Making RAMCloud Writes Even Faster

(Bring Asynchrony to Distributed Systems)

Seo Jin Park

John Ousterhout

PLATFORMLAB

Stanford University

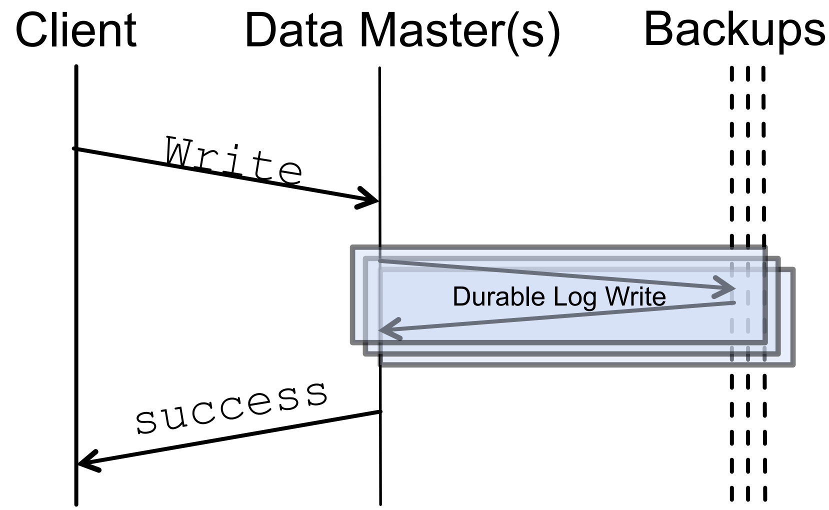
Overview

- **Goal:** make writes asynchronous with consistency.
- **Approach**: rely on client
  - Server returns before making writes durable
  - If a server crashes, client retries previous writes
- **Behavior is still consistent:** linearizable if client is alive
- **Anticipated benefits:**
  - Write latency: 15 μs → 6 μs (even with geo-replication)
  - Lower tail latency
  - Write Throughput: 2-3x higher
- **Some applications don't need durability of last 10ms**

Bring Asynchrony to RAMCloud

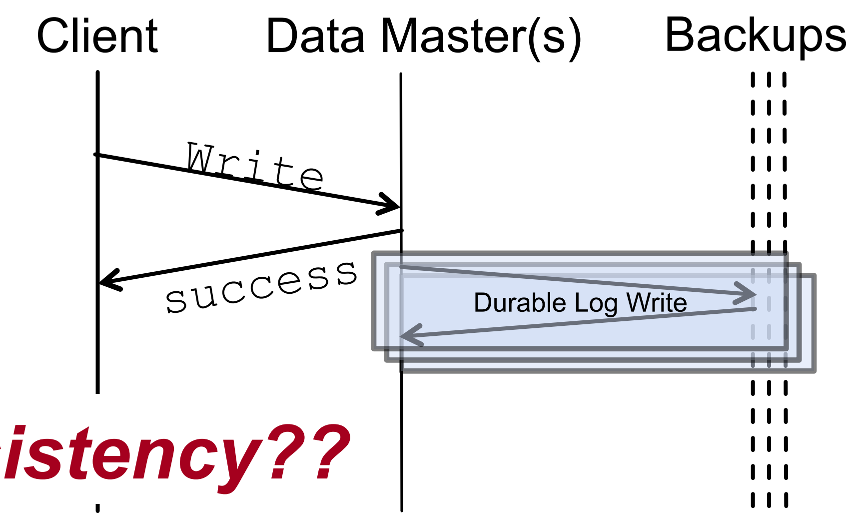
RAMCloud provides linearizability (current)

- Strongest form of consistency for concurrent systems
- Write is blocked while replication
- Write: 15 μs vs. Read: 5 μs
- Wastes cycles in server



Make durability for write happen asynchronously

- Should we give up consistency?



asynchrony = weak consistency??

Consistency in Performant Systems

- **Eventual consistency** is popular in distributed storage
  - Writes are asynchronously durable for best performance
  - Ex) Redis cluster, TAO, MySQL replication
- **Problem:** difficult to reason about the state of system
  - Clients may read different values.
  - Don’t know when updates will be applied
    - Cannot check update was durably queued
    - Write may get applied long after
- **New model: linearizable unless client crashes**

=> Similar to (stronger) **asynchronous file system**

API

- **asyncWrite**(tableId, key, value) → value, version

  … asyncCondWrite(), asyncIncrement() etc

- **sync**() → NULL <waits all updates are durable>

Possible APIs [Feedback requested: are they useful?]

- **rpc.sync**() → NULL <waits 1 update is durable>
- **sync**(CallbackFunc) → NULL

Example

```
ramcloud.asyncWrite(1, “Bob”, “2”);
ramcloud.asyncWrite(1, “Bill”, “2”);
ramcloud.sync();
printf(“Updated Bob and Bill”);
```

New Consistency Model

Durability for write happens asynchronously

Behavior is still consistent

1. **All reads are consistent**
   - Reads are blocked until data become durable
2. **Writes are linearizable unless client crash**
   - When a server crashes, client retries previously returned writes.

- Write is lost only if both client and server crash
- Client may wait for durability before externalization
- Conditional write is still consistent and possible

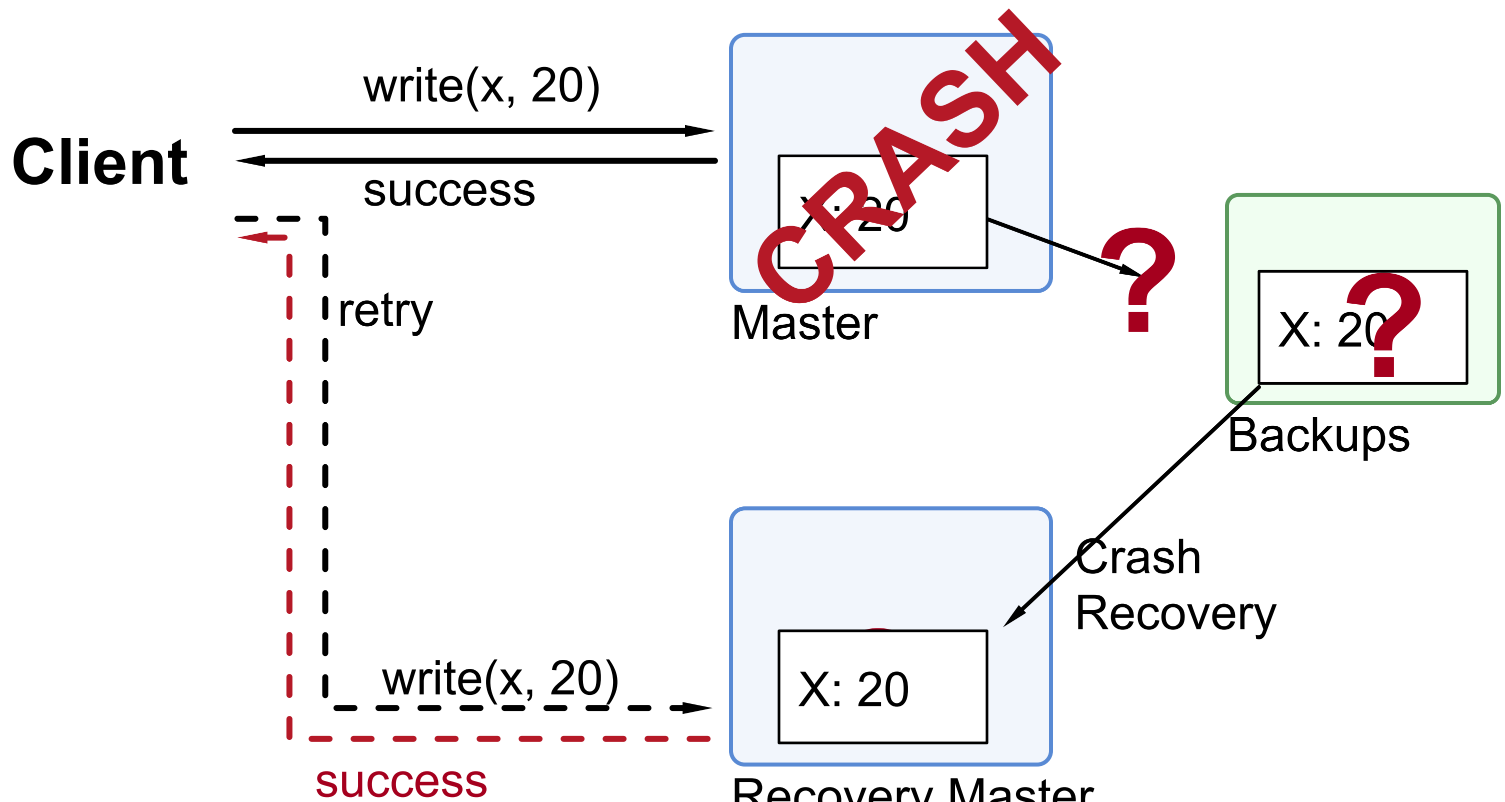
Maintaining Linearizability in Server Crash

In server crash, client retries previously returned writes

- **Goal: Restore the same state as before server crash**
- **Issue 1: Retry may re-execute the same write request**
  - If a server crash, a write may or may not be recovered.
  - Client retries operations that are not yet known to be durable.
  - The retried write may get re-executed, which overwrites and reverts subsequent updates by other clients
- **Issue 2: Retries from different clients may be out of order**
  - End state of system will be different
  - Previously succeeded conditional write may fail (client sees inconsistency)

Issue 1: Retry may re-execute

- **RIFL** (Reusable Infrastructure for Linearizability) [SOSP15] **will let server ignore already completed writes**

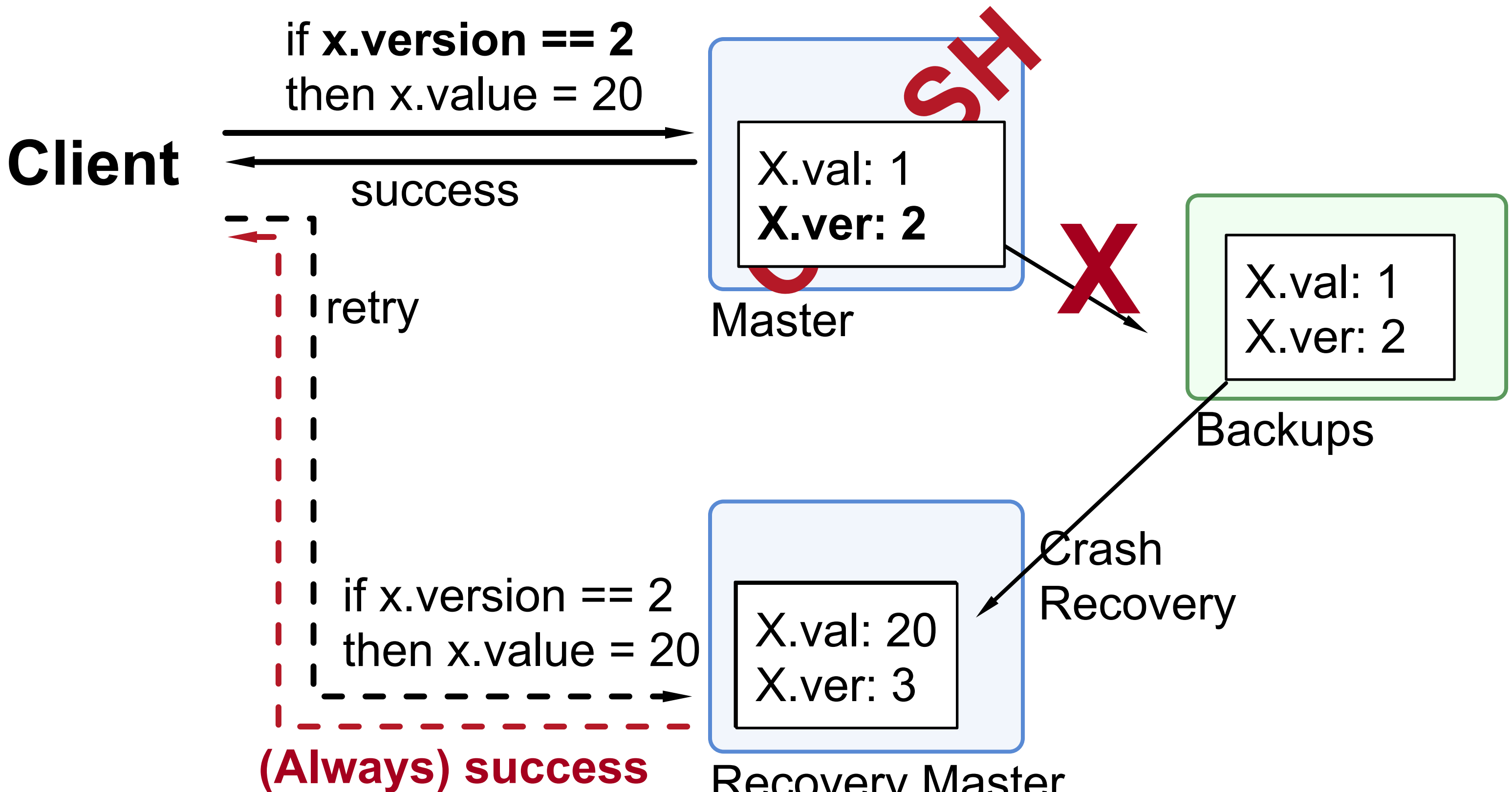


Issue 2: Out of Order Retries

- **Retries from clients may arrive with different order from original execution => linearizability in danger!**
- **Option 1) Use object version to decide final winner**
  - Write: okay
  - Conditional write: can be handled specially.
  - Append? Not possible.
- **Option 2) Allow only 1 not-replicated write: overwrites wait for durable**
  - Any deterministic operations are okay.
  - Weakness: continuously overwritten object can be bad.

Feedback requested:
Is it common and real problem?

Issue 2: Out of Order Retries



Anticipated Benefits

- **Reduces RAMCloud write latency**
- **Completely decouples write latency and replication latency**
  - Consistent **geo-replication** becomes practical
  - Reduced **tail latency:** not affected by 3 backup servers
- **More efficient threading model in servers**
  - No need to spin wait for replication
  - Dedicated replication thread is possible
  - Improves **write throughput** of RAMCloud **2-3x**

Possible Applications?

1. **Don’t care about durability**
   - Durability of last 10ms may not be important
   - Ex) Real-time doc sharing: user cannot distinguish from typo
2. **Split of update / validate clients**
   - End-user can check write was failed. If failed, retry.
   - No surprise resurrection! Validation by read is possible.
   - Ex) Purchase item, redirect to order confirmation page, which is rendered by different web server. Human notices and retries.
3. **Many updates before externalization**
   - Simply sync() before externalizing the success of writes.
   - Any experiences on this?

Need help!

Questions

- **Applications?**
  - How does current web applications use no-sql DB?
- **How useful is ordering guarantee?**
  - Is it important to have some ordering for durability?
- **Callback based API?**
  - Is a single final response to request the only externalization?

Challenges

- **Client-side threading model for accurate timer**

Conclusion

- **Rely on client retry if server crash →** strong consistency with asynchronously durable writes
- **Decoupling durability from critical path can improves performance** (latency ↓, throughput ↑)
- **RIFL** (Reusable Infrastructure for Linearizability) eases design and reasoning of consistency

Q&A