LazyLog: A New Shared Log Abstraction for Low-Latency Applications

Xuhao Luo, Shreesha G. Bhat*, Jiyu Hu*,
Ram Alagappan, Aishwarya Ganesan
University of Illinois Urbana-Champaign

*equal contribution

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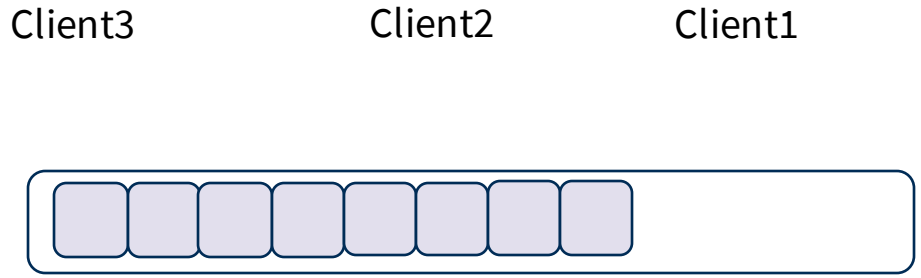

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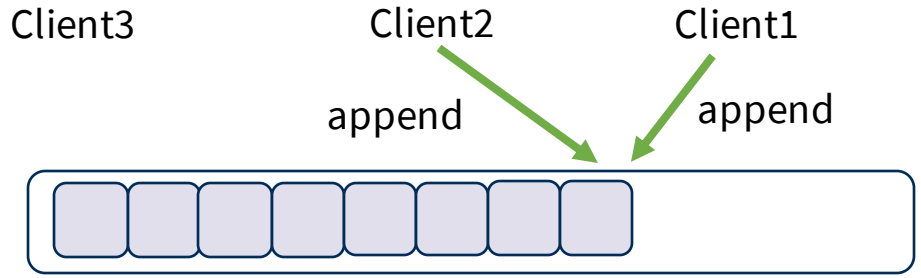

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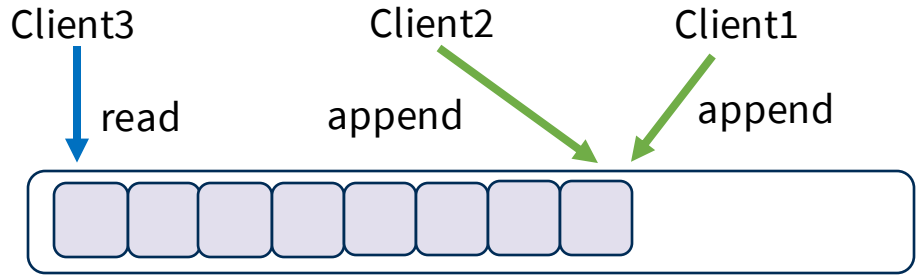

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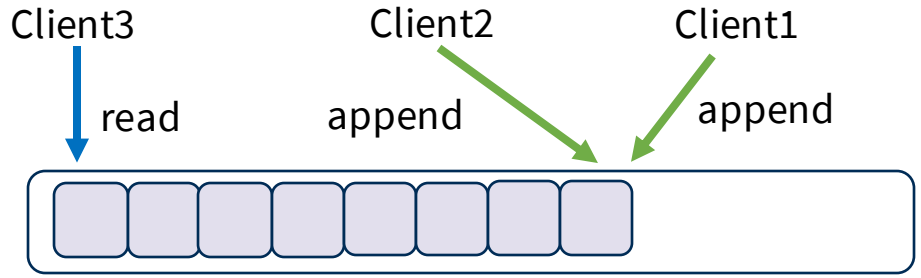

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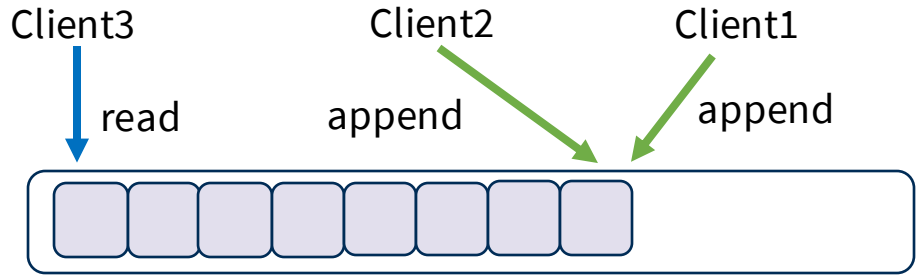

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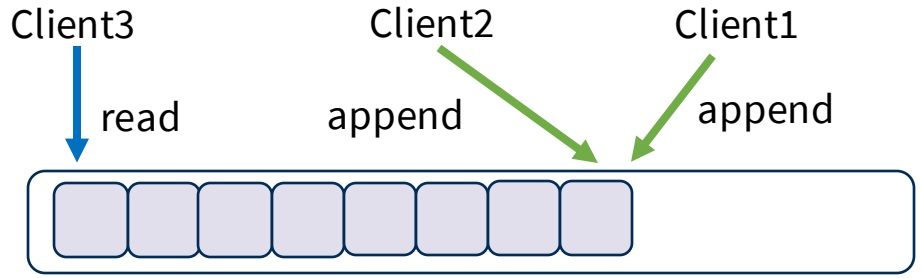

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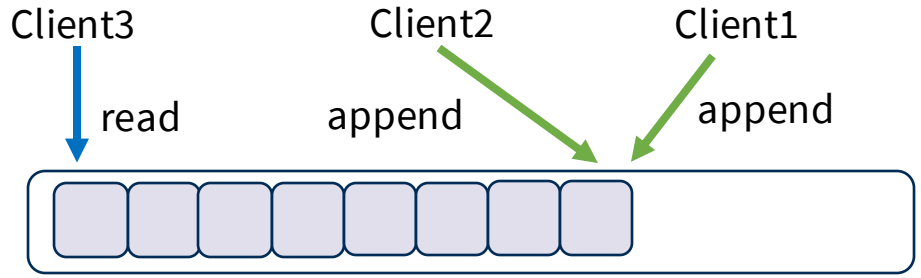

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  - Position of record is decided by the time append completes

Can a shared log avoid eager ordering, yet also preserve the ordering guarantees of conventional shared logs?

LazyLog: Idea and Abstraction

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LazyLog: A new shared log abstraction built upon these ideas

Results Overview

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- Benefits end apps like KV store, audit-logging, checkpointing with LazyLog's low latency

Outline

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LazyLog Insight and Interface

LazyLog System Design

Performance Evaluation

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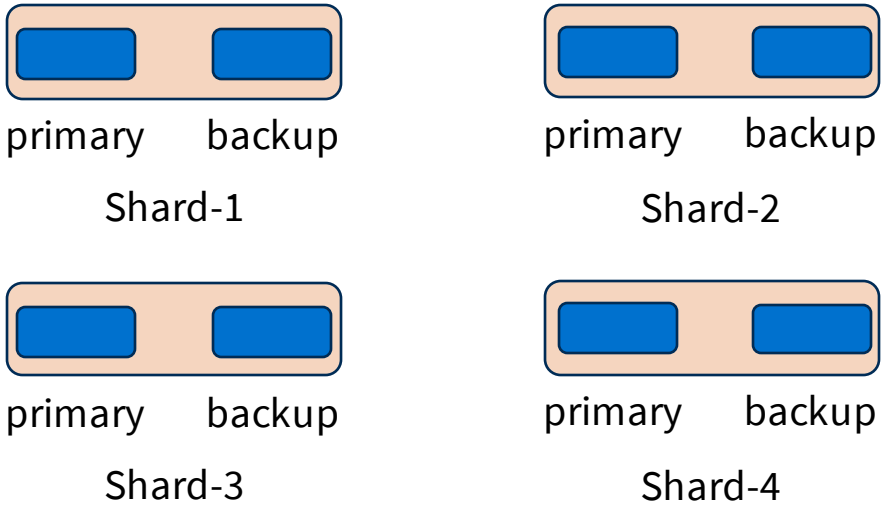

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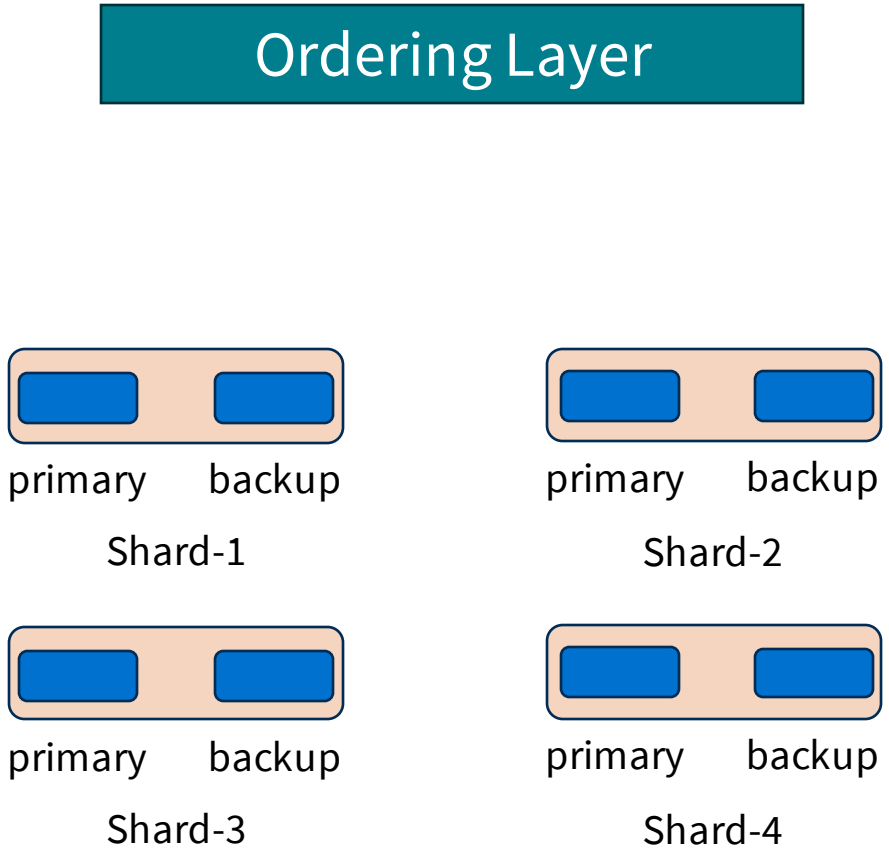

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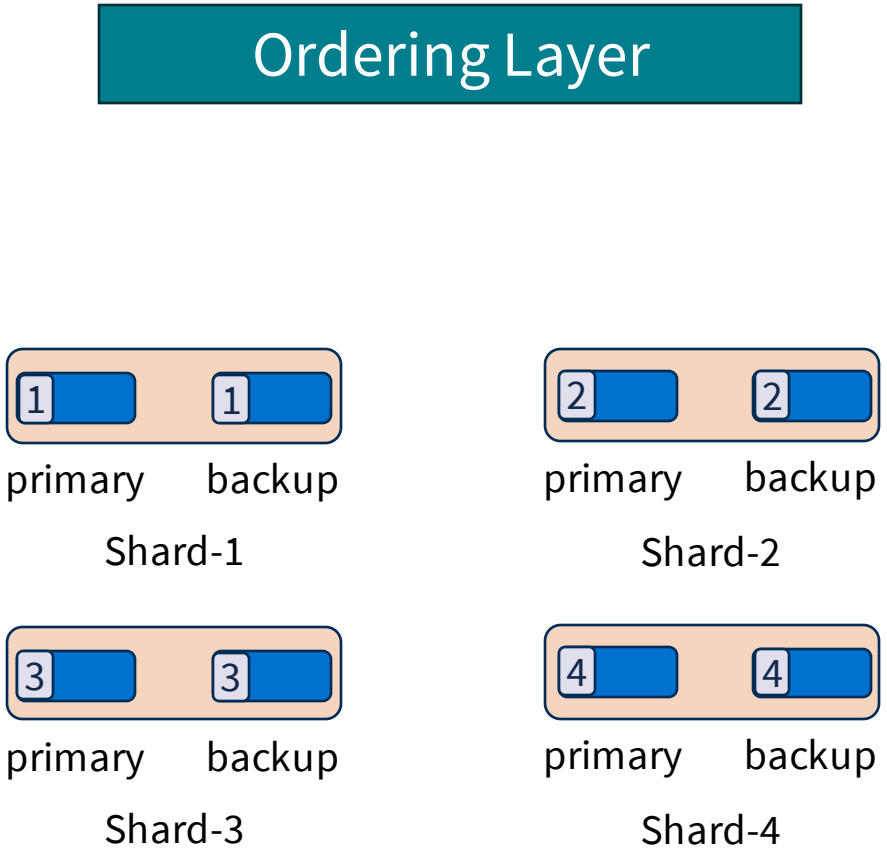
Shared log provides total order across shards



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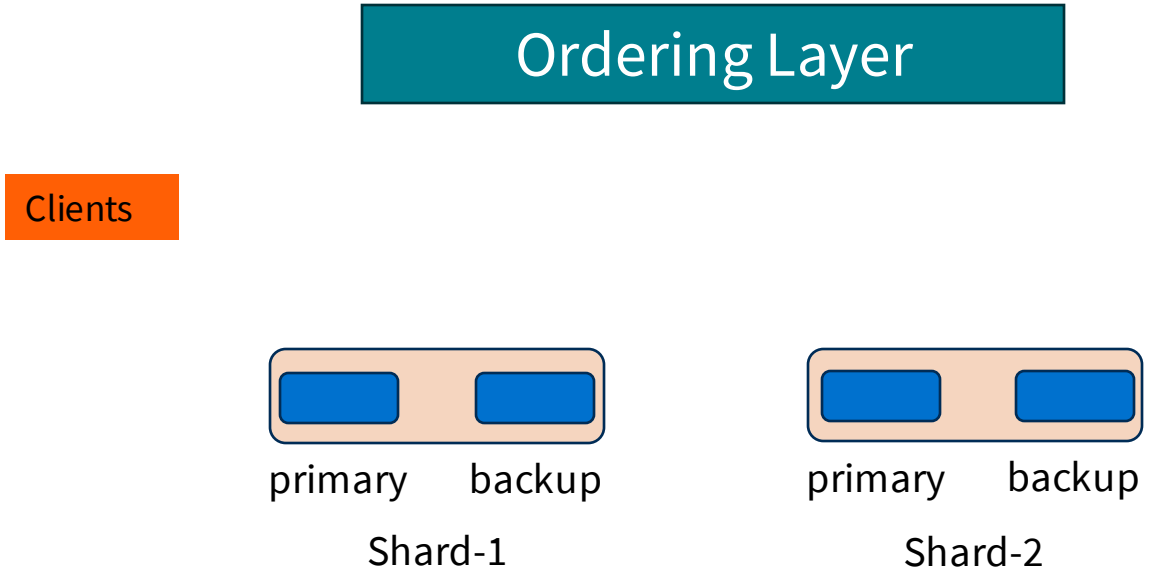

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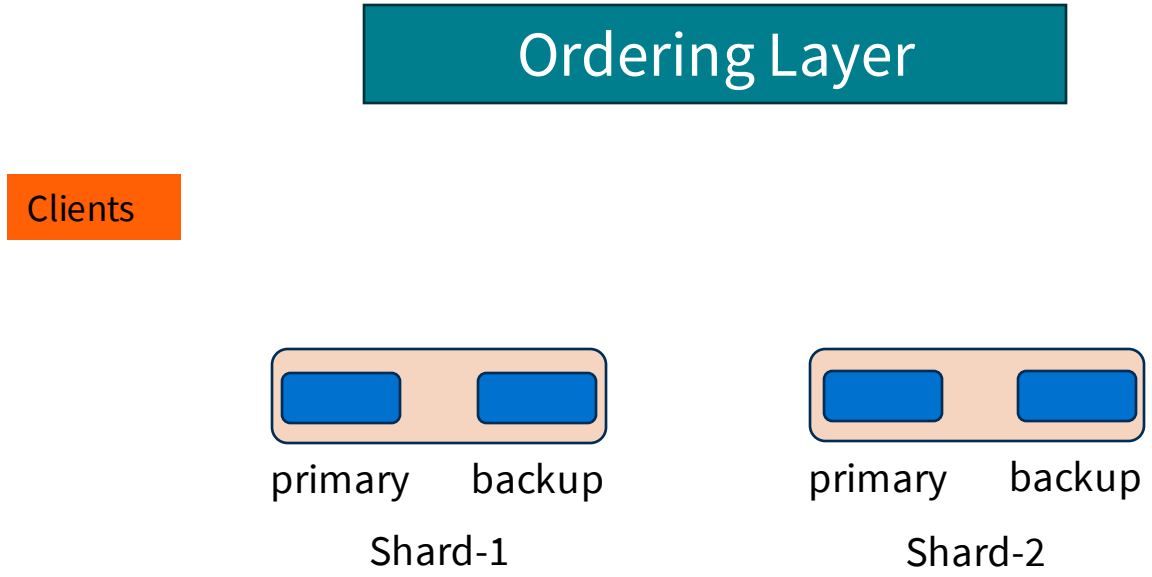

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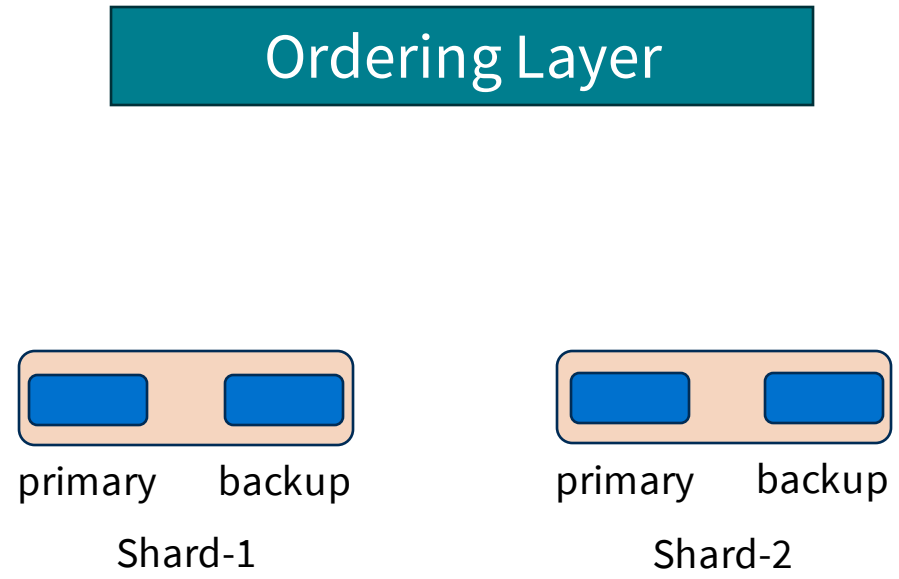

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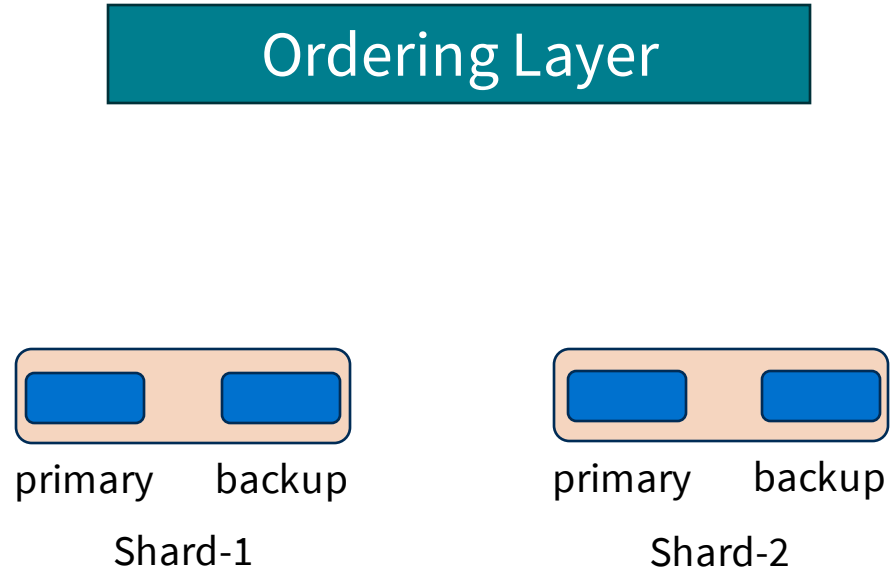

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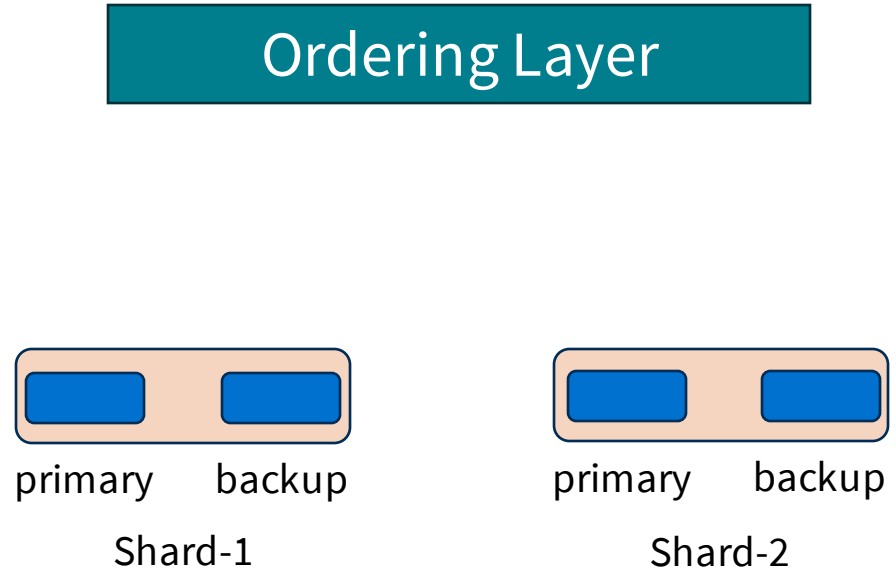

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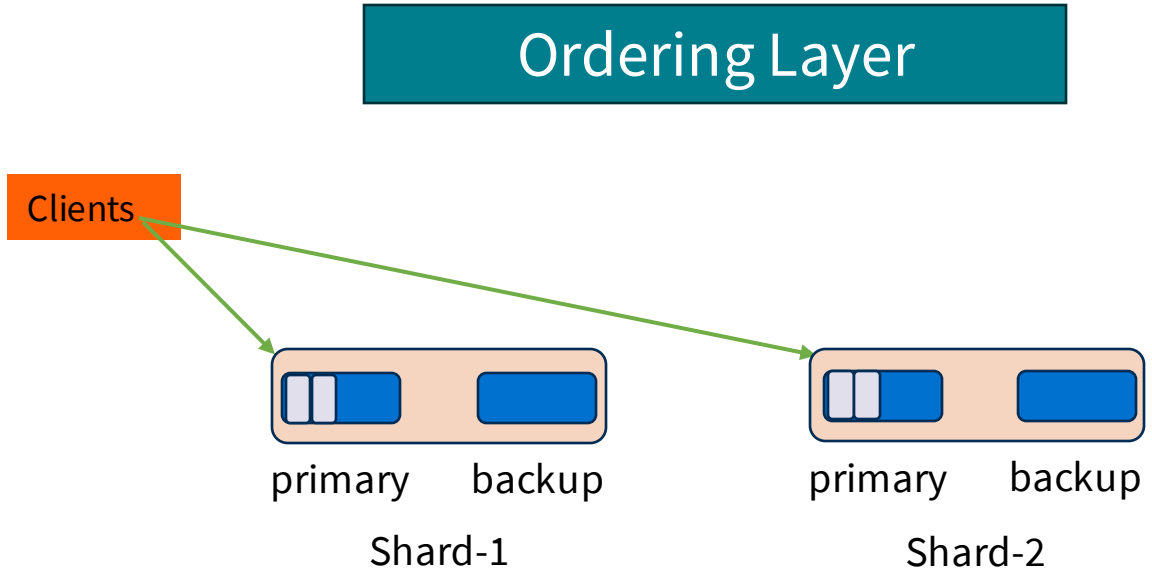

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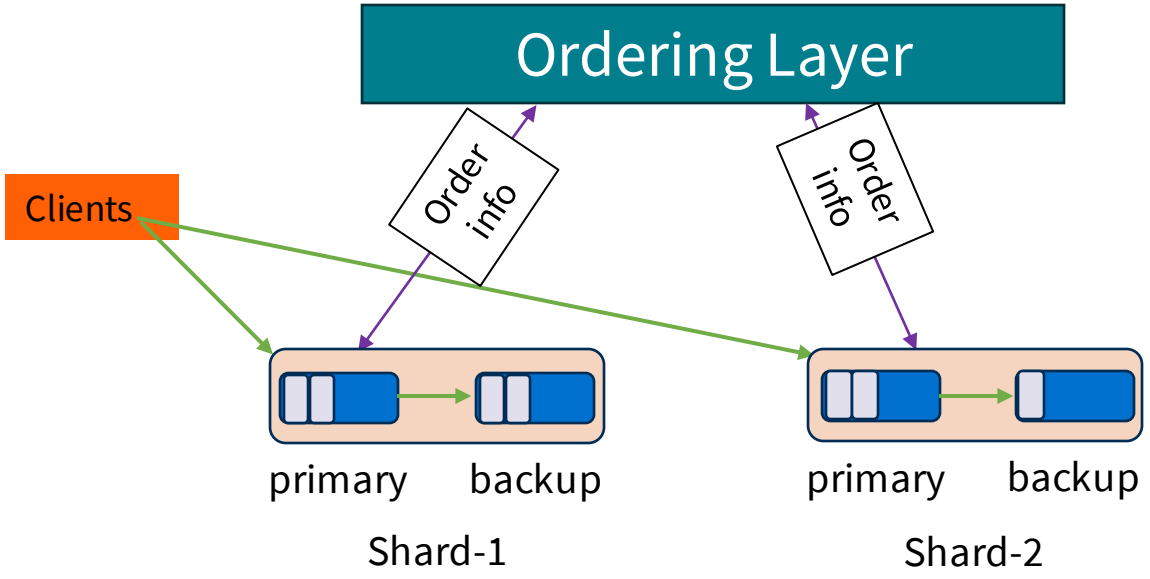

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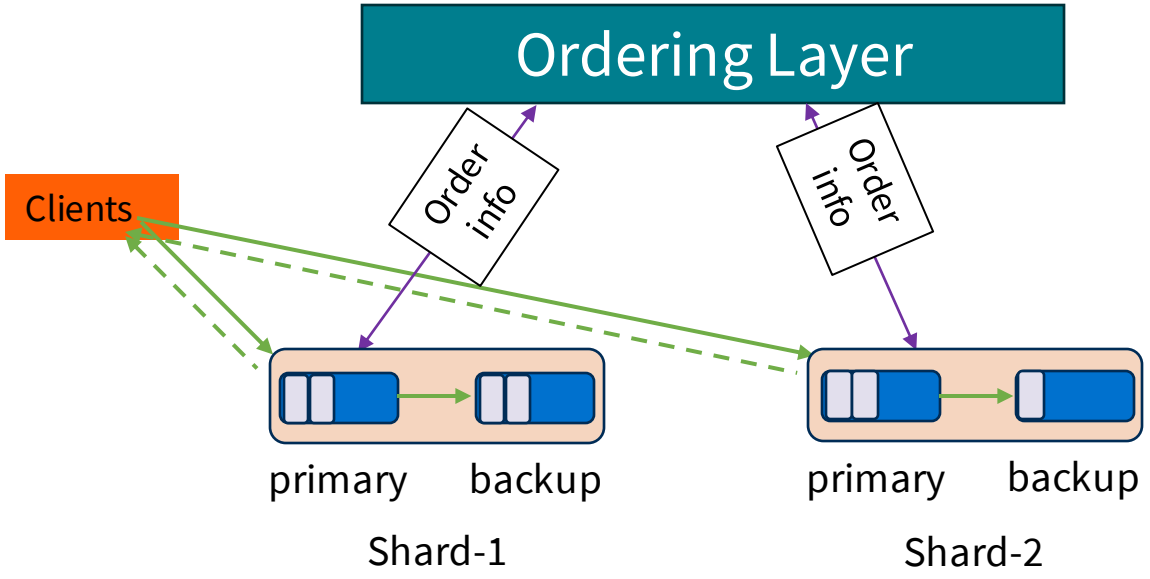

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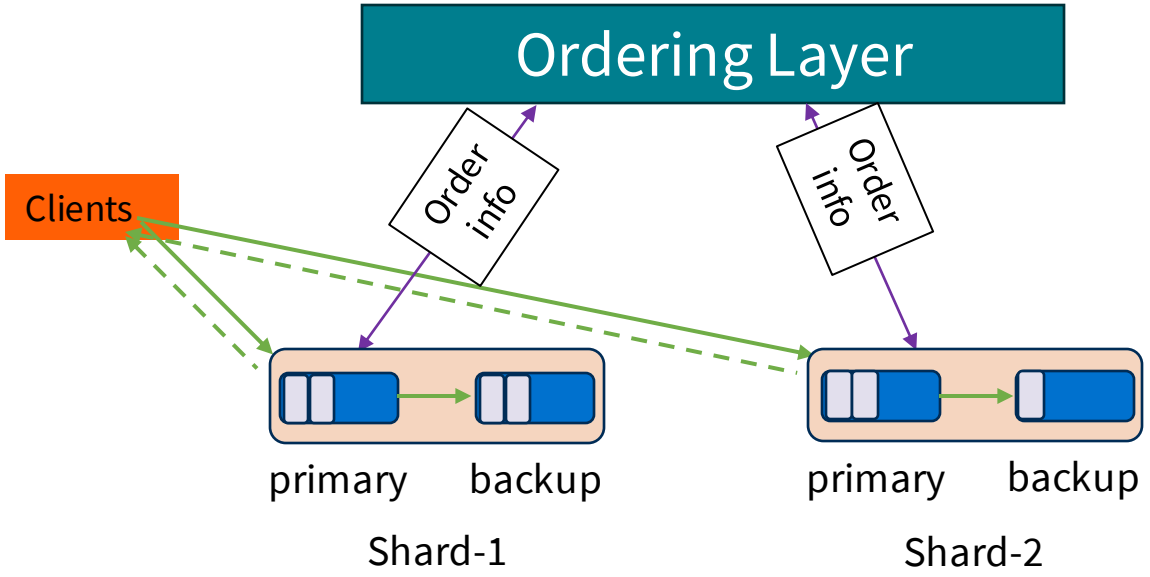

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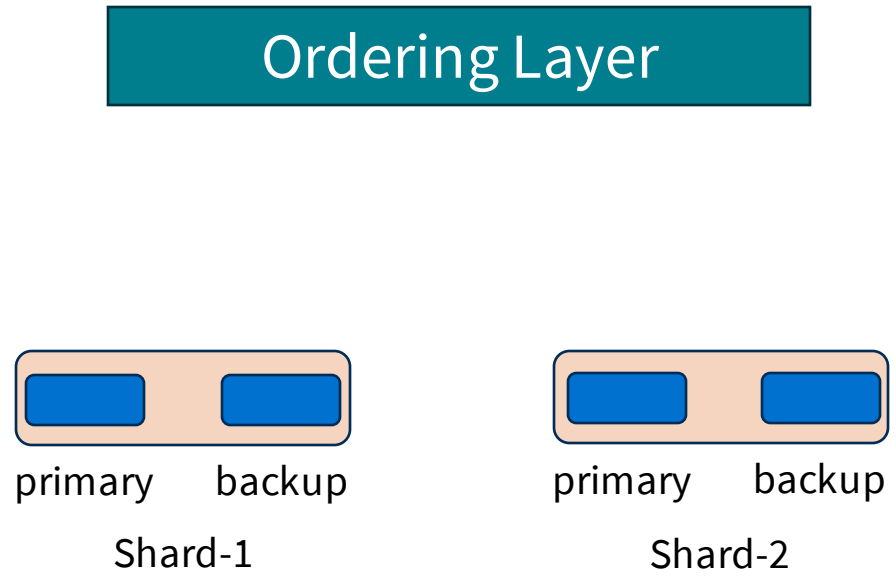

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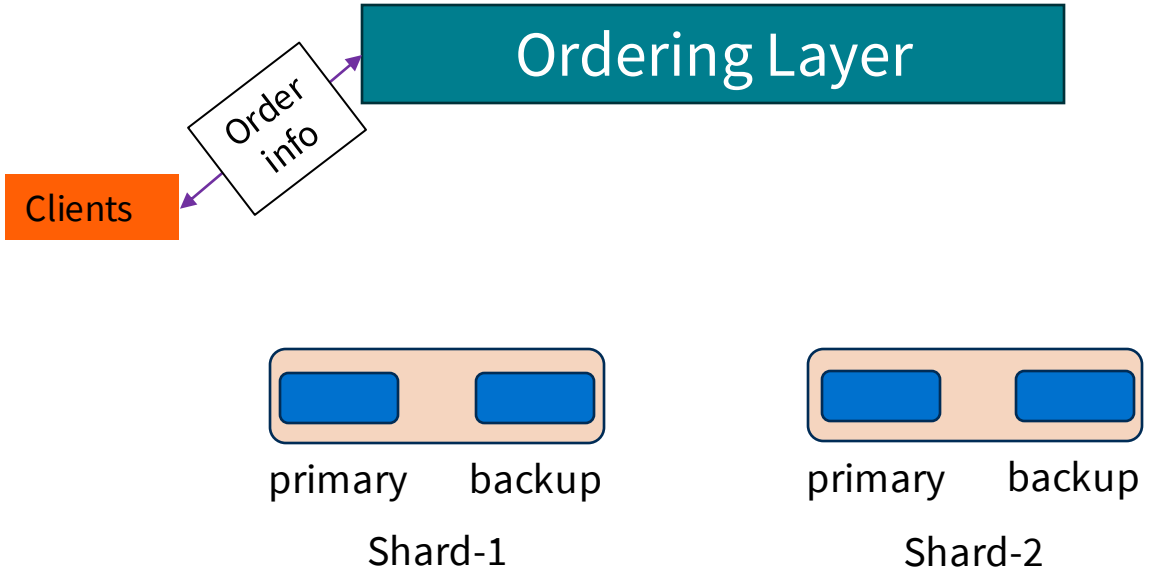

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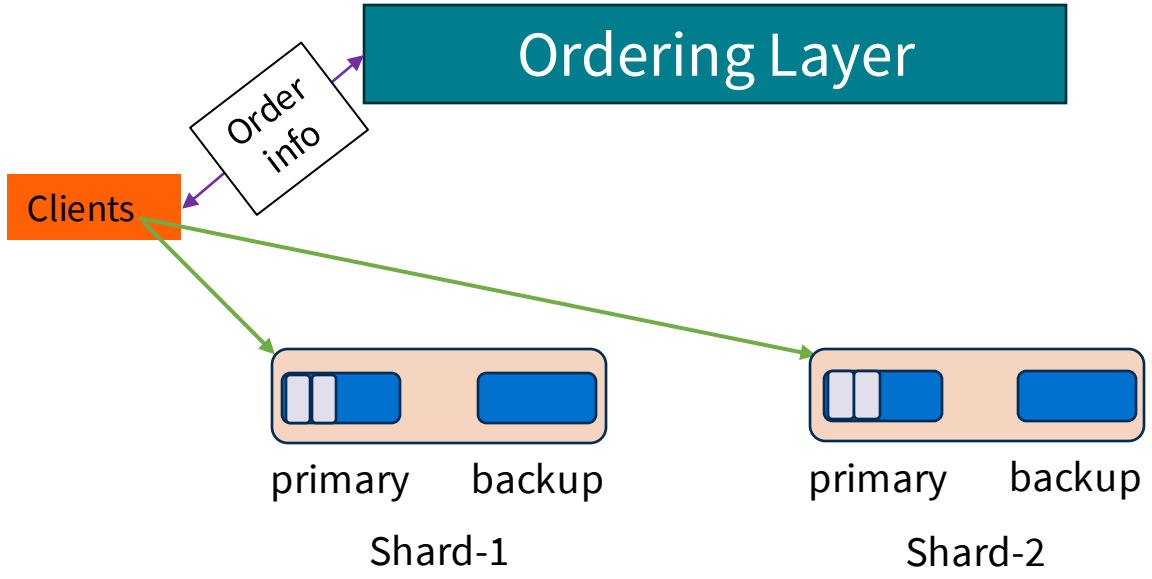

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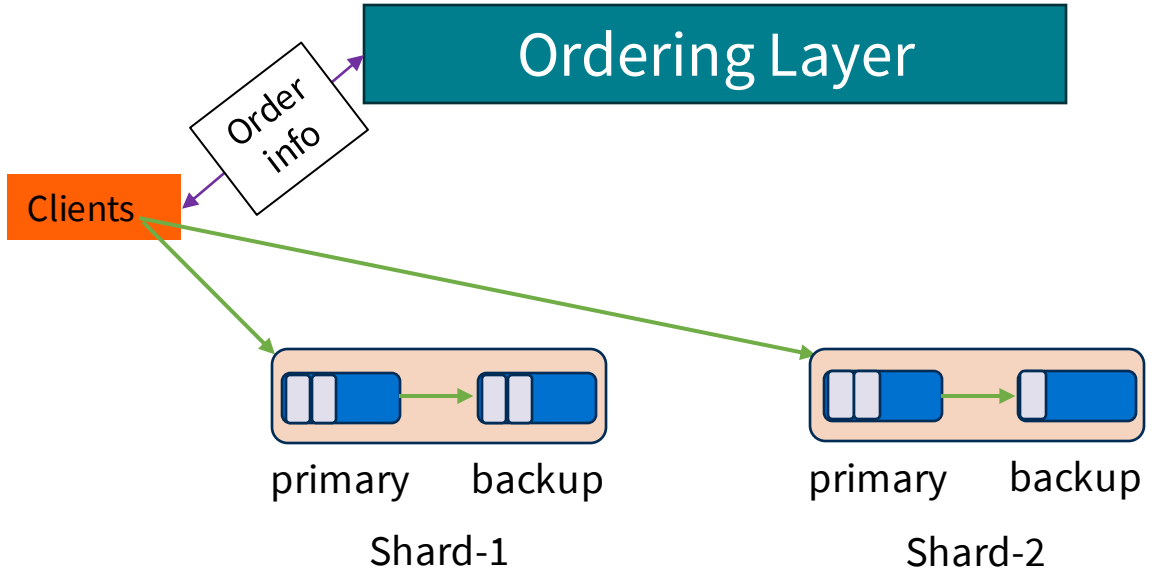

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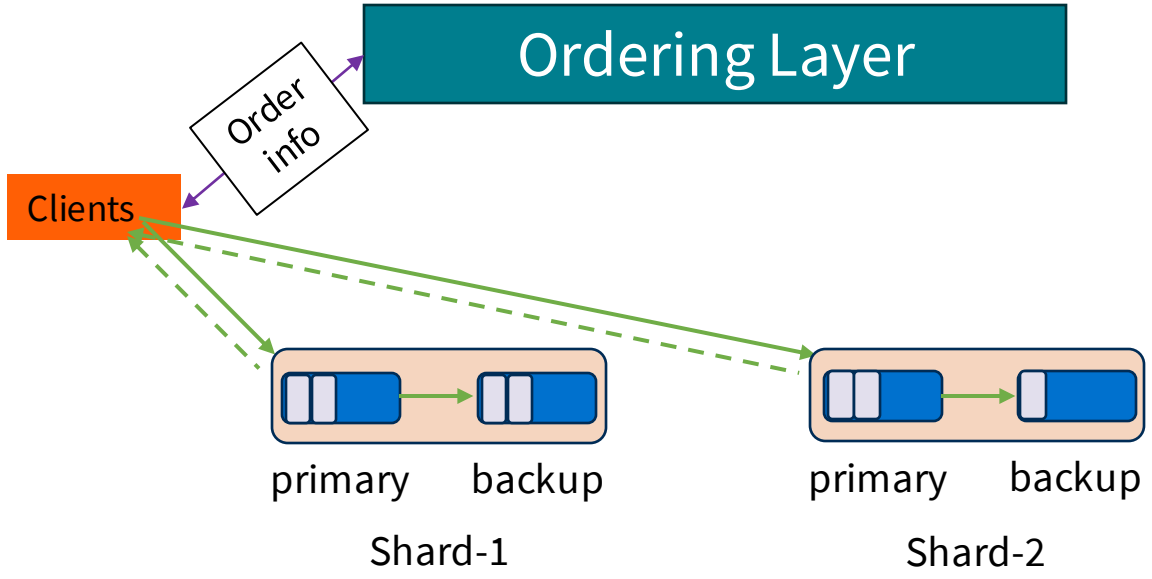

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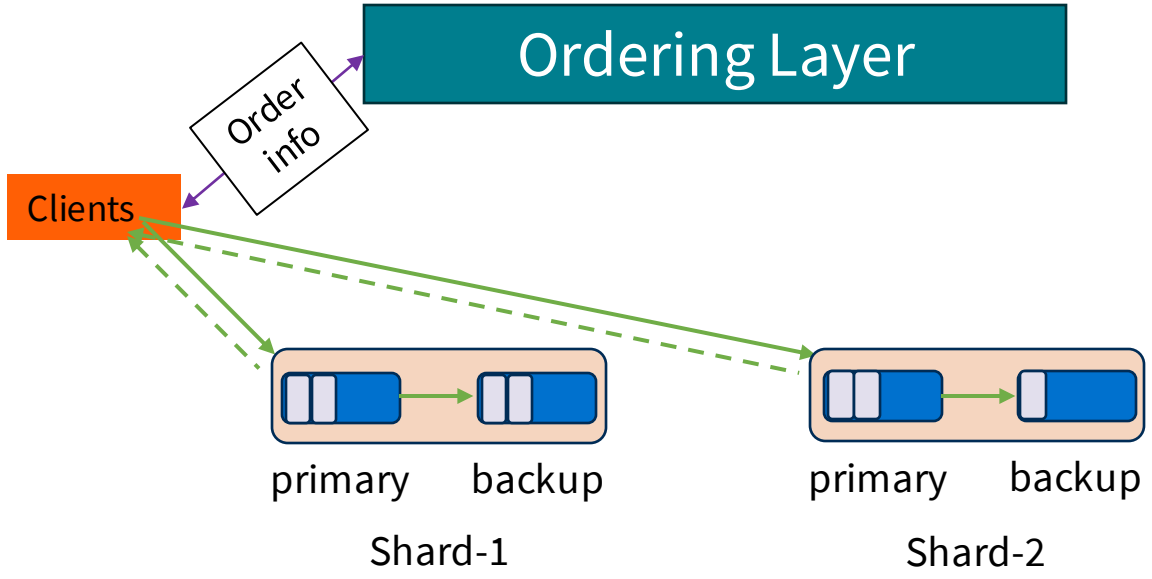

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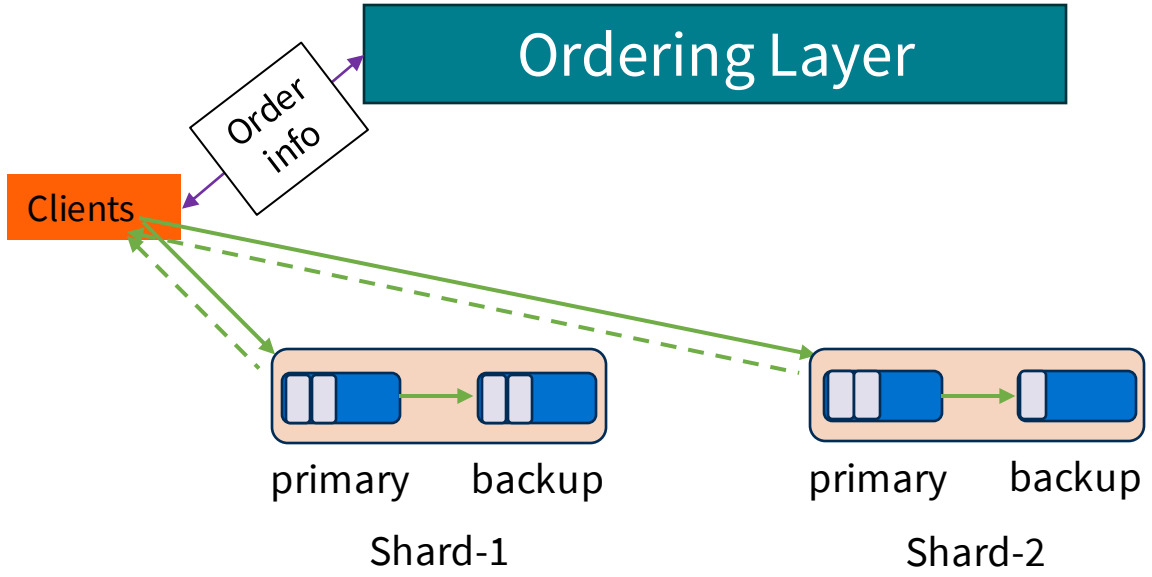

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A 2023 survey by RedPanda:

1/3 of 300 practitioners rated

ingestion latency as the primary

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A shared log can thus defer ordering upon appends
But establish it before reads arrive

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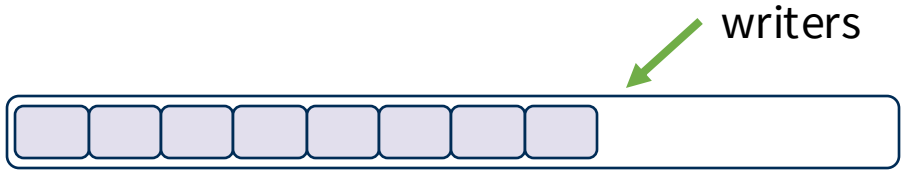

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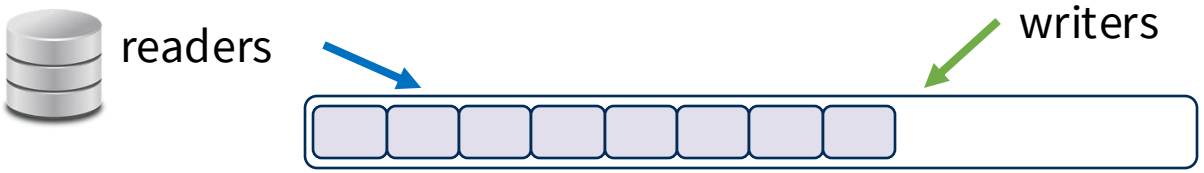

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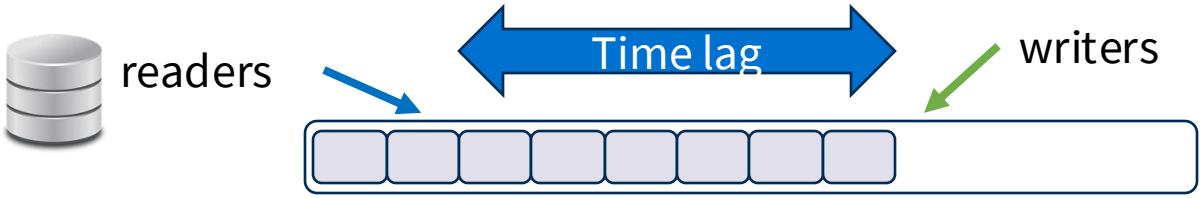

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③ Readers and writers are time-decoupled: readers typically lag behind writers

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LazyLog's insights also hold for them

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Abstraction

- LazyLog doesn't bind a record to a position upon append
  - Only makes the record durable
  - Guarantee the record will be eventually bound to correct position
- LazyLog lazily binds records to positions and enforces ordering before the positions can be read

Interface

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  - Guarantee the record will be eventually bound to correct position
- LazyLog lazily binds records to positions and enforces ordering before the positions can be read

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Interface

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bool append(record r);

// read 'len' records starting at 'from'
list read(logpos_t from, uint64_t len);
```

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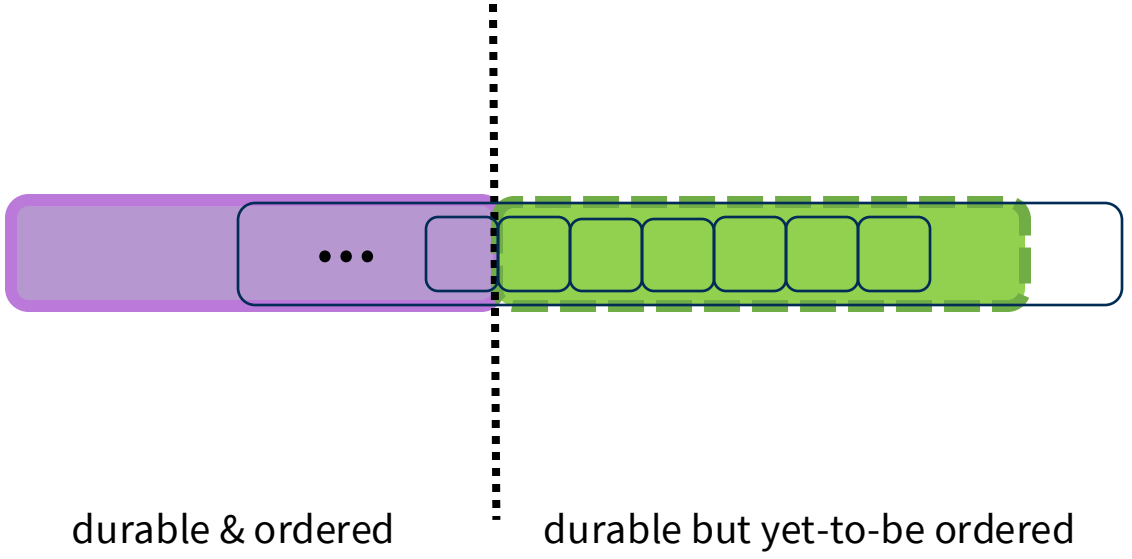

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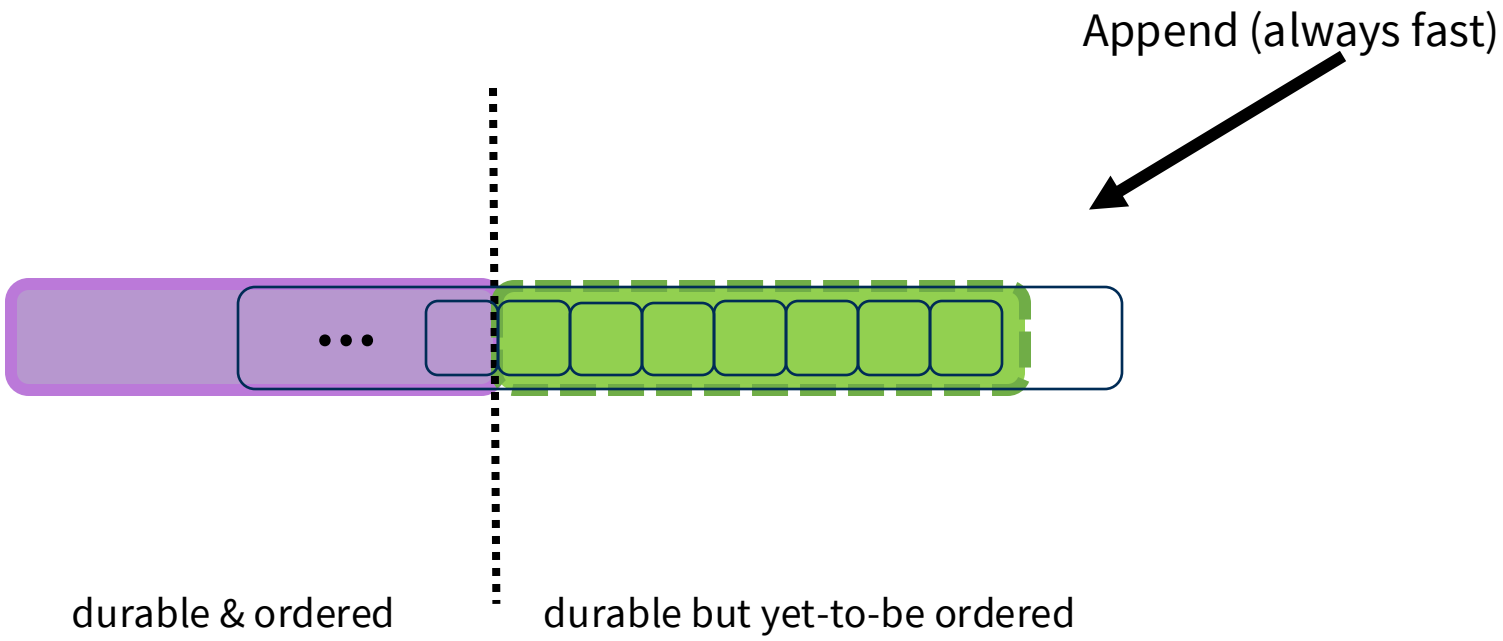

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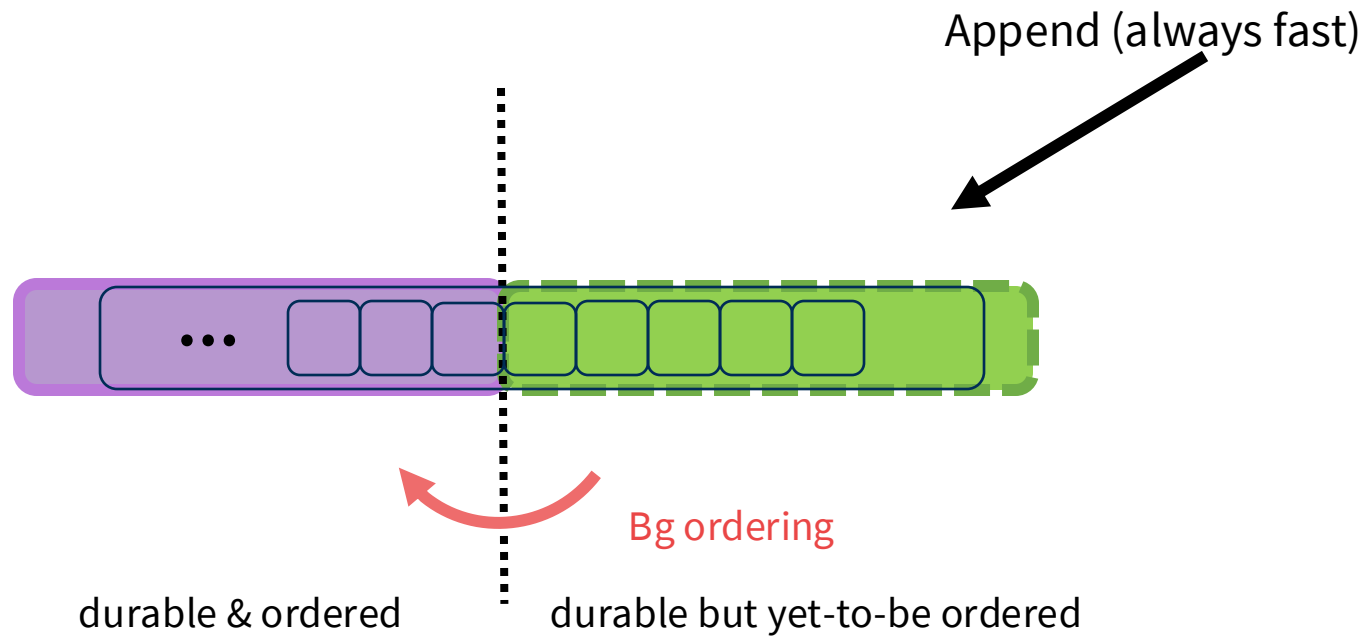

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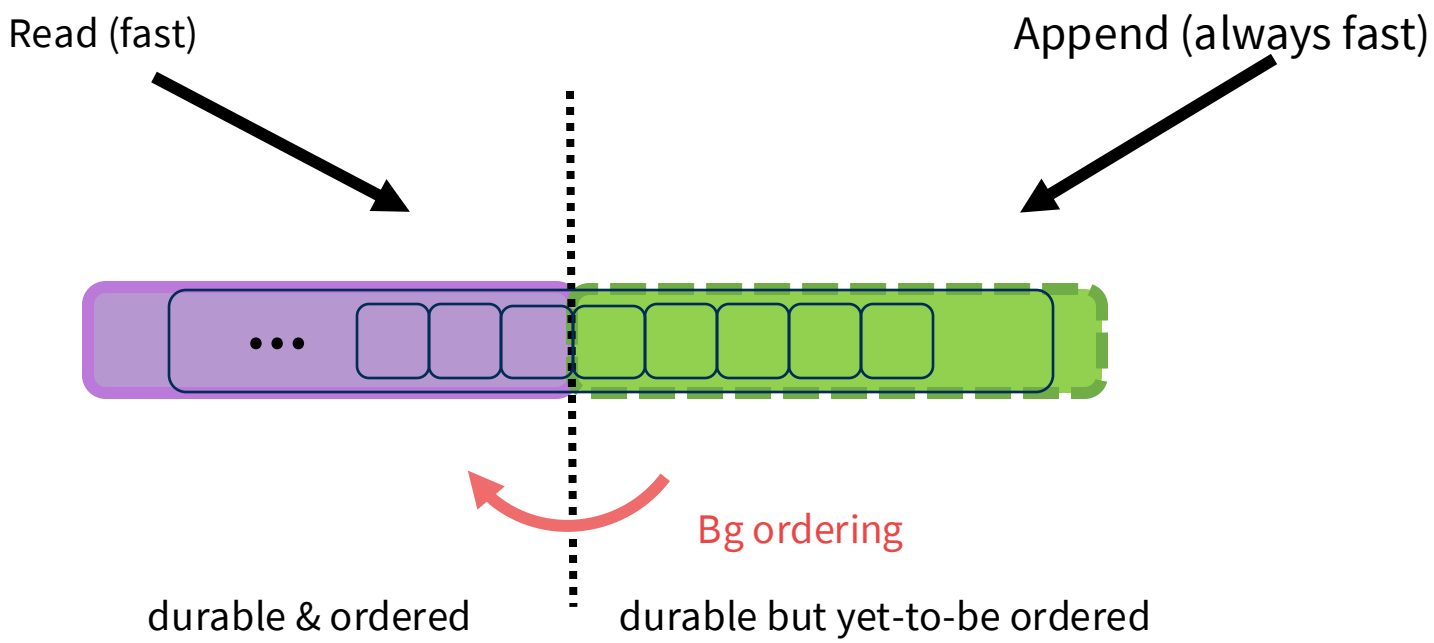

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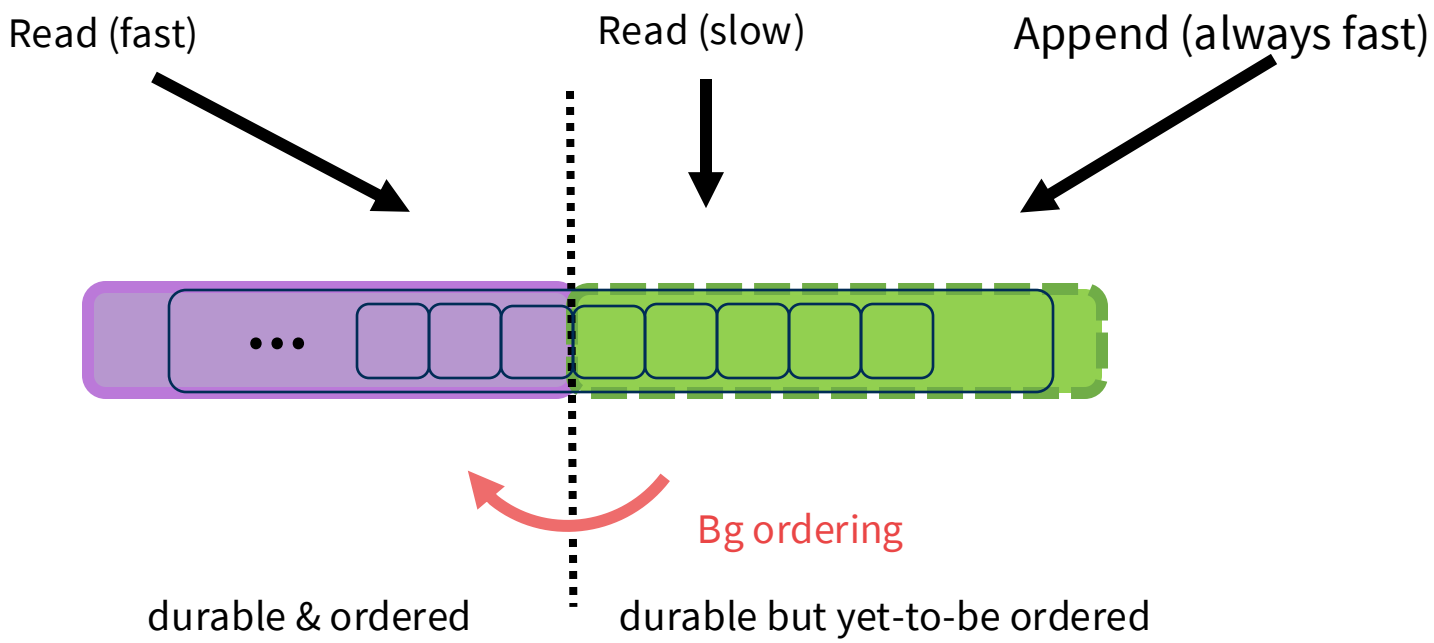

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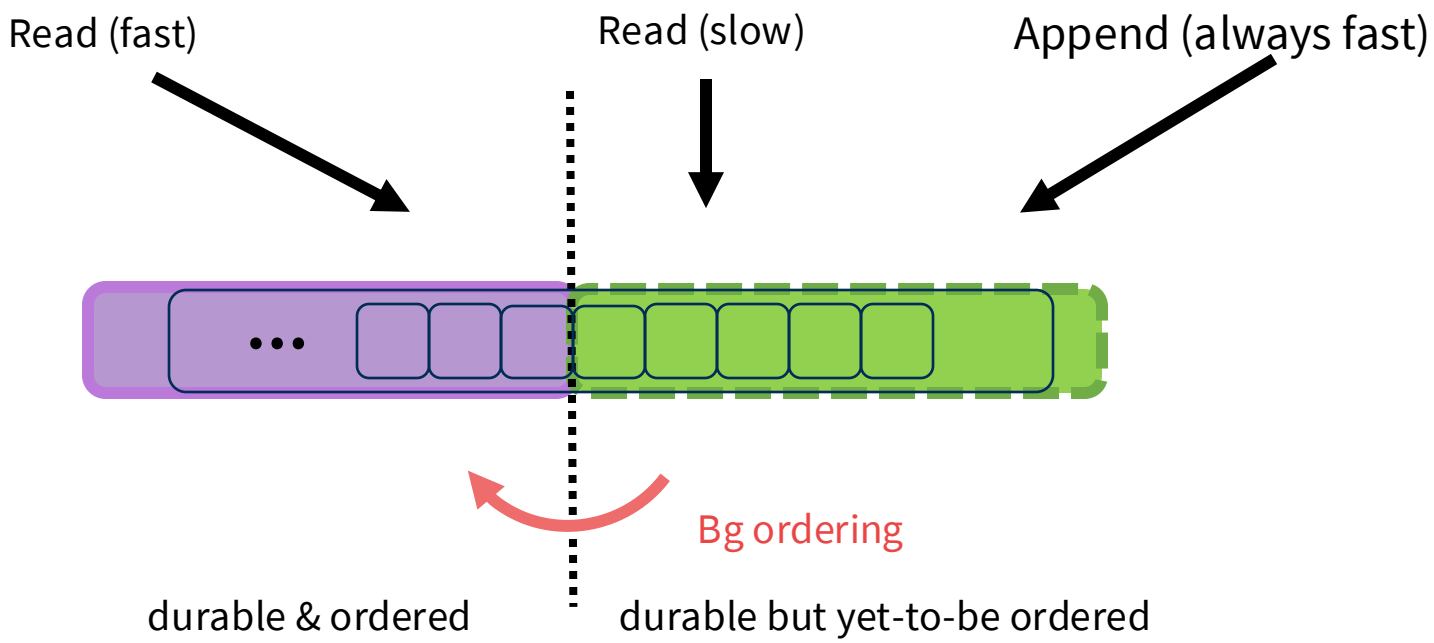

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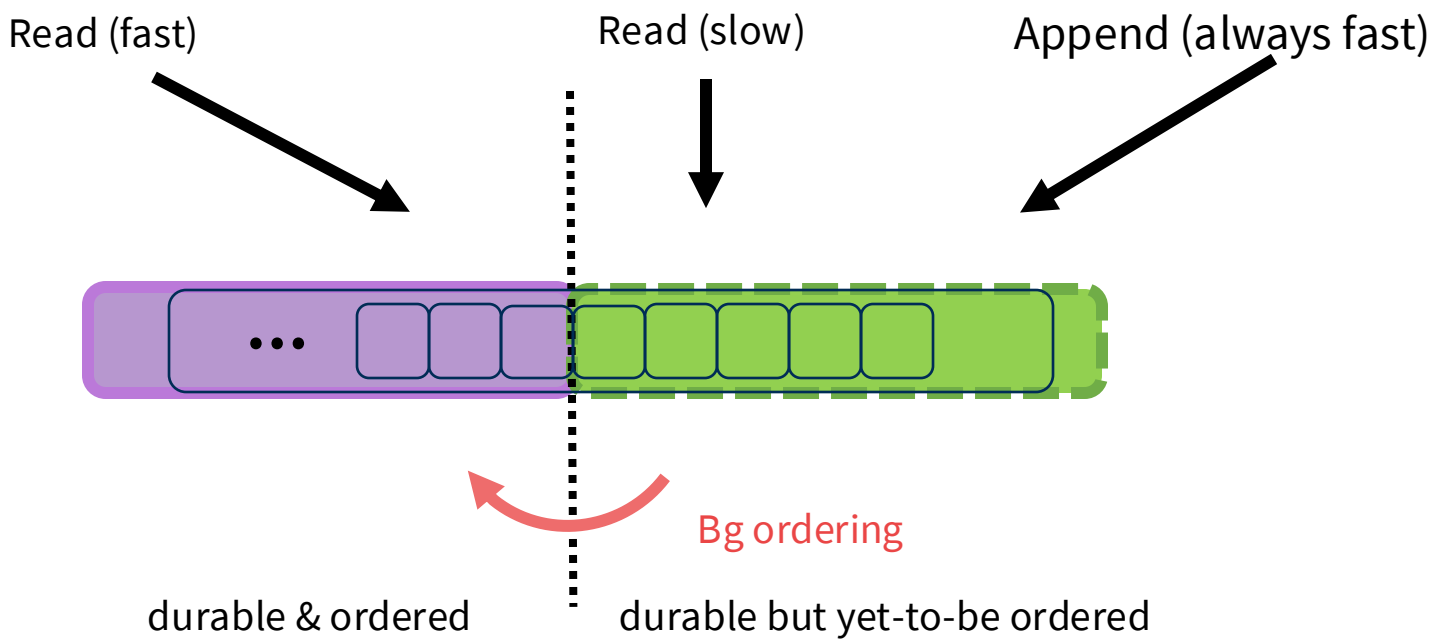

- For many apps – reads are always fast
- Even if immediately read, LazyLog preserves the performance of eager shared logs
  - never worse than an eager-ordering shared log!

Related Work

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- Enabled by our new observations about modern shared-log applications

Outline

Introduction

Motivation

LazyLog Insight and Interface

LazyLog System Design

Performance Evaluation

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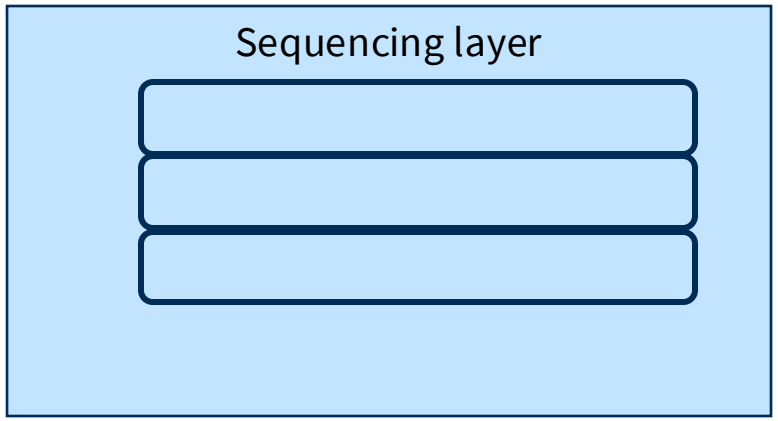
Designed an implementation of the LazyLog interface: Erwin

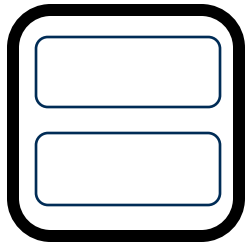
Offers linearizable ordering across shards with 1-RTT appends

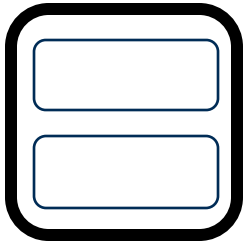
Offers about a million 4KB appends/sec on our testbed

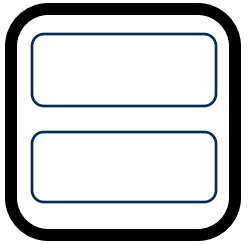
Erwin's Goal: 1-RTT Append



Clients


shard1


shard2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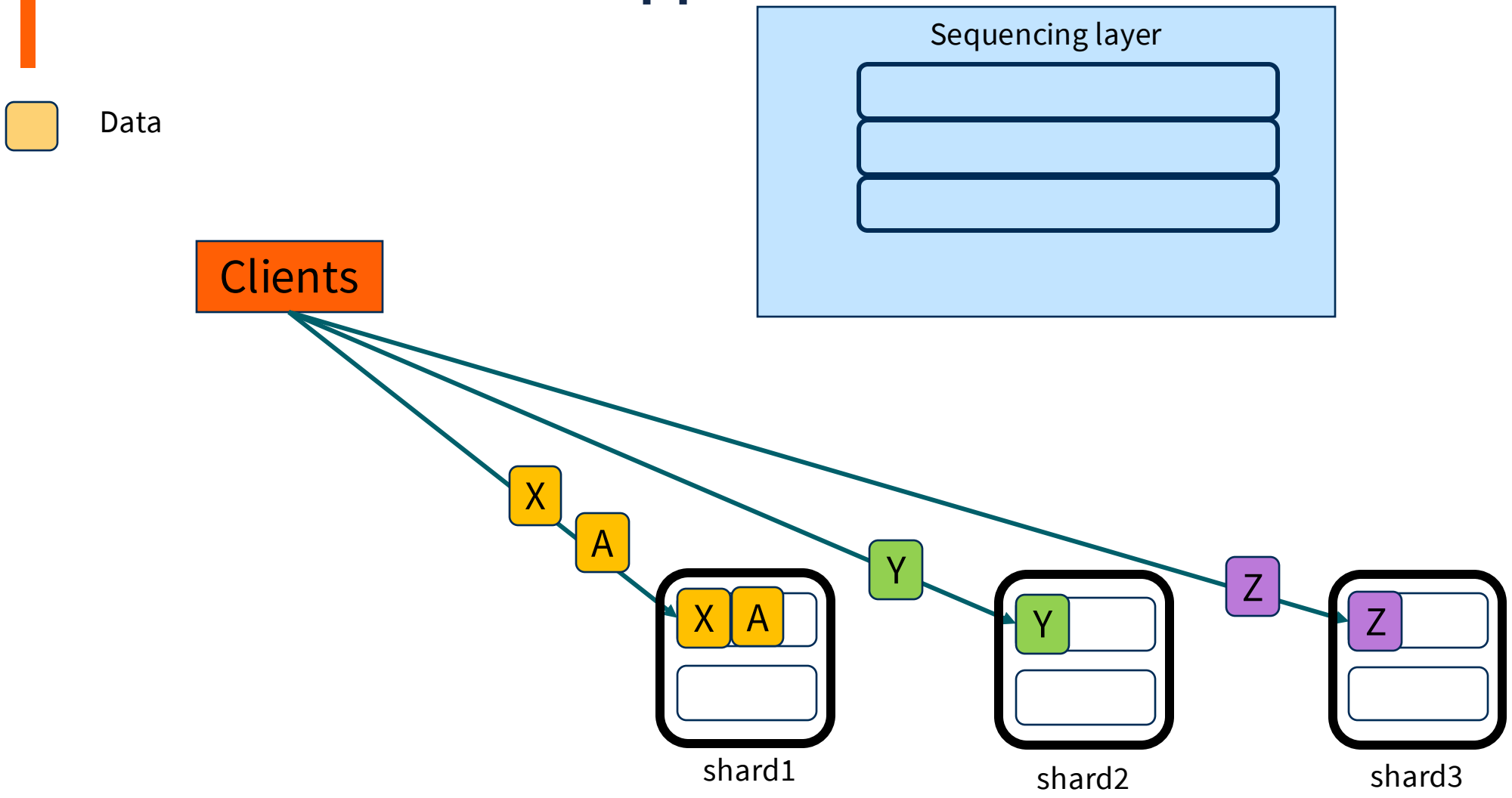

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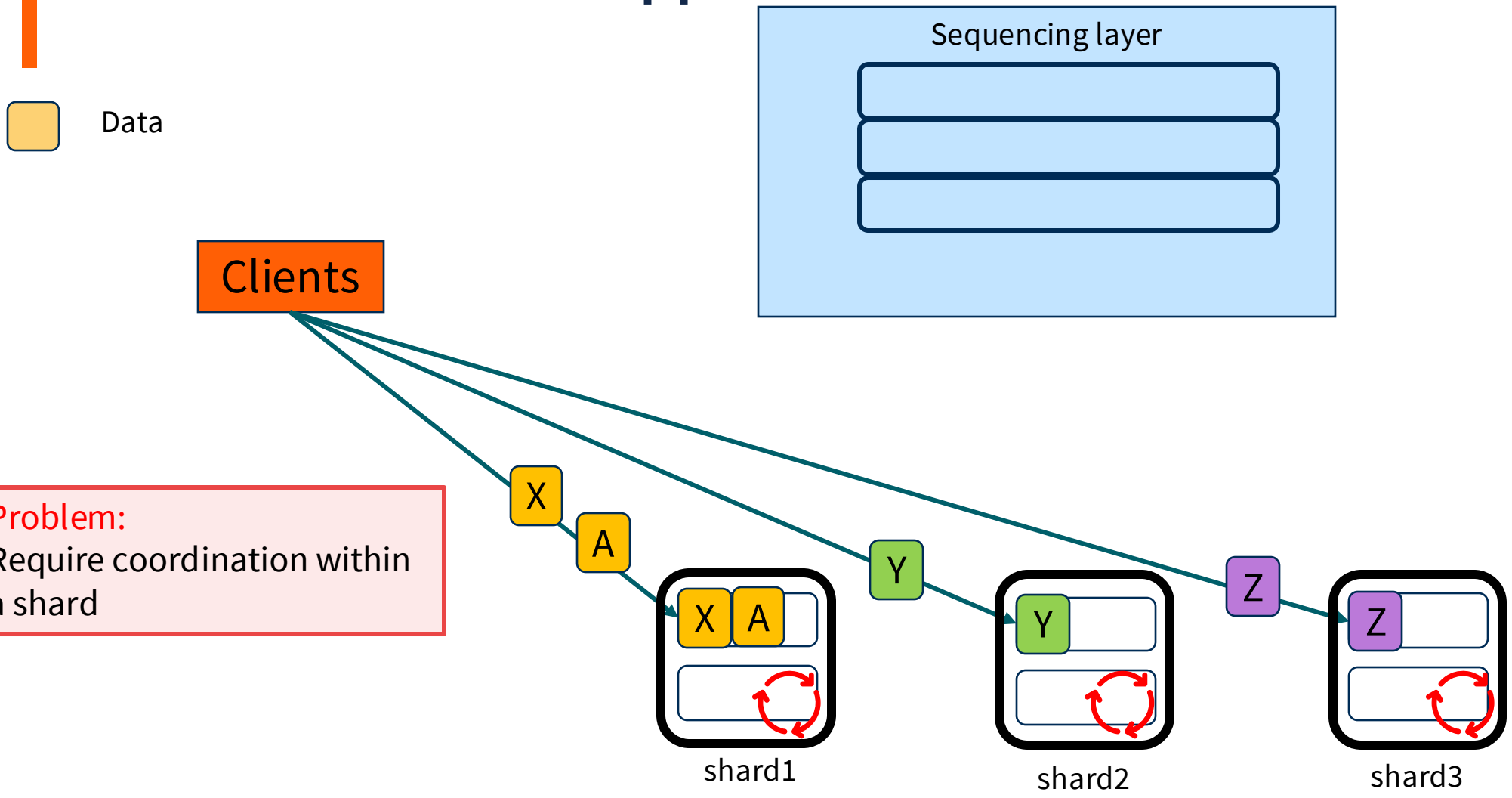

Problem:
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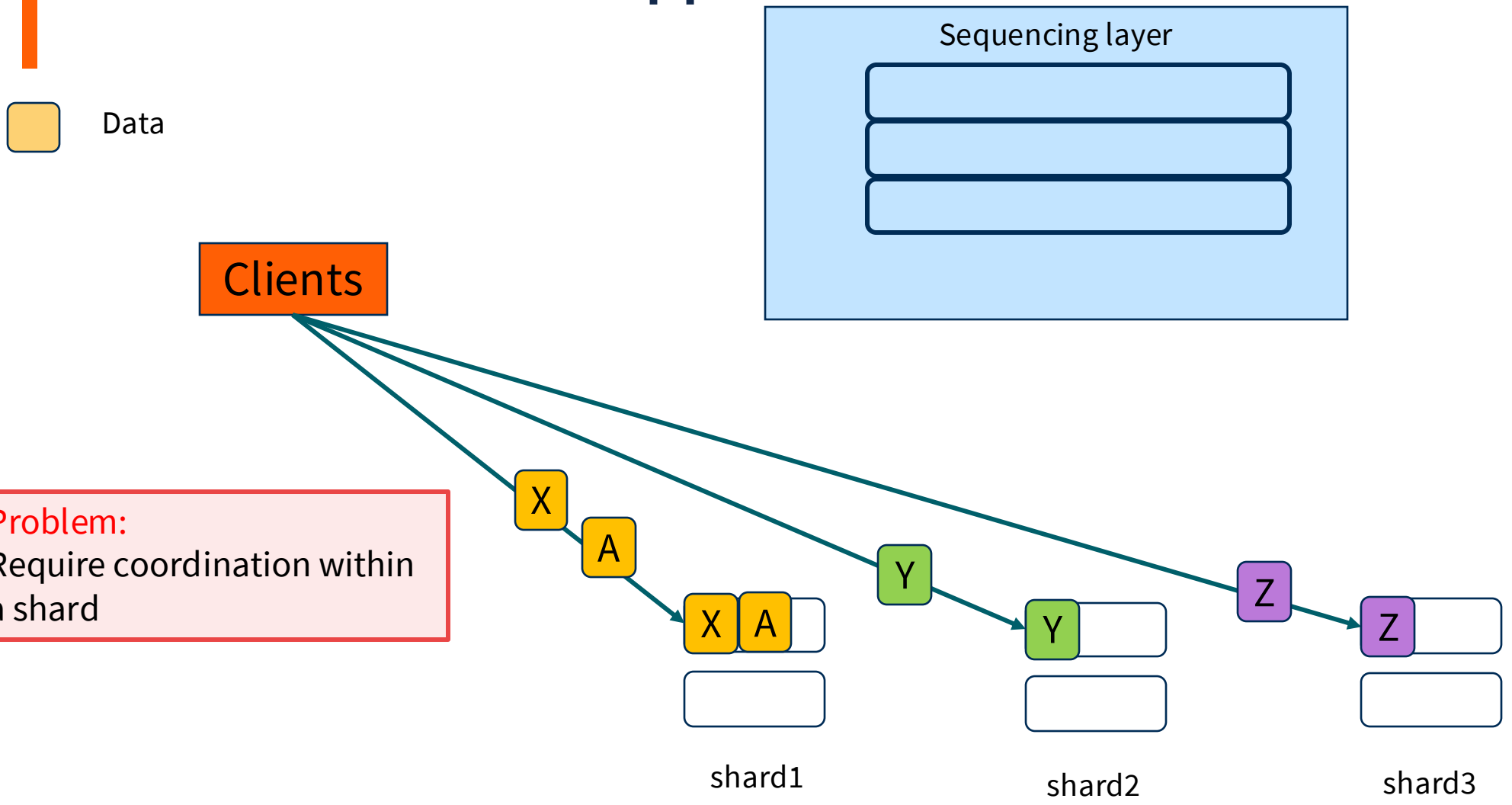

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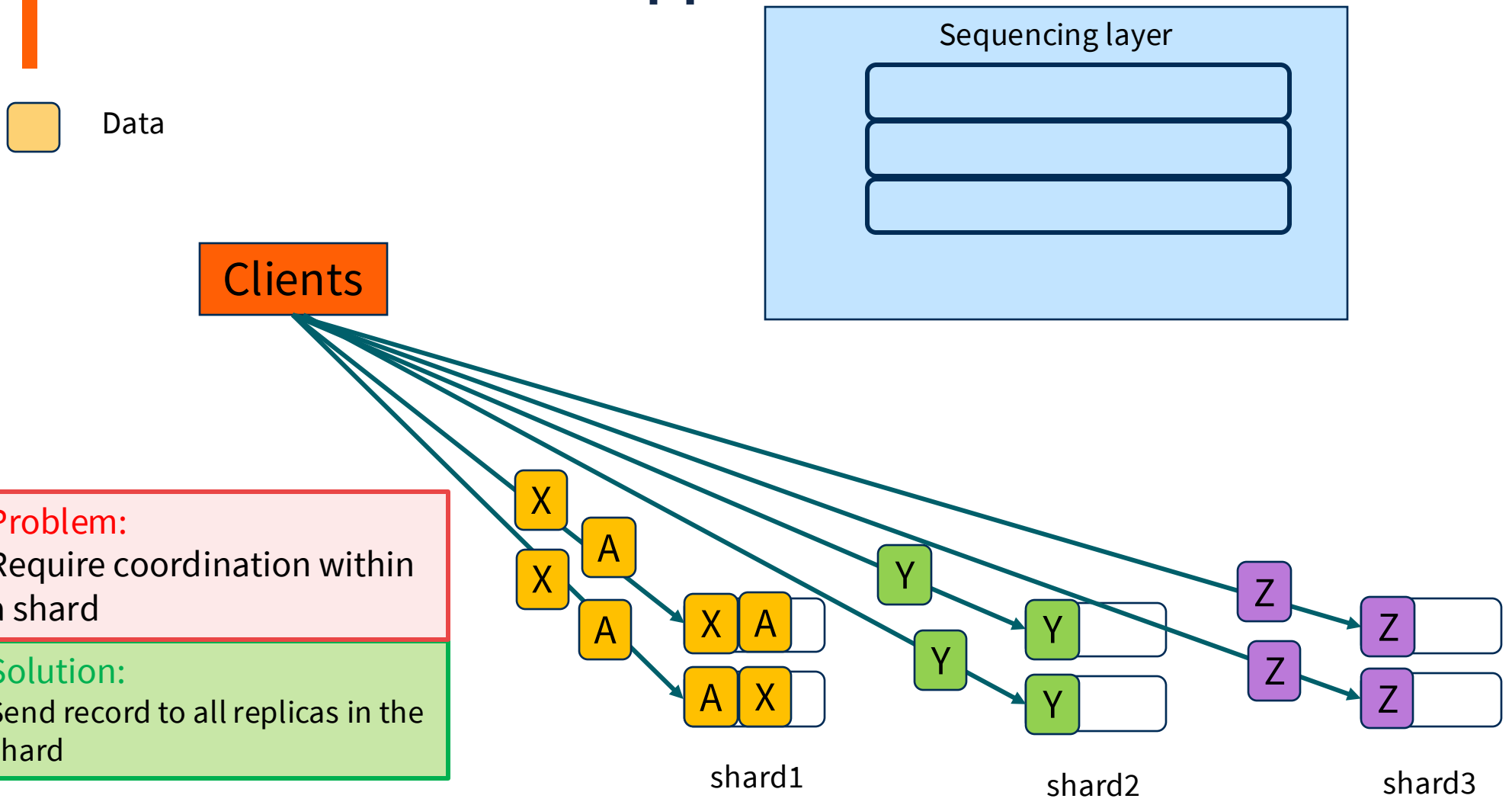

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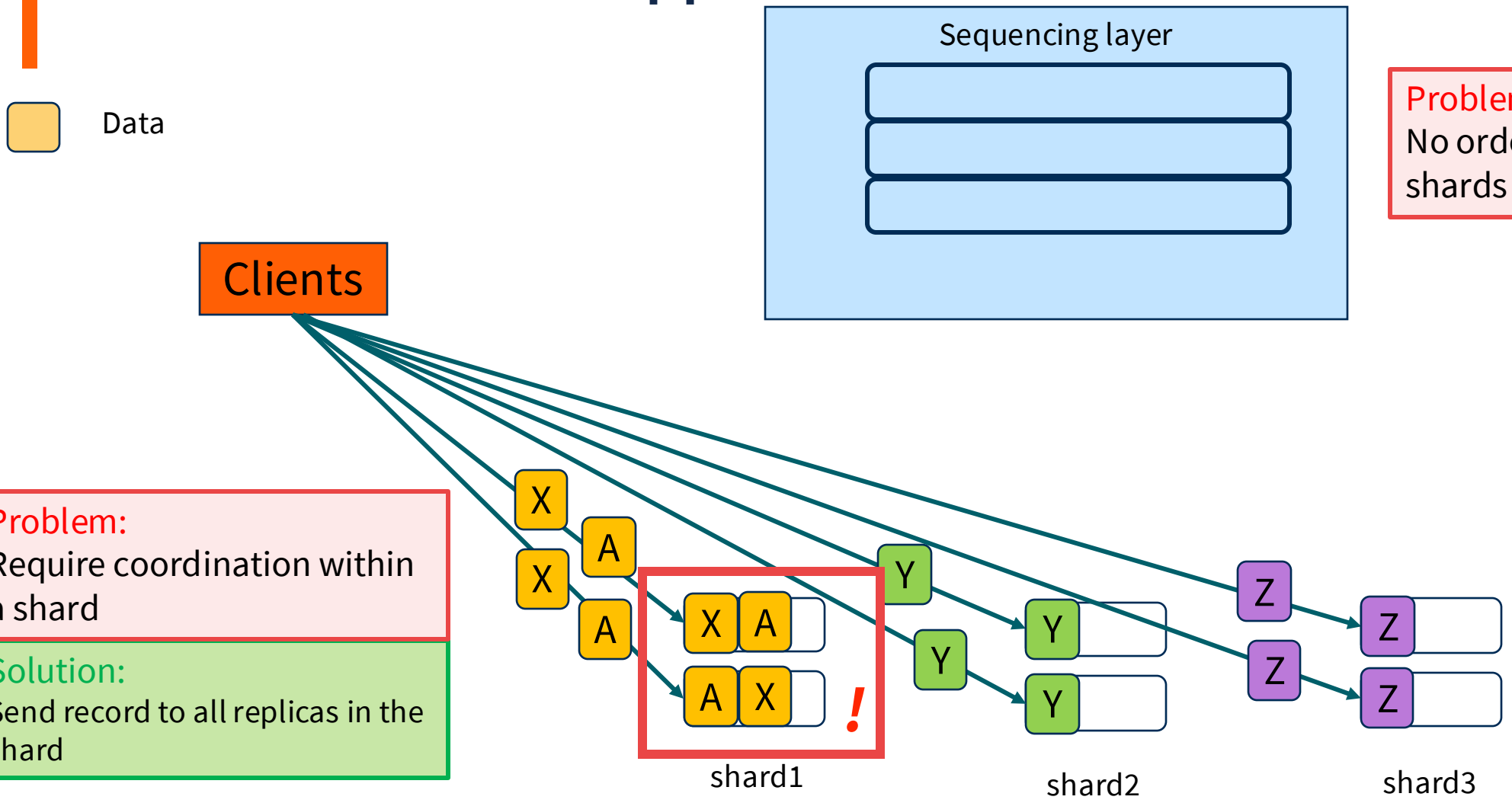

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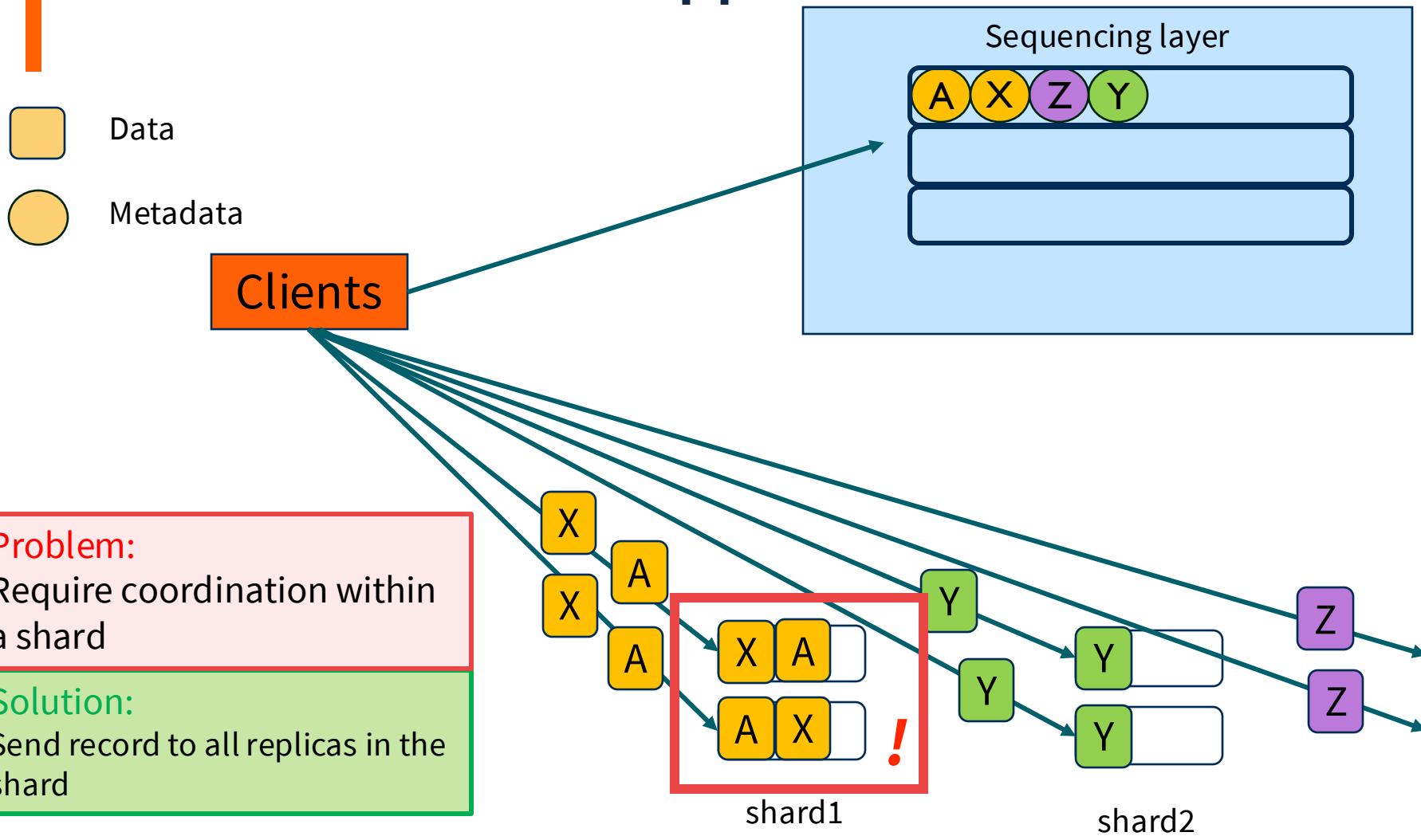

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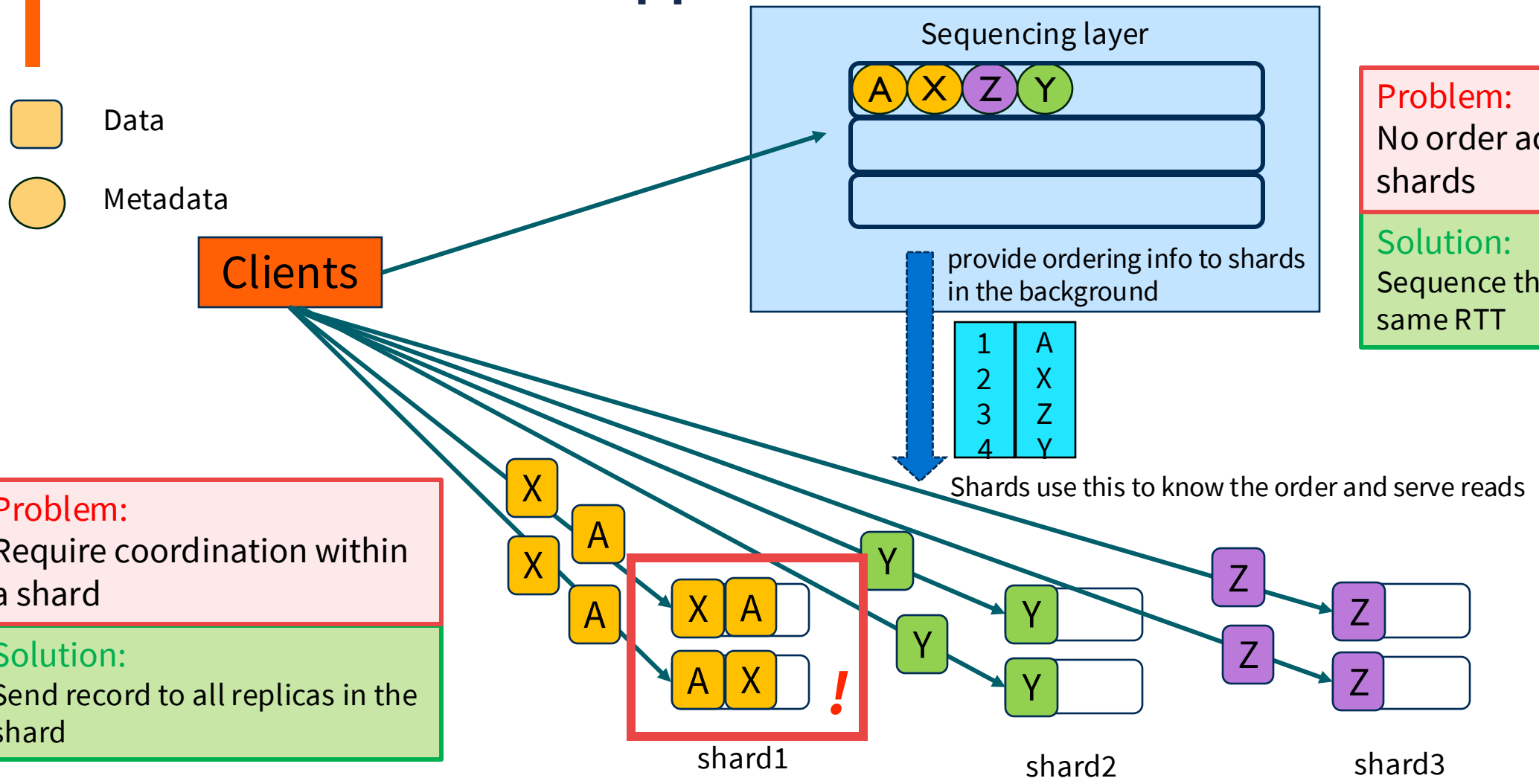

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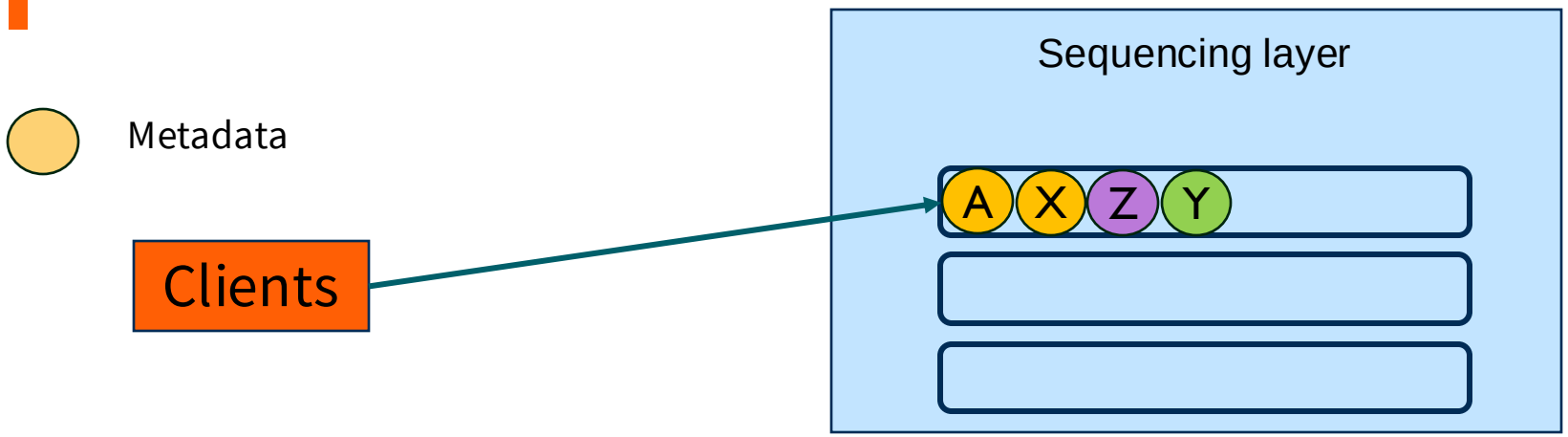

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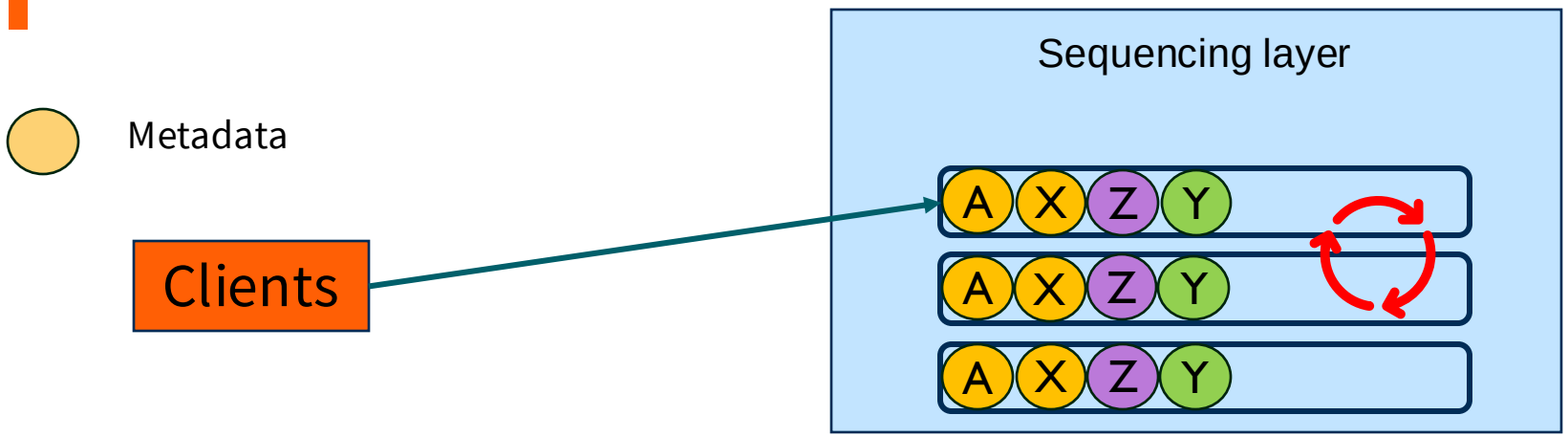

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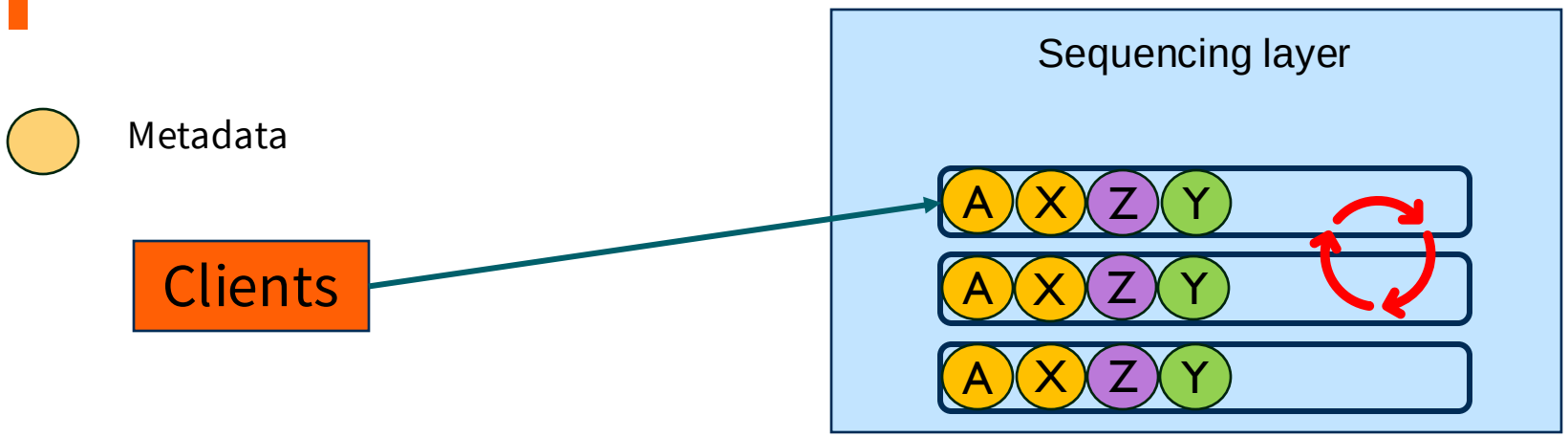

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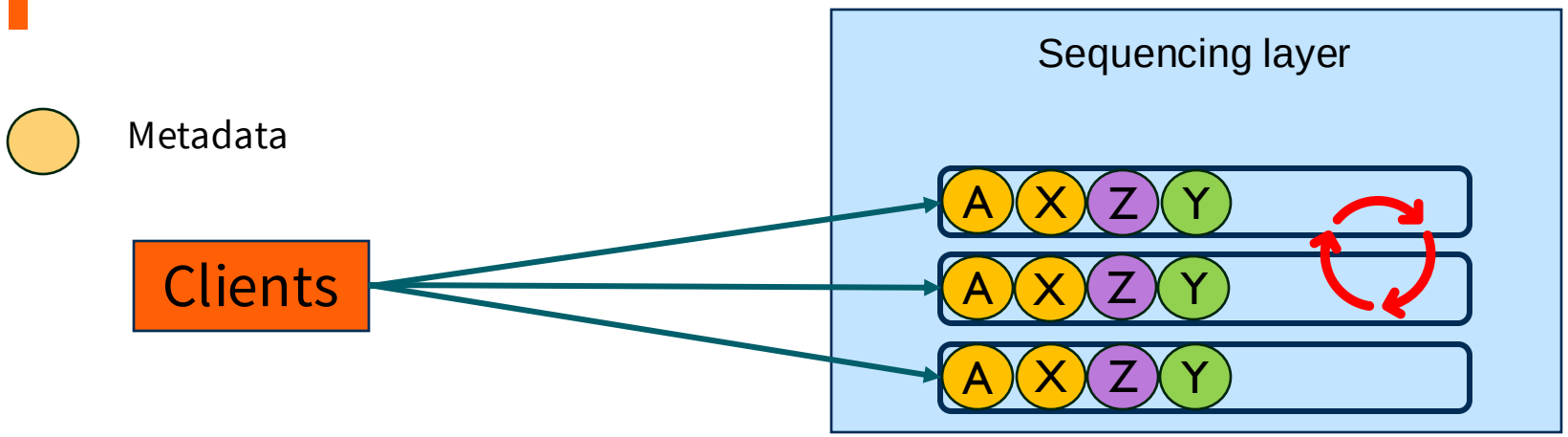

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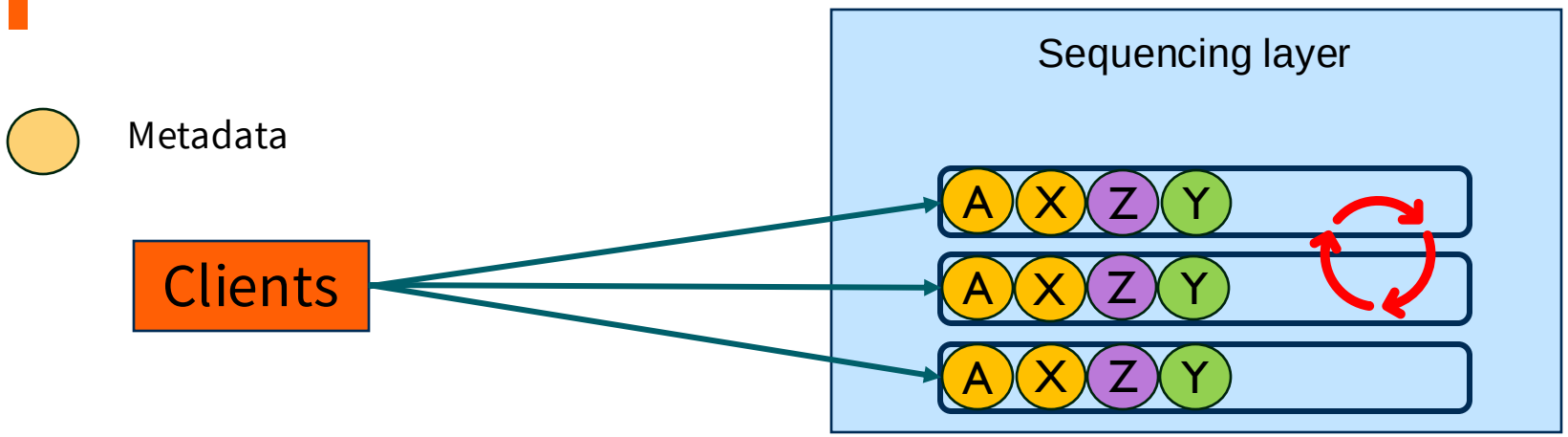

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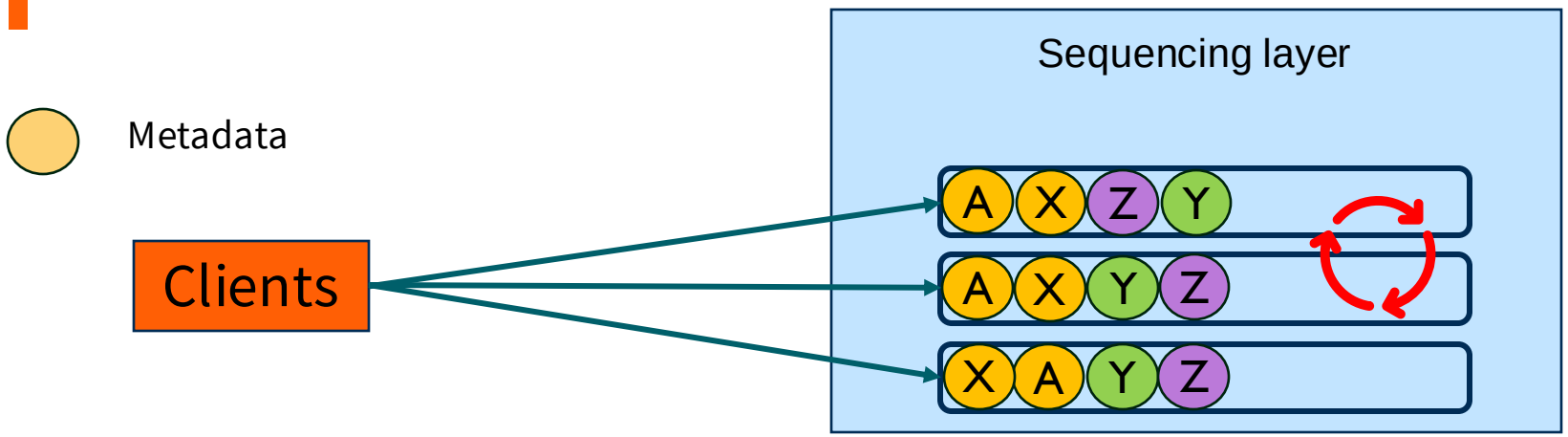

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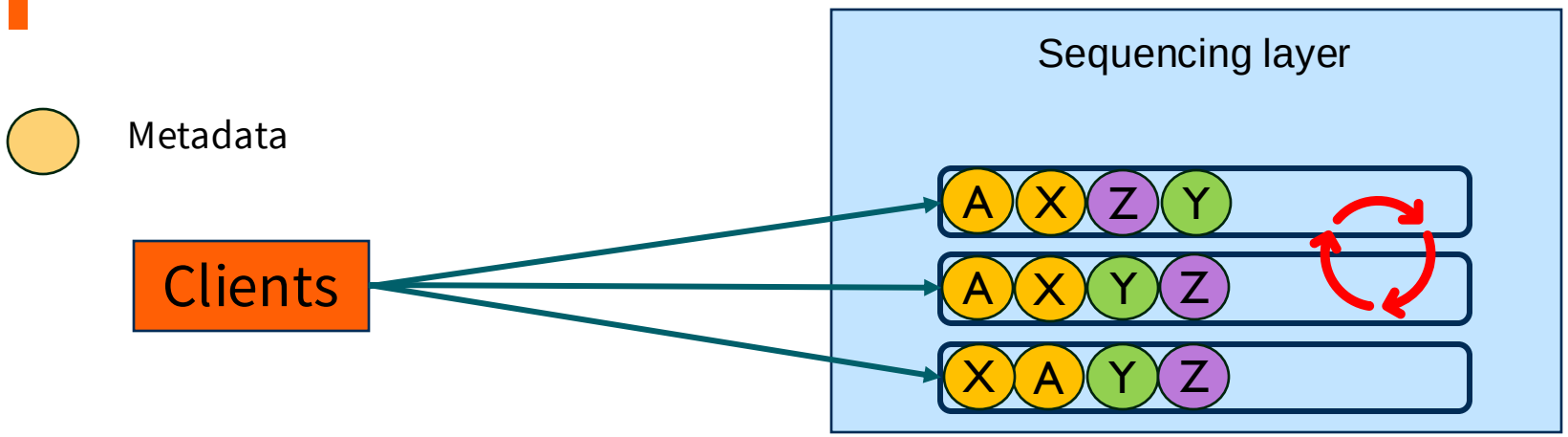

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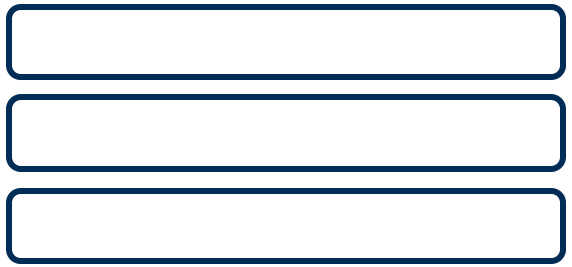
- Clients write to shard replicas in 1RTT; in same RTT, write metadata to **all** seq replicas
  - Appends complete in 1 RTT
- Erwin allows different orders across sequencing replicas
  - but without violating the linearizability

Correct Lazy Sequencing



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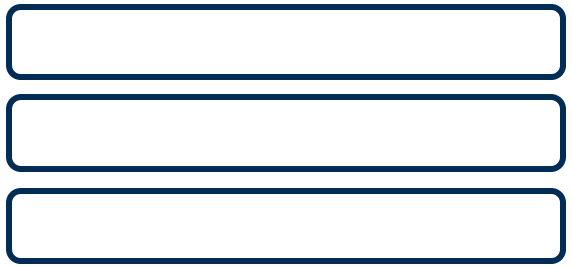

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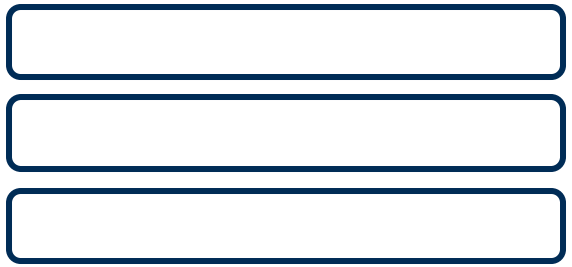

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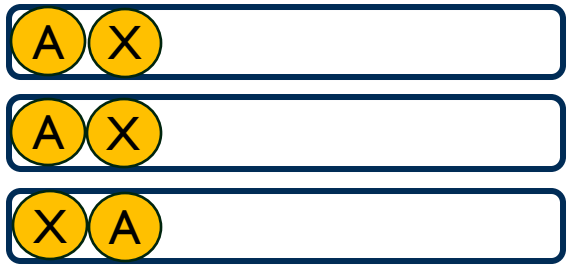

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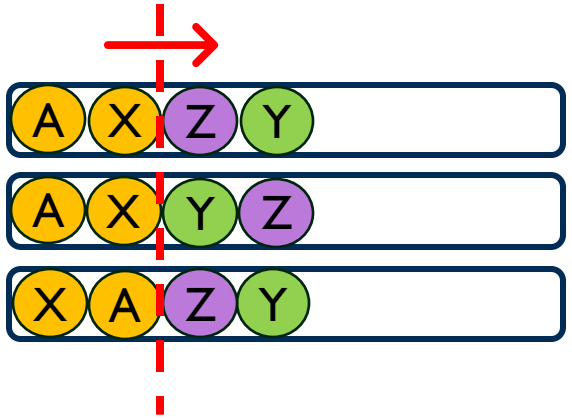

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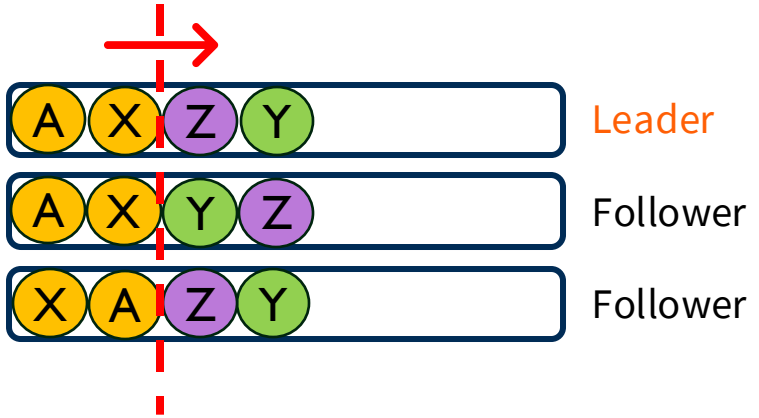

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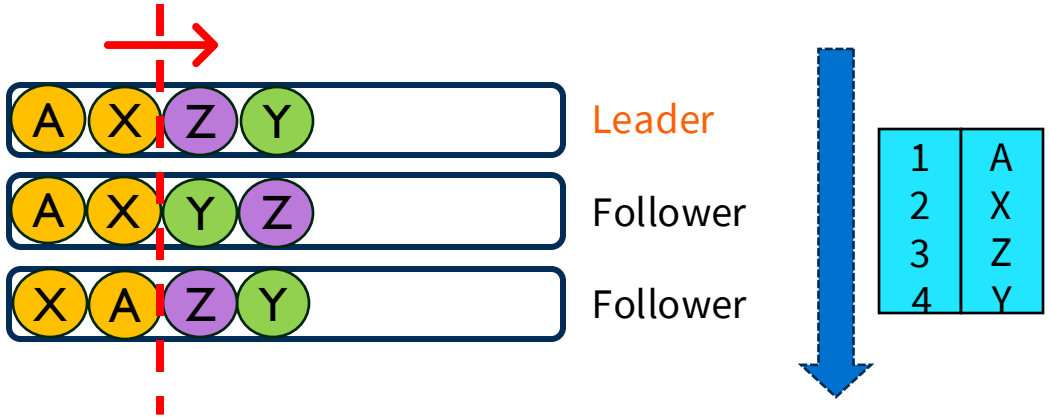

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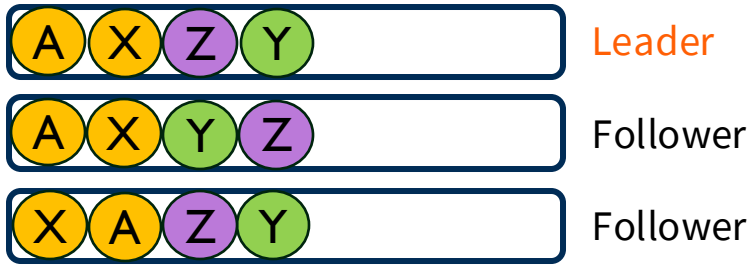
- Send leader's order to shards

Handle Sequencing Leader Failure

Exposed order must be preserved upon failures!



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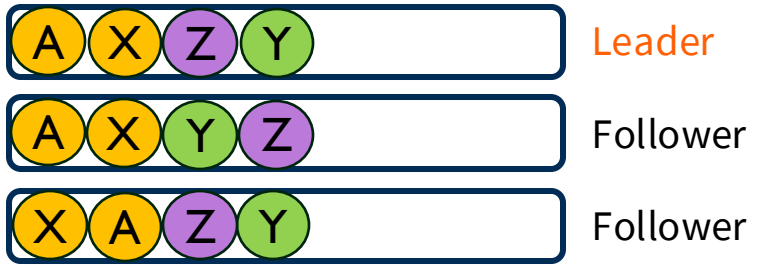

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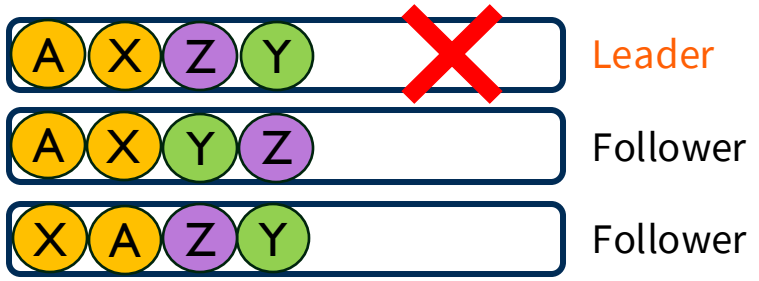

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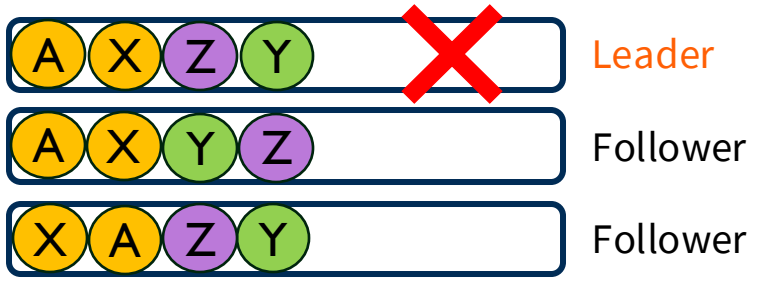

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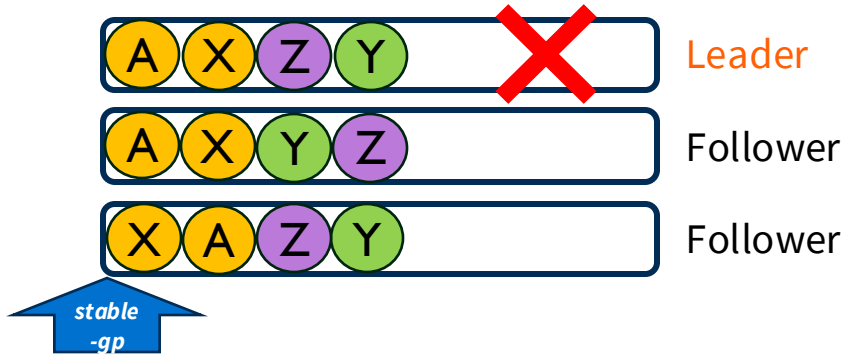

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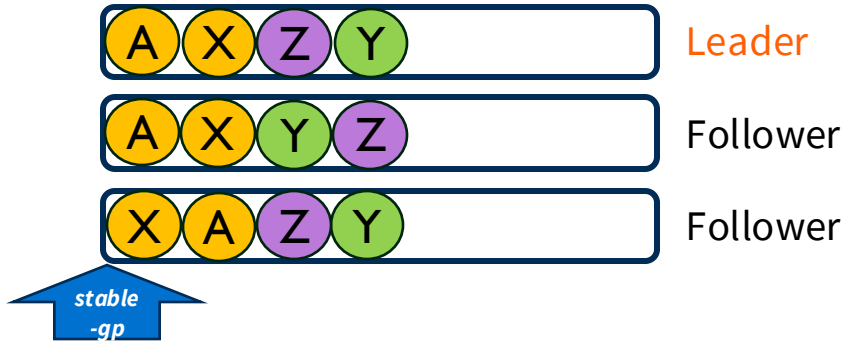

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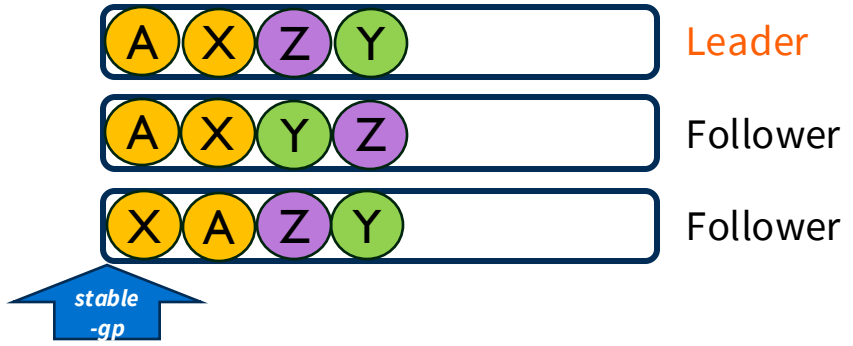

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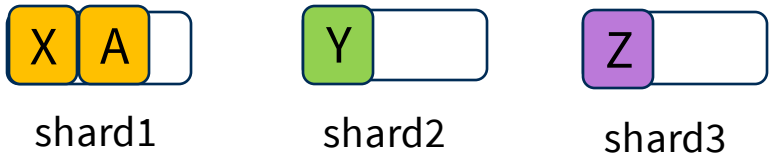

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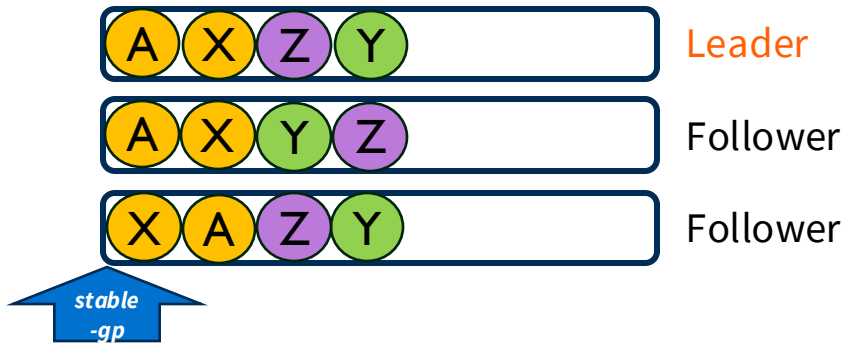

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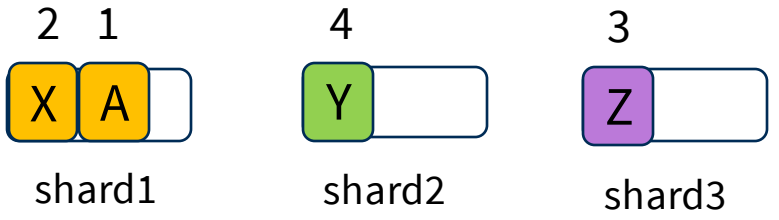

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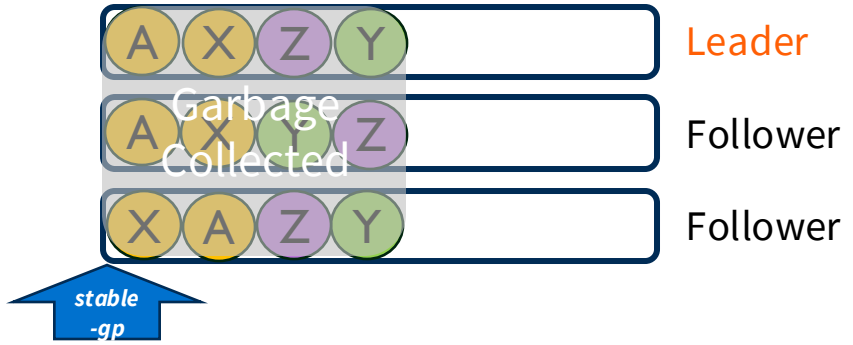

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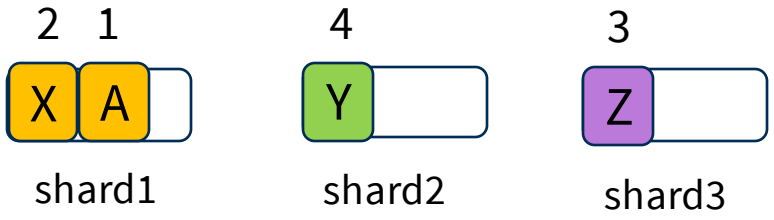

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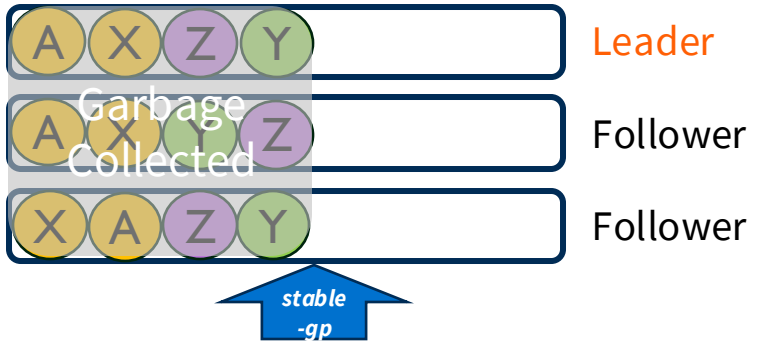

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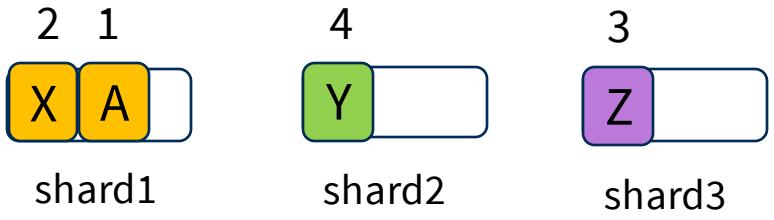

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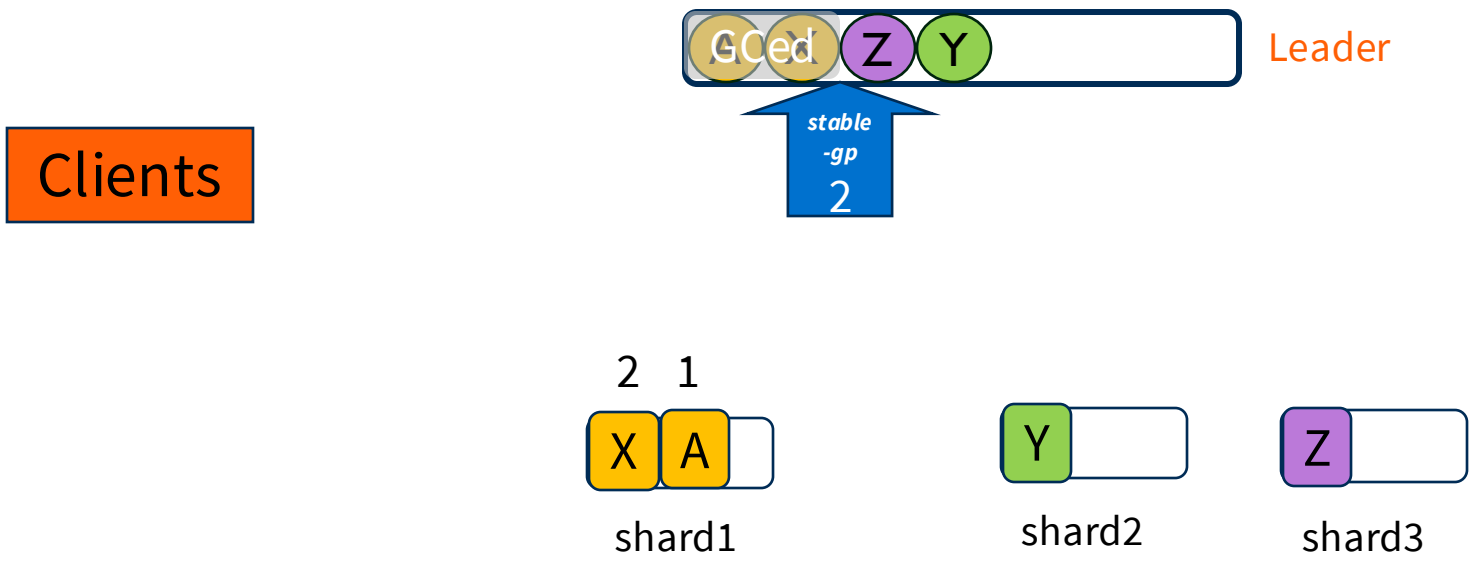
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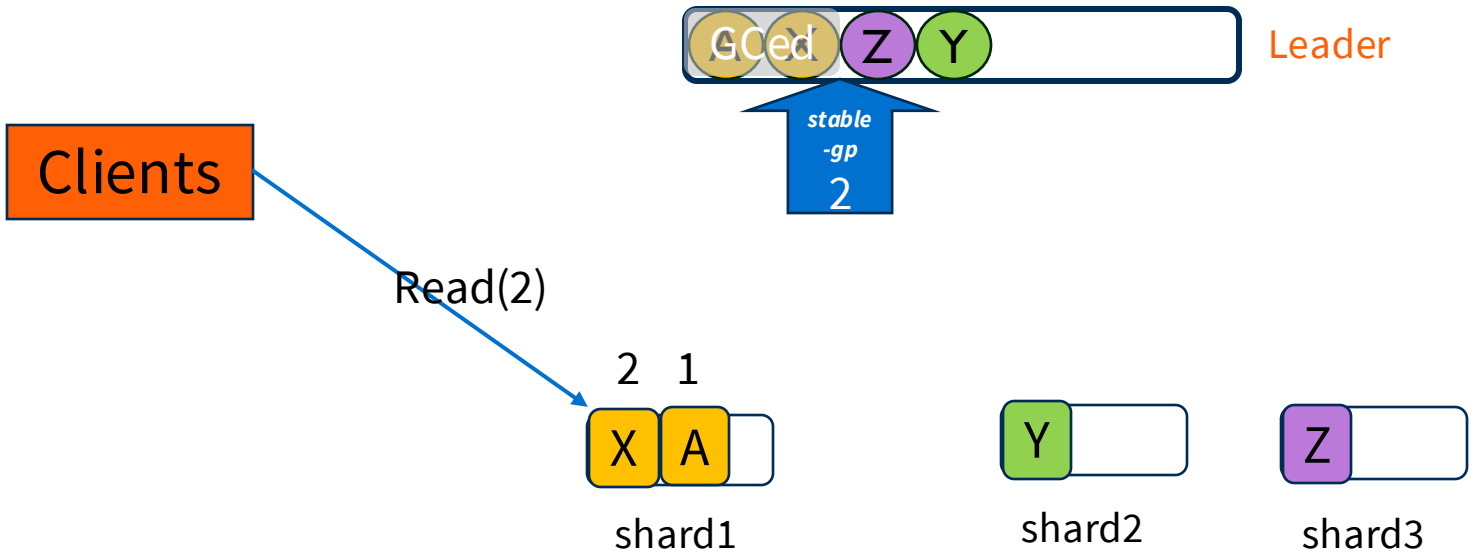

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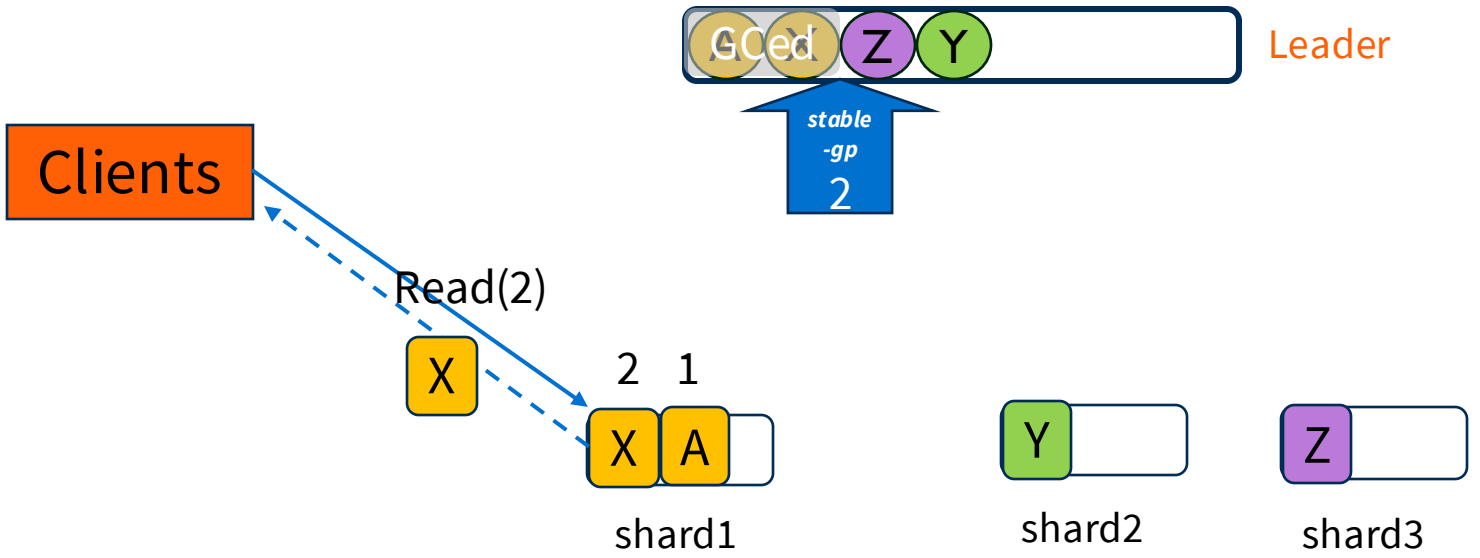

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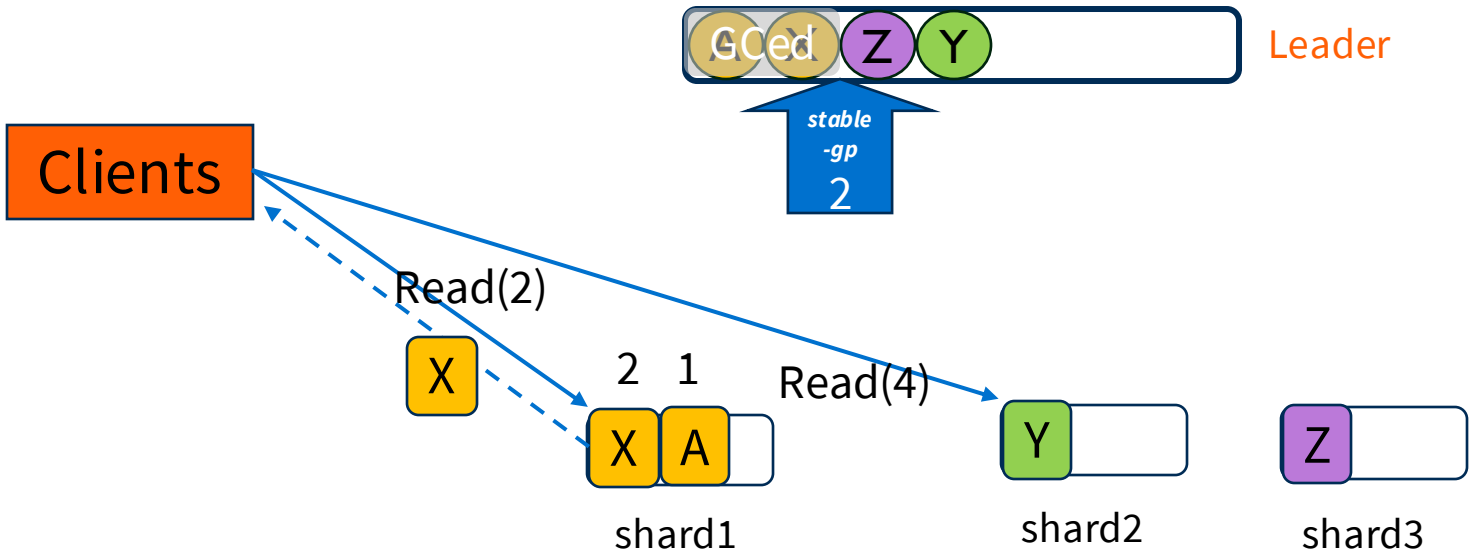

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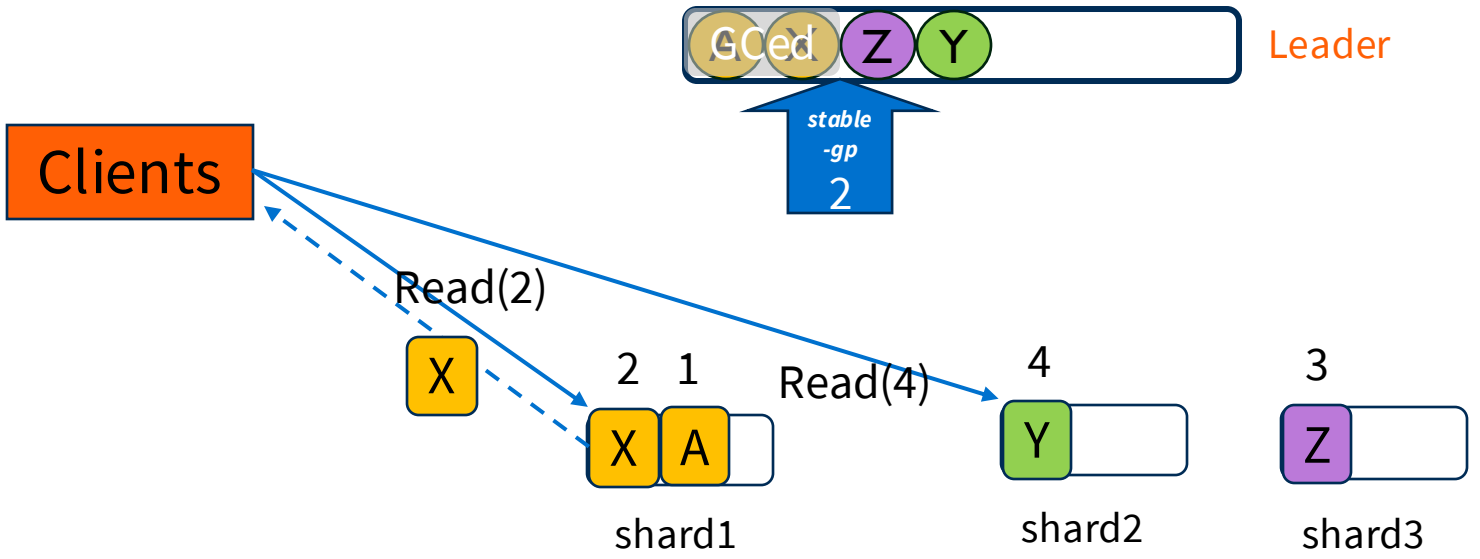

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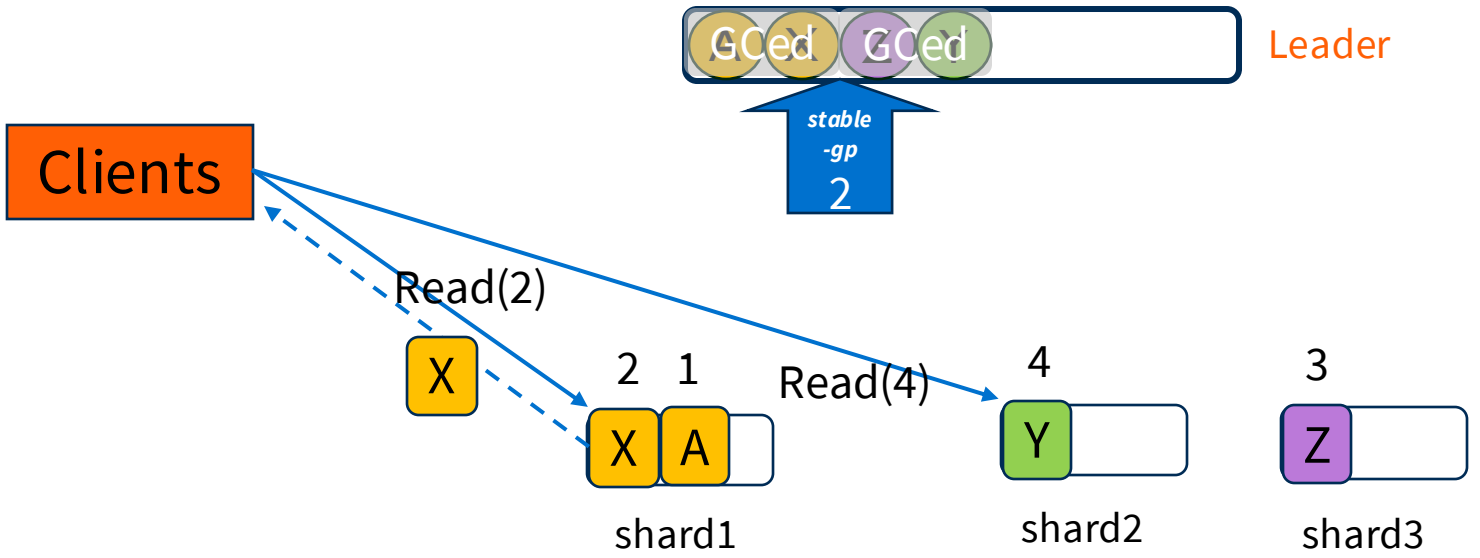

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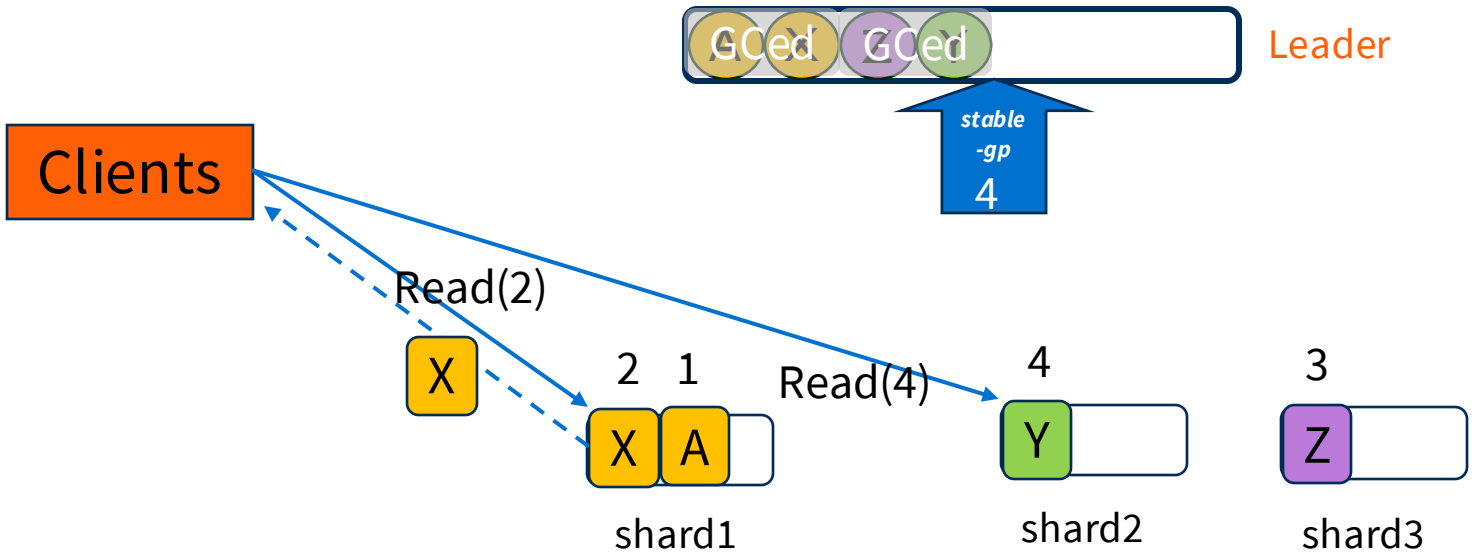

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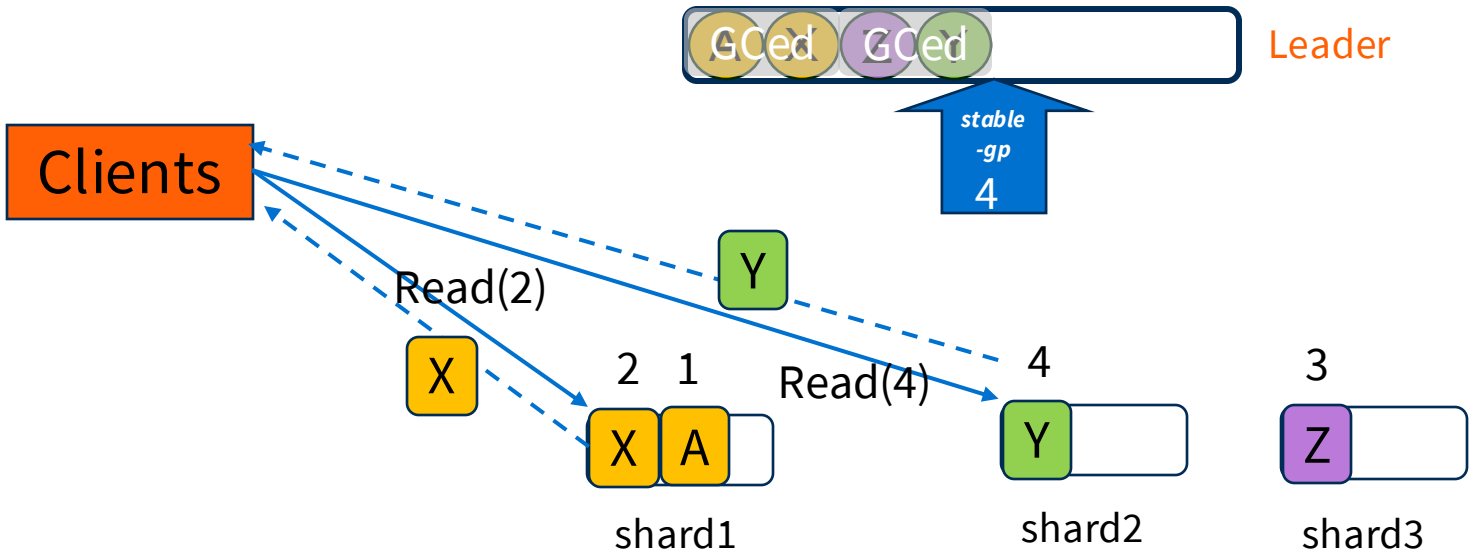

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Outline

Introduction

Motivation

LazyLog Insight and Interface

LazyLog System Design

Performance Evaluation

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- What's the latency benefit of lazy ordering?
- How do reads perform in LazyLog?
- Do end applications benefit?

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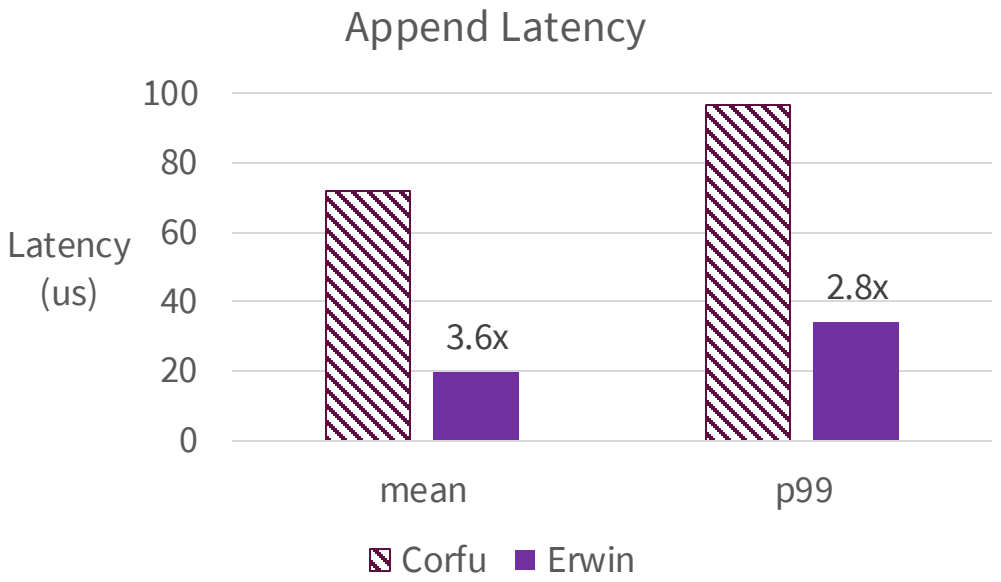

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- Avg: By 3.6x compared to Corfu
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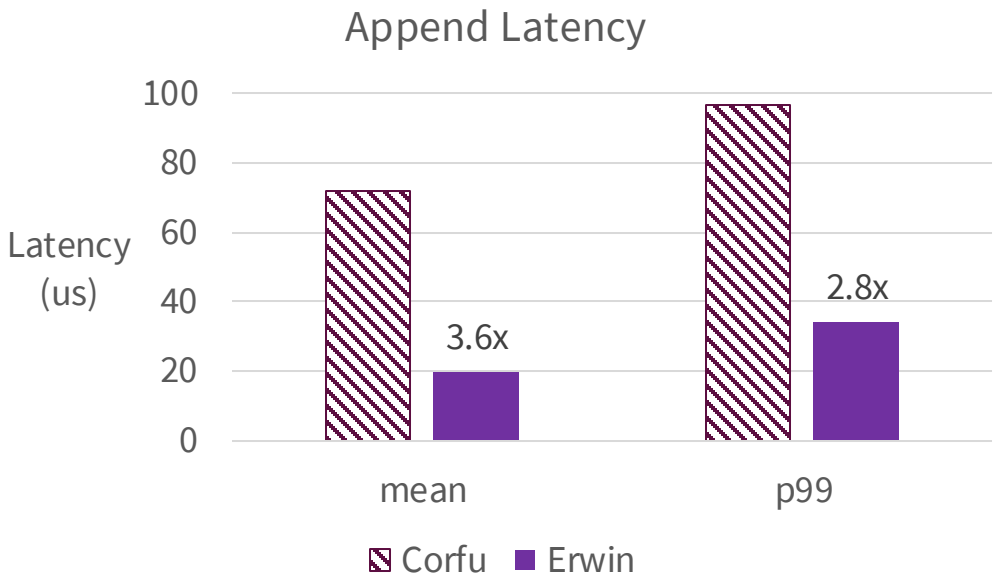

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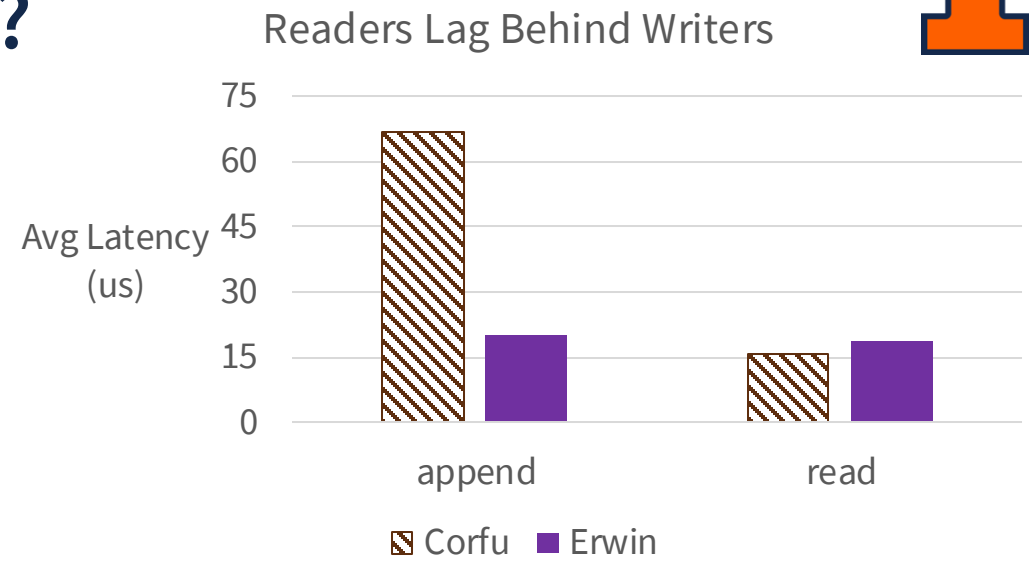

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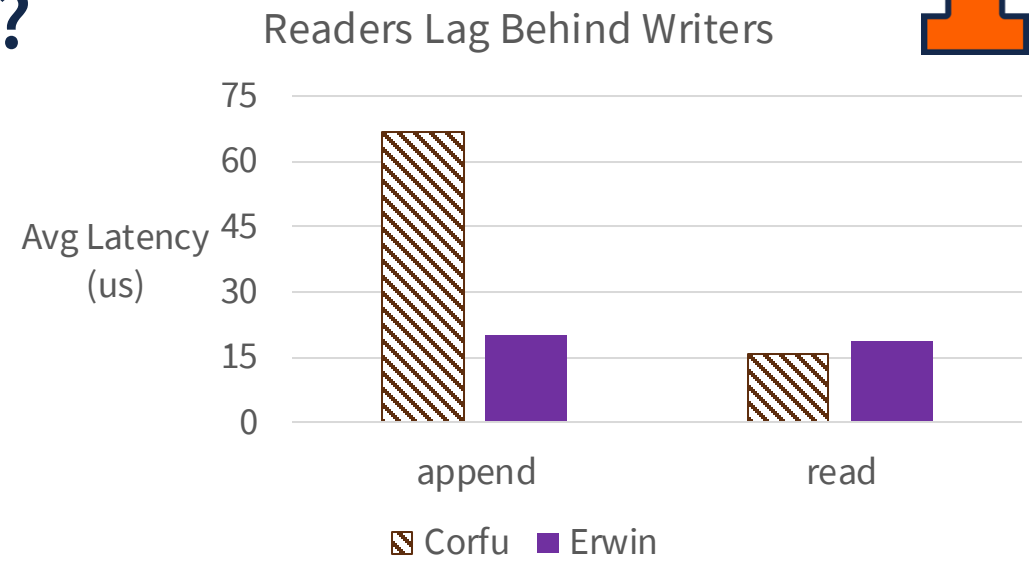

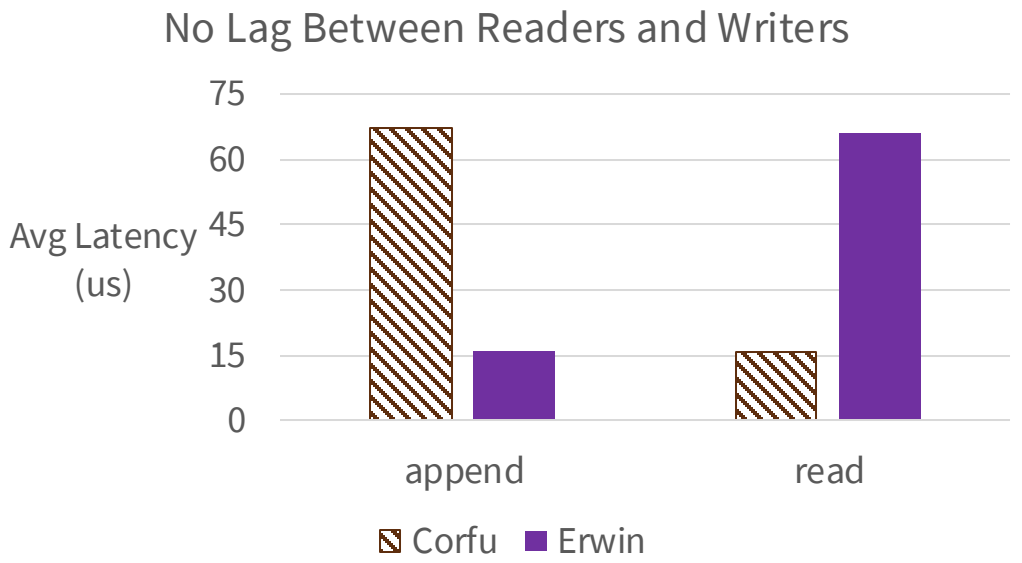

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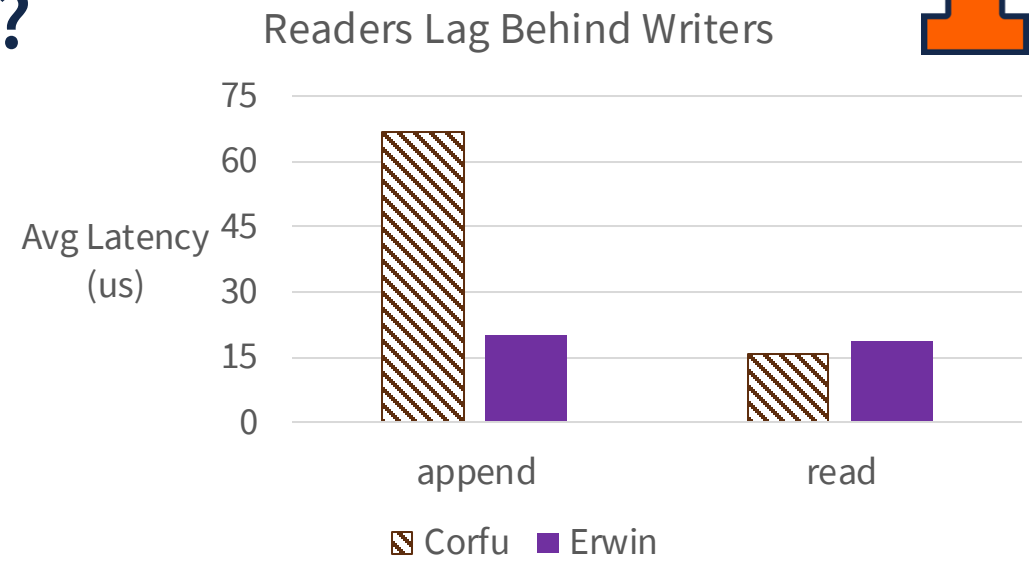

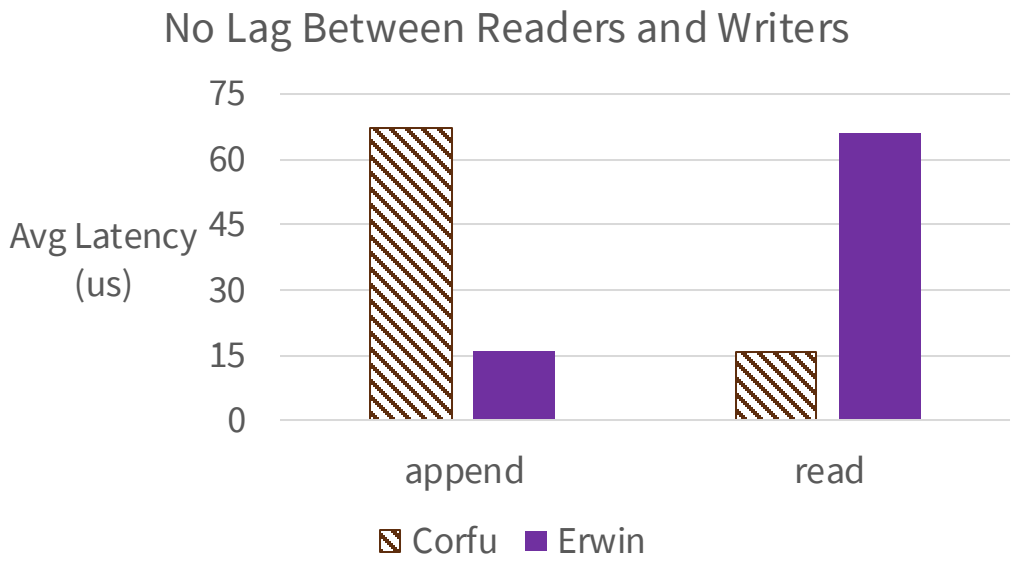

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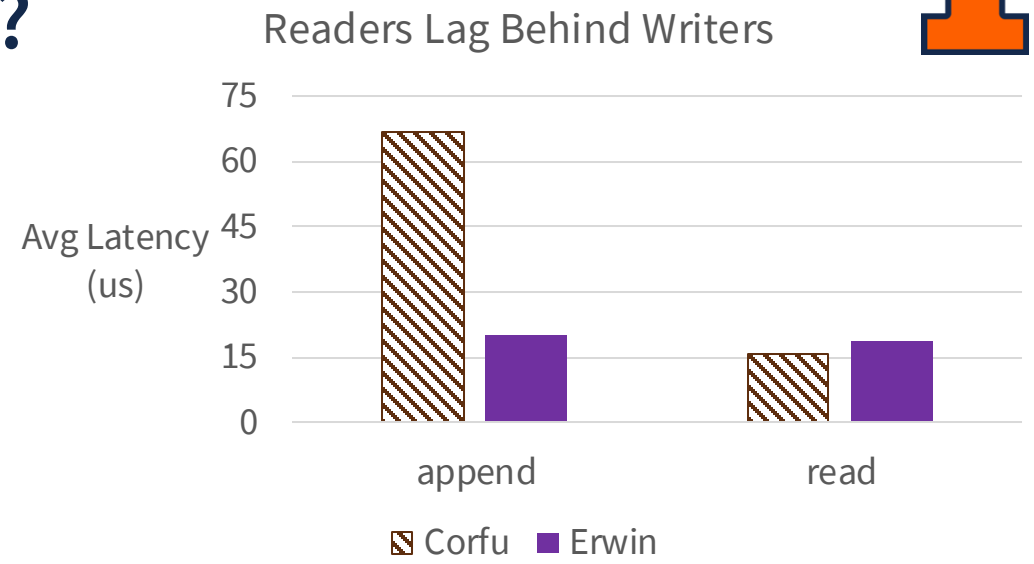

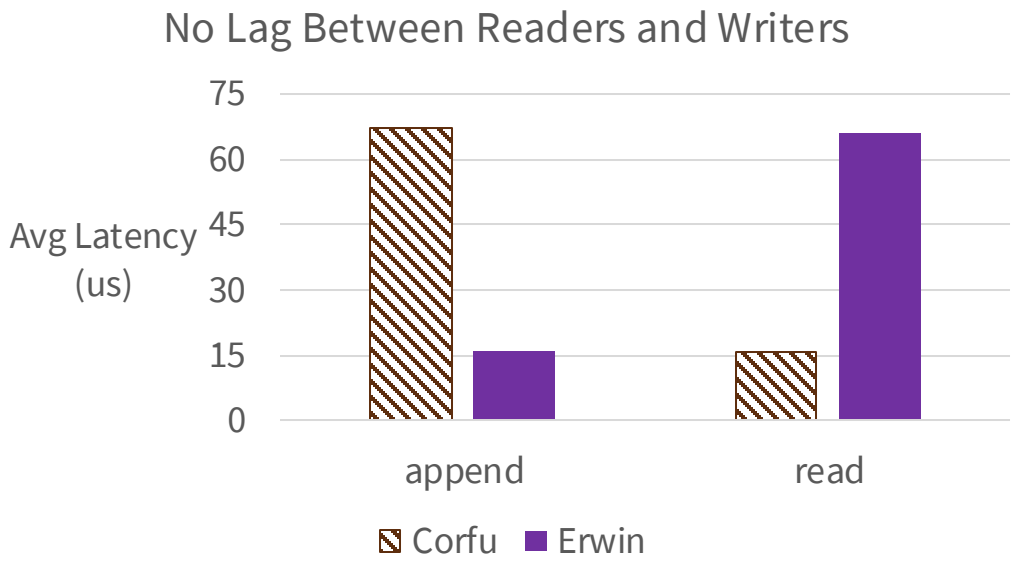

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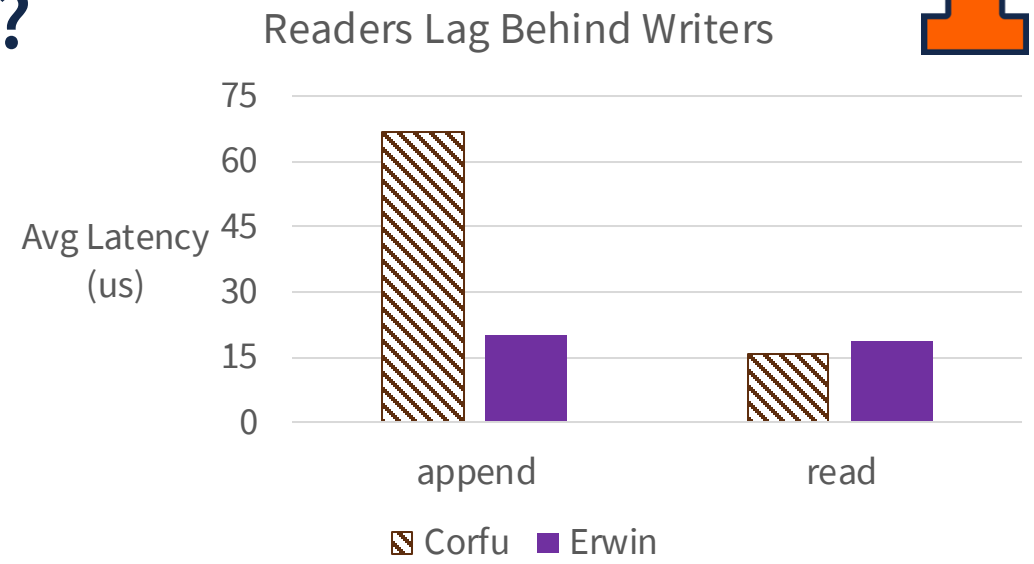

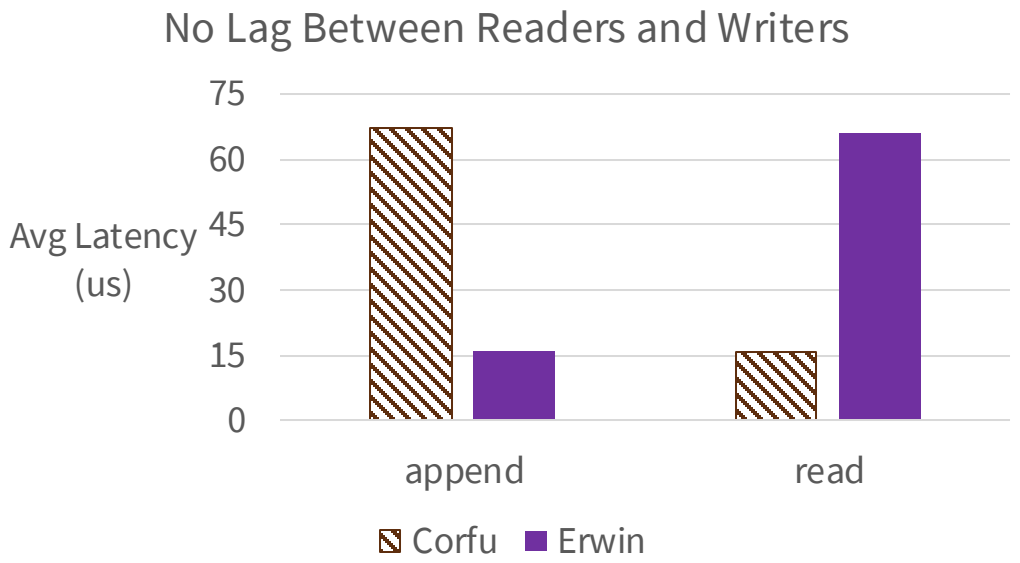

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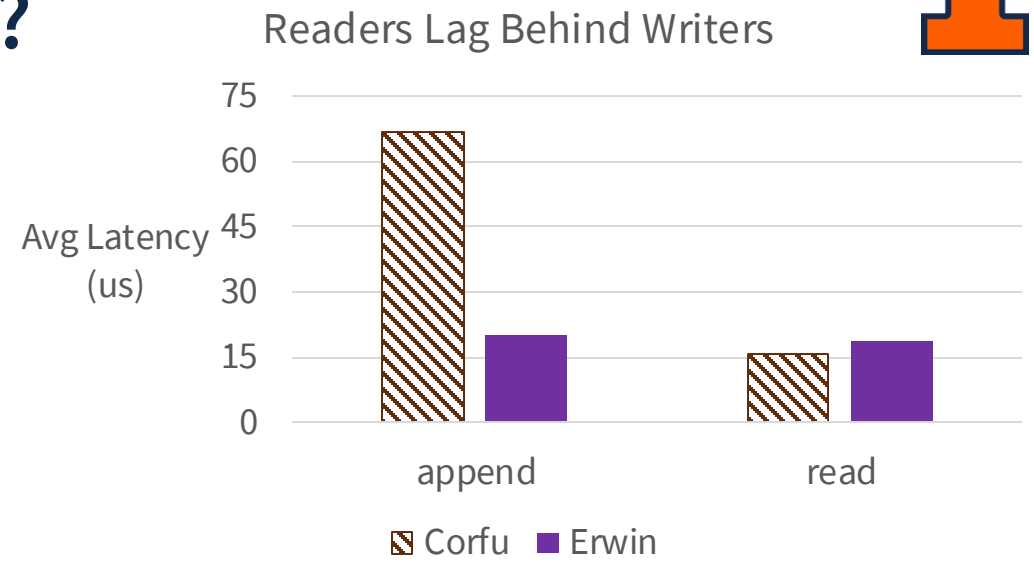

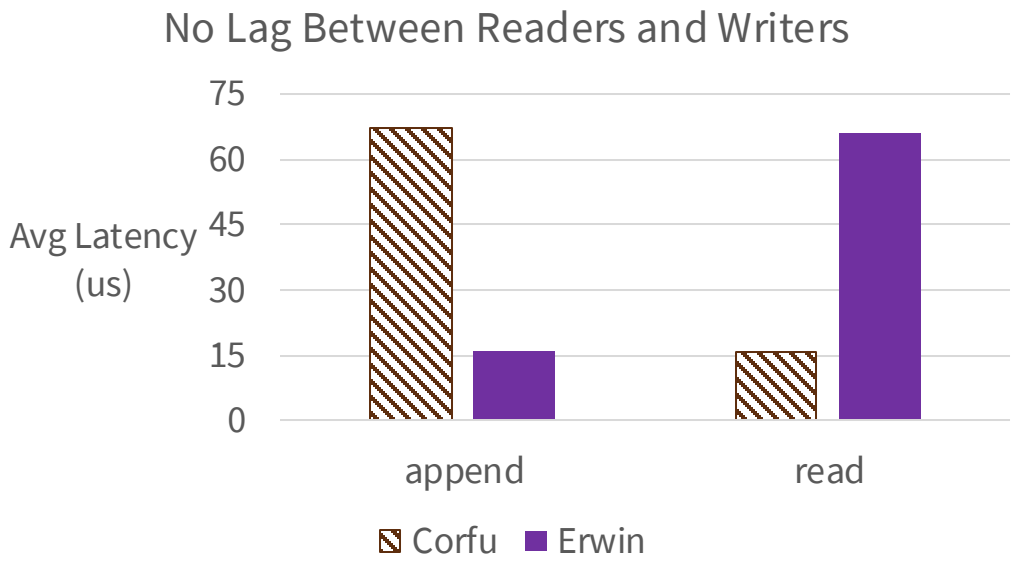

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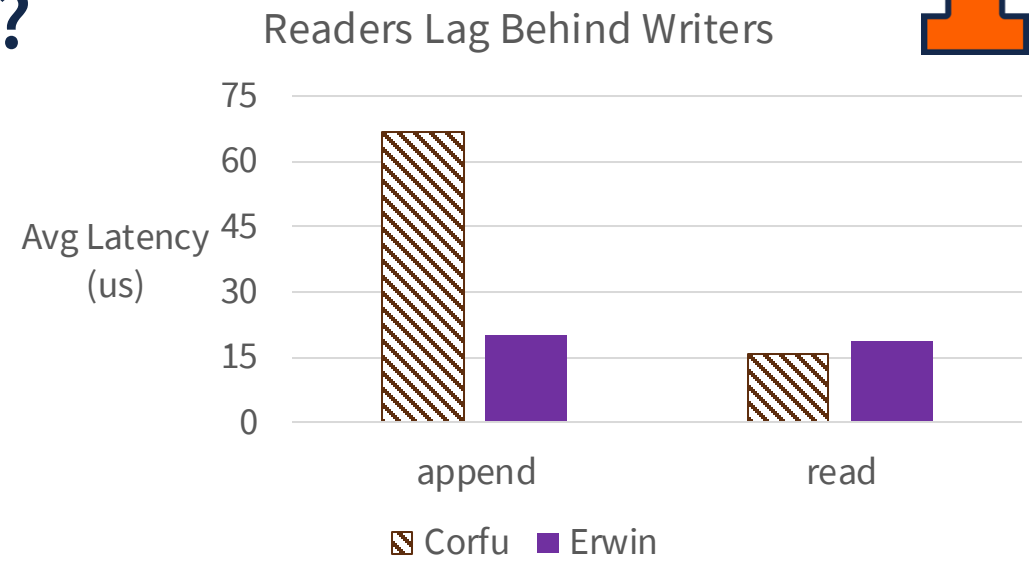

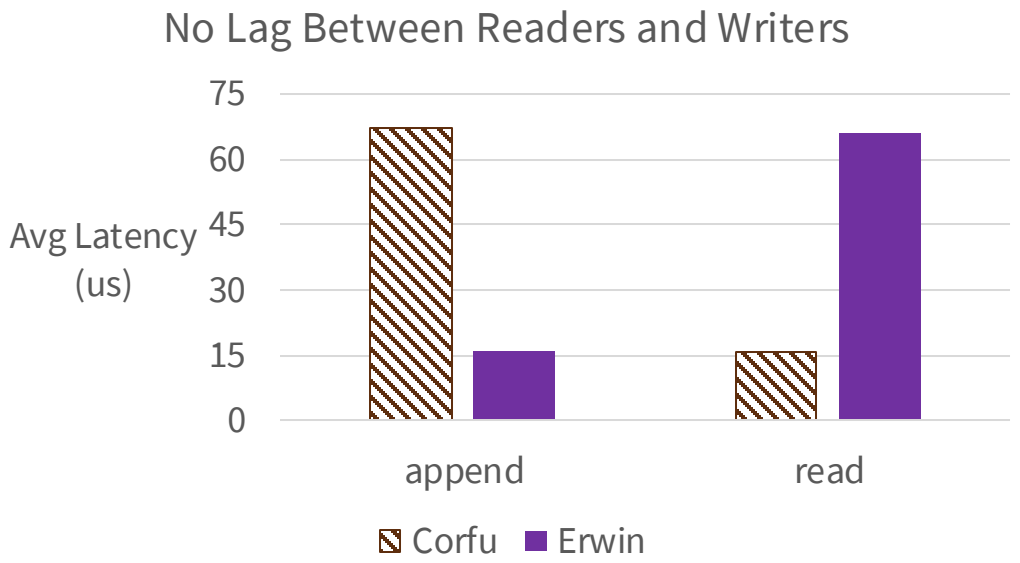

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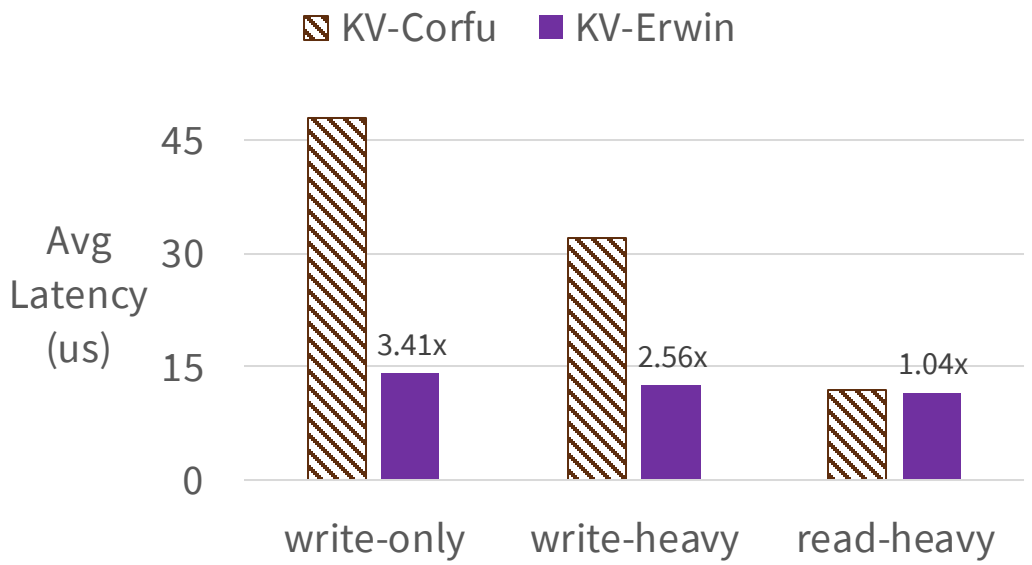

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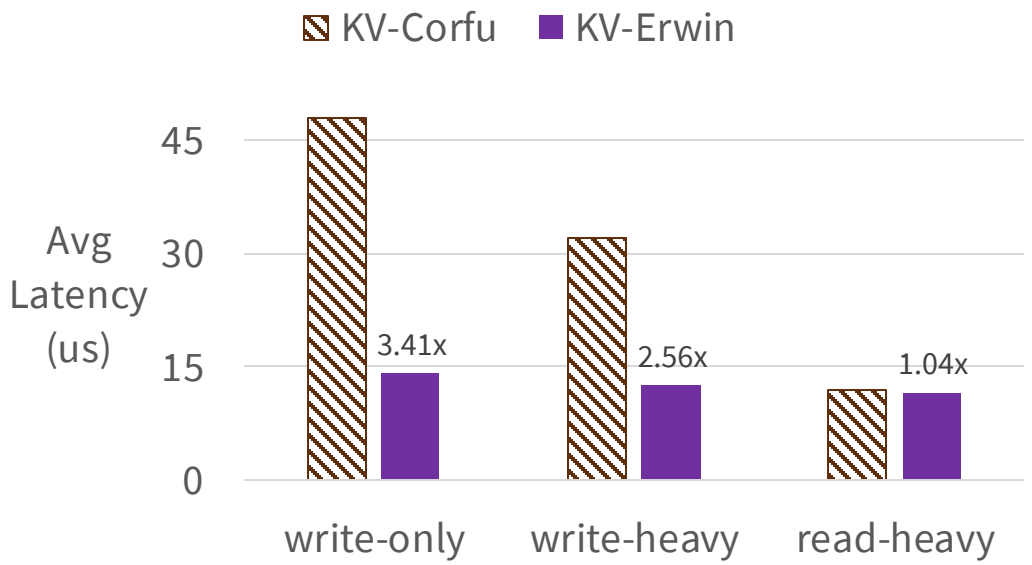

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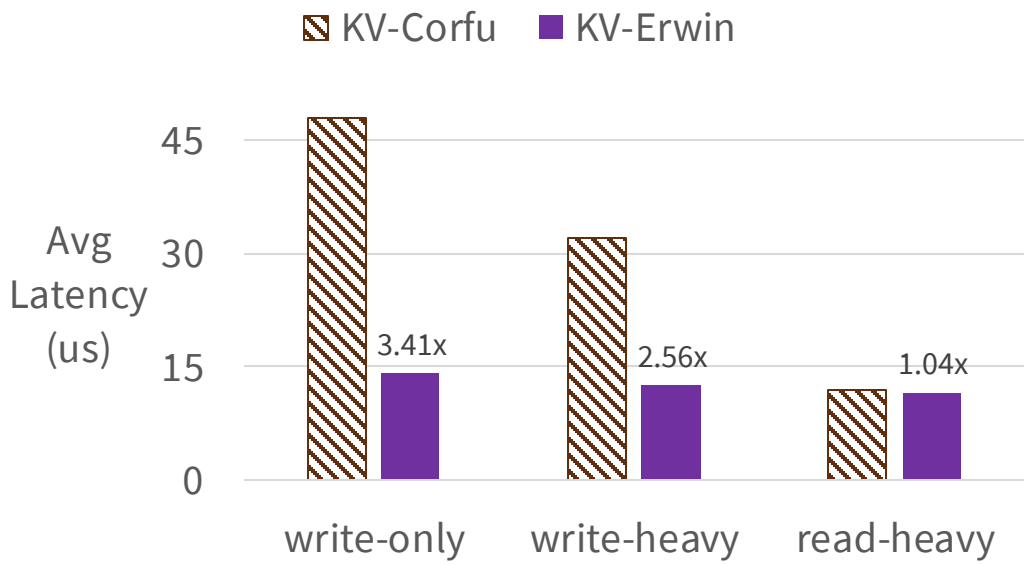

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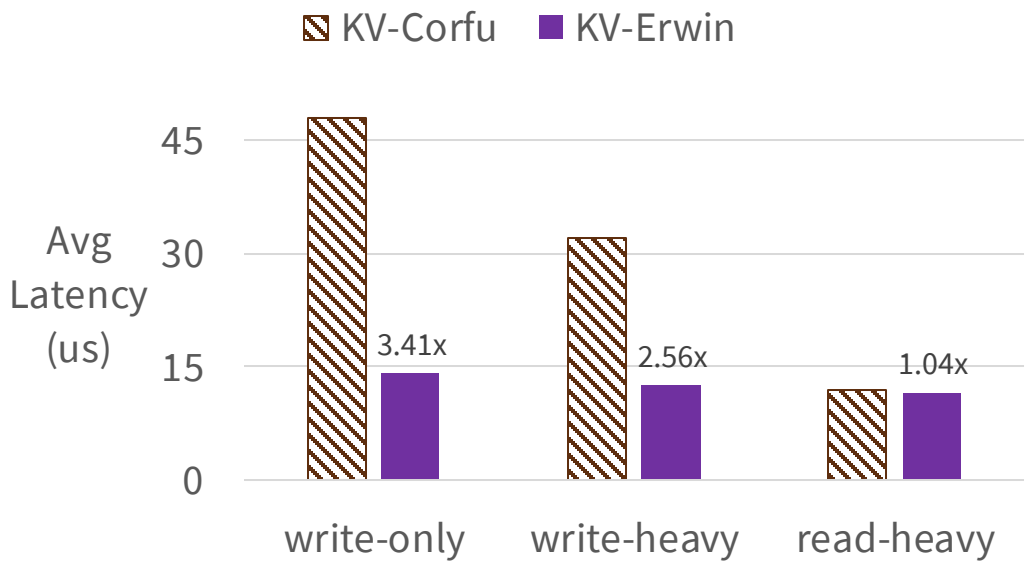
- Benefit is more pronounced when shared-log interaction takes significant partition of app request execution



More in the Paper

- More experiments in the paper
- Another implementation:
  - Erwin-bb (black-box): Treat shards as black boxes. Can work with any PB/Raft shard or even Kafka.

See our paper for more details

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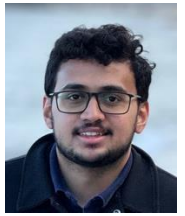
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