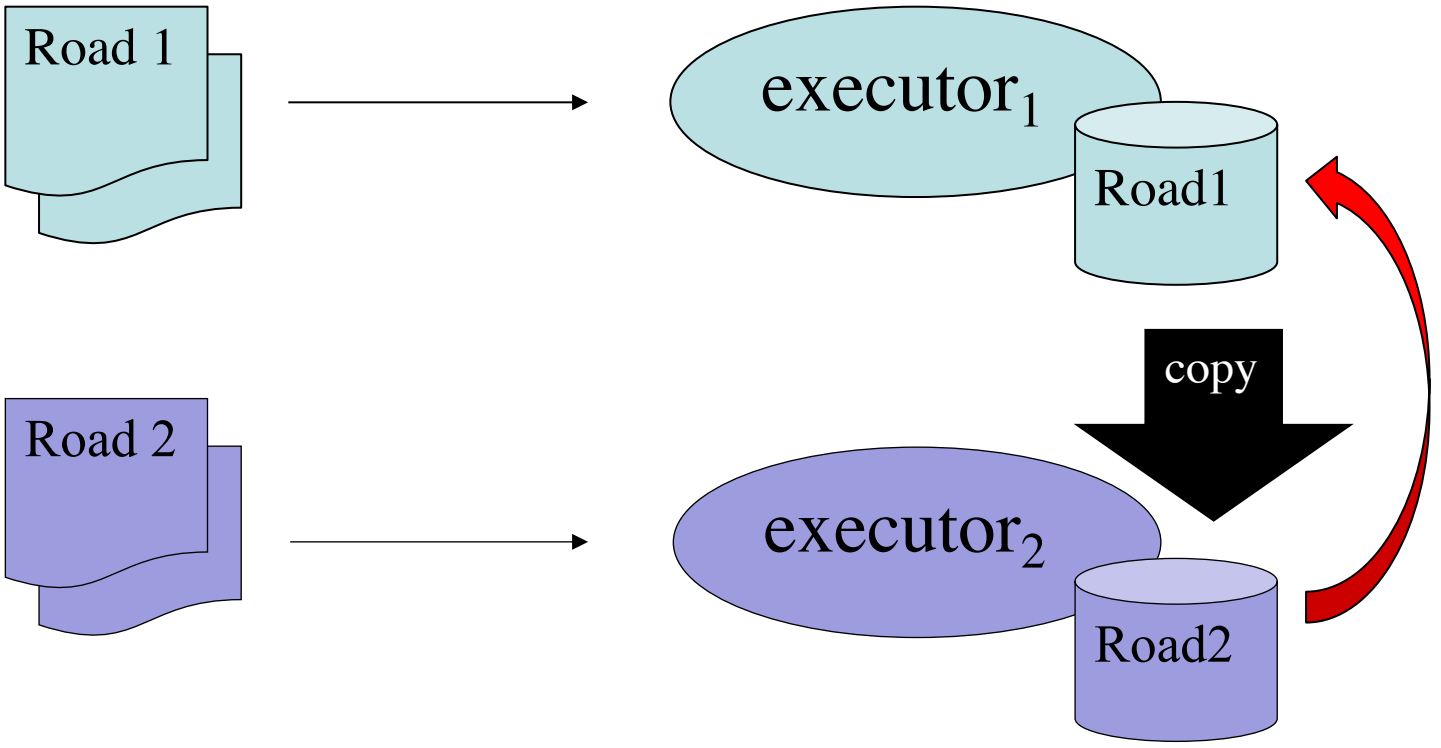

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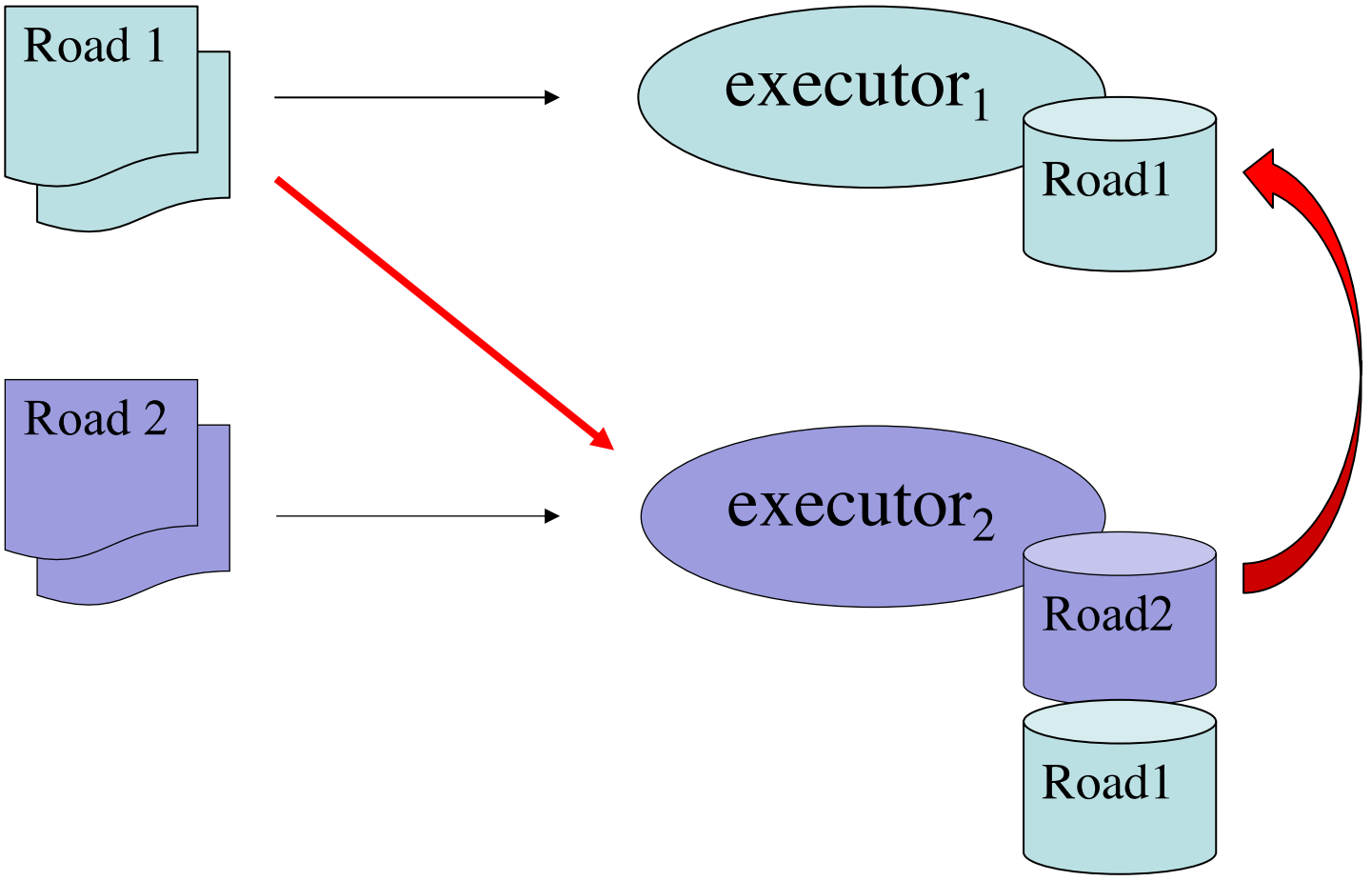

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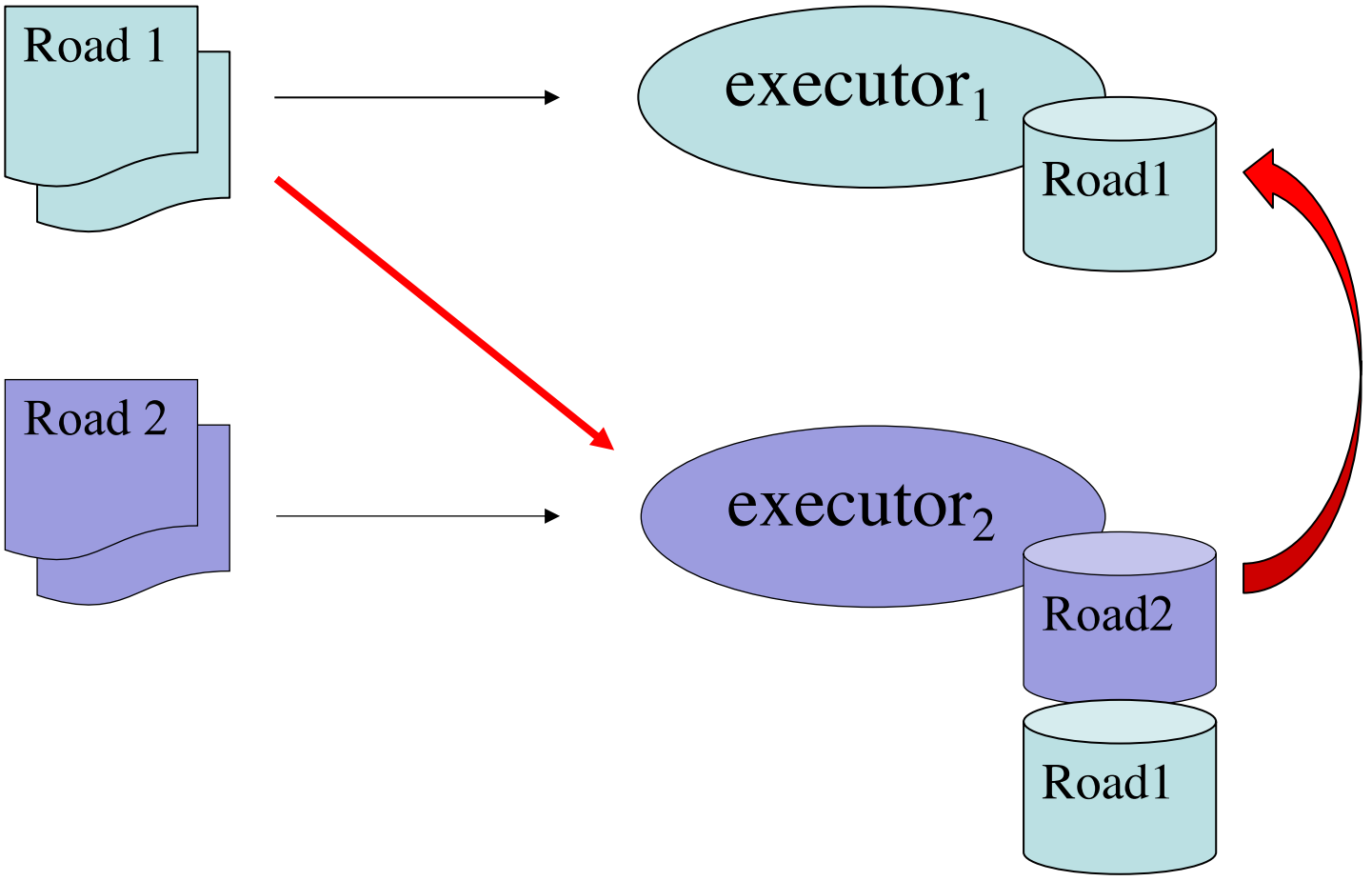

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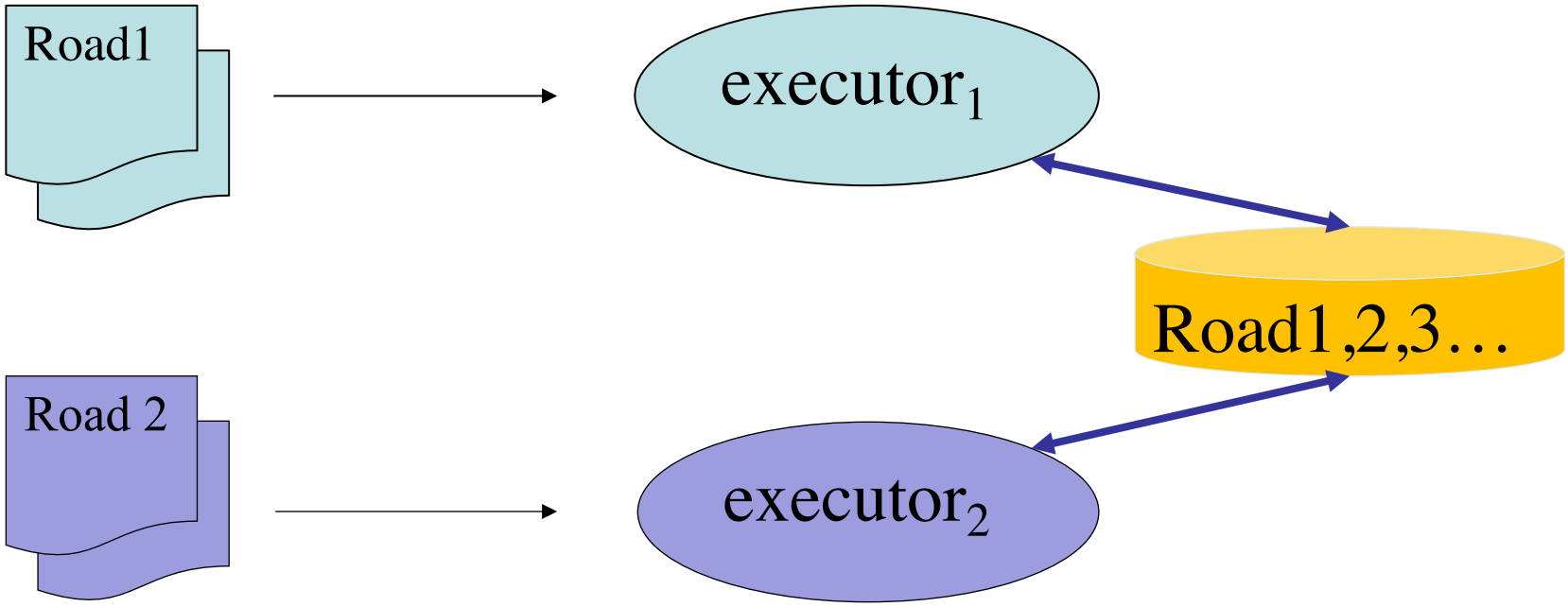
Can not efficiently handle general case

Lock-based State Sharing



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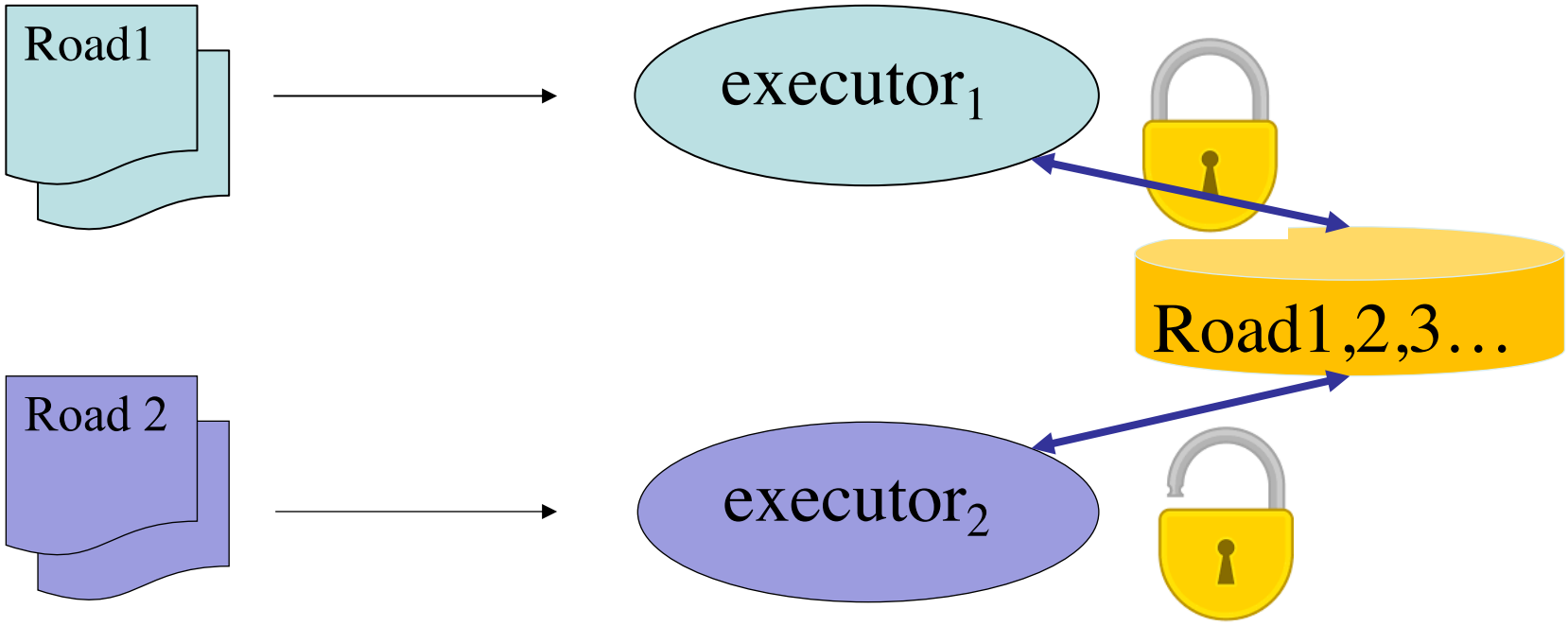

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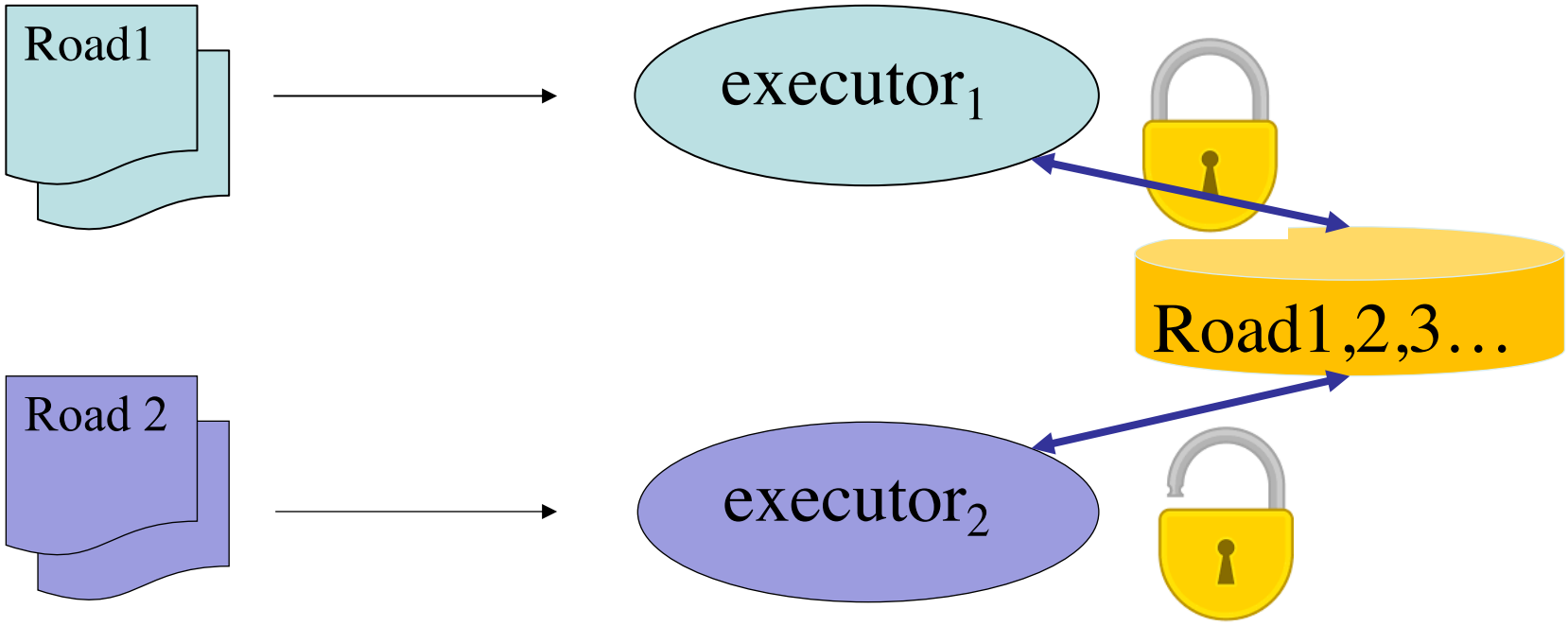

Lead to poor performance

Access Ordering

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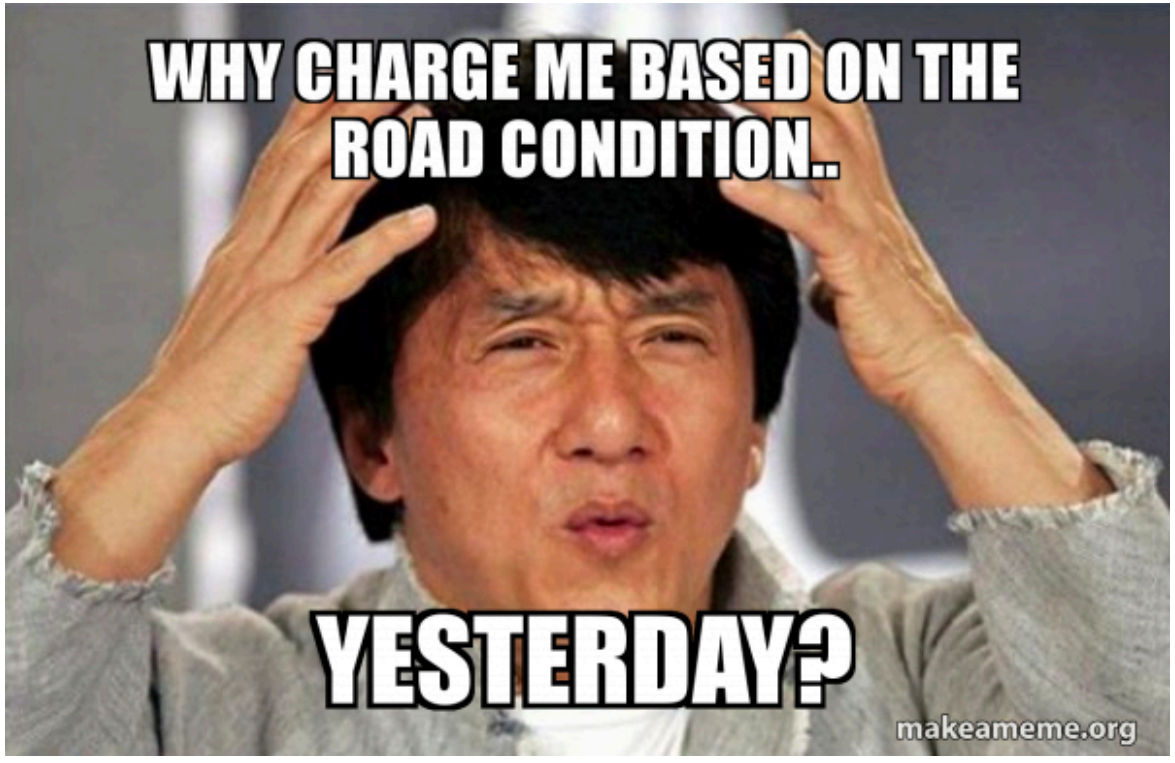

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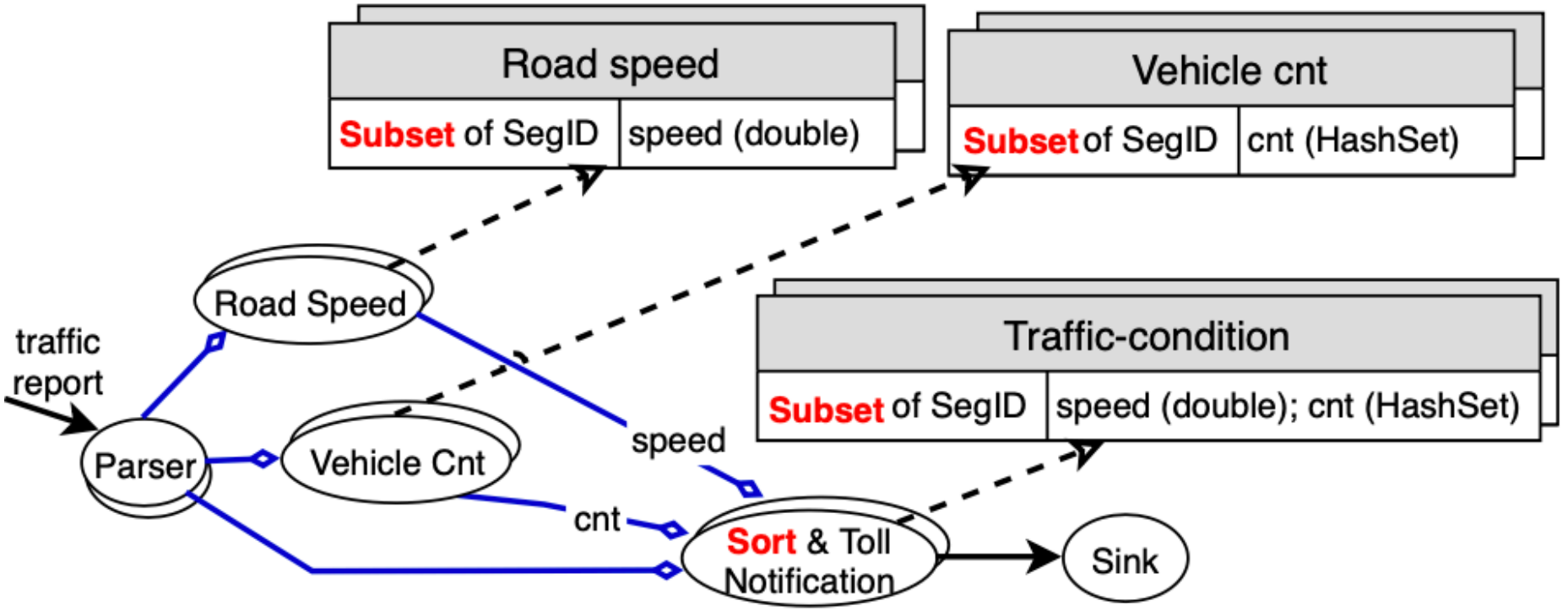

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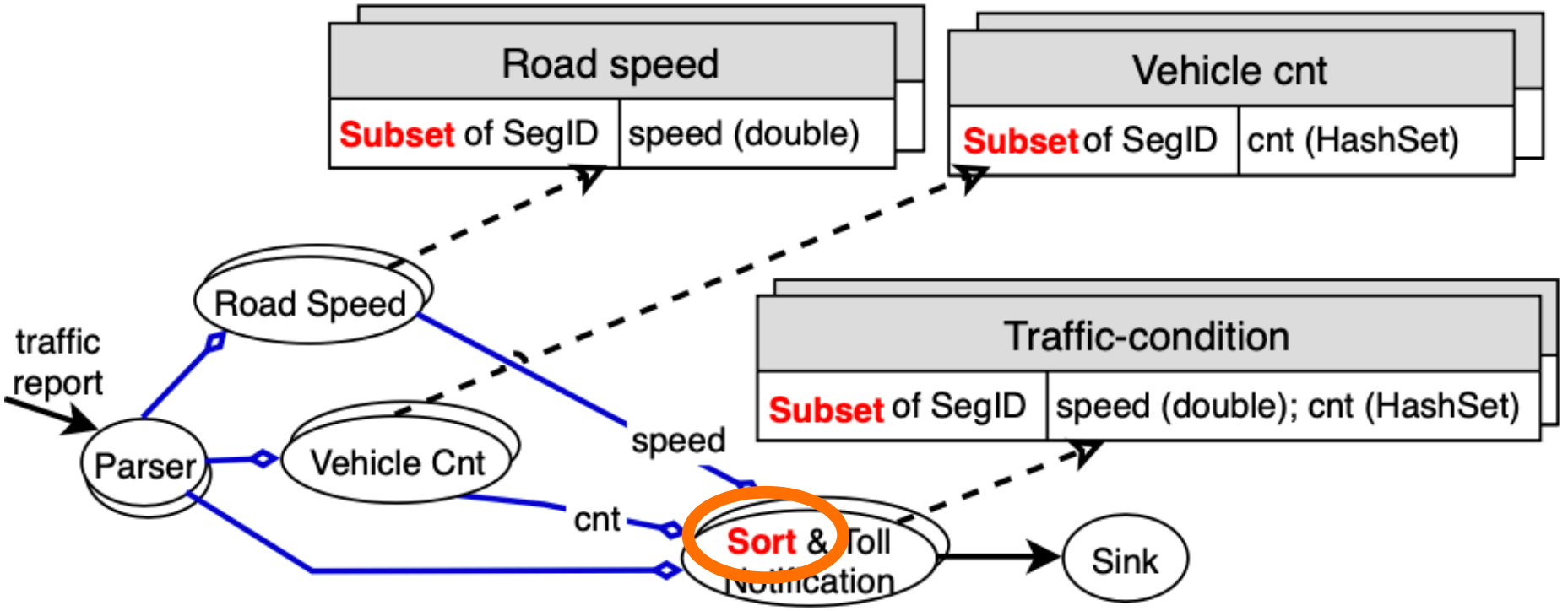

Common workaround:

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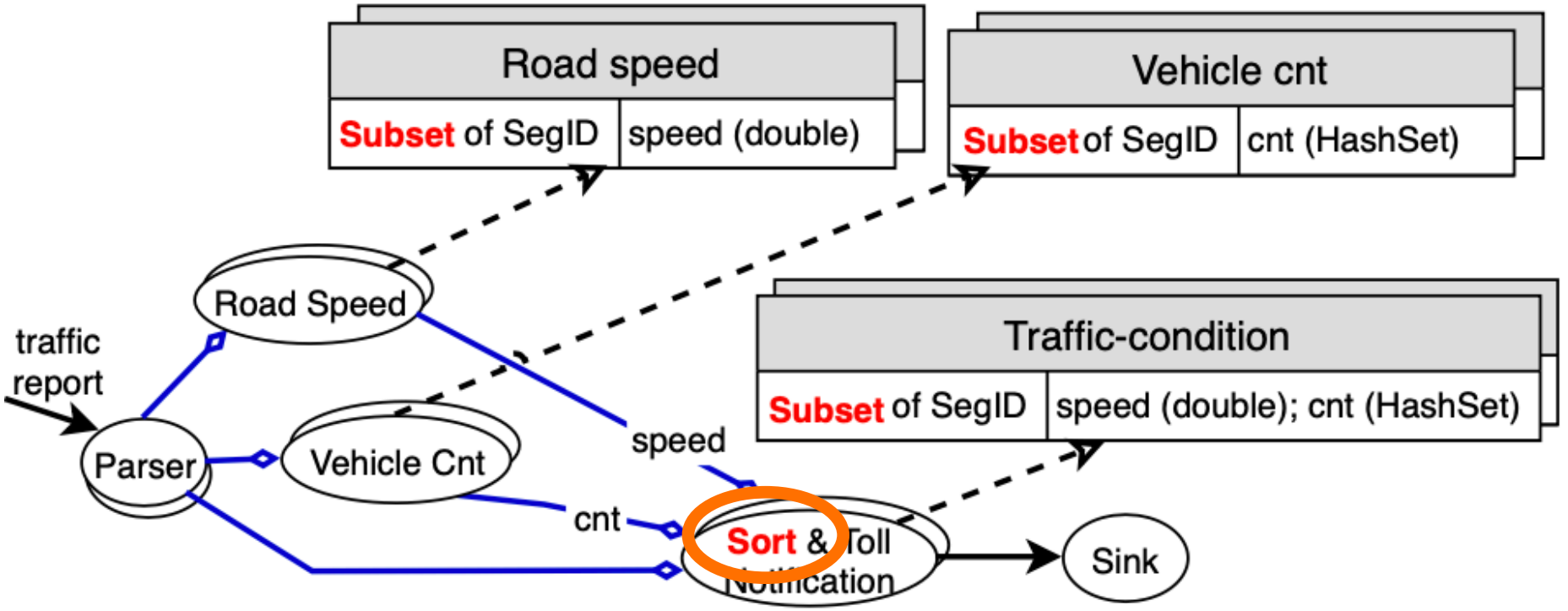

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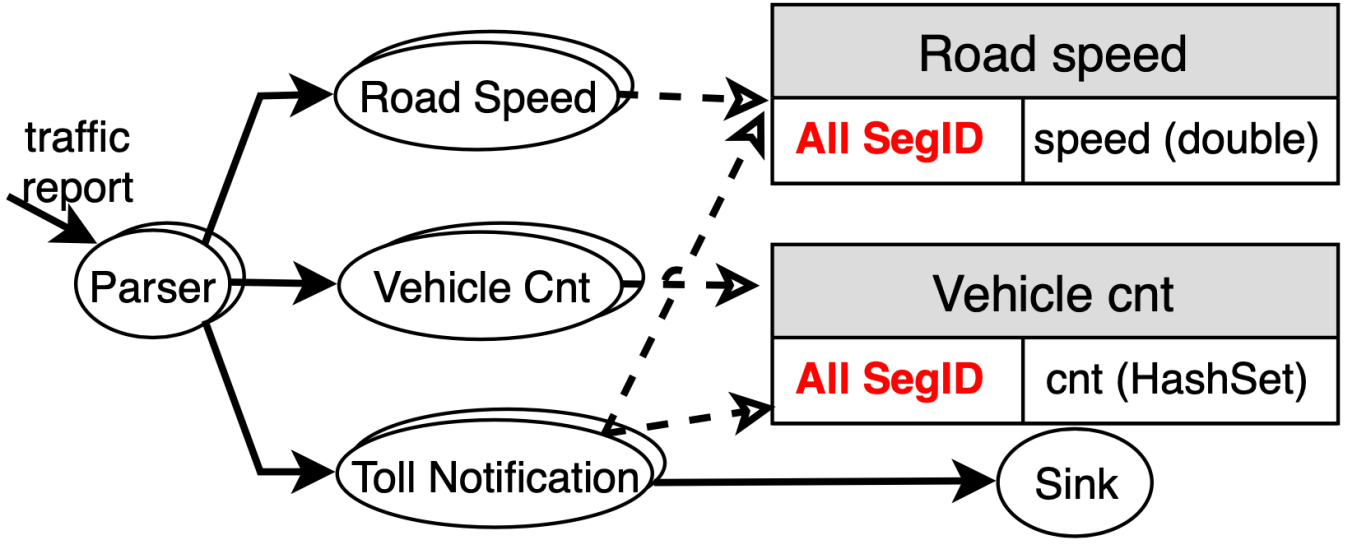

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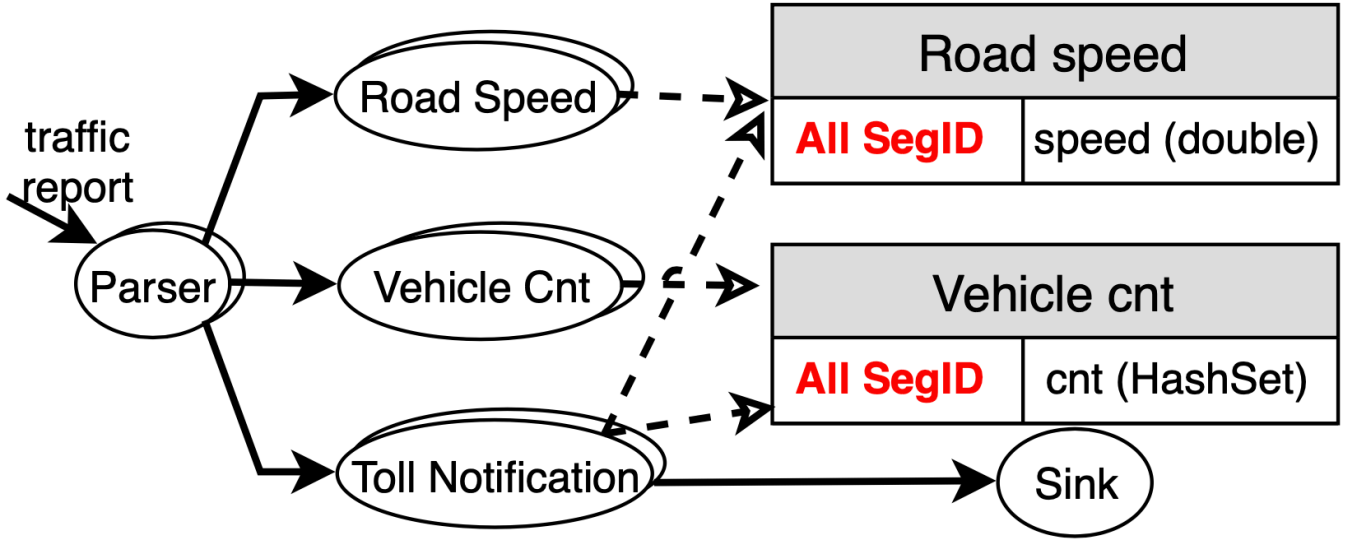

Employing transactional schematics.

- State transaction (txn_{ts}):
  1. txn_{t1} {*Update Road1 Cnt, update Roadx…*} @ 10:00;
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- Correct schedule: $txn_{t1} \prec txn_{t2} \prec \ldots txn_{tn}$

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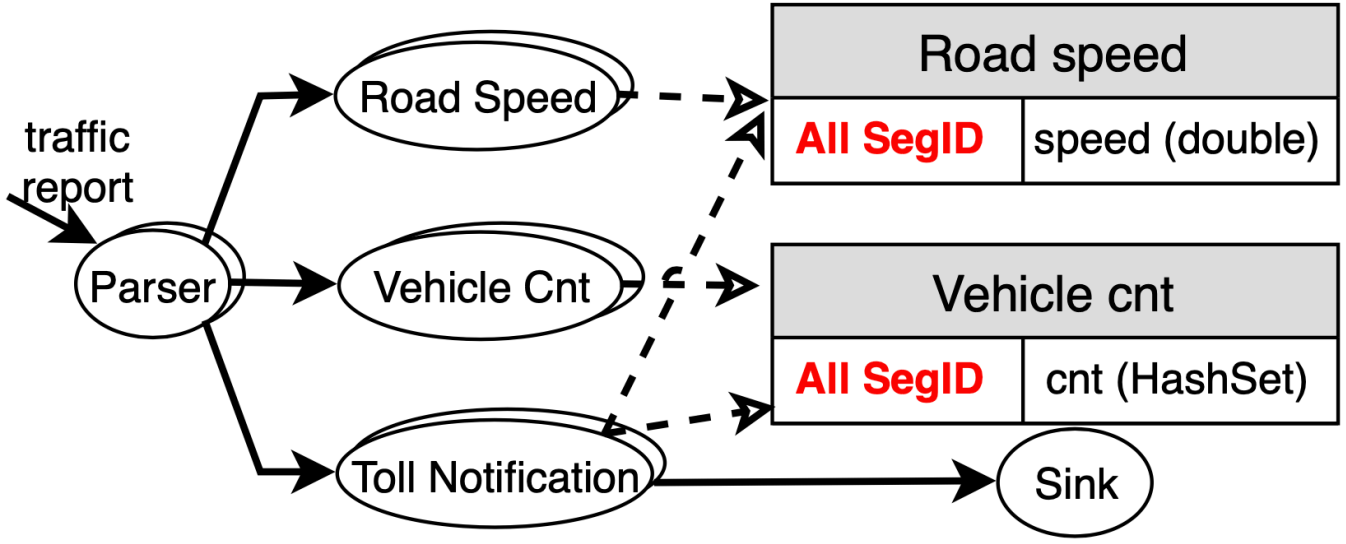

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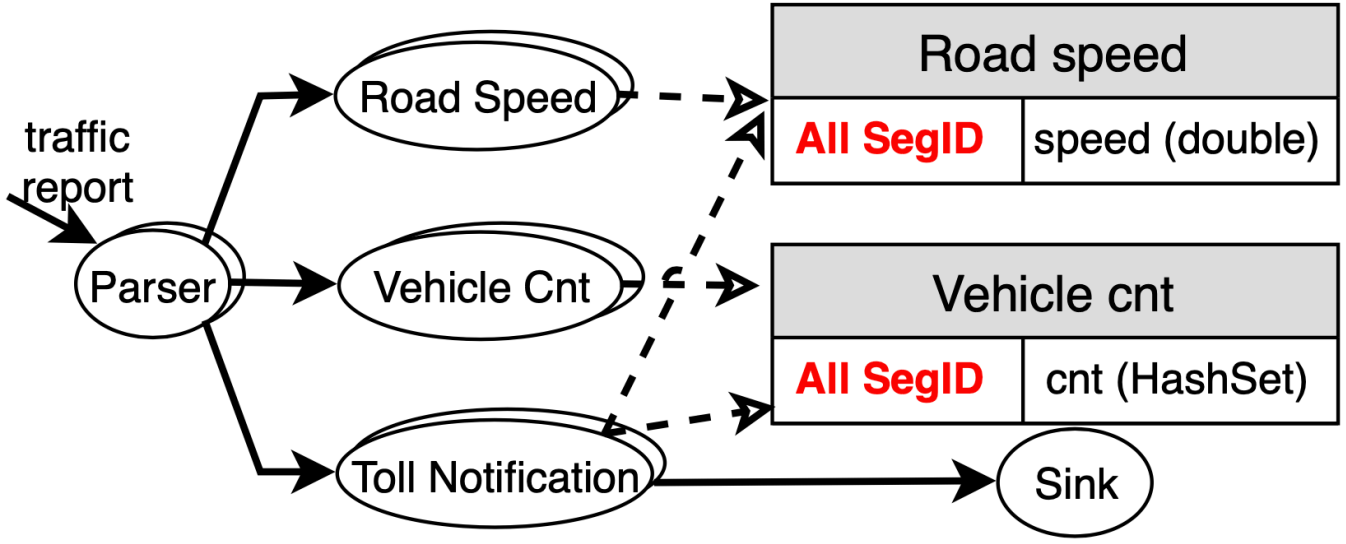

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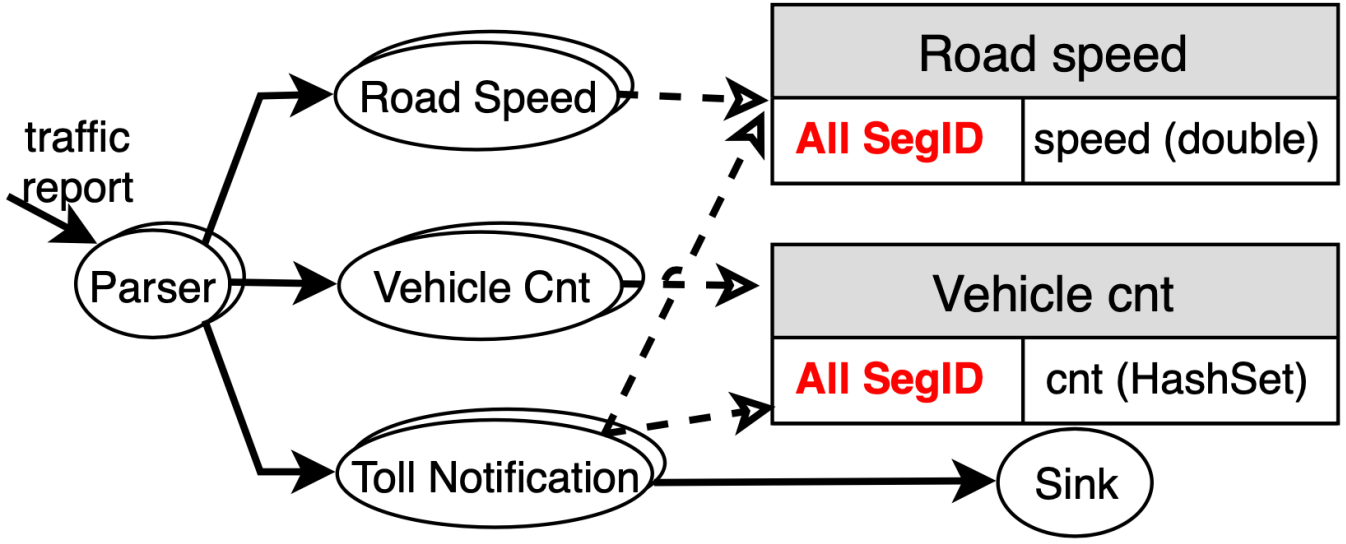

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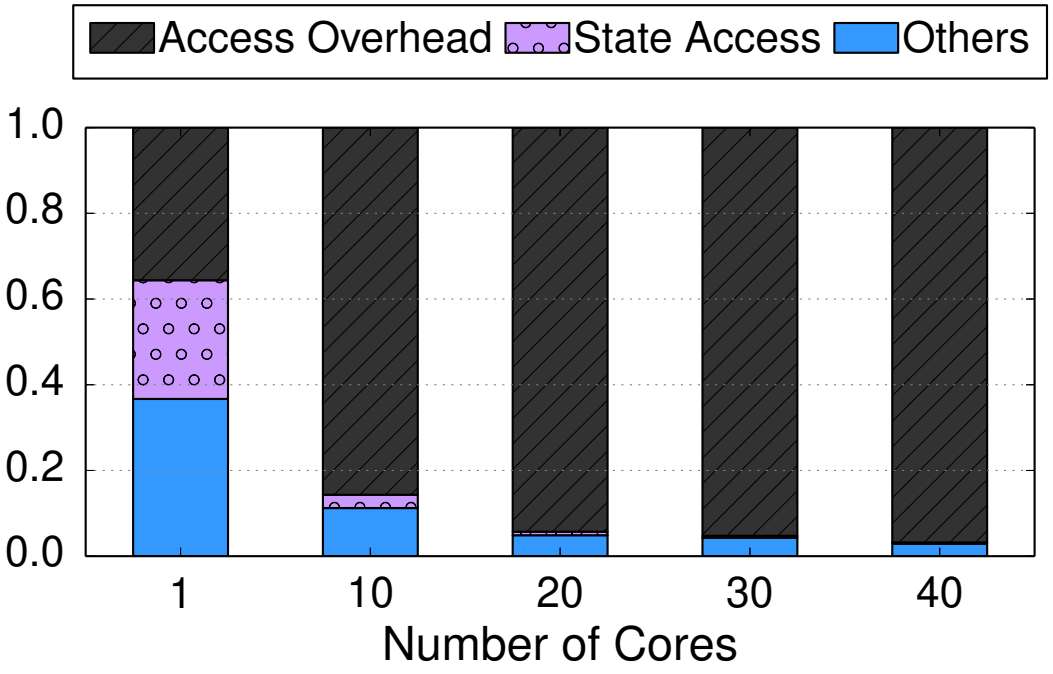

[1] S-Store: Streaming Meets Transaction Processing, VLDB'15

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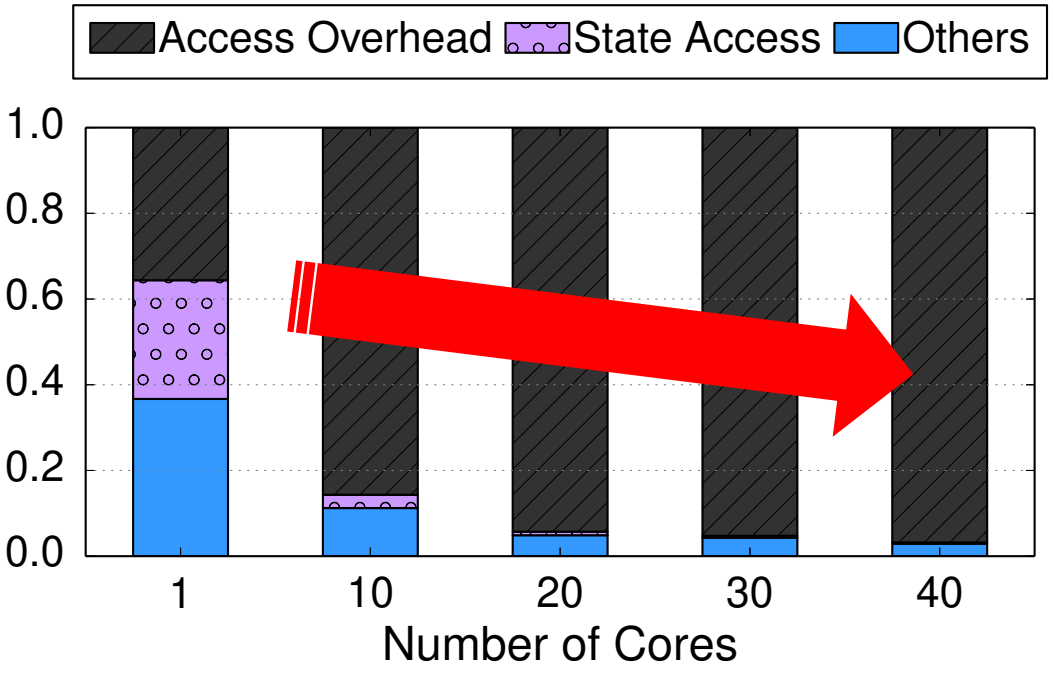

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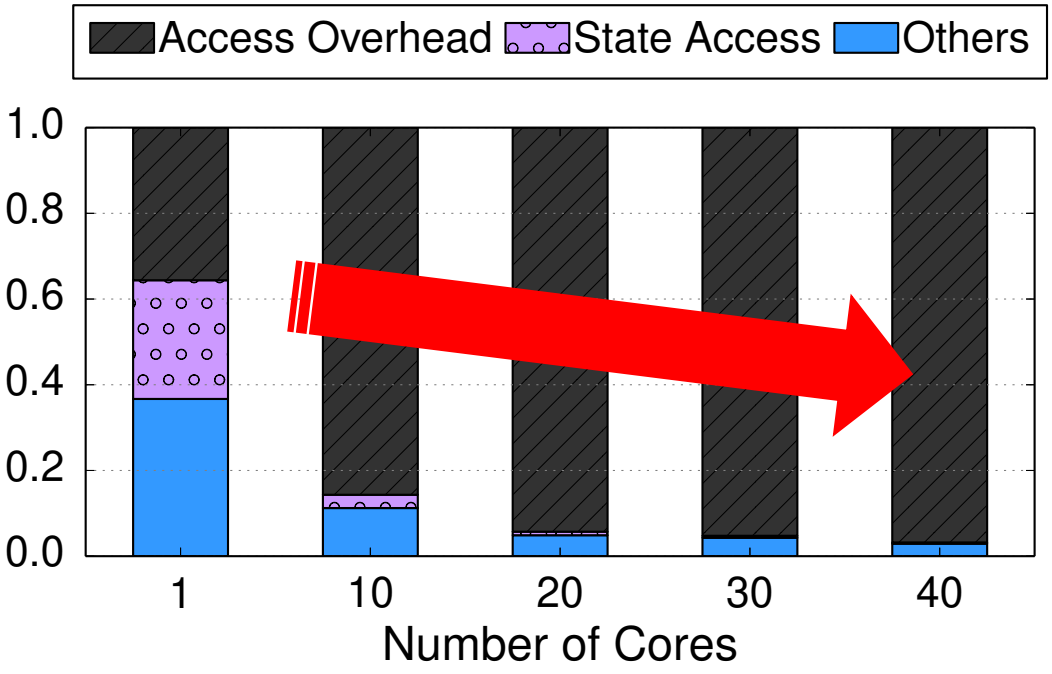

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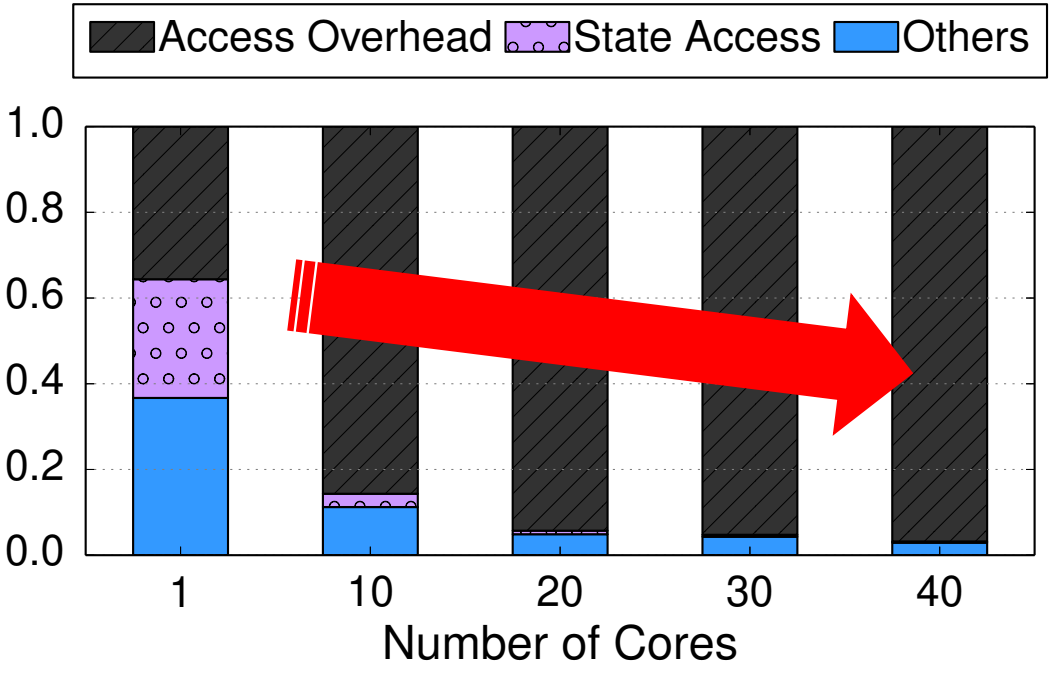

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A new solution for scaling concurrent state access is needed!

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  - TStream (An extension of BriskStream[2])
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[2] BriskStream: Scaling Data Stream Processing on Shared-Memory Multicore Architectures, SIGMOD'19

Design Overview

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- **Design 1) Dual-Mode Scheduling**
  - Exposing Parallelism
- **Design 2) Dynamic Restructuring Execution**
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Up to 4.8 times higher throughput with similar or even lower processing latency!

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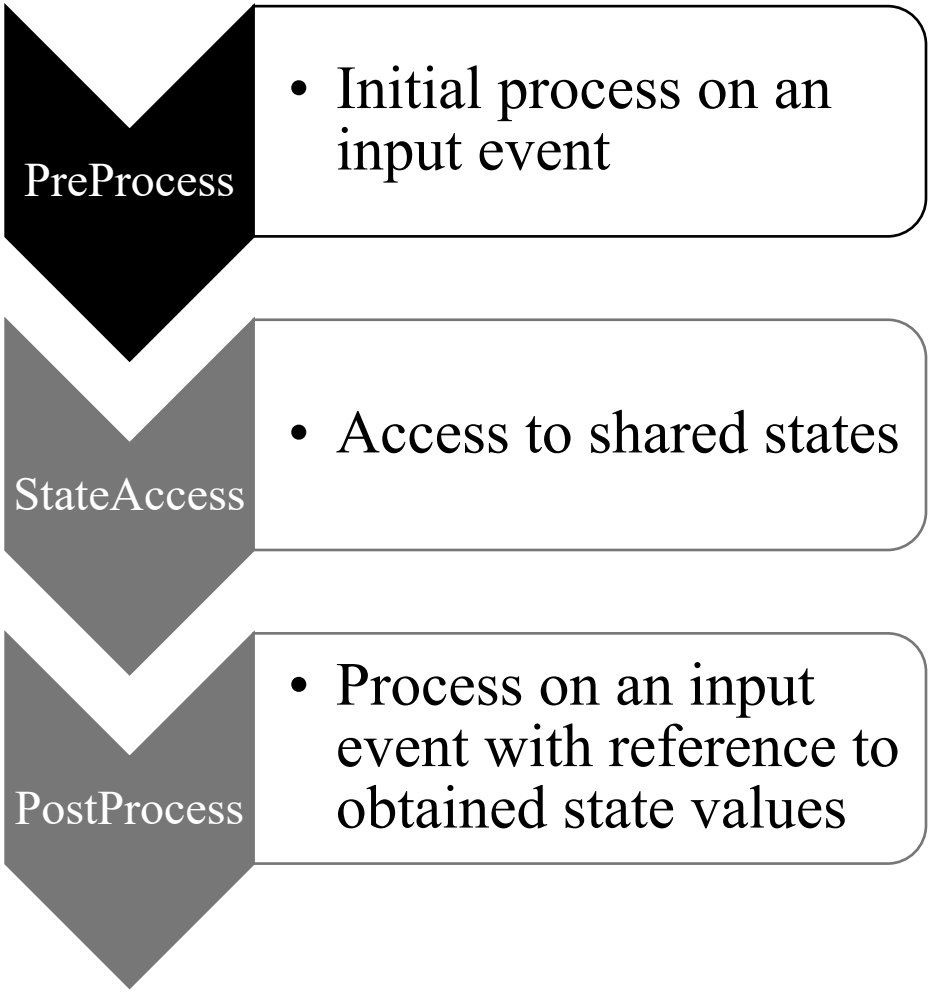

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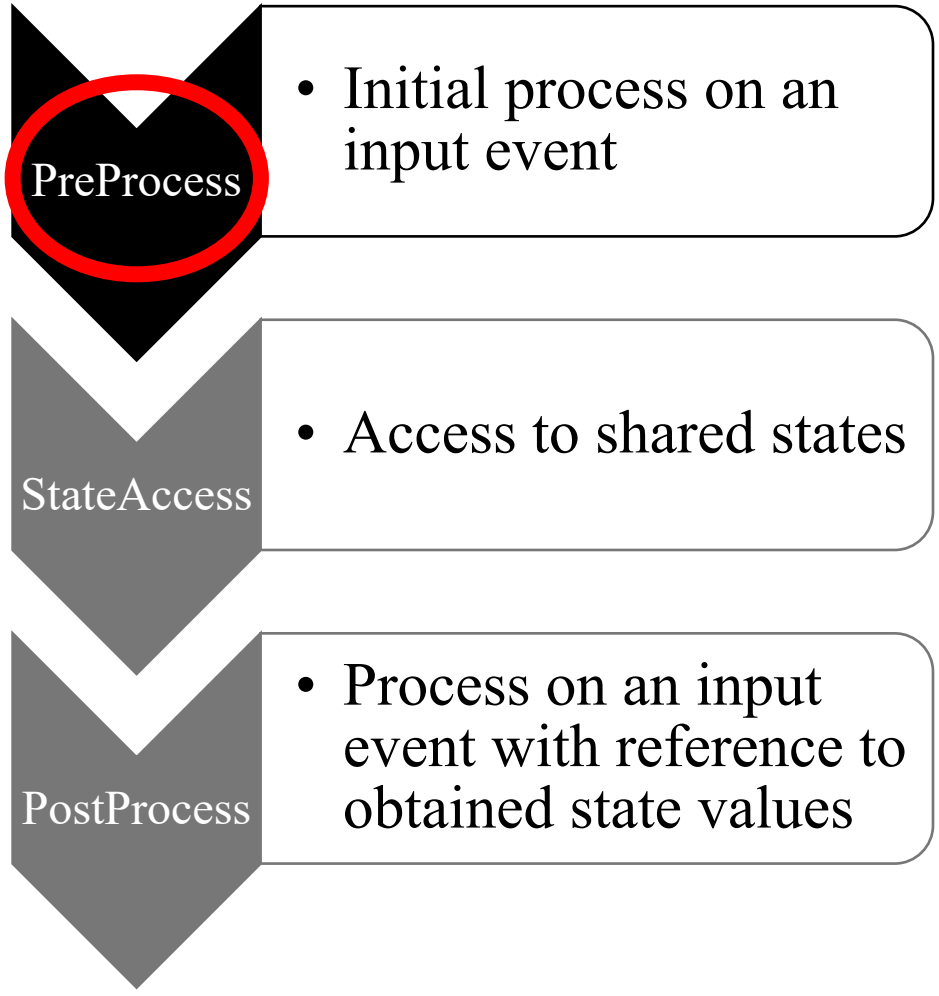

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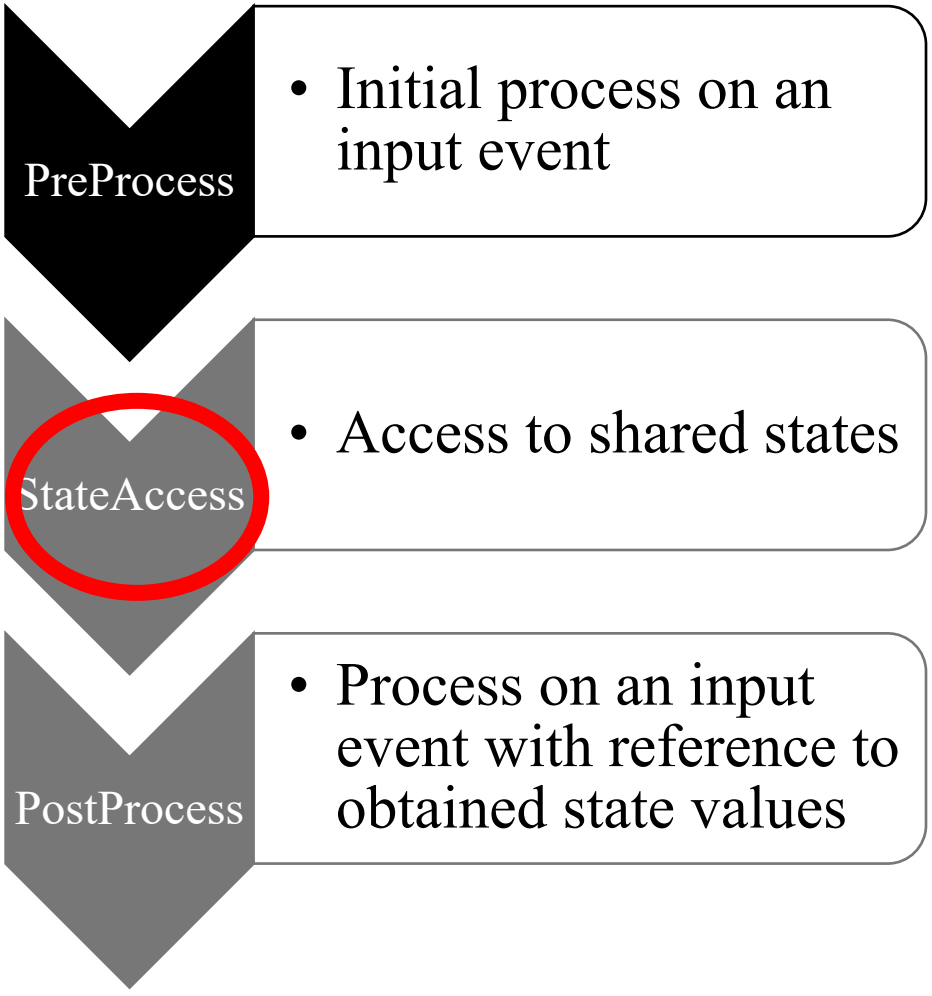

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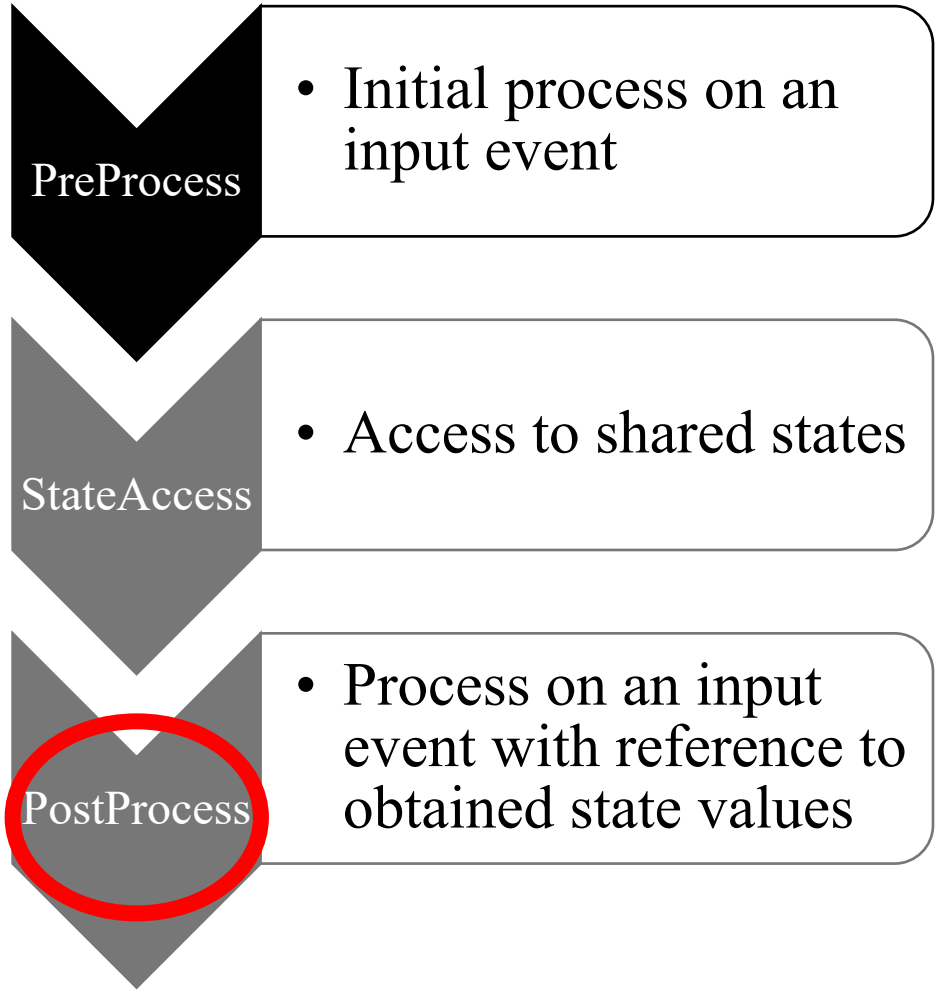

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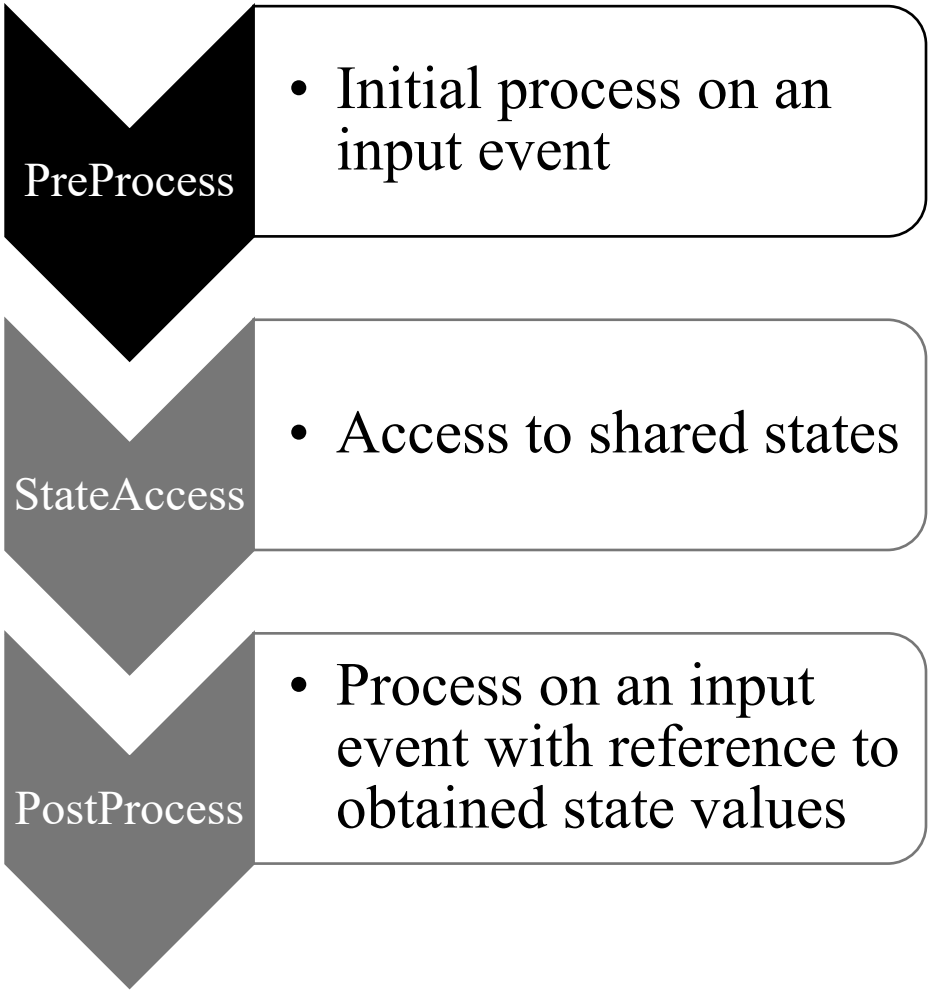

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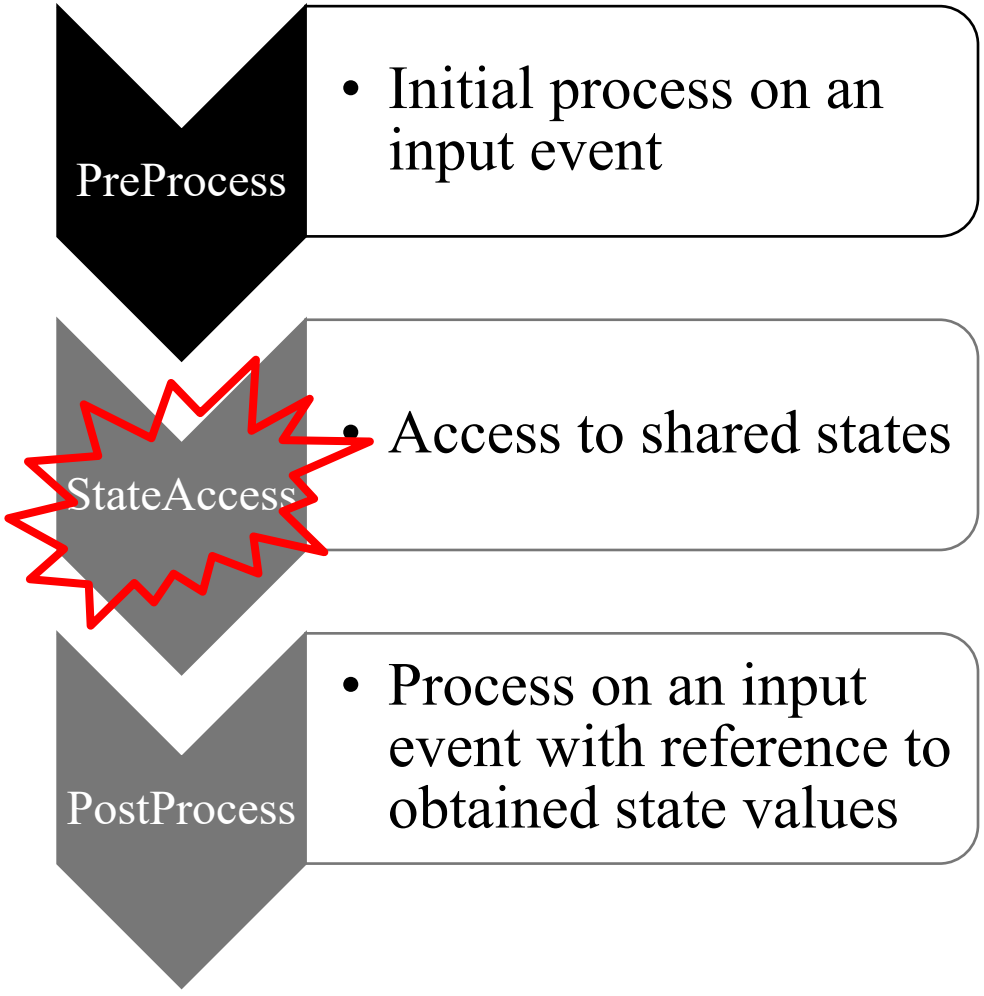

- State access is often the bottleneck.
- It *unnecessarily* blocks all subsequent processes.

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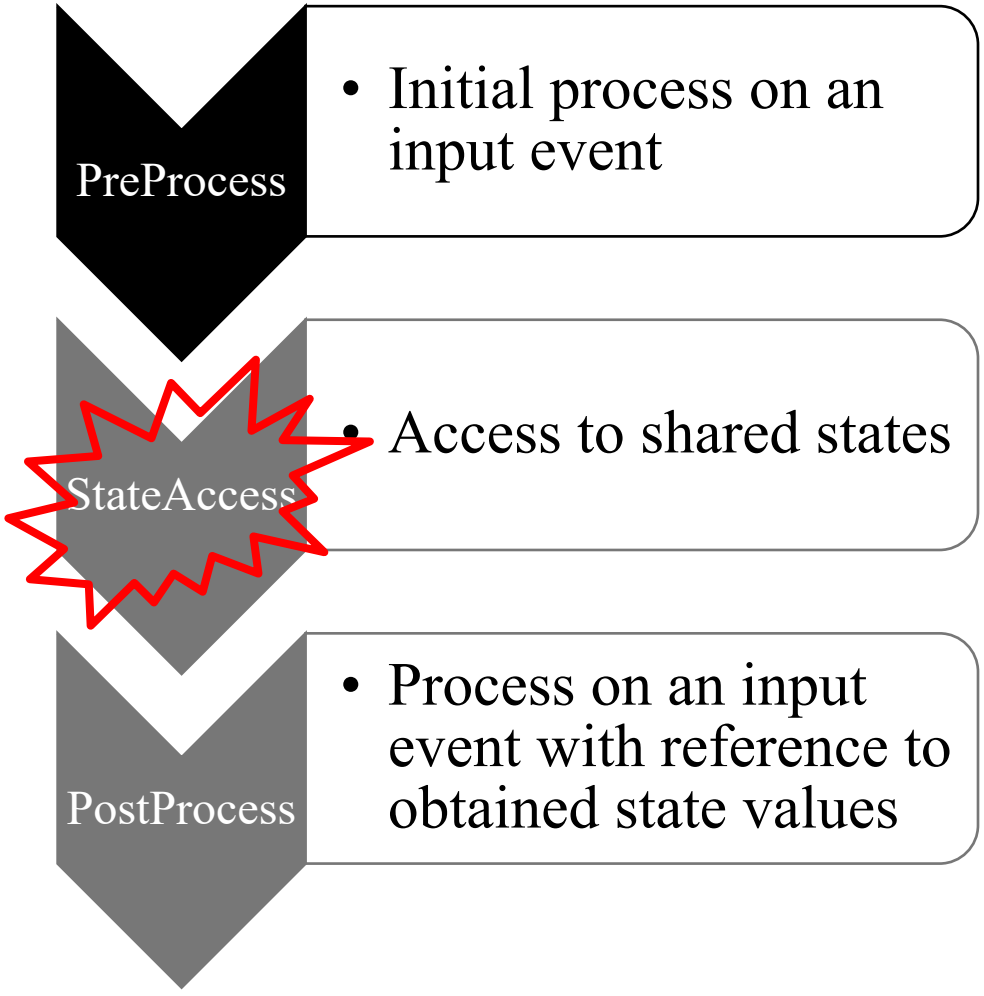

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Let's postpone it.

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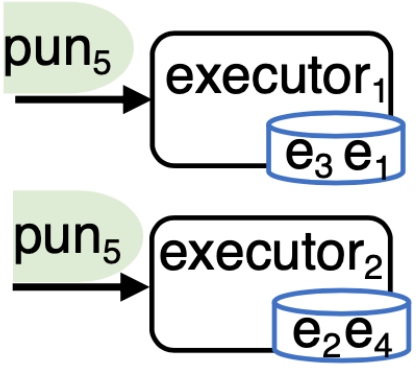

(a)PreProcess

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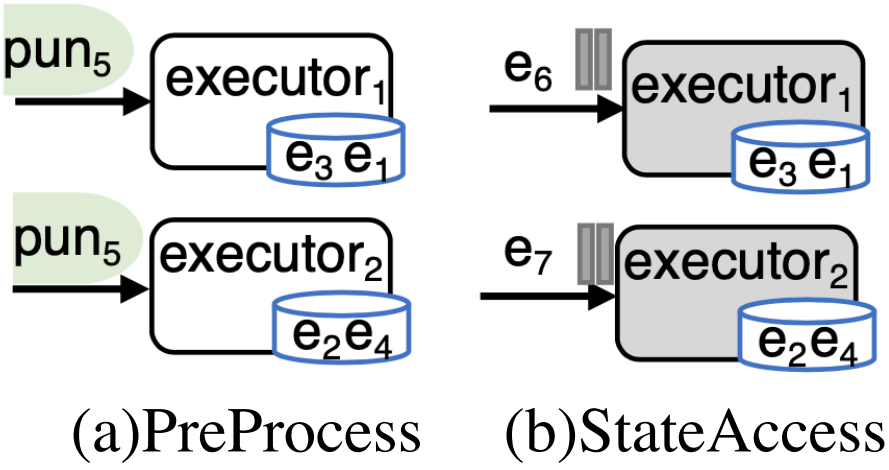

(a)PreProcess (b)StateAccess

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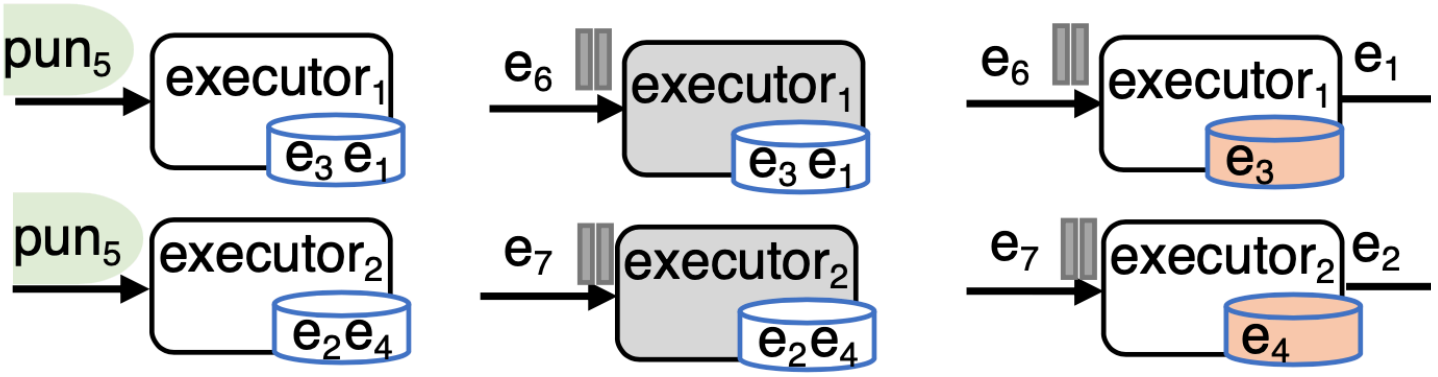

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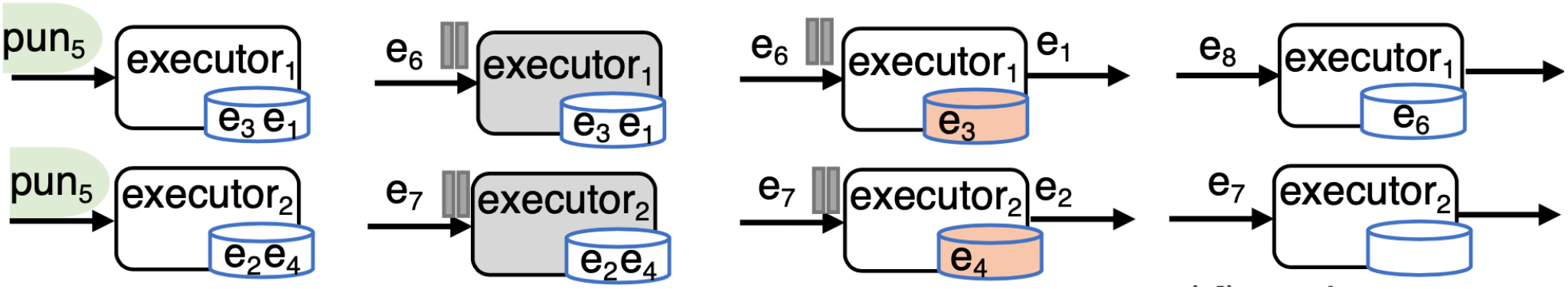

(a)PreProcess (b)StateAccess (c)PostProcess (d)PreProcess

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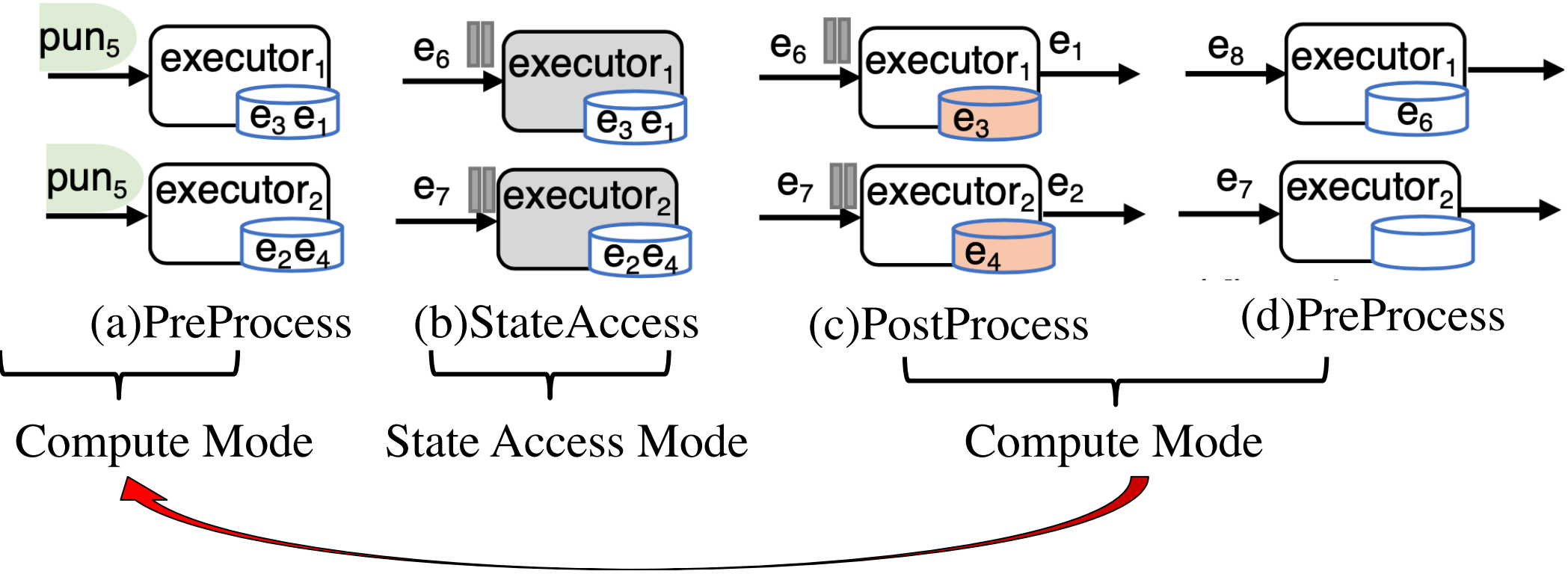

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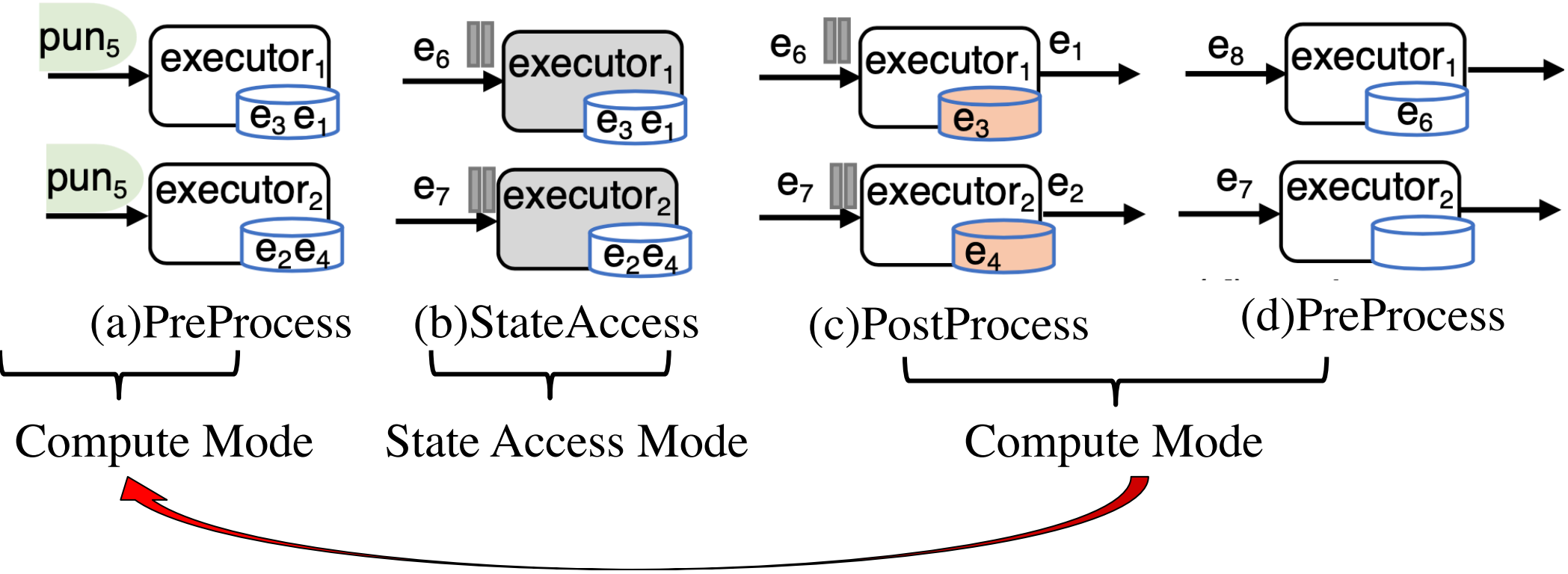

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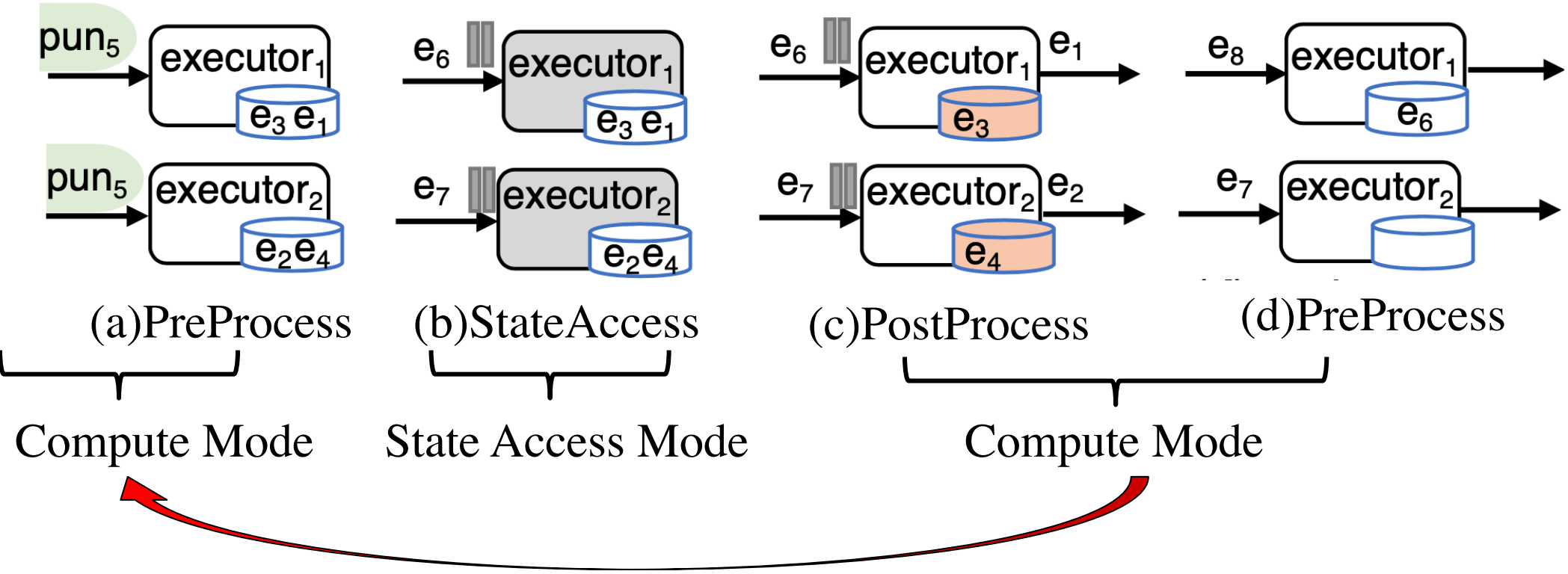

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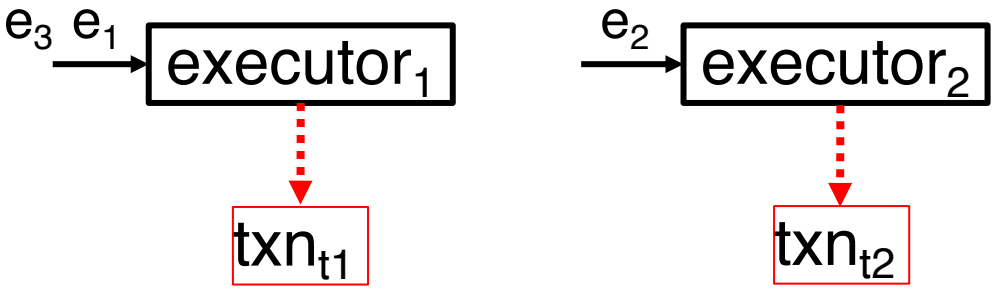

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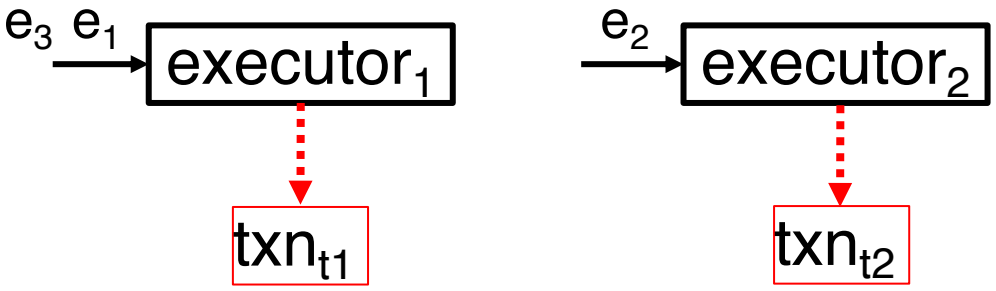

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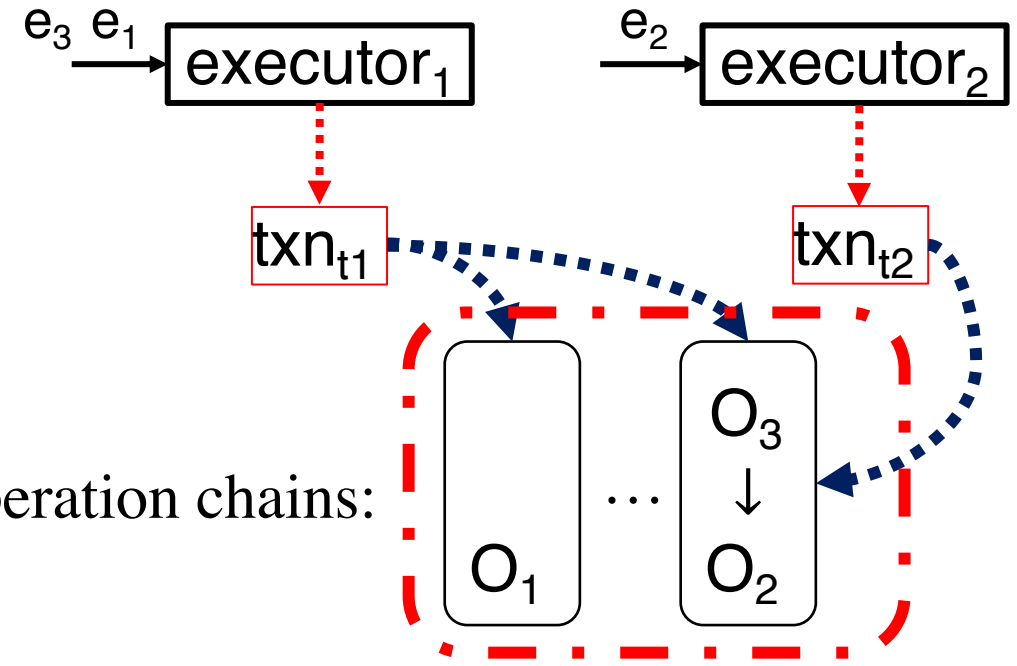

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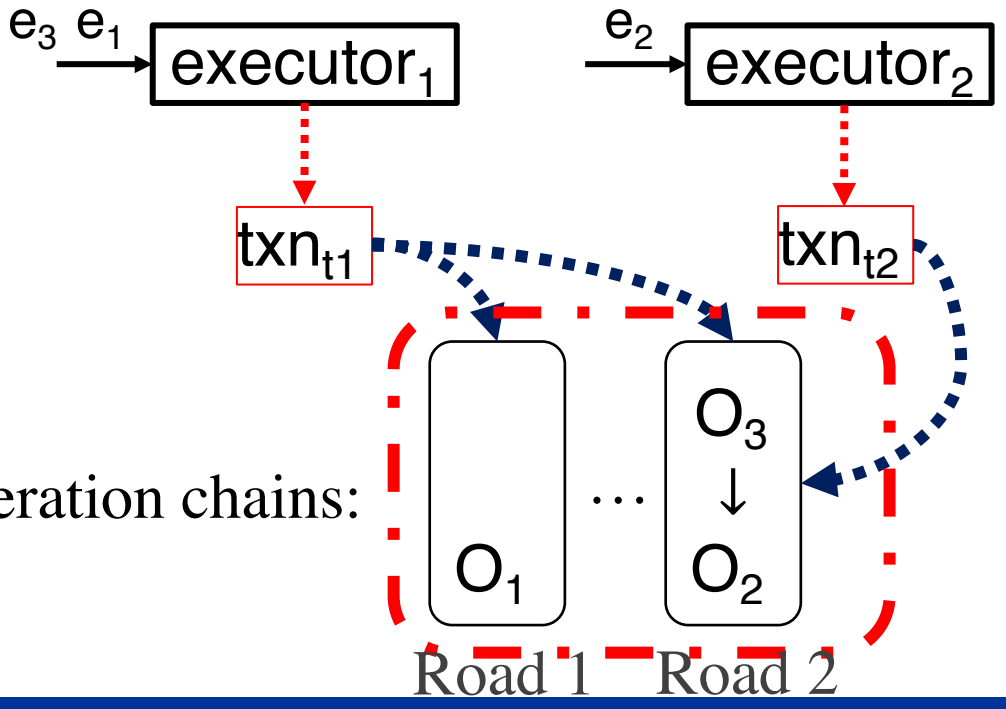

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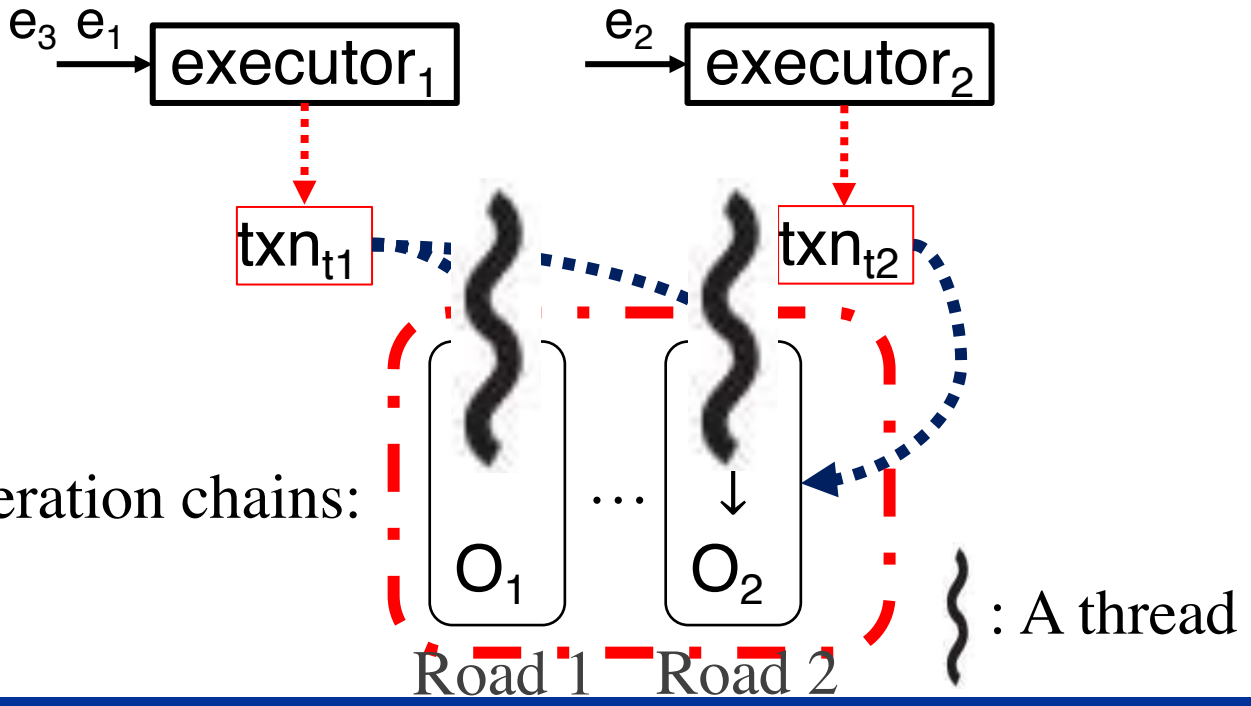

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Outline

- **Motivation**
- **State-of-the-art**
- **Our Approach**
- **Experimental Results**

Benchmark Workloads

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- **Four applications:**
  - Grep Sum (GS); Streaming Ledger (SL); Online Bidding (OB); Toll Processing (TP).
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Experiments conducted on a 4-socket Intel Xeon E7- 4820 server with 128 GB DRAM.

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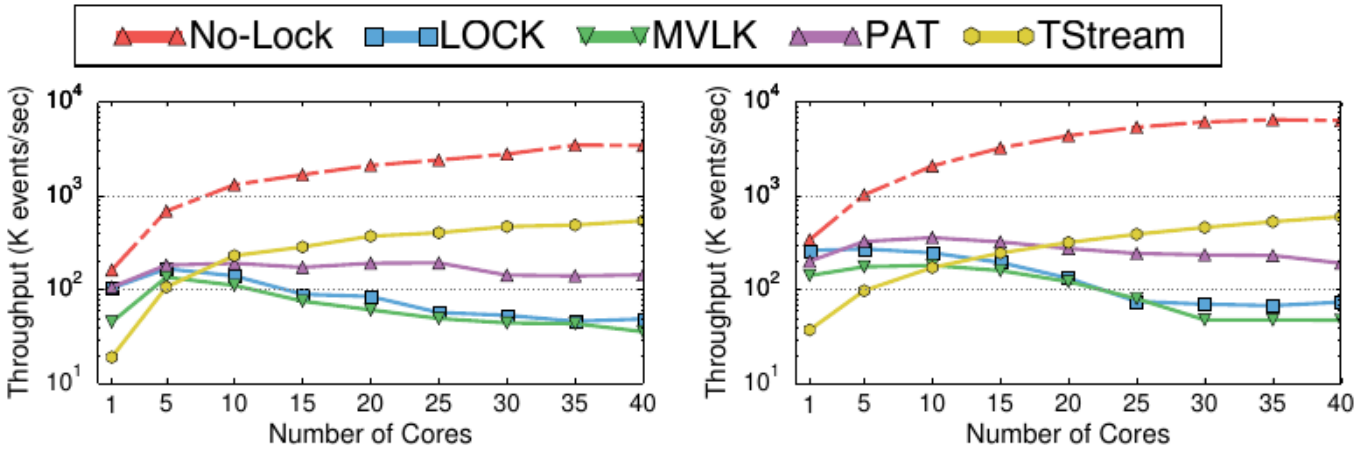

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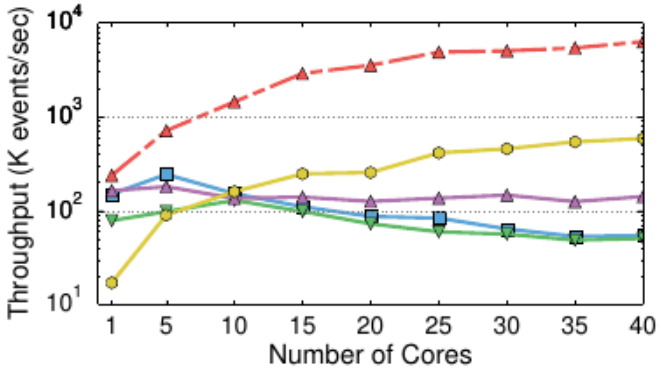

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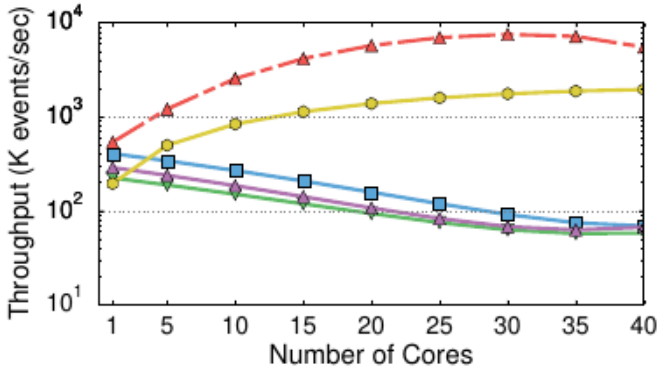

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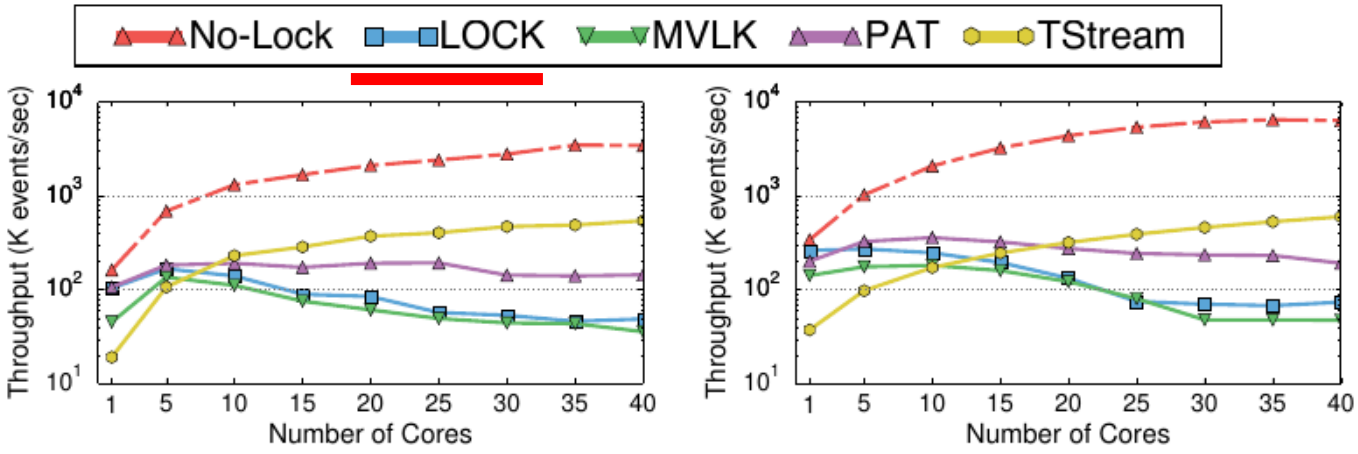

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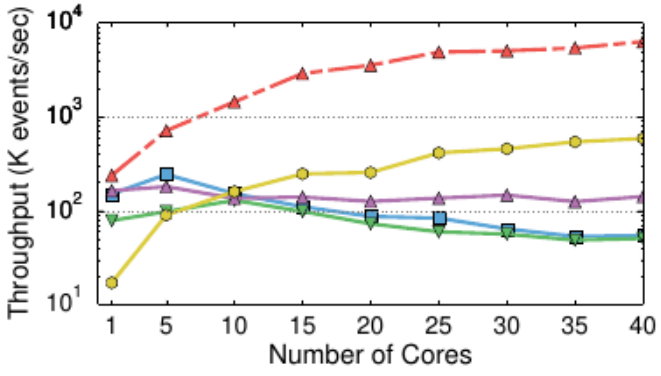

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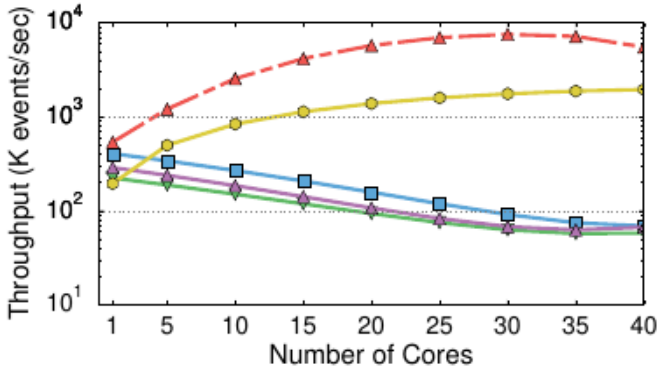

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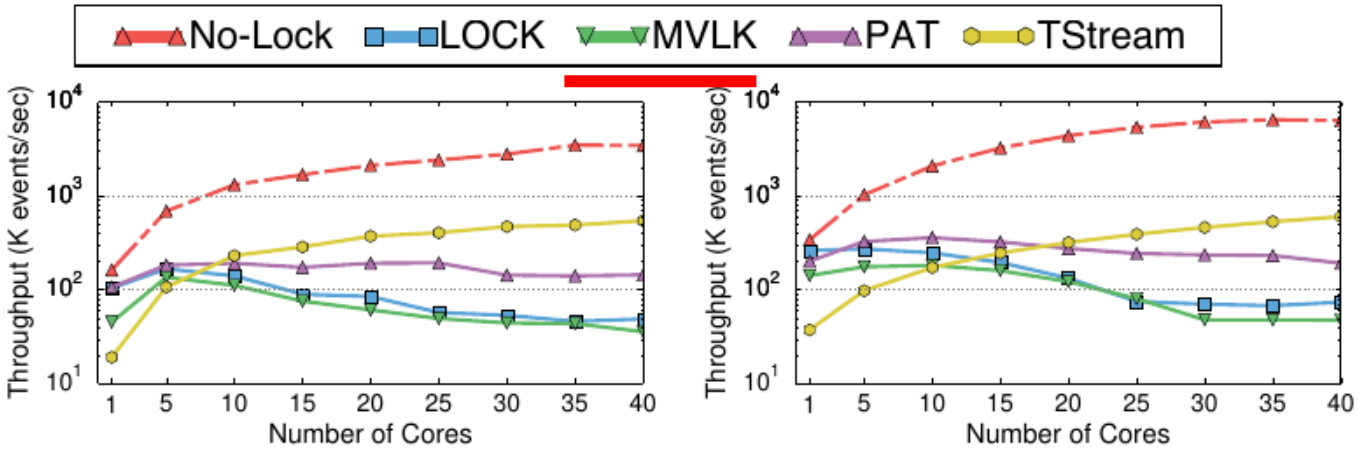

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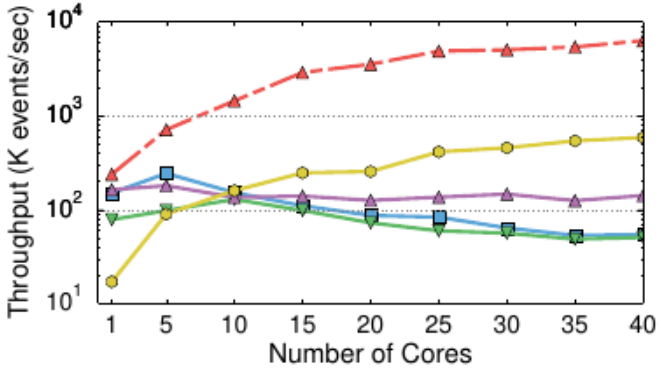

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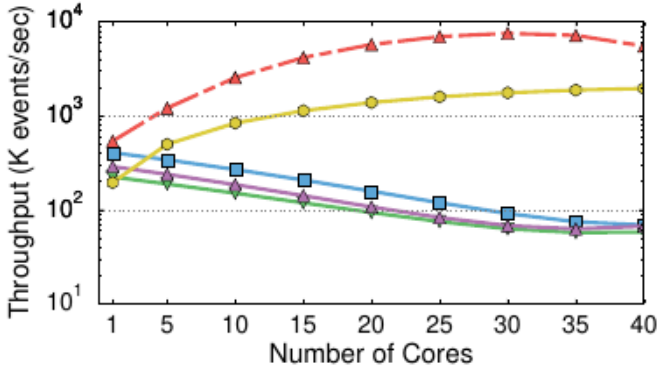

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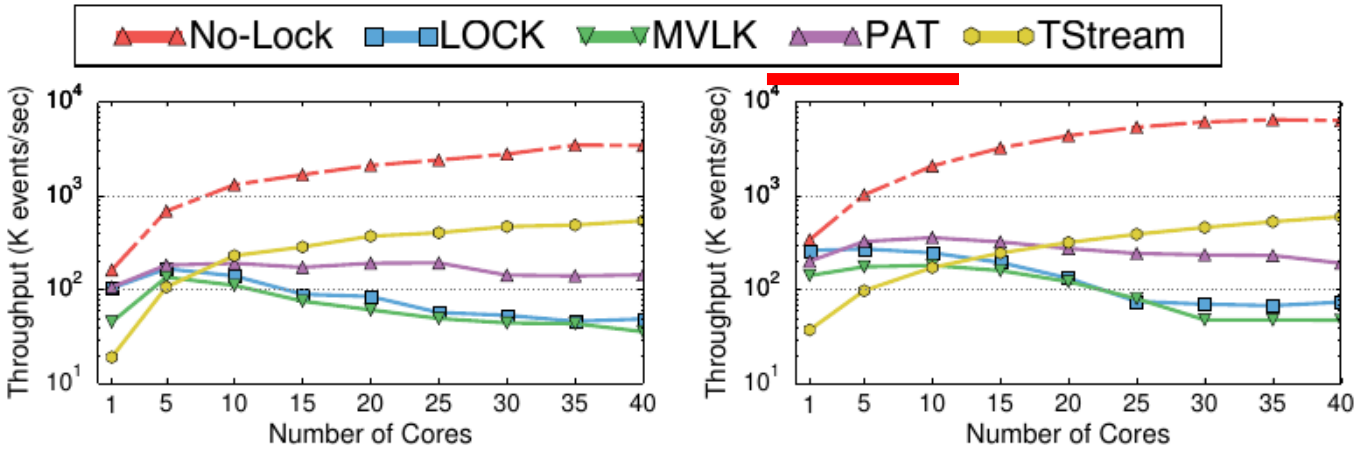

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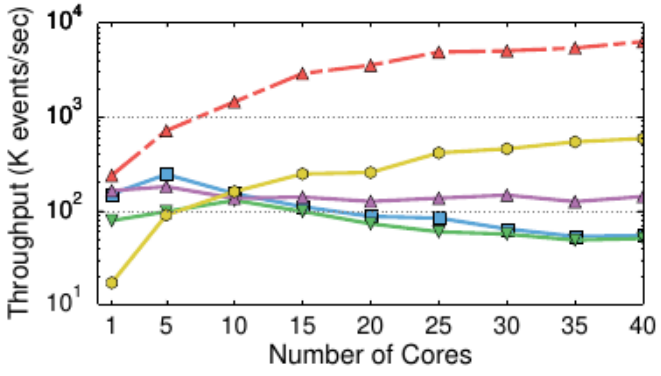

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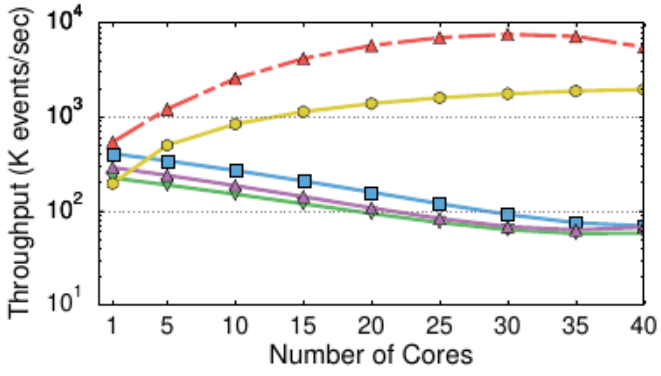

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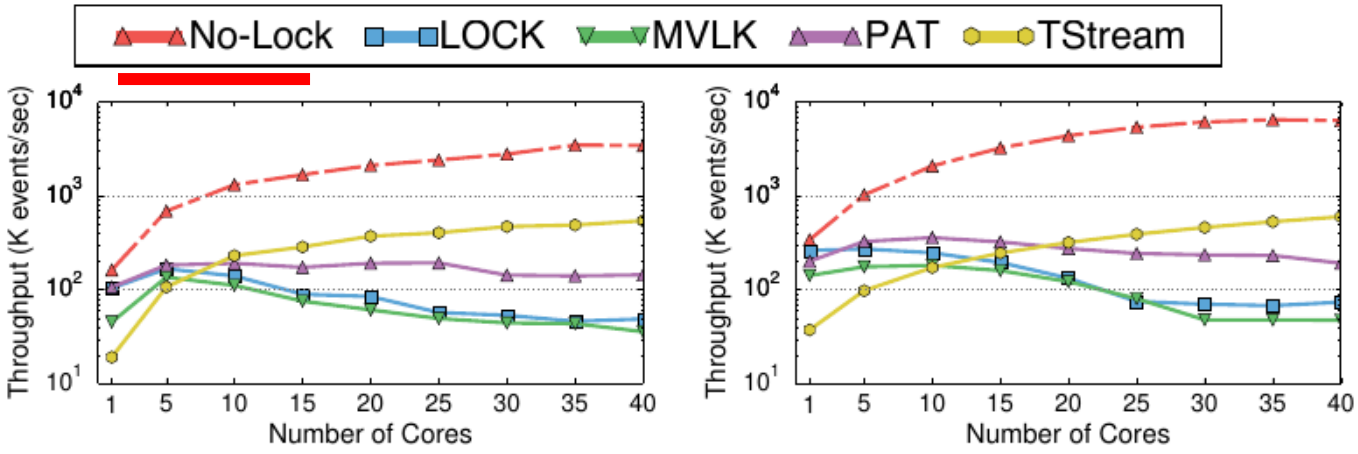

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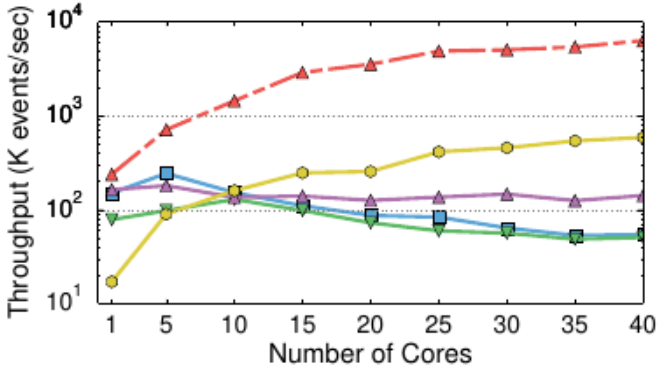

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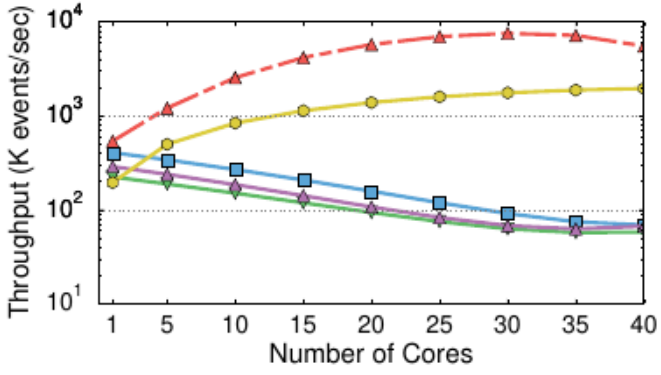

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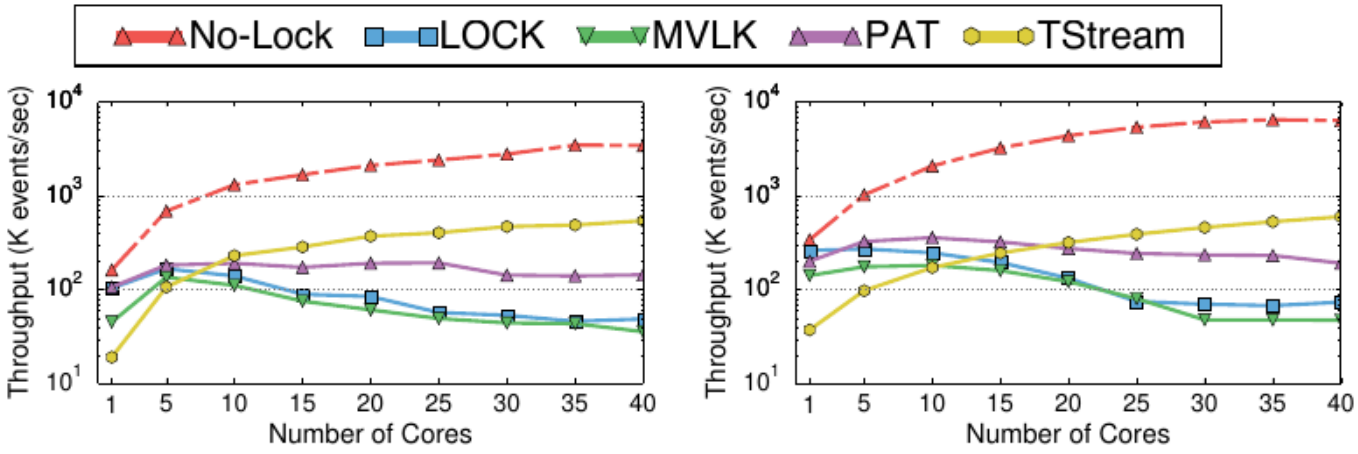

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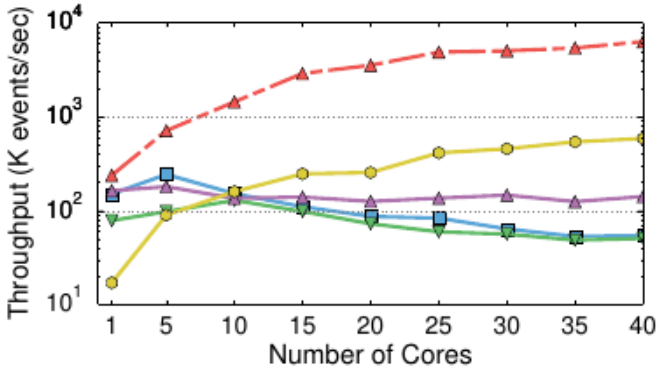

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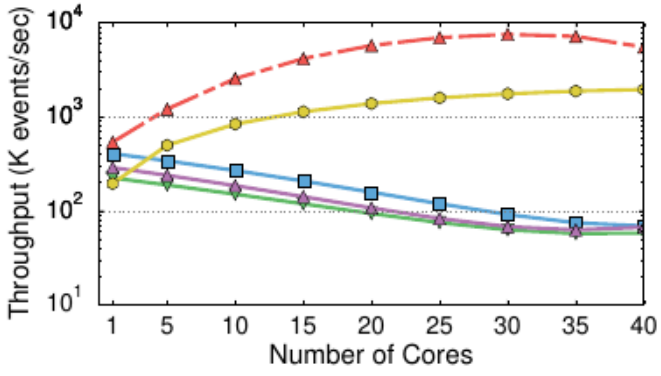

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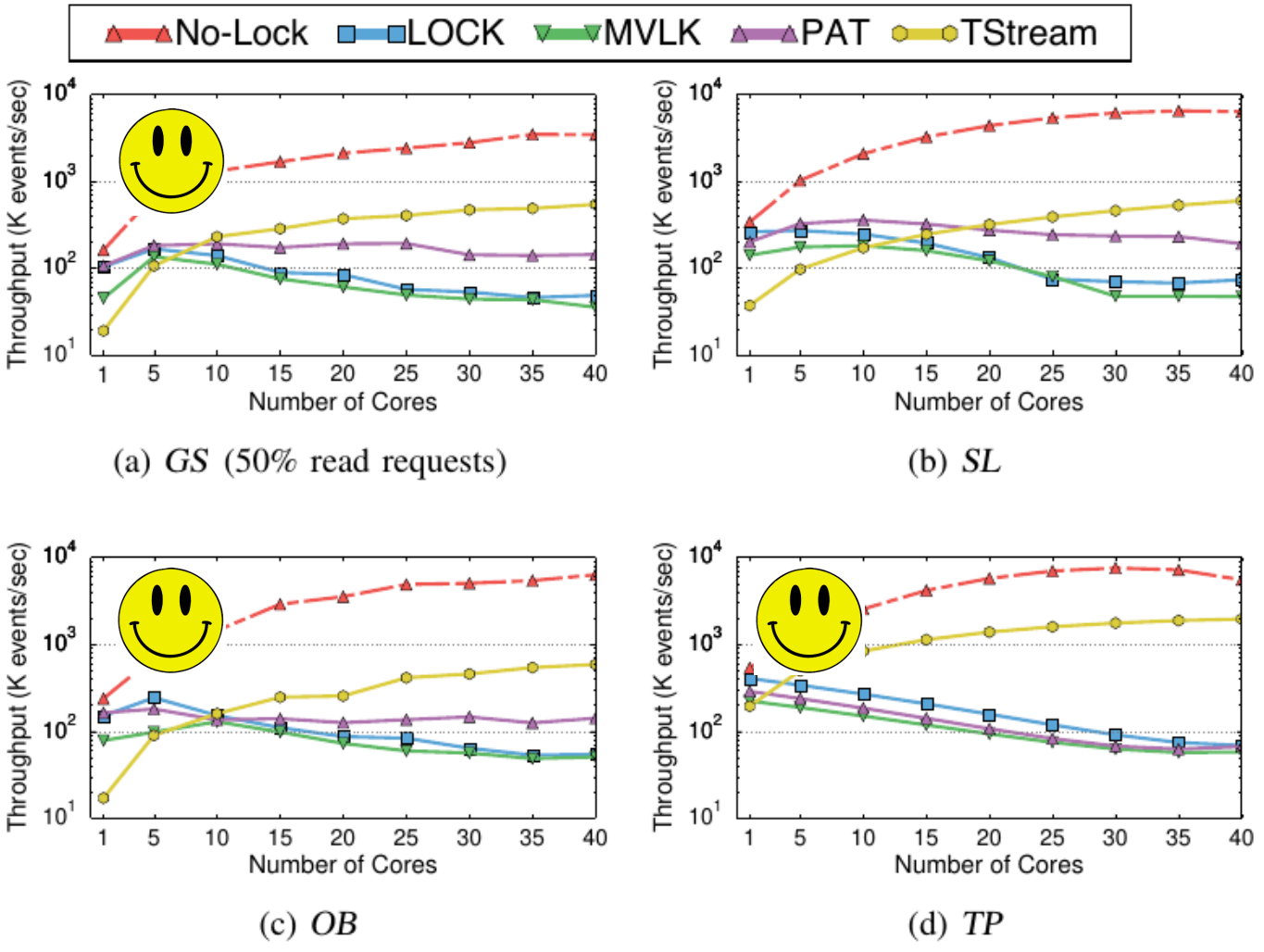

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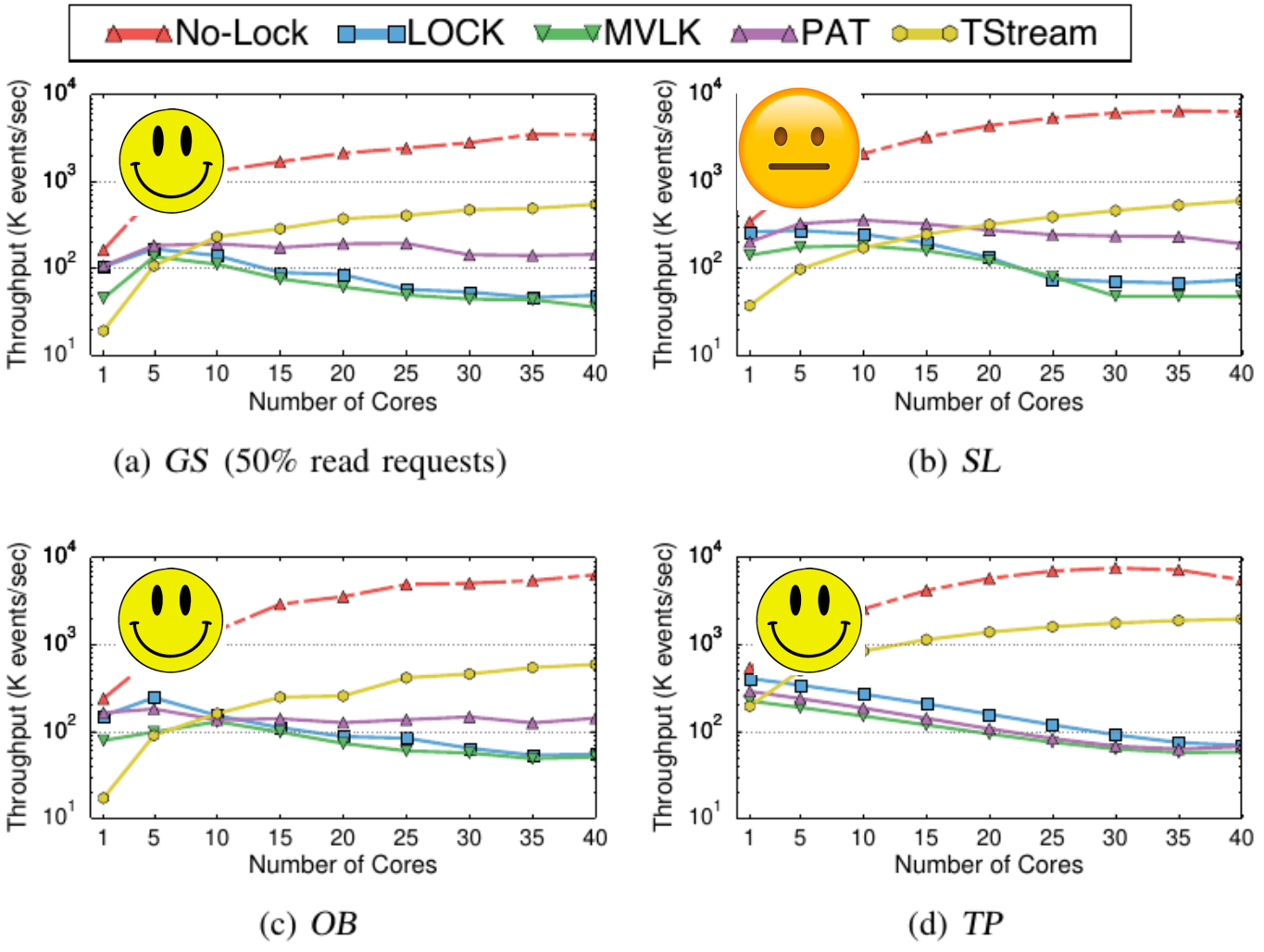

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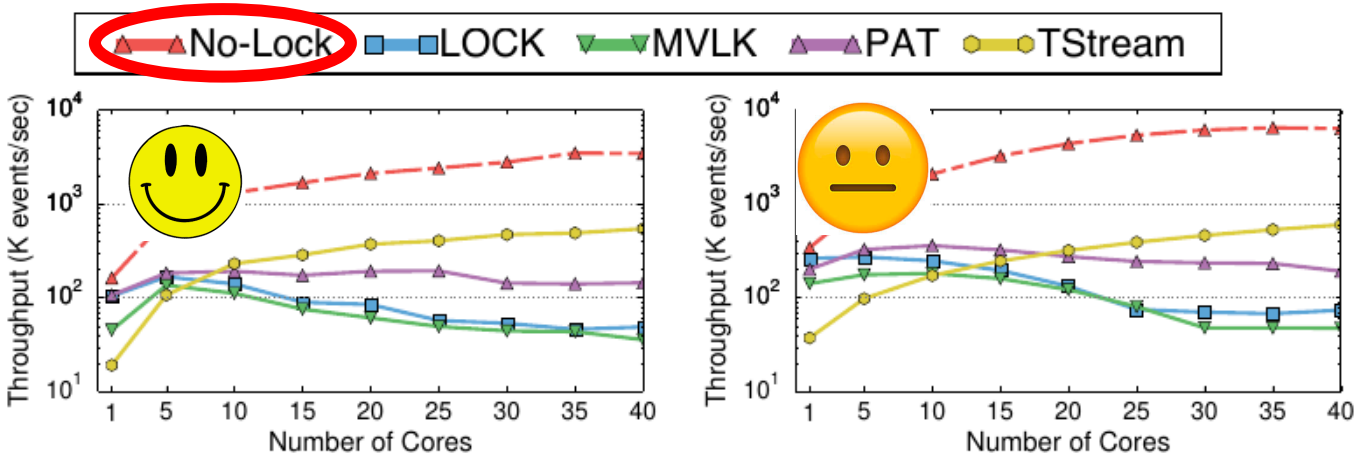

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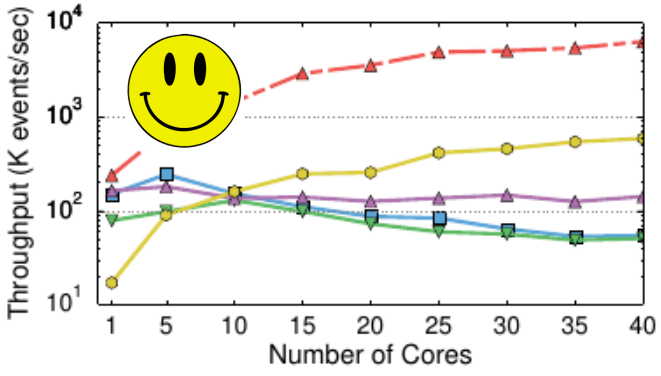

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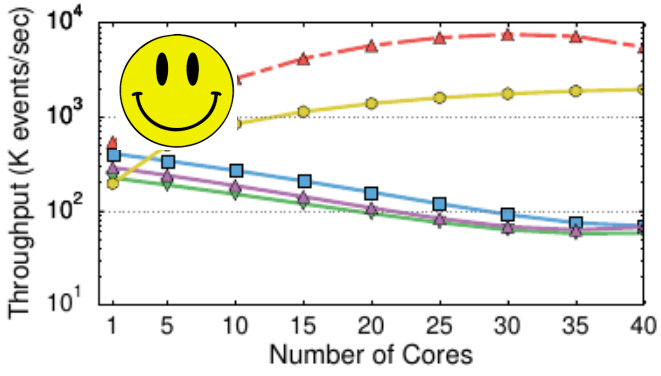

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- [Results] TStream performs constantly better than prior solutions under varying workloads.

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https://github.com/Xtra-Computing/briskstream/tree/TStream

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Current Work

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(lead by Prof. Volker Markl)

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Thank you!

shuhao.zhang@tu-berlin.de

Competitor Schemes

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① Ordering-lock-based approach (LOCK).

② Multi-versioning-based approach (MVLK).

③ Static-partition-based approach (PAT).

- S-Store

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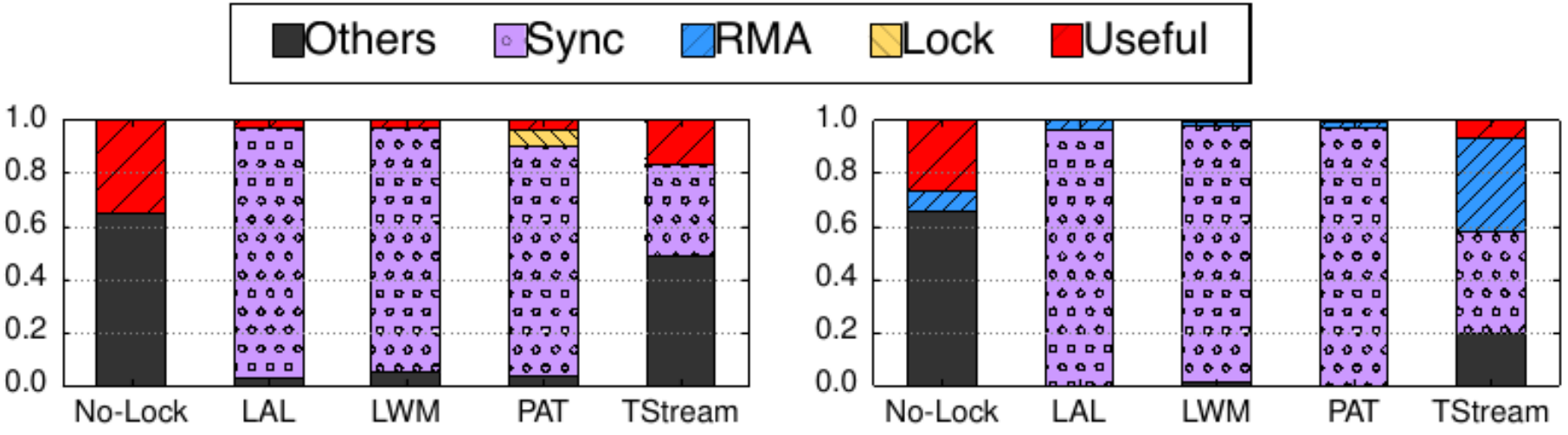

(a) Single socket

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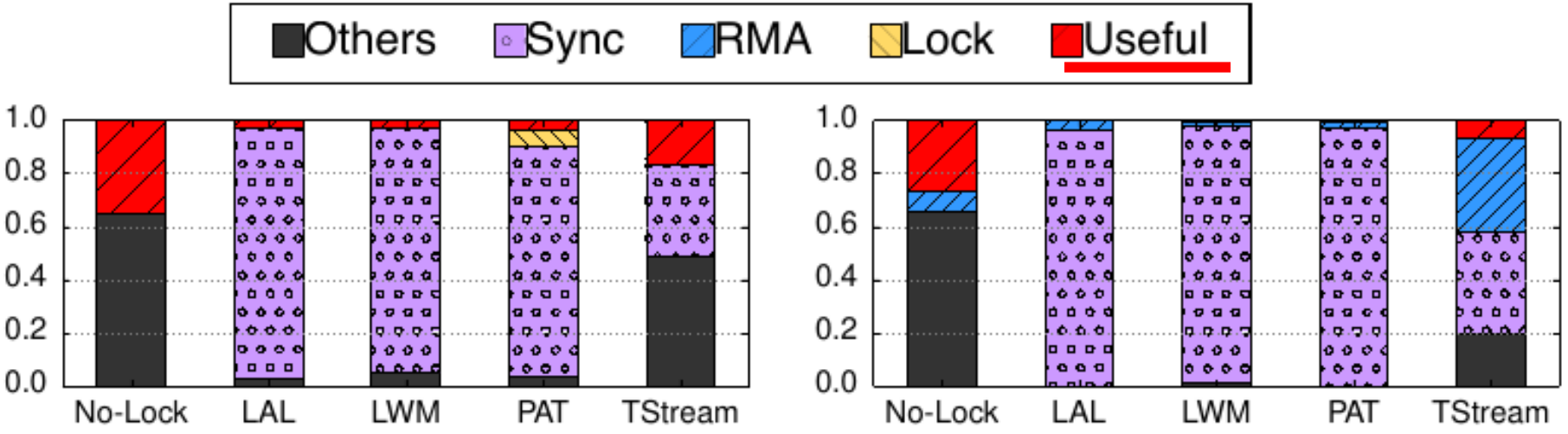

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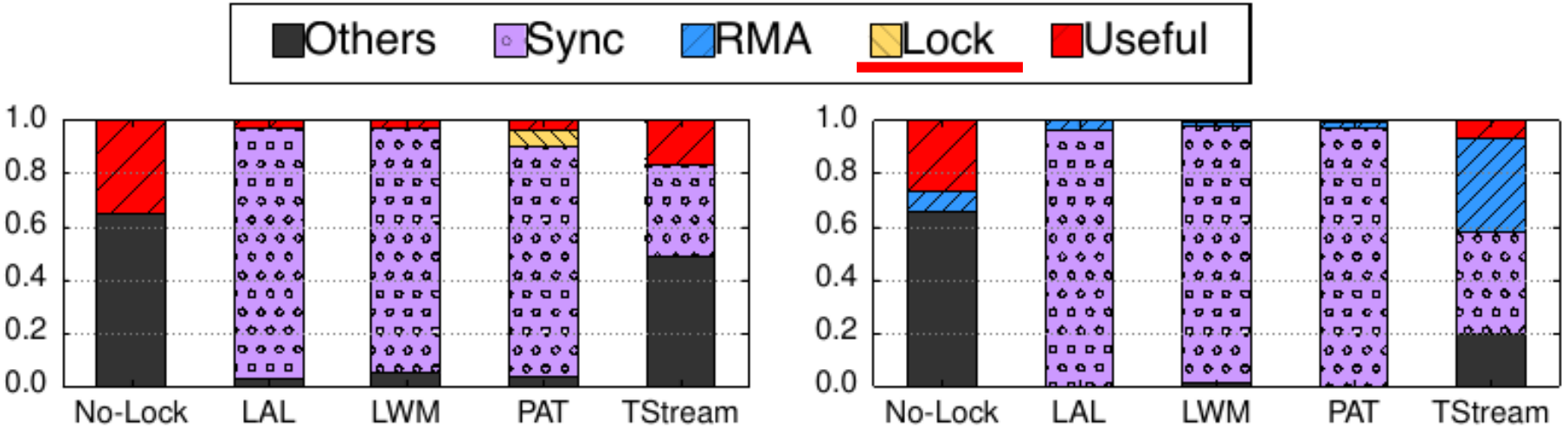

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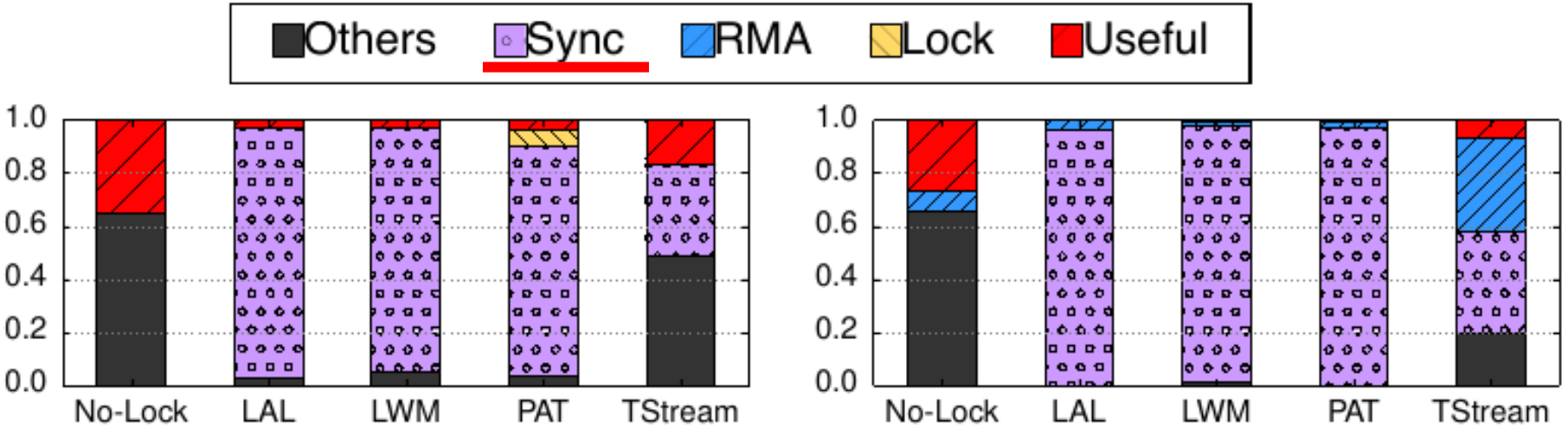

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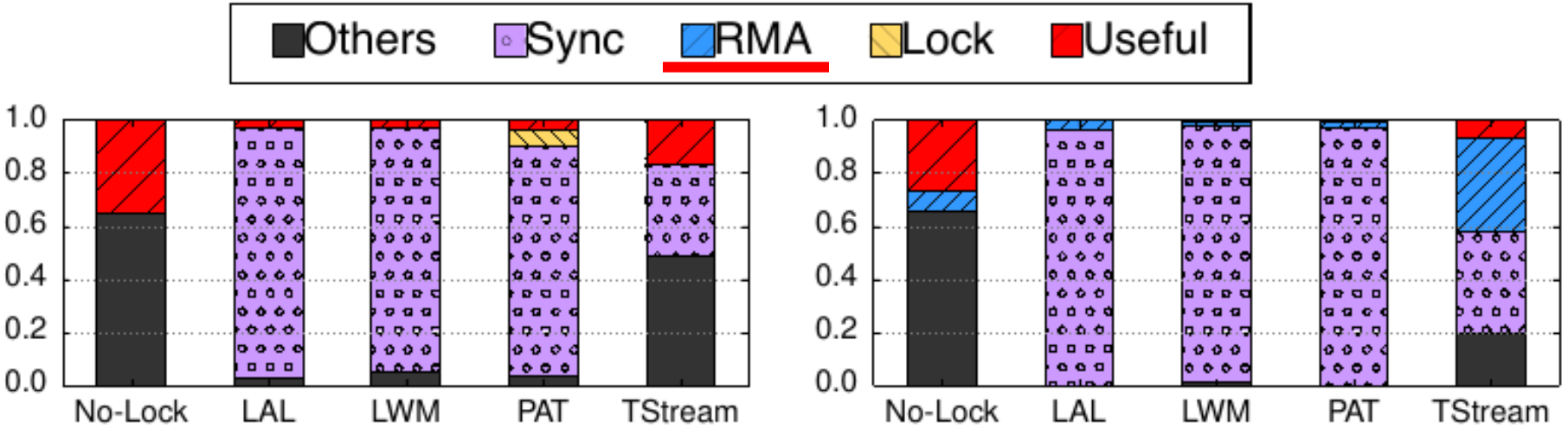

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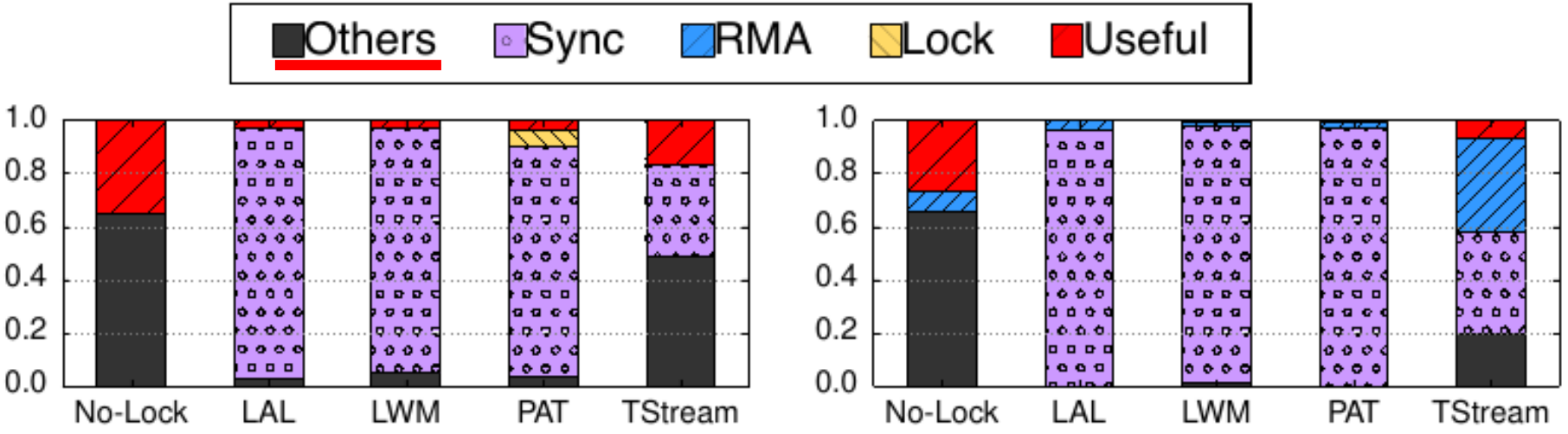

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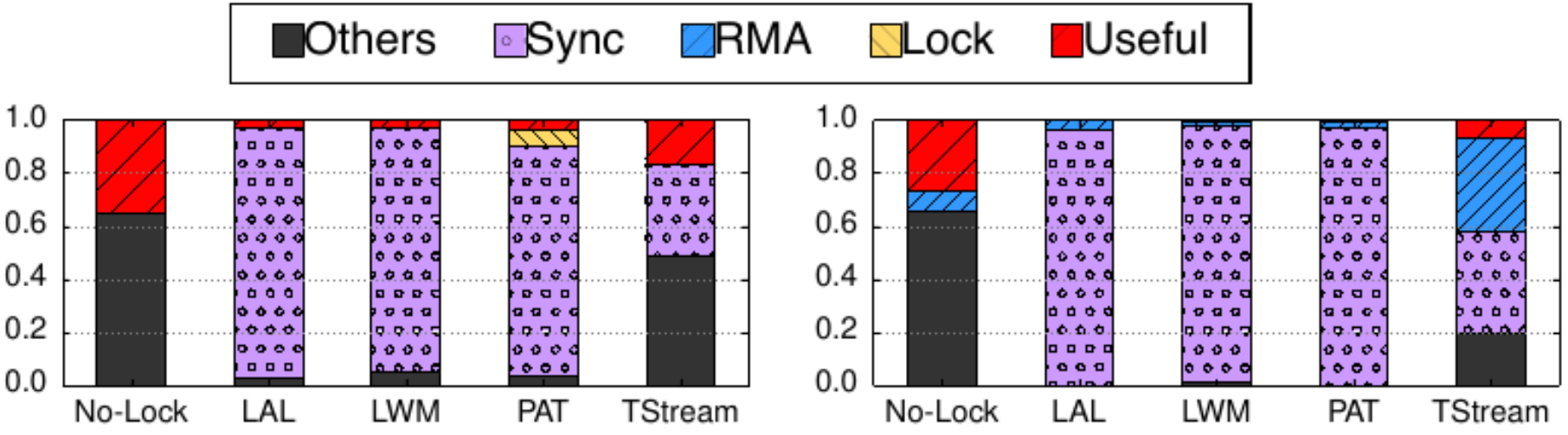

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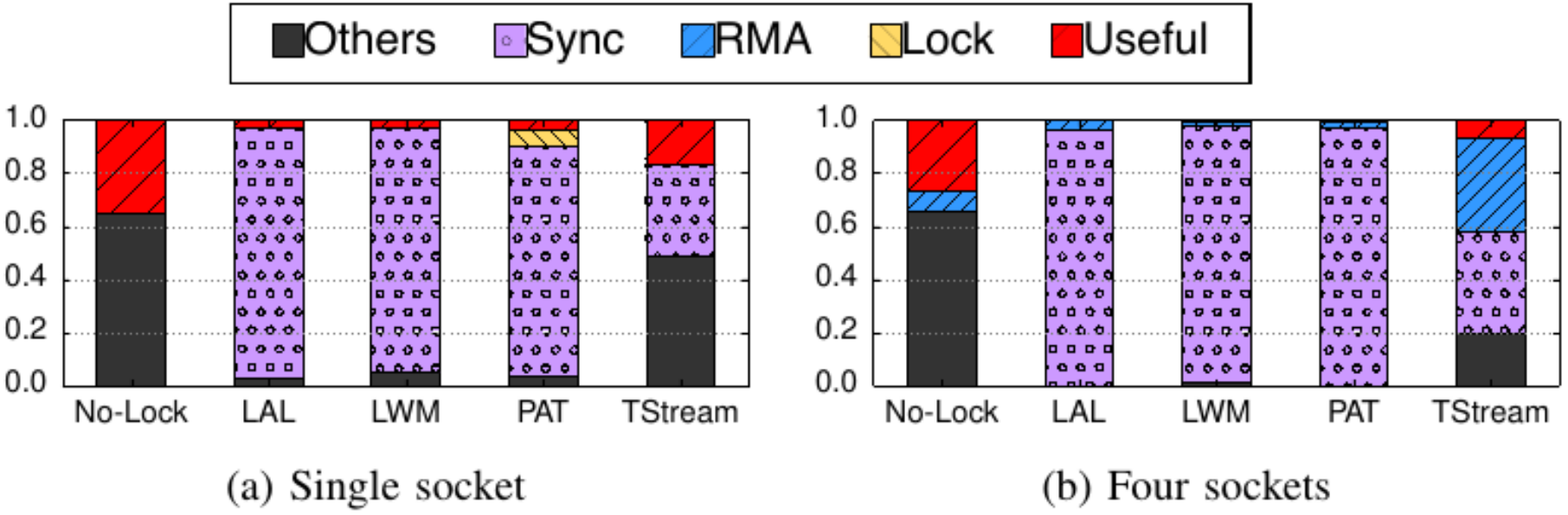

(a) No-Lock scheme spends more than 60% in others mainly due to index look up.

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(c) TStream involves high RMA overhead.

NUMA-aware optimization detailed in our paper.

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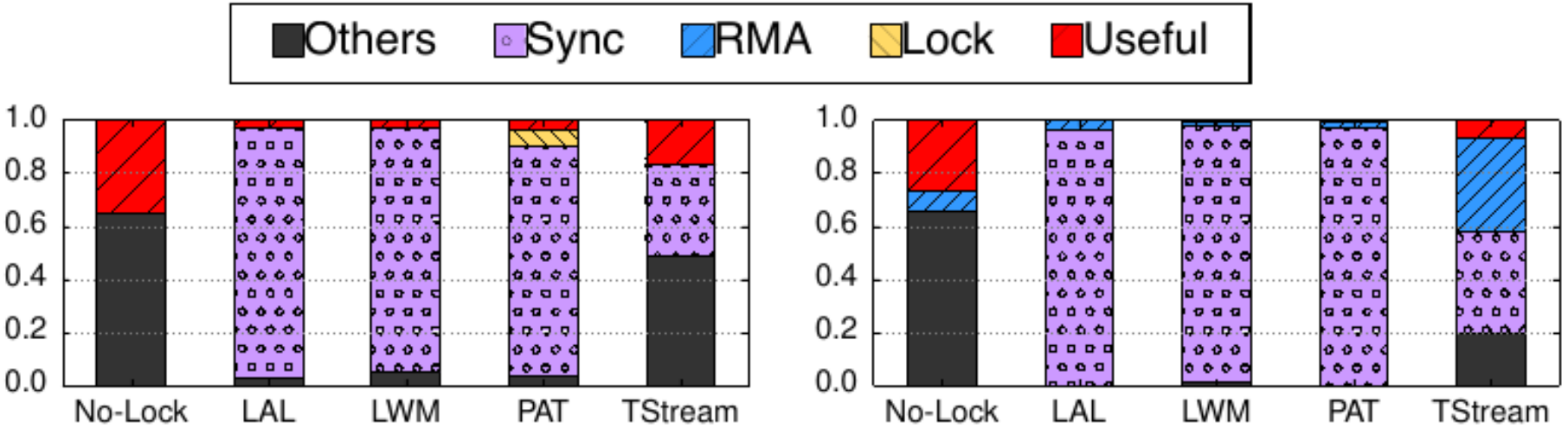

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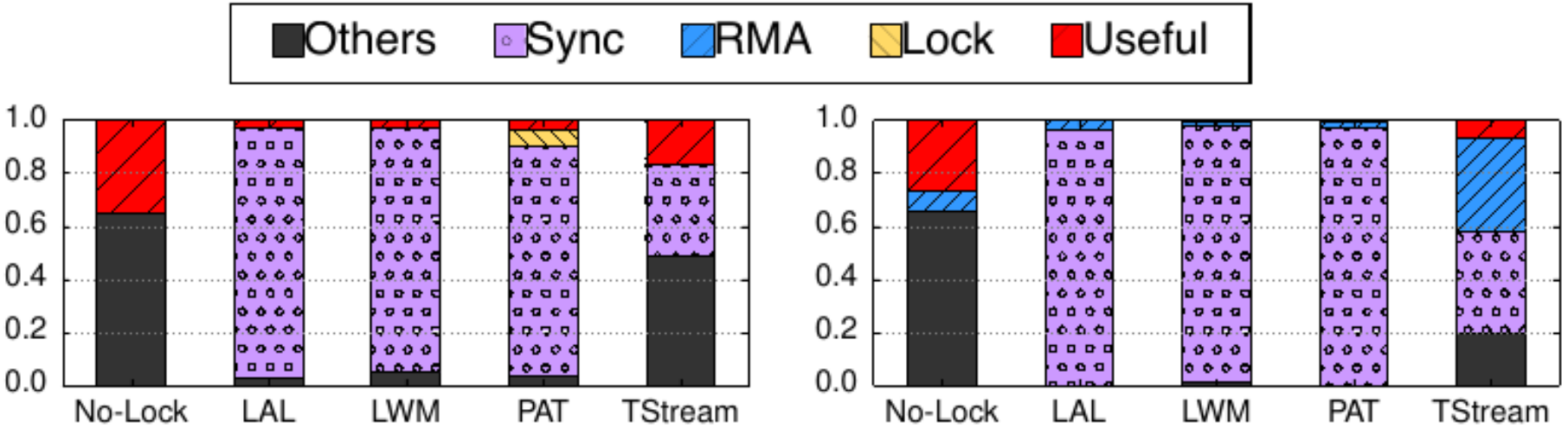
(c) TStream involves high RMA overhead.

NUMA-aware optimization detailed in our paper.

Runtime Breakdown



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Stay tuned for future work