Beyond reCAP: Local Reads and Linearizable Asynchronous Replication

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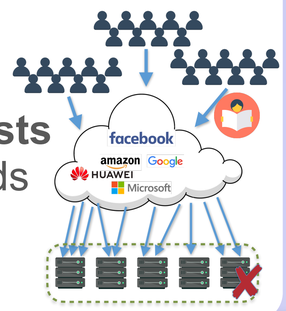
Motivation

Online Services & Cloud Applications

Characterized by
- Many **concurrent requests**
- **Read intensive** workloads
- Need for **data reliability**
  → run on fault-prone h/w



Fault-tolerant Replicated Datastores

- **Crash-tolerance**: data are replicated
- **High performance**: especially for reads
- **Strong consistency** under **asynchrony**
  → correct — even if timeouts do not hold

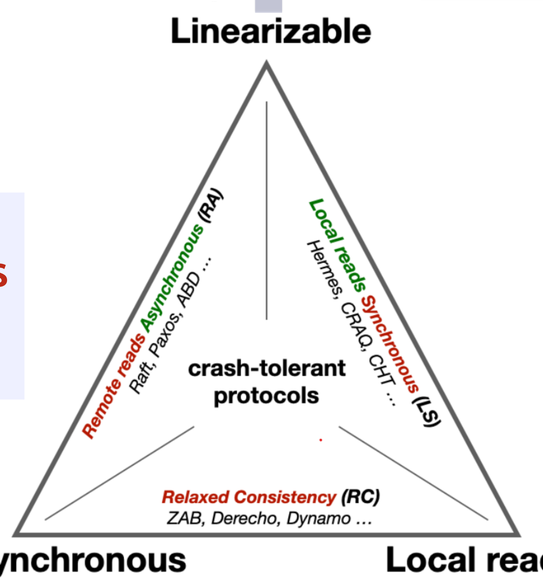
Crash-tolerant Replication Protocols

determine actions for *reads* and *writes*

Ideal features
1. **Linearizable**
2. **Asynchronous**
3. **Local reads**: for max perf.

Theory

Crash-tolerant protocols: 2 out of 3



RA protocols:
- Remote (costly) reads
+ Linearizable
+ Asynchronous

LS protocols:
- Synchronous
+ Linearizable
+ Local reads

RC protocols:
- Relaxed Consistency
+ Asynchronous + Local reads

The L²AW theorem

Any ***L**inearizable* ***A**synchronous* read/write register implementation that tolerates a crash (**W**ithout blocking reads or writes), has no ***L**ocal reads*.

So can we not improve read performance without compromizes?

L²AW vs. CAP

Both Linearizability & Asynchrony

L²AW read performance in its tradeoff
Key for read-dominant workloads

Fault-tolerance

CAP: network partitions
+ msg loss + partitioned nodes exec ops to violate safety

L²AW: server crashes
+ no msg loss + crashed nodes do not exec ops to violate safety

When must compromise?

CAP: during network partitions (not during partition-free) sacrifice safety or progress of ops

L²AW: always sacrifice local reads (even if crashes have not occurred)

Practice

Almost Local Reads (ALRs)

Inevitably ALR latency > local reads
But **little or no extra** network and processing **costs to remote replicas**

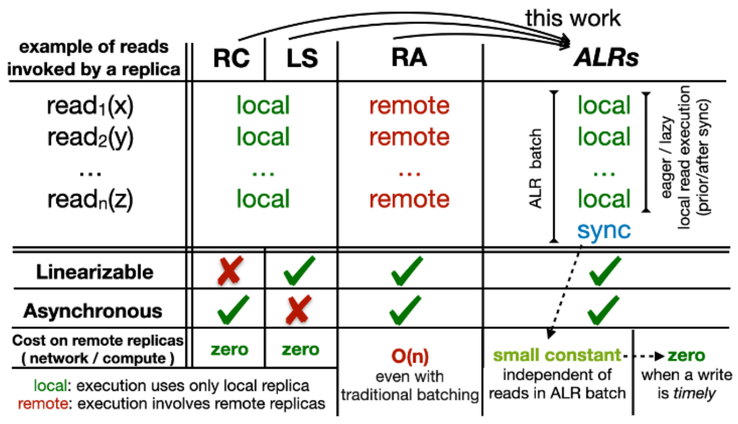
ALRs batch reads with a twist

Exec all reads in batch w/ local replica
+ one sync per batch on remote nodes

Syncs are cheap!

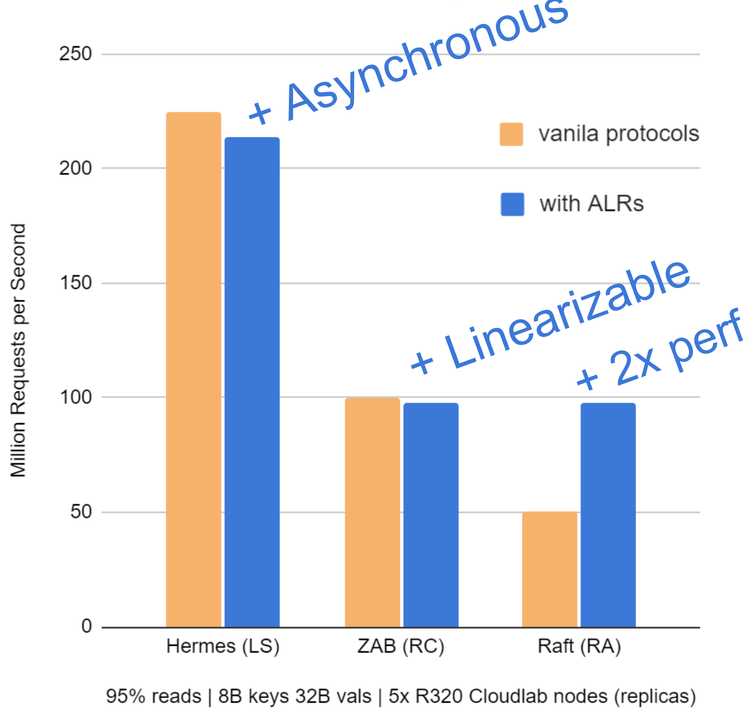
- writes act as implicit zero-cost syncs
- explicit sync has small constant cost
- 1 sync per batch regardless its size

Add missing piece to protocols of all 3 (RC, LS, RA) categories



✓ **RC with ALRs → Linearizable**
✓ **LS with ALRs → Asynchronous**
✓ **RA with ALRs → Performant**

ALR-enhanced throughput of state-of-the-art protocols



95% reads | 8B keys 32B vals | 5x R320 Cloudlab nodes (replicas)

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†This work occurred when the authors were at the University of Edinburgh.