High Availability For Key-Value Stores Using Checkpoint/Restore

Fadhil Abubaker, Hussain Sadiq Abuwala

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  - Performance.
- Rely on an external layer to provide replication?

External Replication Layer

Push replication outside of the database system, delegating it to an external layer.

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- ...Checkpoint/Restore?

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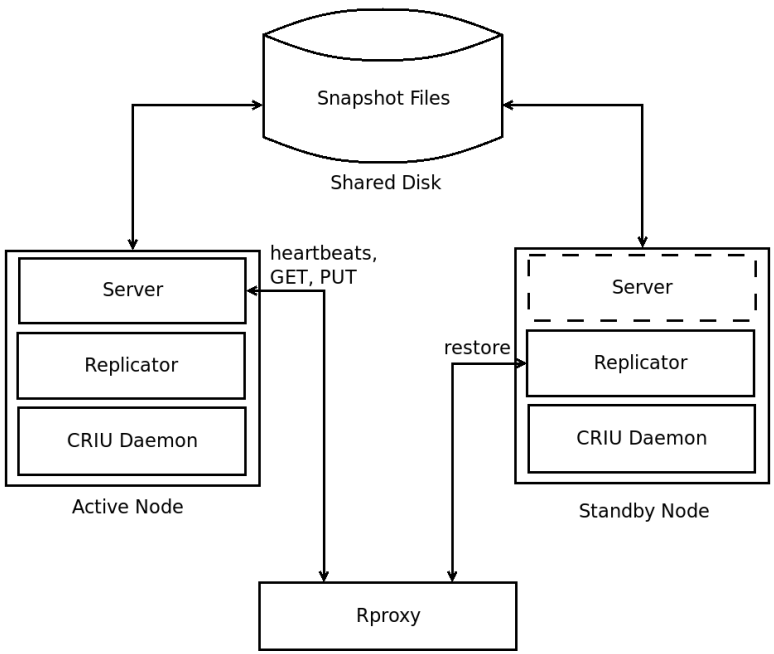
- The application can be then restored back to the point it was frozen using the checkpoint files.
- Integrated with container runtimes such as OpenVZ, LXC/LXD, Docker, Podman, etc.
- Commonly used for container live-migration.

System Architecture

Normal Operation



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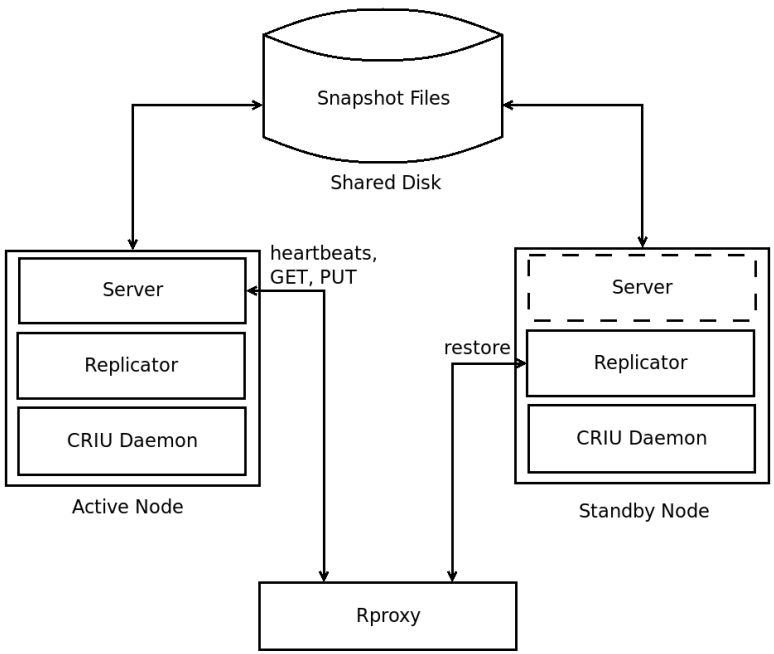

- clients send requests to the **rproxy**.

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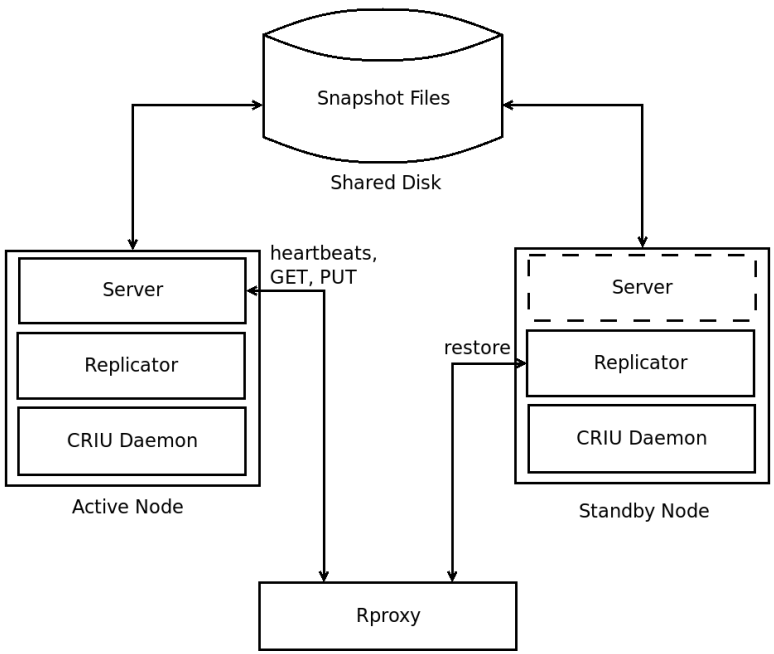

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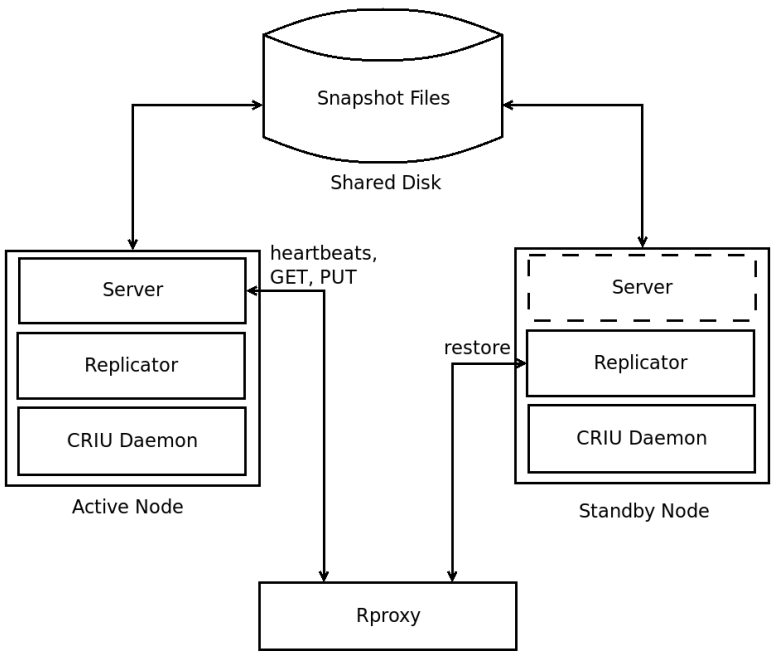

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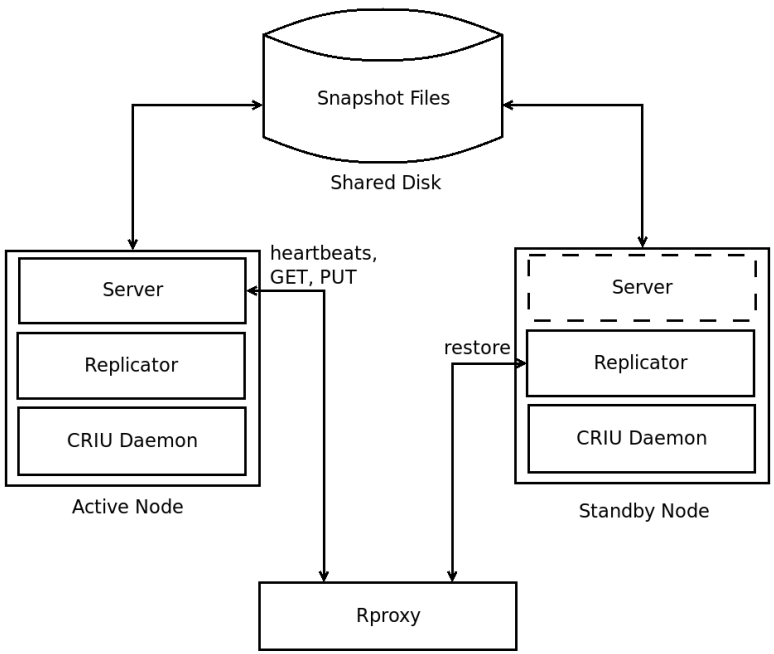

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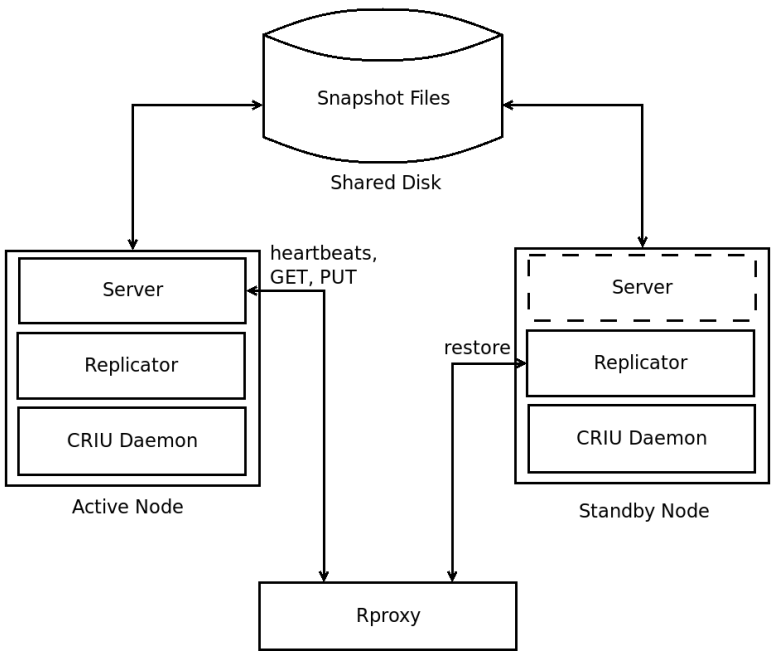
- request is forwarded to the active **server**.
- **server** calls `checkpoint` endpoint on the **replicator** after *n* updates.
- **replicator** interfaces with the **C/R daemon** and saves a snapshot to the shared-disk.

System Architecture

Failover Process



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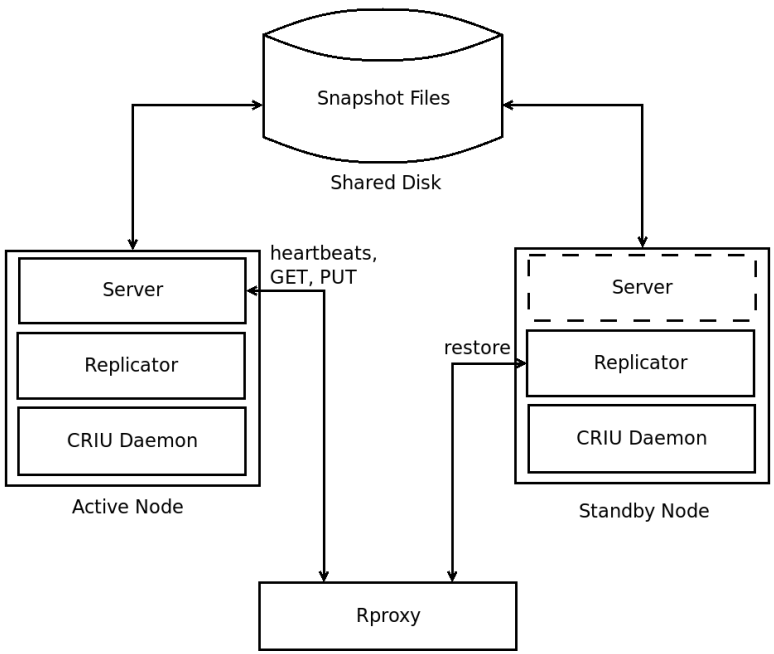

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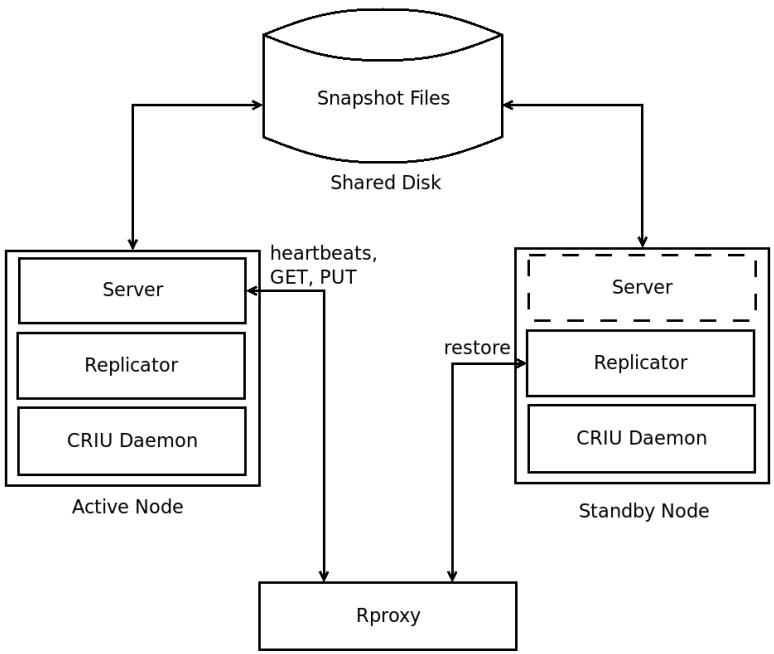

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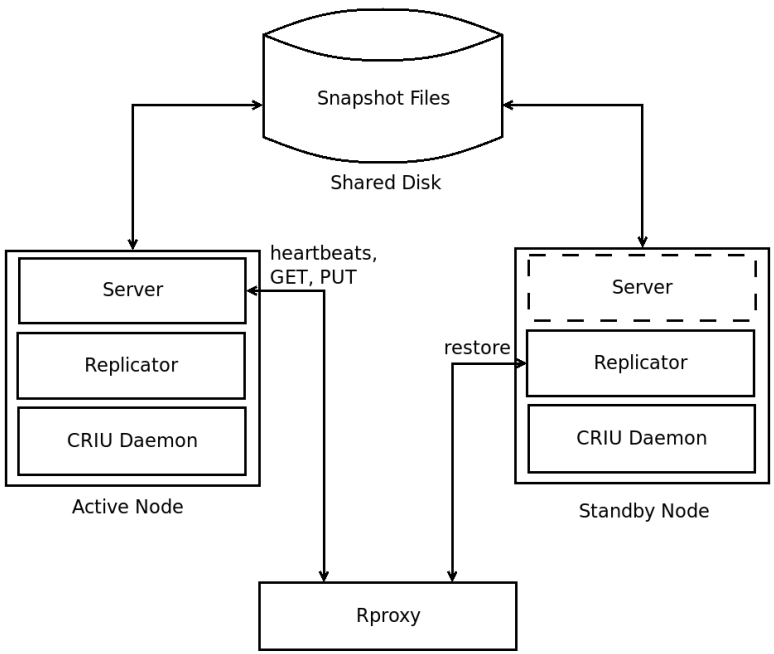

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- On timeout, calls the `restore` endpoint on standby **replicator**.
- **replicator** restores the **server** from the latest snapshot on the shared-disk.
- Normal operations resume, with requests forwarded to the standby.

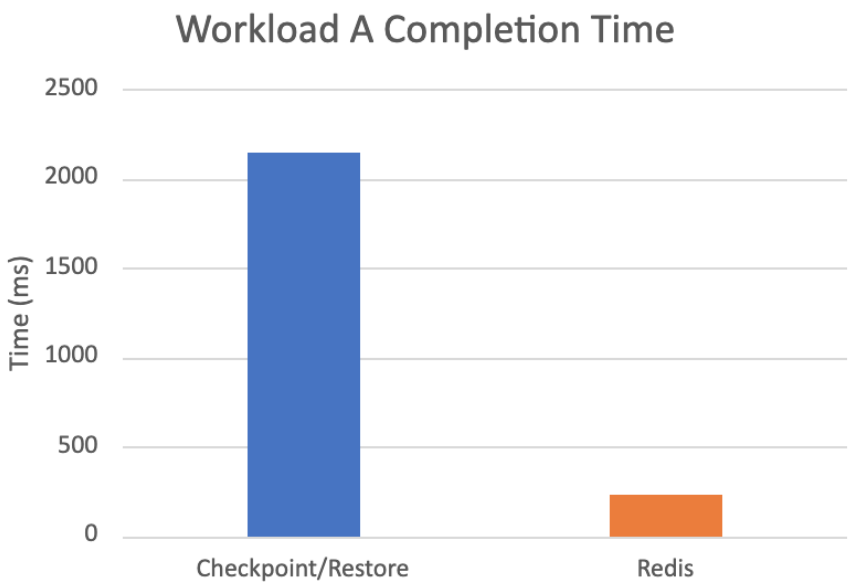
Evaluation

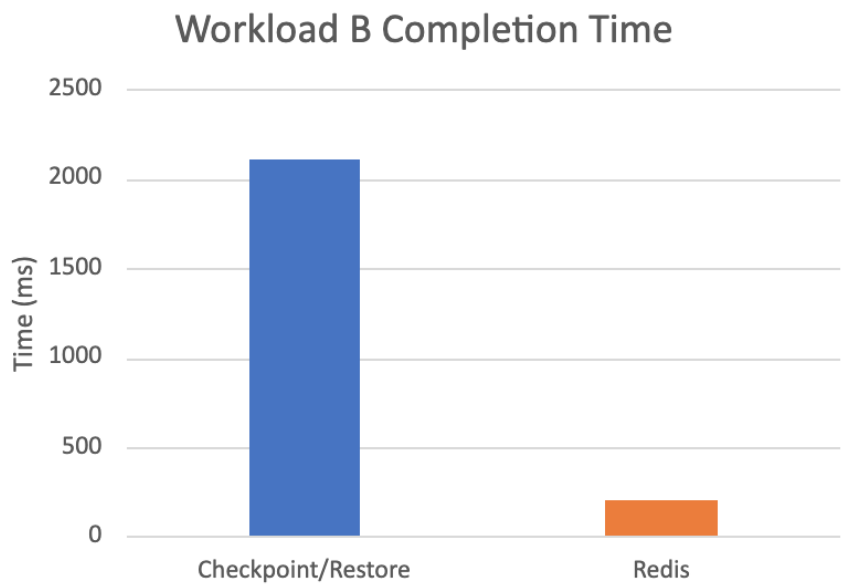
Methodology

- Yahoo! Cloud Serving Benchmark.
- Implemented a custom YCSB interface to support our key-value store.
- Each workload consists of 1000 operations.
- Workload A: 50/50 read/write mix.
- Workload B: 95/5 read/write mix.
- Snapshots were captured after every 250 updates.

Evaluation

Storage Performance vs Redis (No Replication)

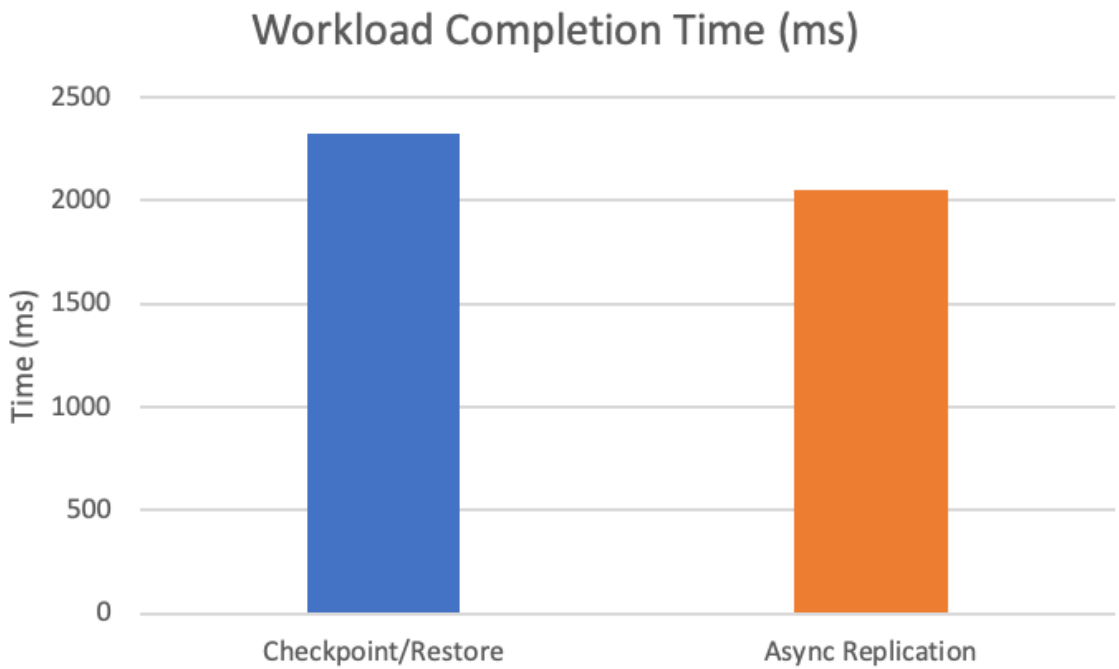




Storage performance likely suffers due to HTTP and JSON overhead.

Evaluation

Replication Performance vs Asynchronous Replication



Requests are blocked while snapshots happen, leading to slightly higher completion times.

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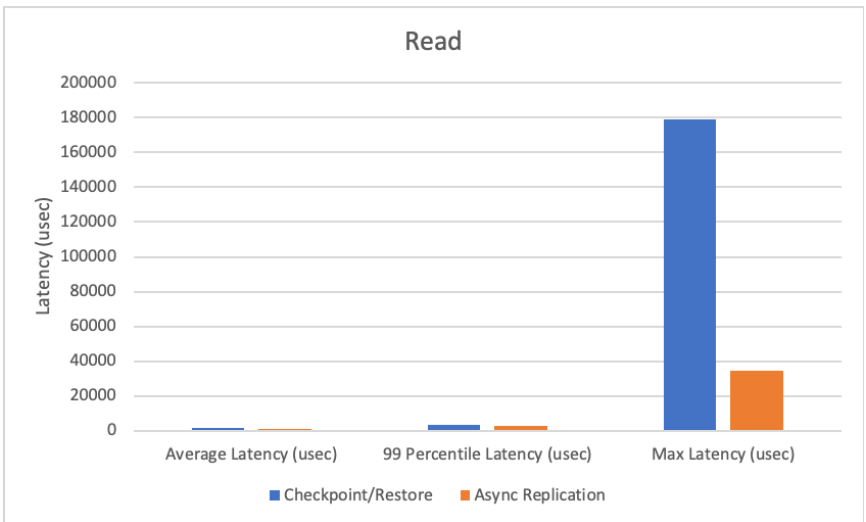

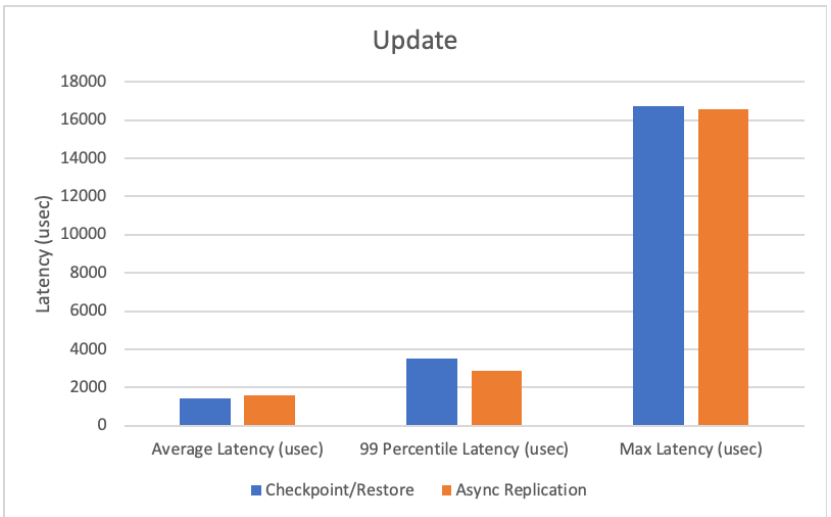

Discrepancy exists for max latency on reads due to snapshots blocking unlucky read requests.

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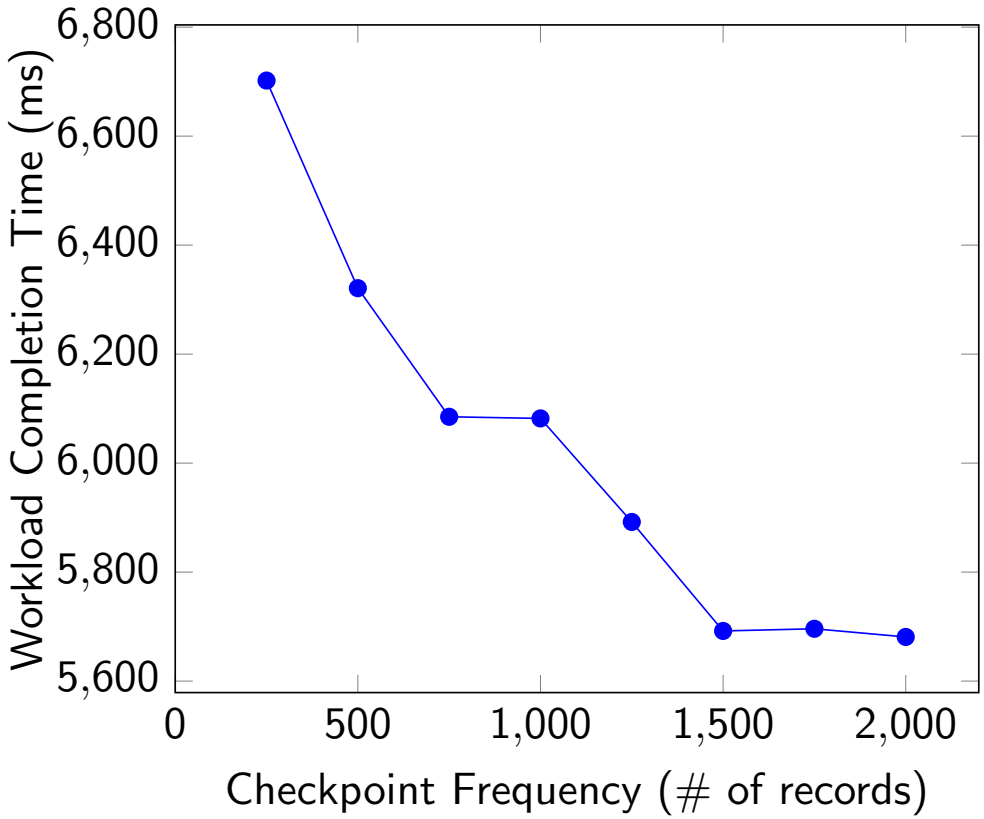
Impact of Checkpoint Frequency on Workload Completion



Custom workload with 5000 insert operations with varying checkpoint intervals.

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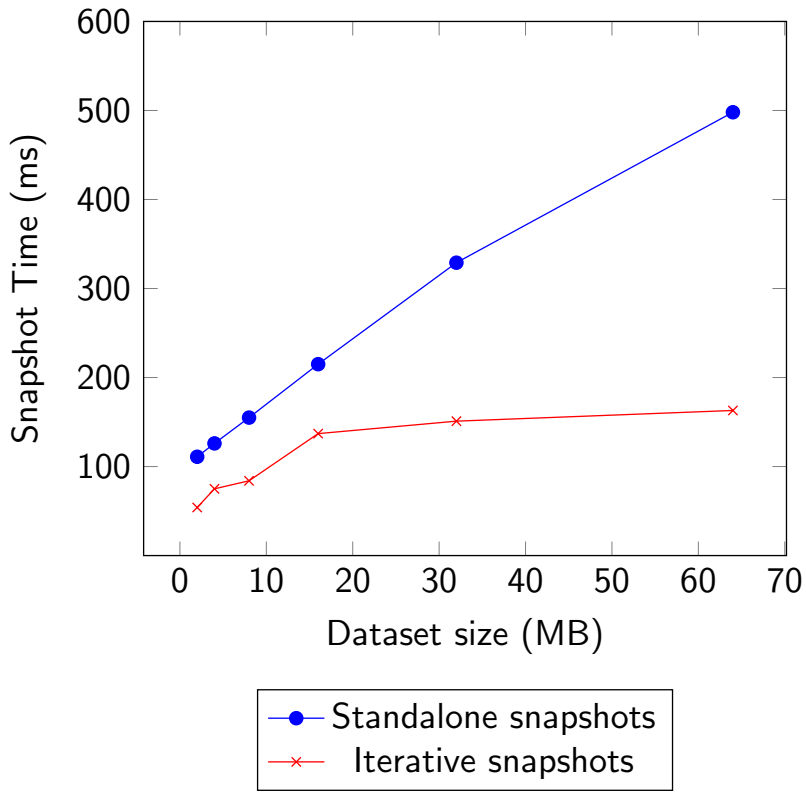
Standalone vs Iterative Snapshots



Iterative snapshots track changes in memory pages across consecutive checkpoints, making it more efficient.

Demo

Questions?