FASTER State Management for Timely Dataflow

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Problem Statement

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- As state grows stream processing systems can:
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  - Offload state to secondary storage
- We explore the trade-off between these approaches through an integration of Timely Dataflow with FASTER

Demonstration

Demonstration Outline

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SELECT (P.name, P.city, P.state, A.id)
FROM Auction A, Person P
WHERE A.seller = P.id
        AND (P.state IN (`OR’, `ID’, `CA’))
        AND A.category = 10;
```

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DRAFT

Timely Dataflow [2]

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[3] Derek G Murray, Frank McSherry, Rebecca Isaacs, et al. 2013.
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- A stream processing system based upon the Naiad [3] dataflow model

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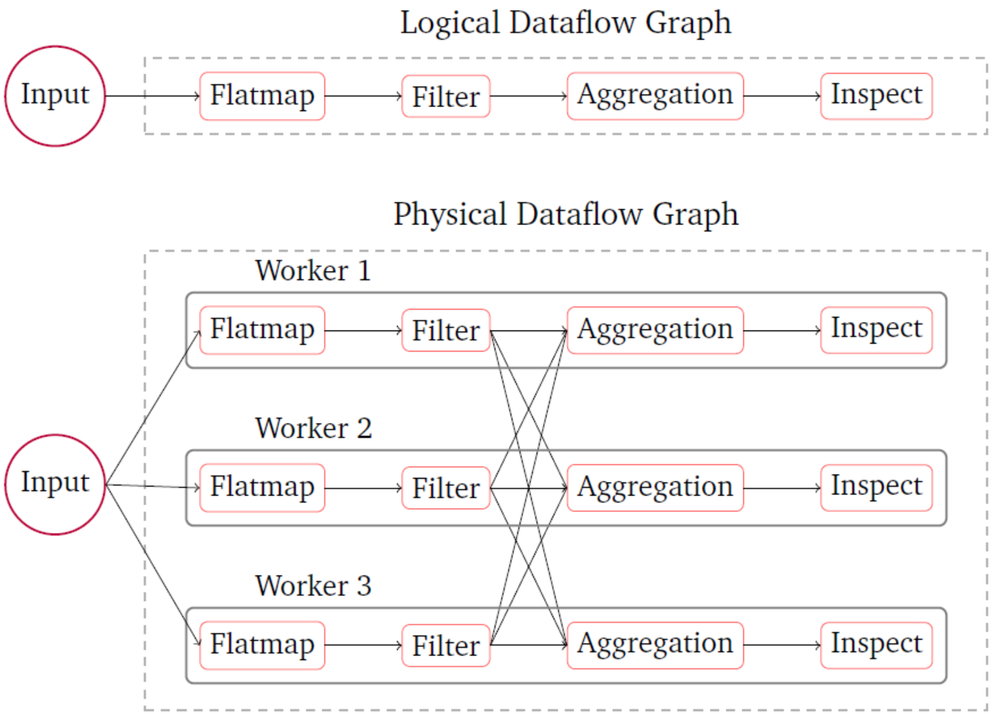

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FASTER [4]

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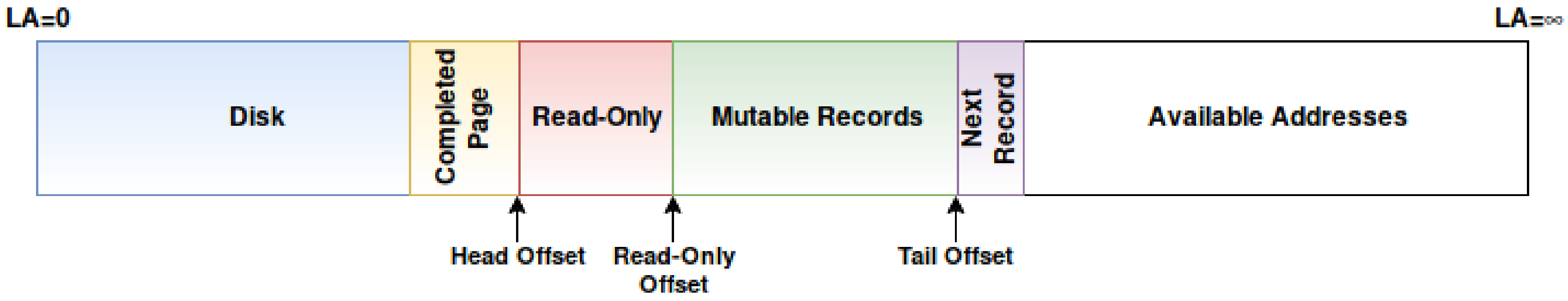

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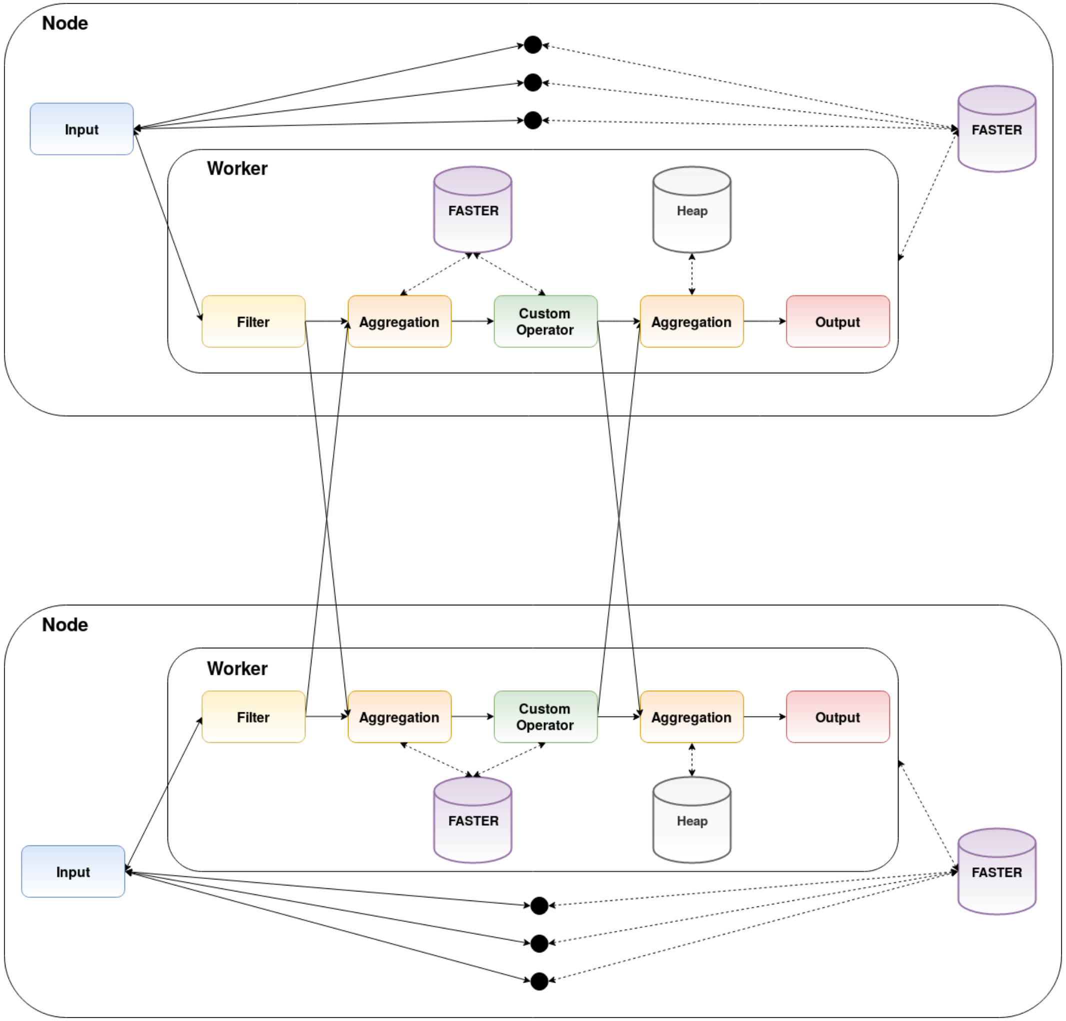

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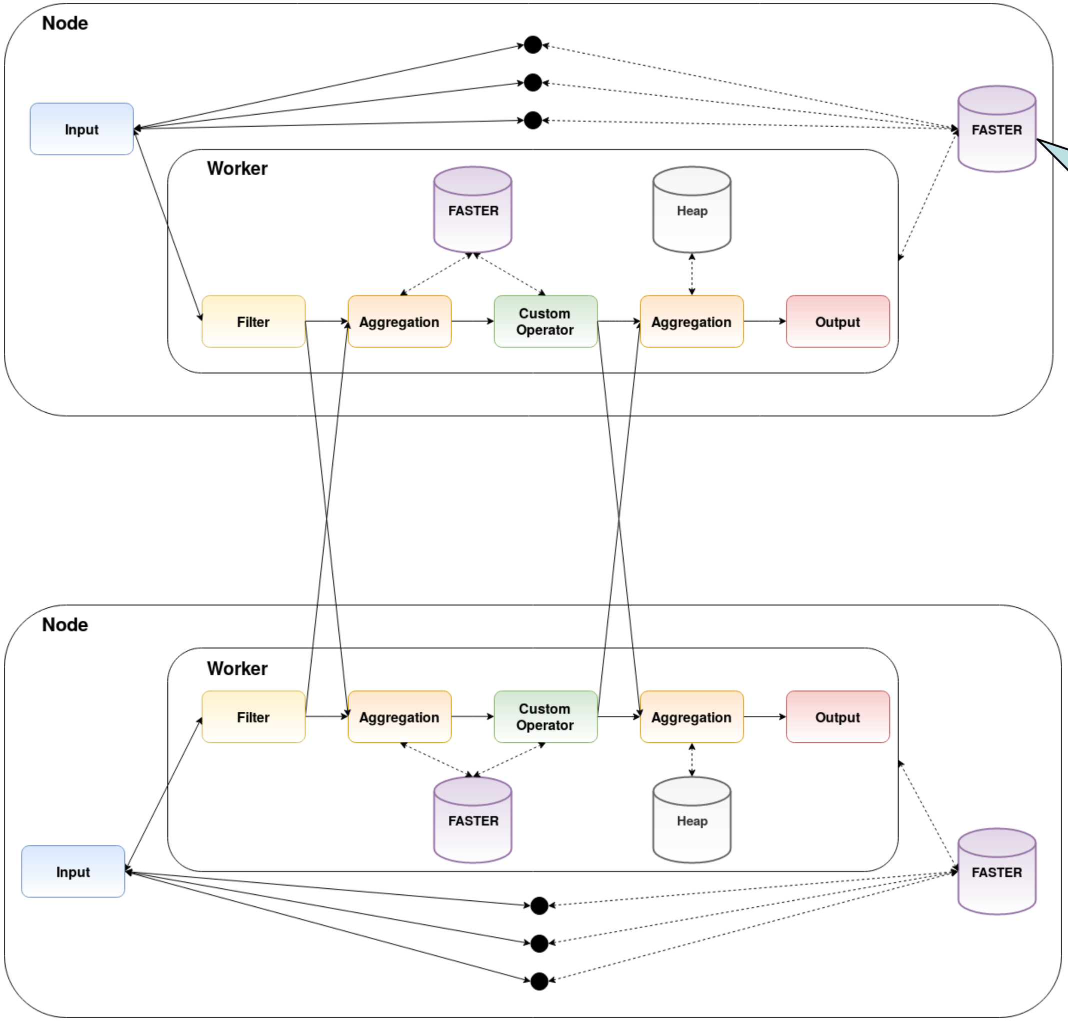
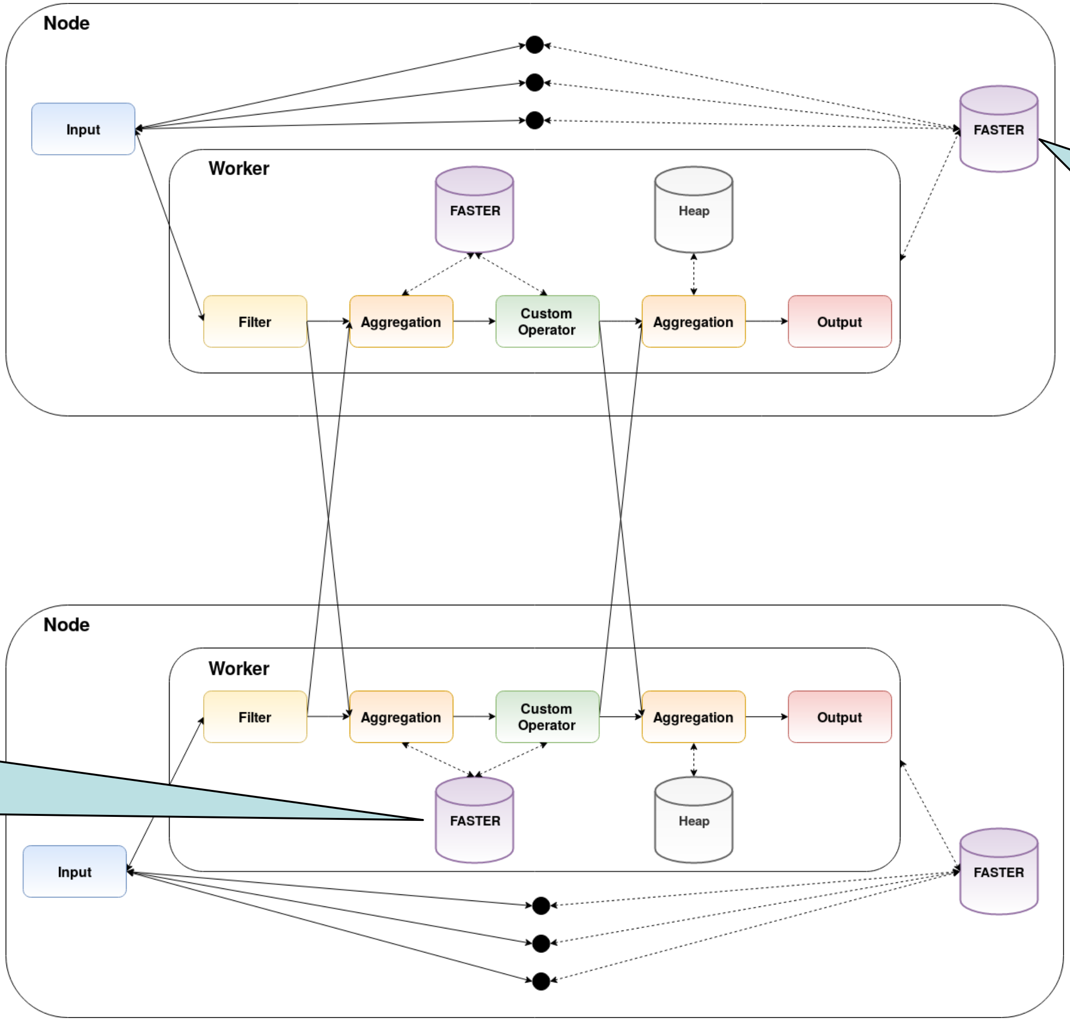


Node-level backend

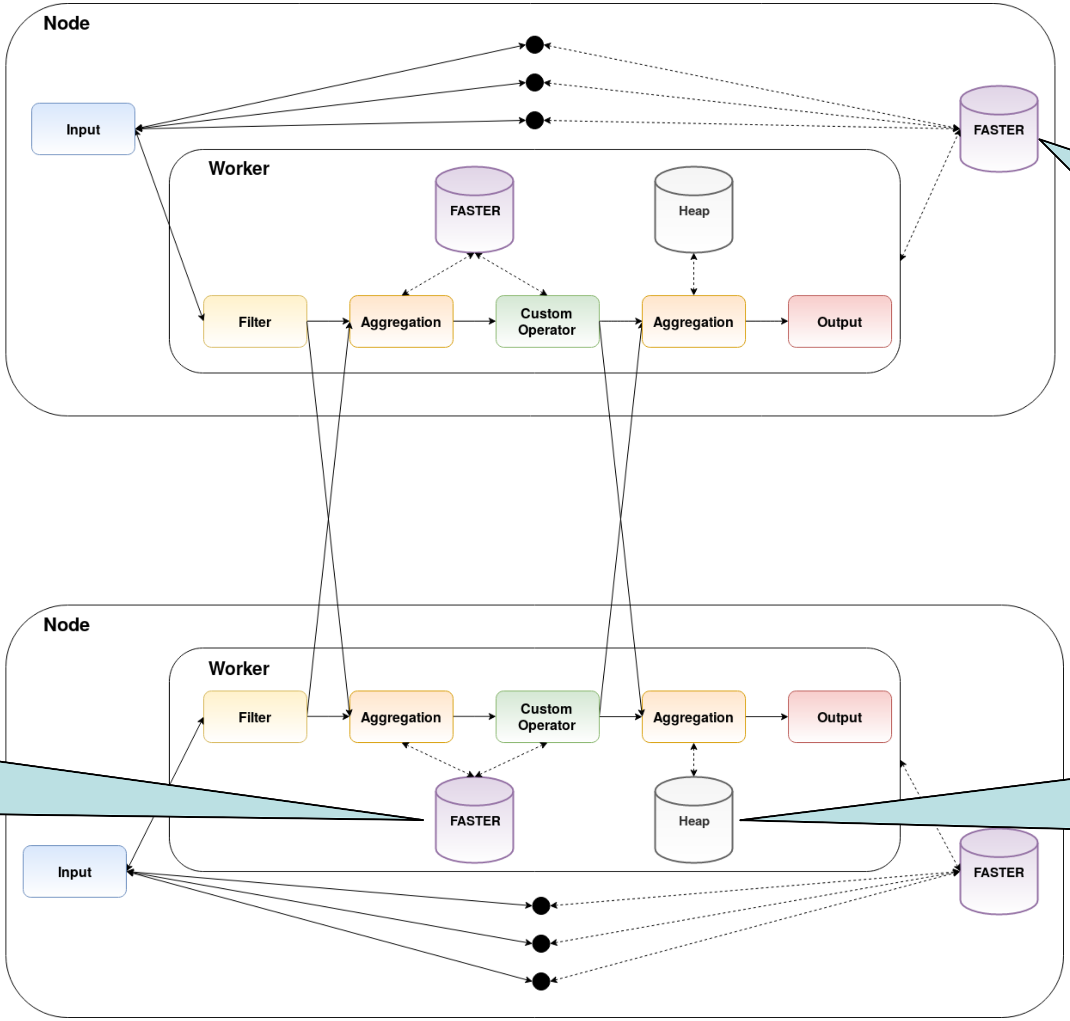
FASTER State Management for Timely Dataflow



Node-level backend

Worker-level backend

FASTER State Management for Timely Dataflow

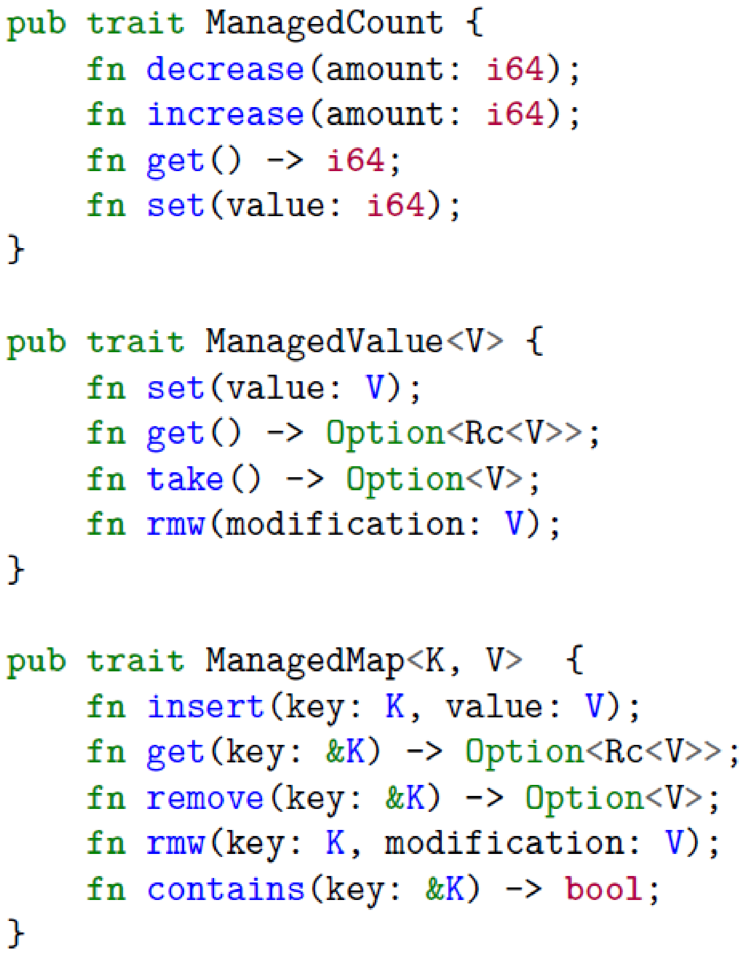


Node-level backend

Worker-level backend

Operator-level backend

Managed State Primitives



```
pub trait ManagedCount {
    fn decrease(amount: i64);
    fn increase(amount: i64);
    fn get() -> i64;
    fn set(value: i64);
}

pub trait ManagedValue<V> {
    fn set(value: V);
    fn get() -> Option<Rc<V>>;
    fn take() -> Option<V>;
    fn rmw(modification: V);
}

pub trait ManagedMap<K, V>  {
    fn insert(key: K, value: V);
    fn get(key: &K) -> Option<Rc<V>>;
    fn remove(key: &K) -> Option<V>;
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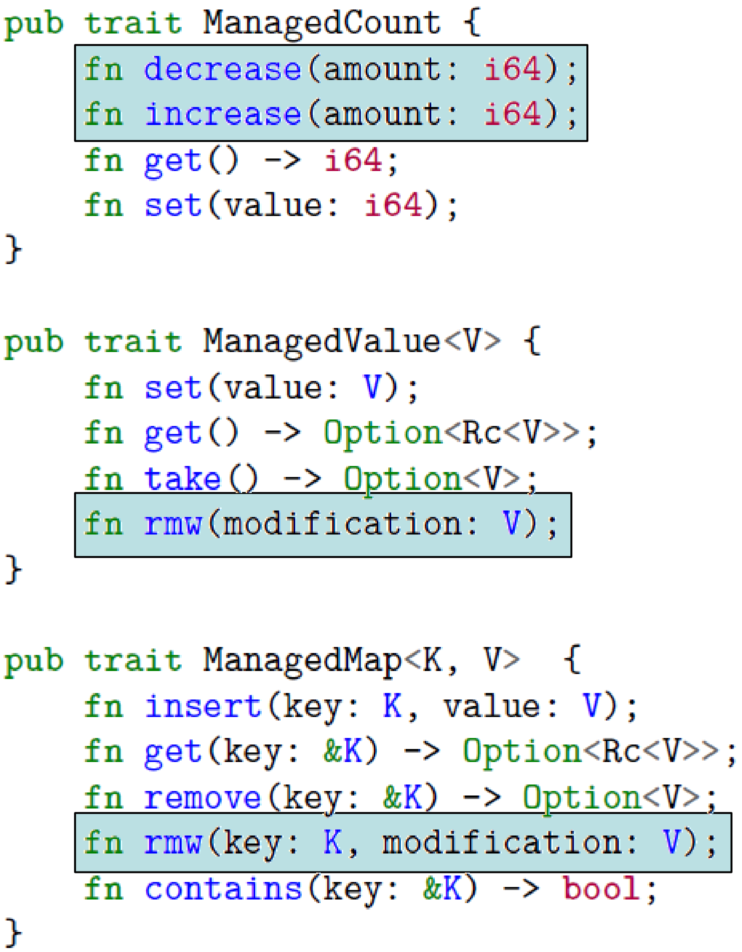
    fn contains(key: &K) -> bool;
}
```

Managed State Primitives



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Back to the demonstration

Evaluation

Evaluating FASTER State Management for Timely Dataflow

- Multiple machines with 4 physical cores and 16 GB RAM
- 200 GB non-volatile memory express (NVMe) SSD
- Machines communicate with up to 3500 Mbps bandwidth

NEXMark Query 3 recap

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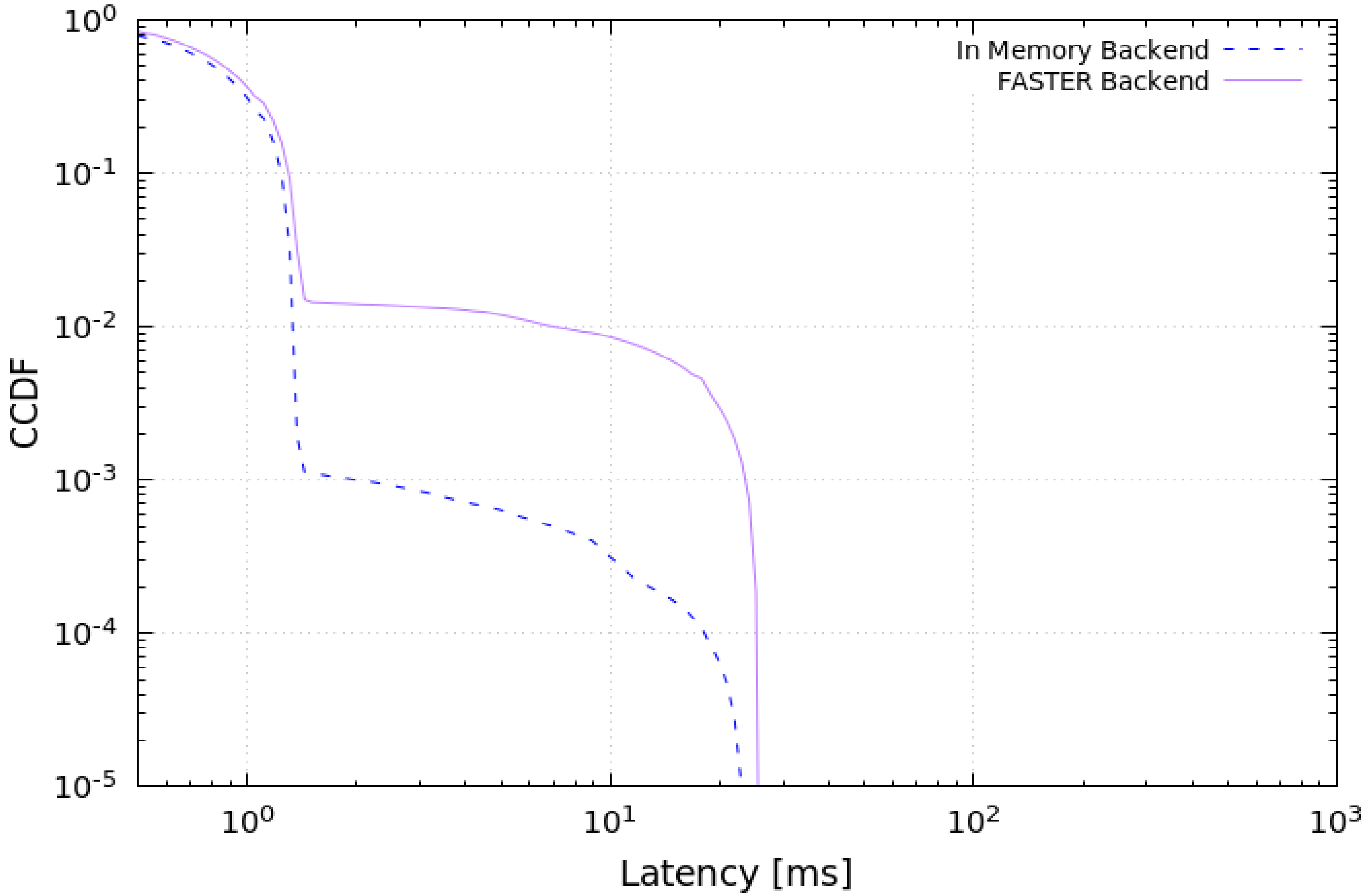
FASTER performance overhead versus native data structures



Query 3
(Incremental Join)

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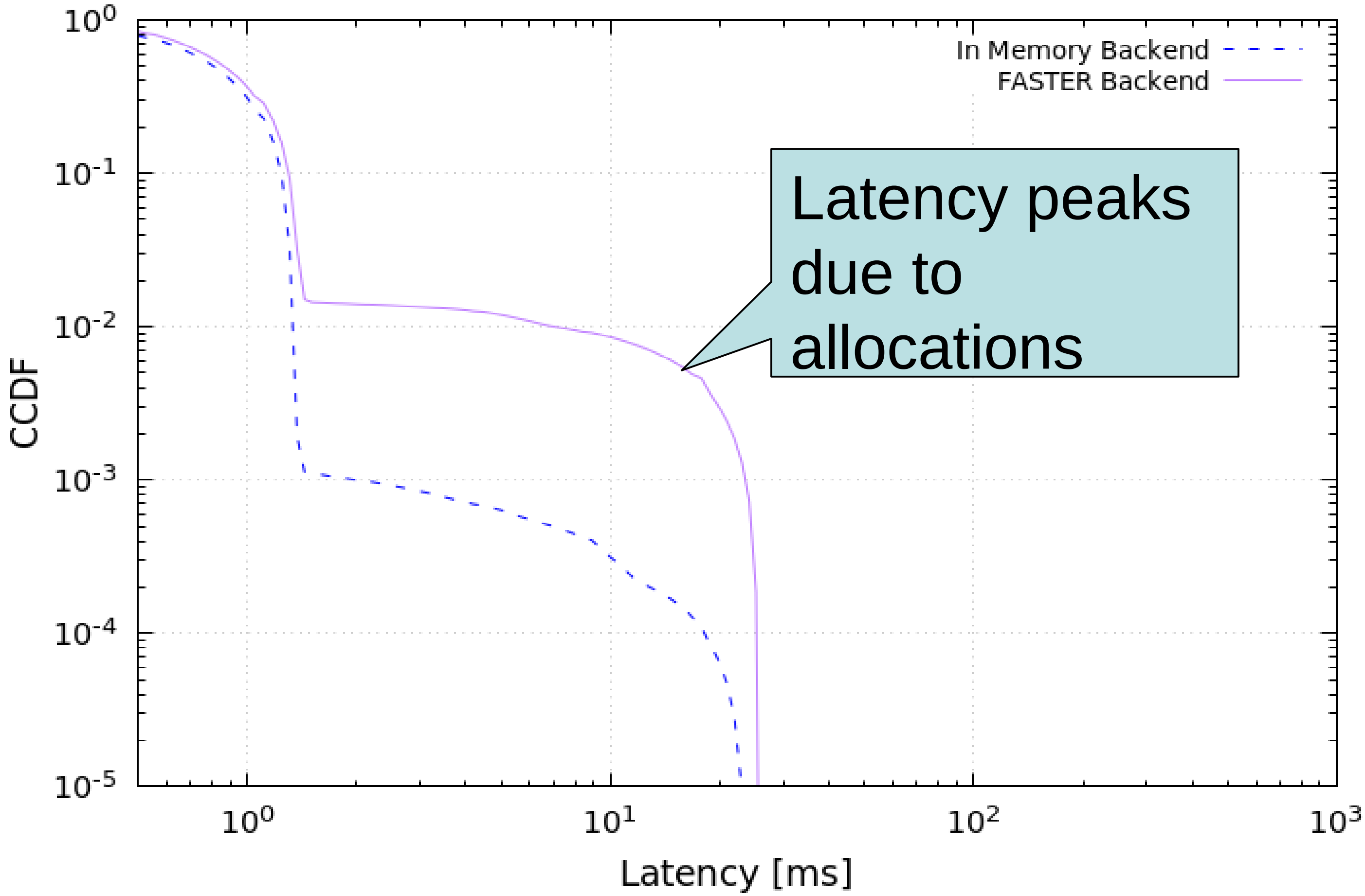

Latency peaks due to allocations

Query 3
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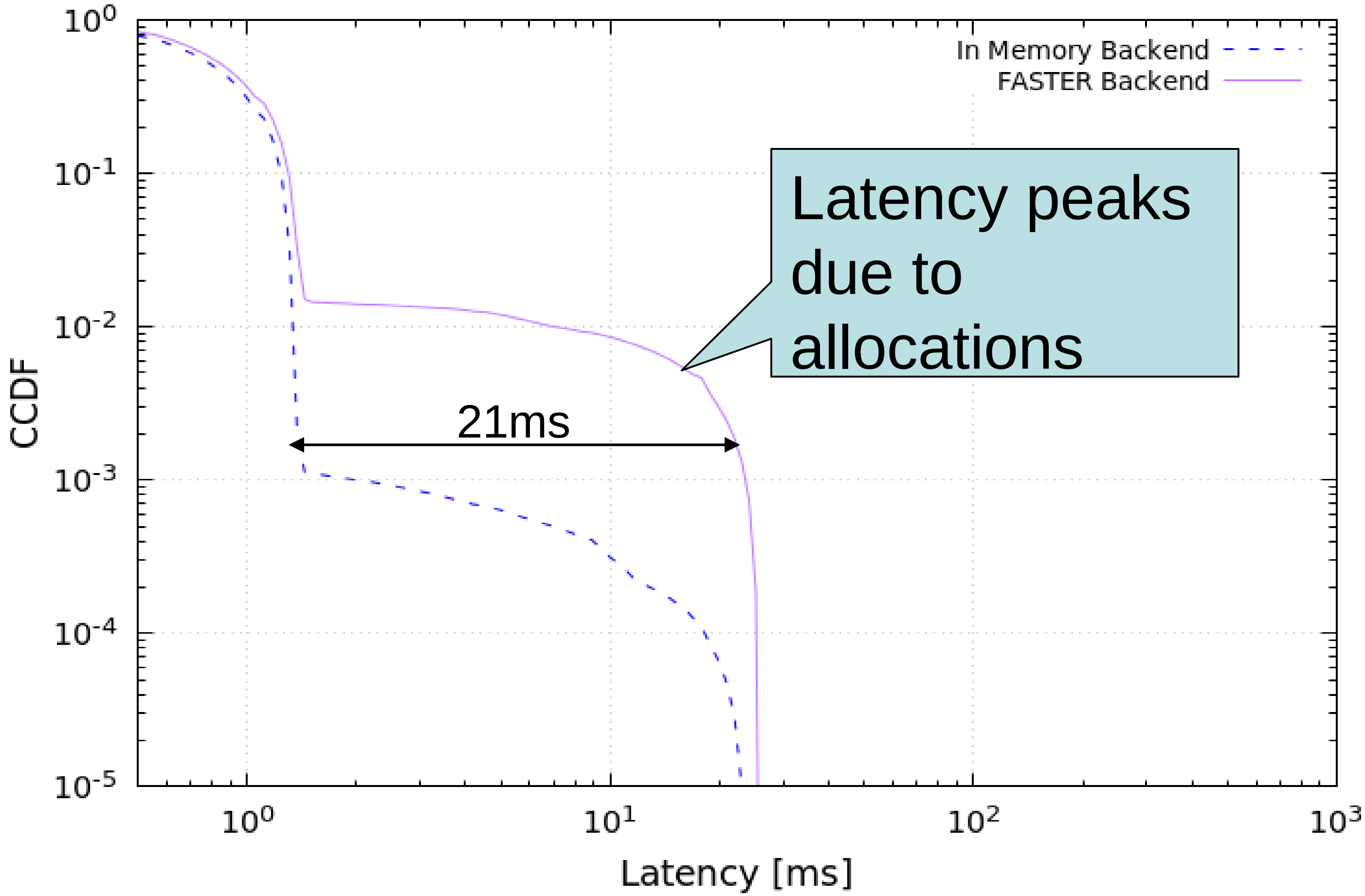


21ms

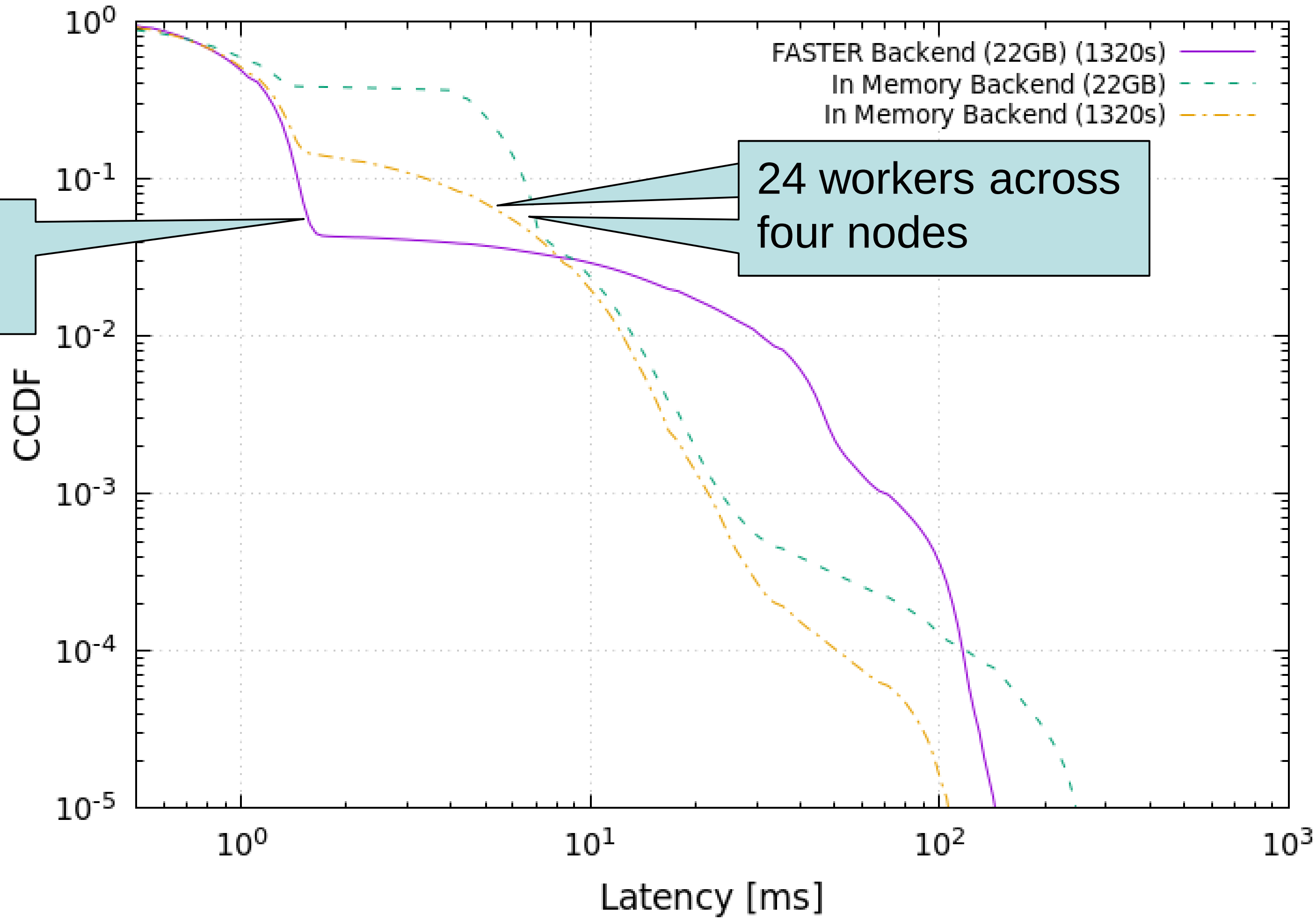
Latency peaks due to allocations

Query 3
(Incremental Join)

Evaluating the trade-off between scaling-out and using secondary storage

- Compare using FASTER on a single worker to scaling-out and using 24 workers across 4 nodes
- Run Query 3 for 1320s to accumulate 22 GB on FASTER
- Run in-memory for 1320s and 4983s to compare

Evaluating the trade-off between scaling-out and using secondary storage

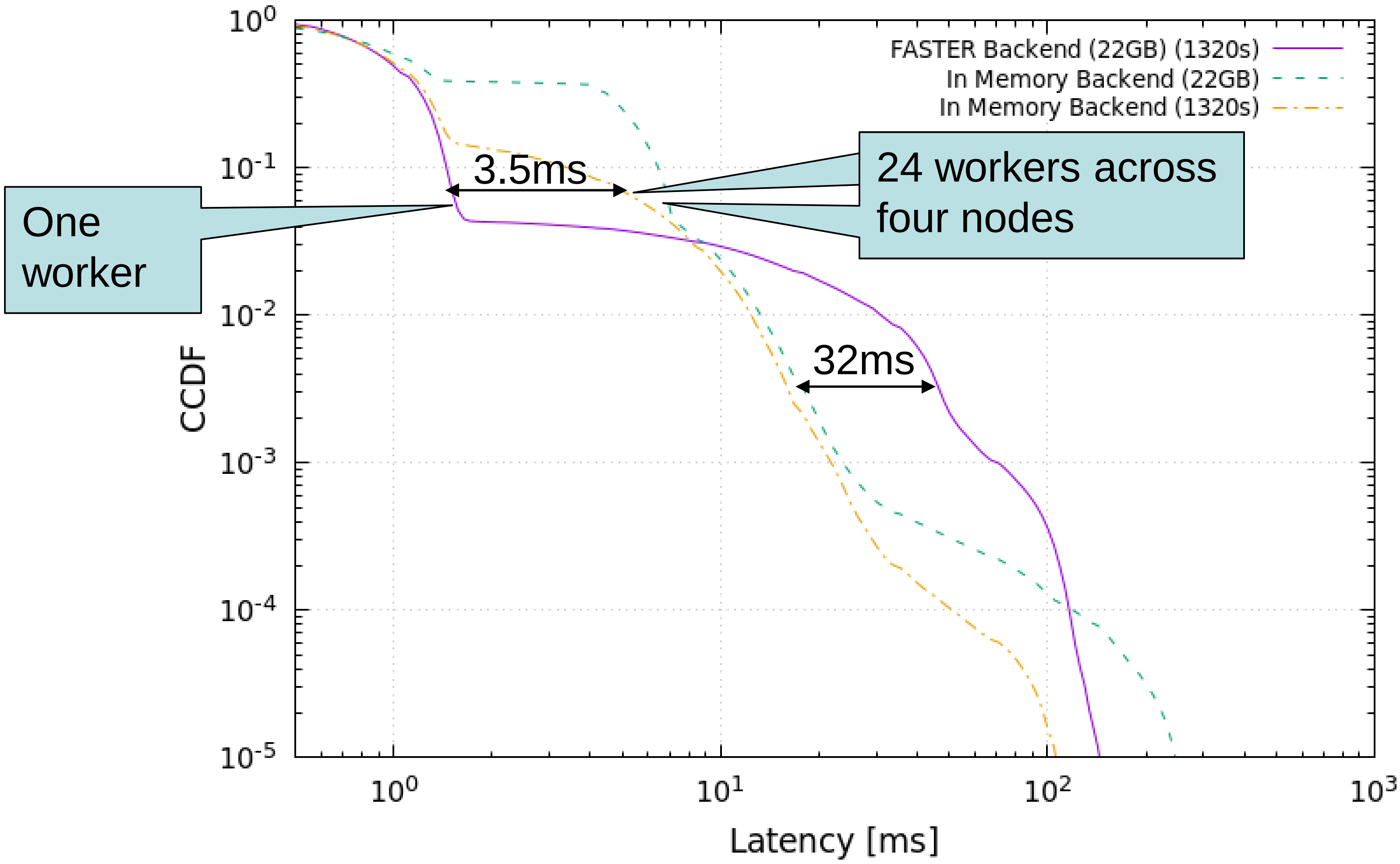


One worker

24 workers across four nodes

Evaluating the trade-off between scaling-out and using secondary storage

Systems@ETH zürich



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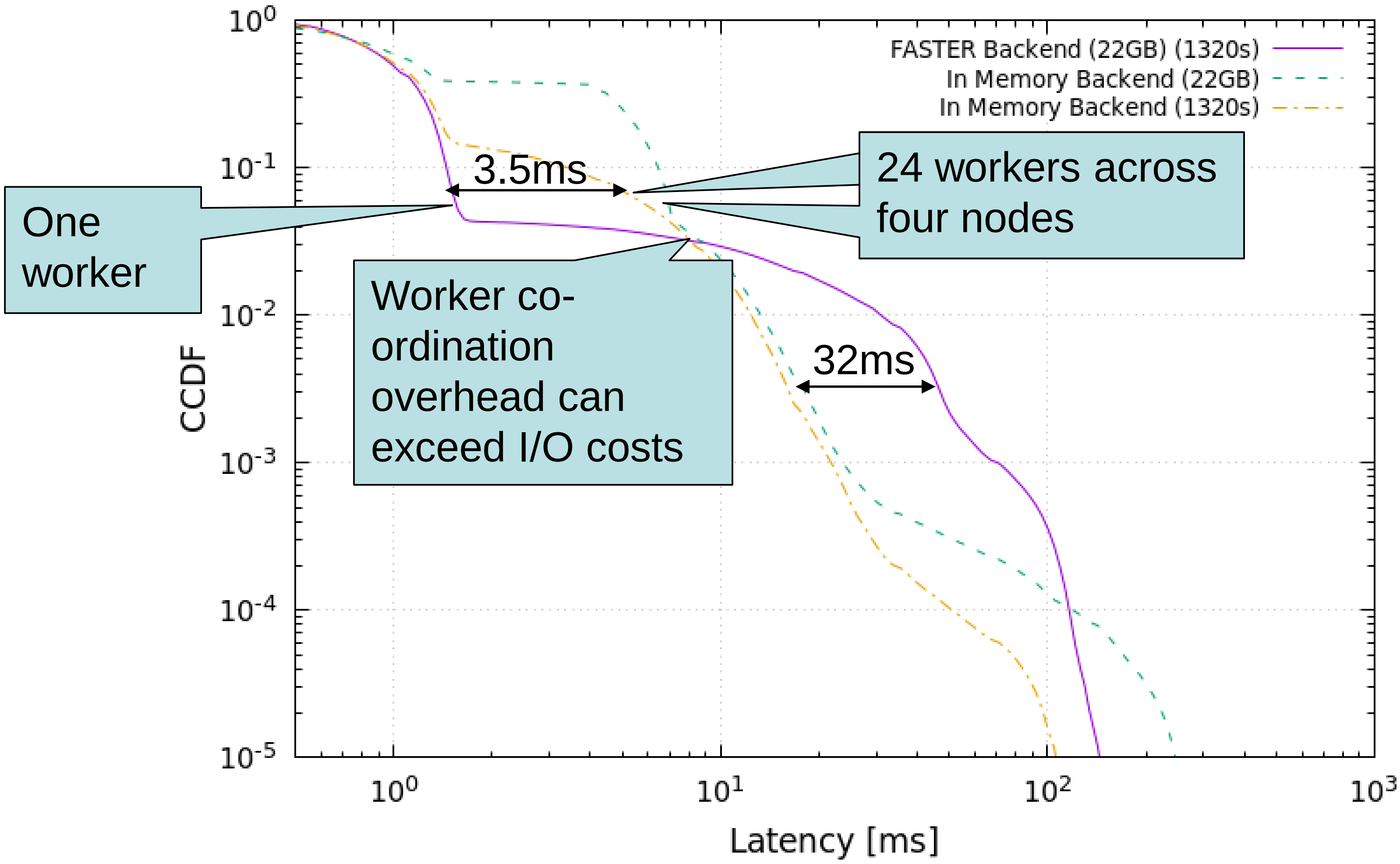

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Worker co-ordination overhead can exceed I/O costs

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- State management for larger-than-memory operator state is a relevant topic
- Using FASTER to store state across main memory and secondary storage incurs acceptable overhead
- In some cases it is preferable to rely on secondary storage for storing larger-than-memory state rather than scaling out to more nodes

Additional resources

- https://github.com/faster-rs/faster-rs
- https://github.com/faster-rs/FASTER
- https://github.com/matthewbrookes/timely-dataflow/tree/state_crate
- https://github.com/matthewbrookes/nexmark_timely_faster
- Matthew Brookes. 2019. *FASTER State Management for Strymon*. Master’s thesis. ETH Zürich.