TAO: Facebook's Distributed Data Store for the Social Graph

Presented by Zongheng Yang
CS294 Big Data

Nov 9, 2015

Graph stores in the wild

Graph stores in the wild

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twitter / **flockdb**

A distributed, fault-tolerant graph database

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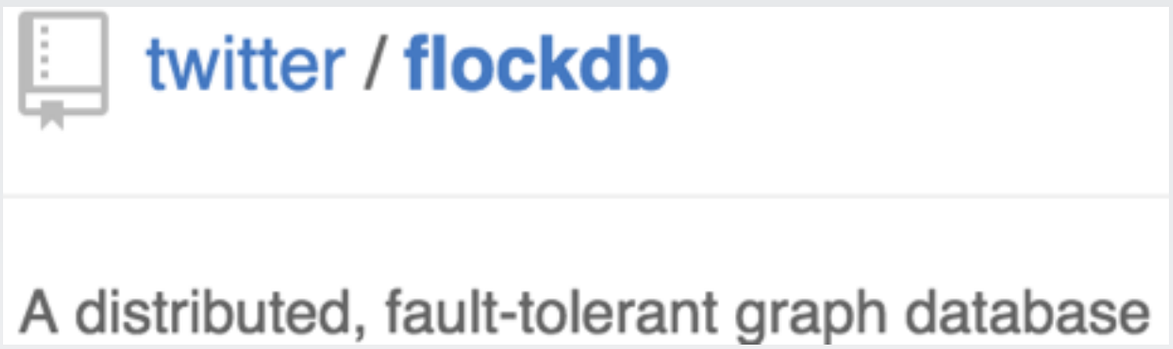

LinkedIn's GraphDB

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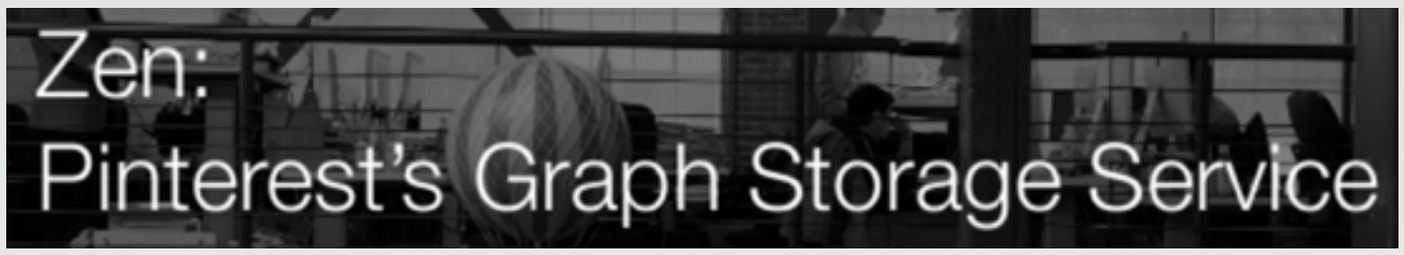

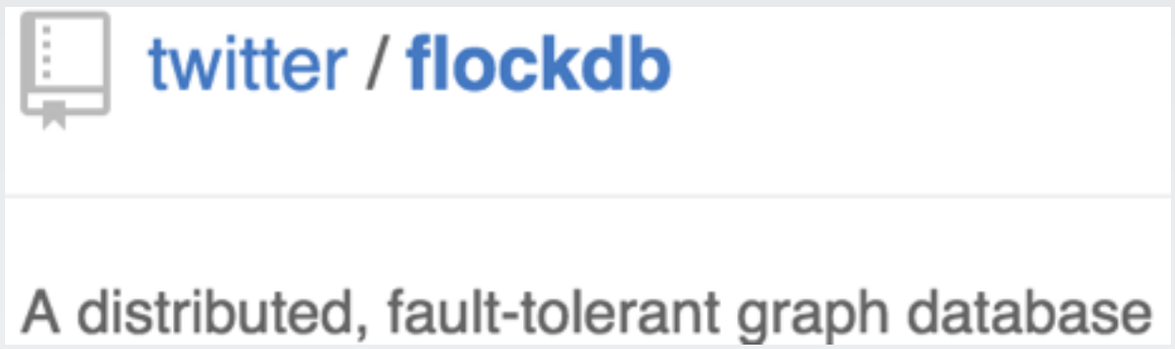

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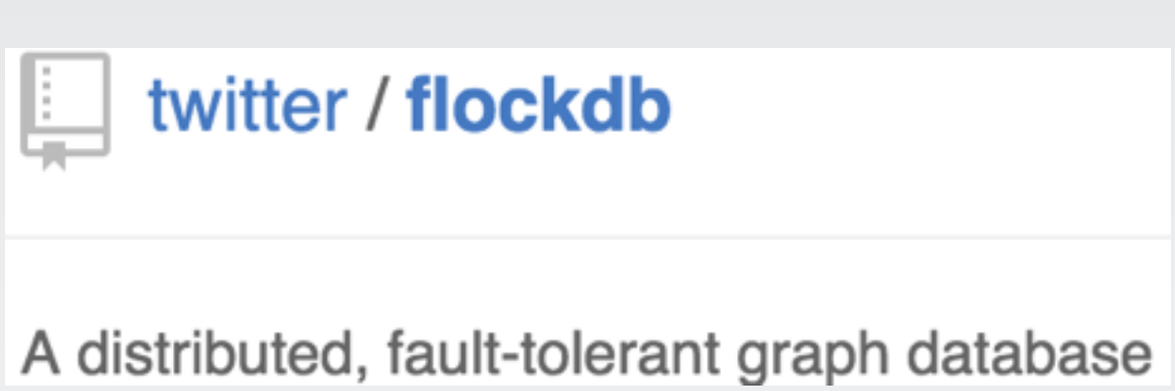

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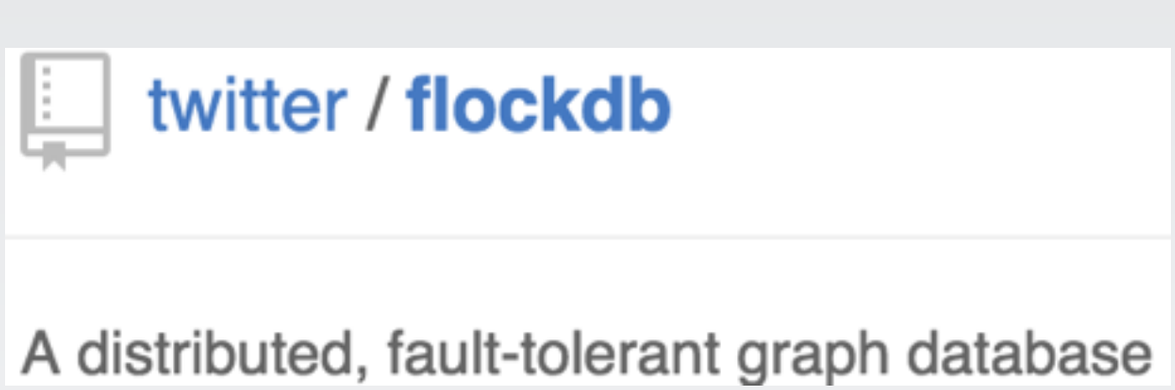


LinkedIn's GraphDB

Graph stores in the wild

neo4j

twitter / flockdb

A distributed, fault-tolerant graph database

TITAN

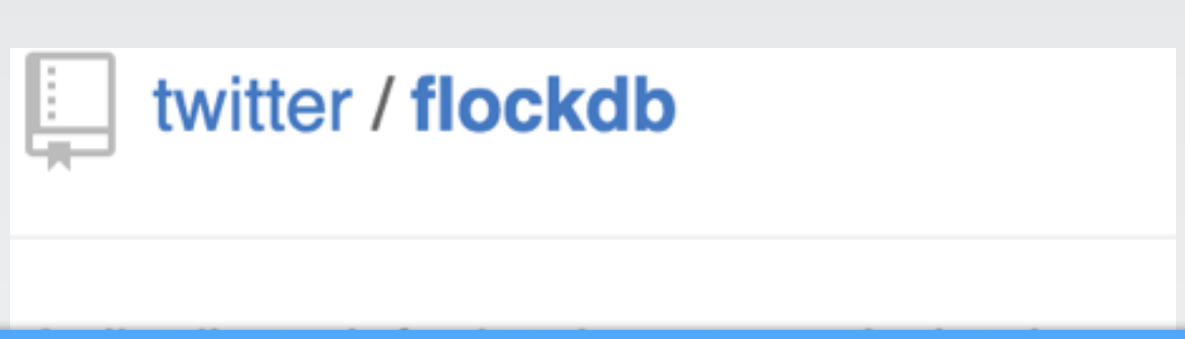
LinkedIn's GraphDB

OrientDB®

Key diff. from Graph Processing: user-facing!

Graph stores in the wild

neo4j



Very active space, both in industry & academia

Key diff. from Graph Processing: user-facing!

Graph stores in the wild

neo4j

Huge variance in scale and approach

Very active space, both in industry & academia

Key diff. from Graph Processing: user-facing!

Problem

User-facing serving of a billion-node, trillion-edge social graph

- FB full graph in O(petabyte), not gonna fit in my laptop

Extremely high read load, due to freshness & privacy filtering

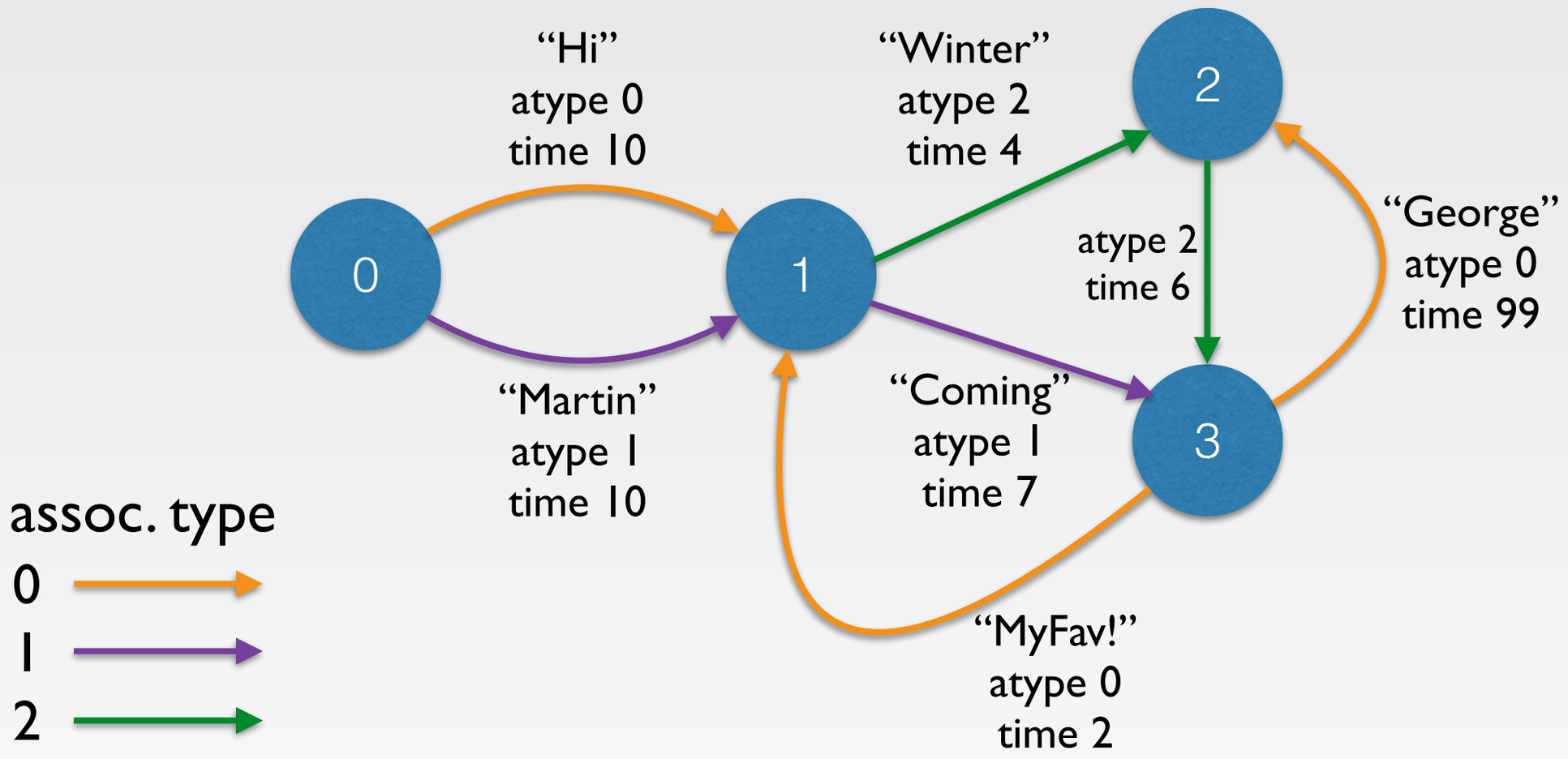
- sustained > one billion queries per second

Previous approach: lookaside memcache + MySQL:

1. KV pair is inefficient
2. expensive read-after-write consistency

Data Model

Object: (id) → (otype, (key → value)∗)
Assoc.: (id1, atype, id2) → (time, (key → value)∗)
Association List: (id1, atype) → $[a_{\text{new}} \ldots a_{\text{old}}]$



API

CHECKED_IN → [(id 123, time 11/8/2015 9:30am), …]

LIKED → [(id 123, time 11/8/2015 11am), …]

```
assoc_range(src, atype, off, len)
obj_get(nodeId)
assoc_get(src, atype, dstIdSet, tLow, tHigh)
assoc_count(src, atype)
assoc_time_range(src, atype, tLow, tHigh, len)
```

“50 most recent check-ins to Golden Gate Bridge”

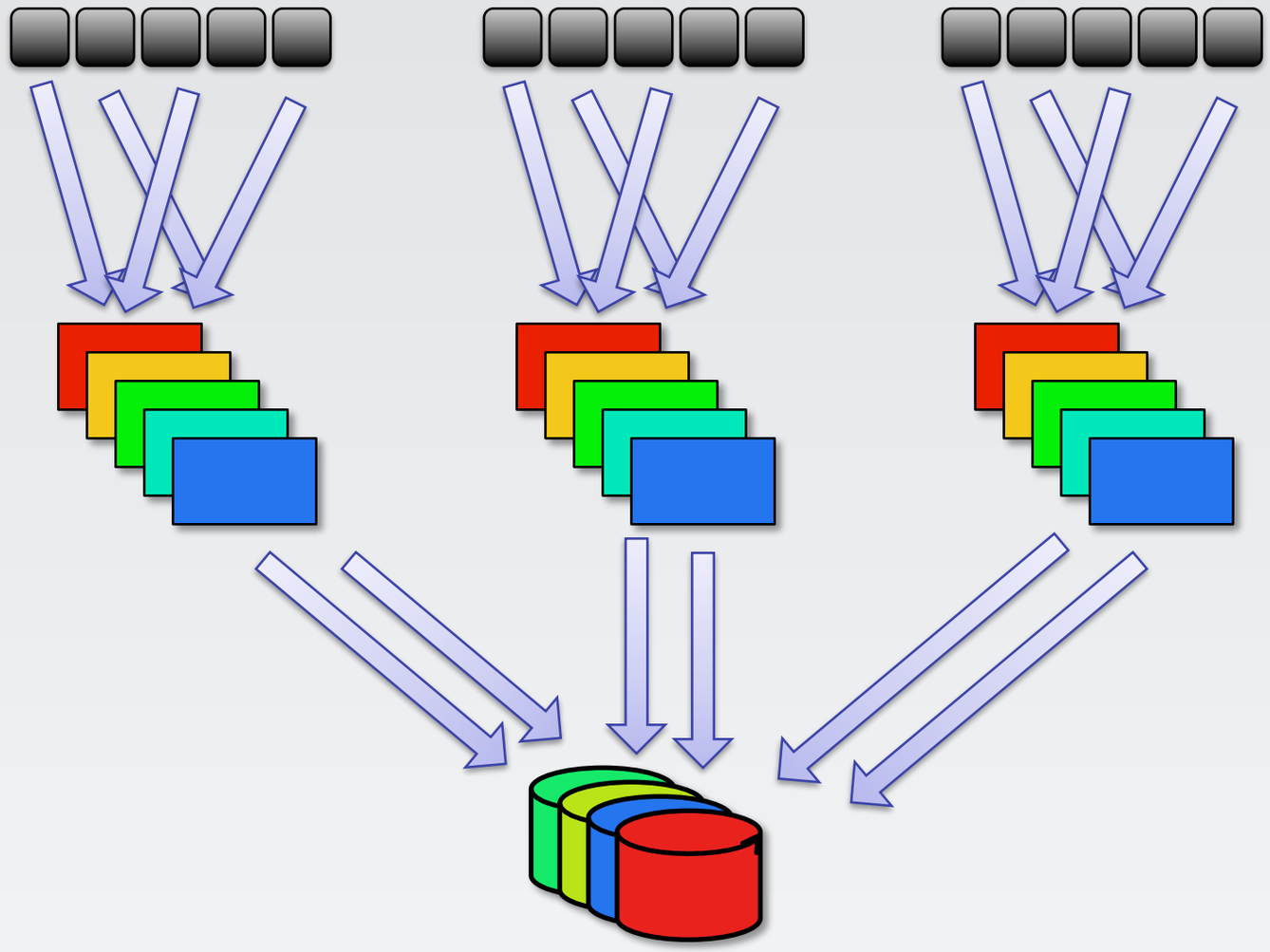
“10 most recent check-ins within last 24hr”

Architecture

Web servers

Cache

Database



Adapted from Bronson et al., ATC 13

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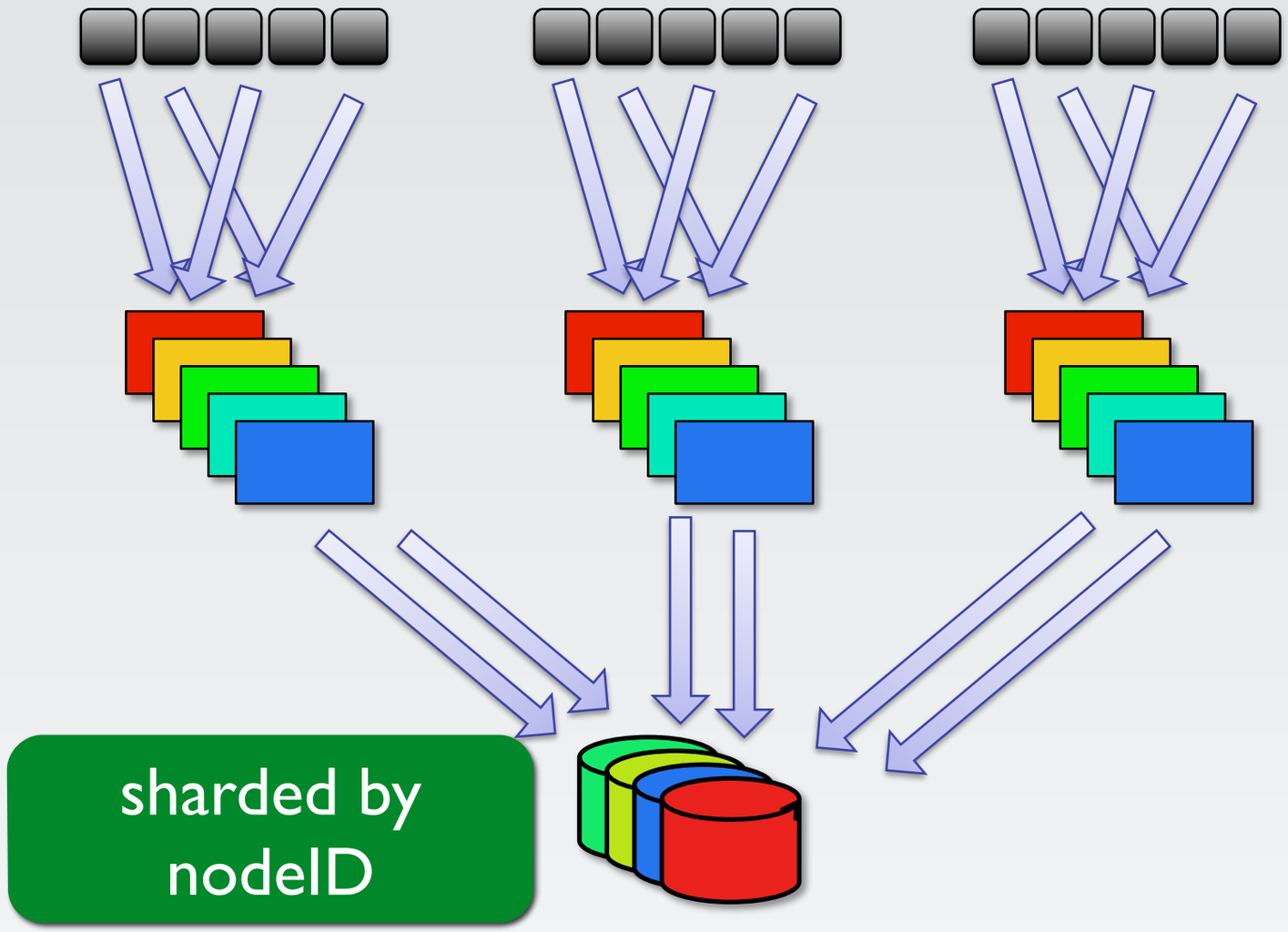

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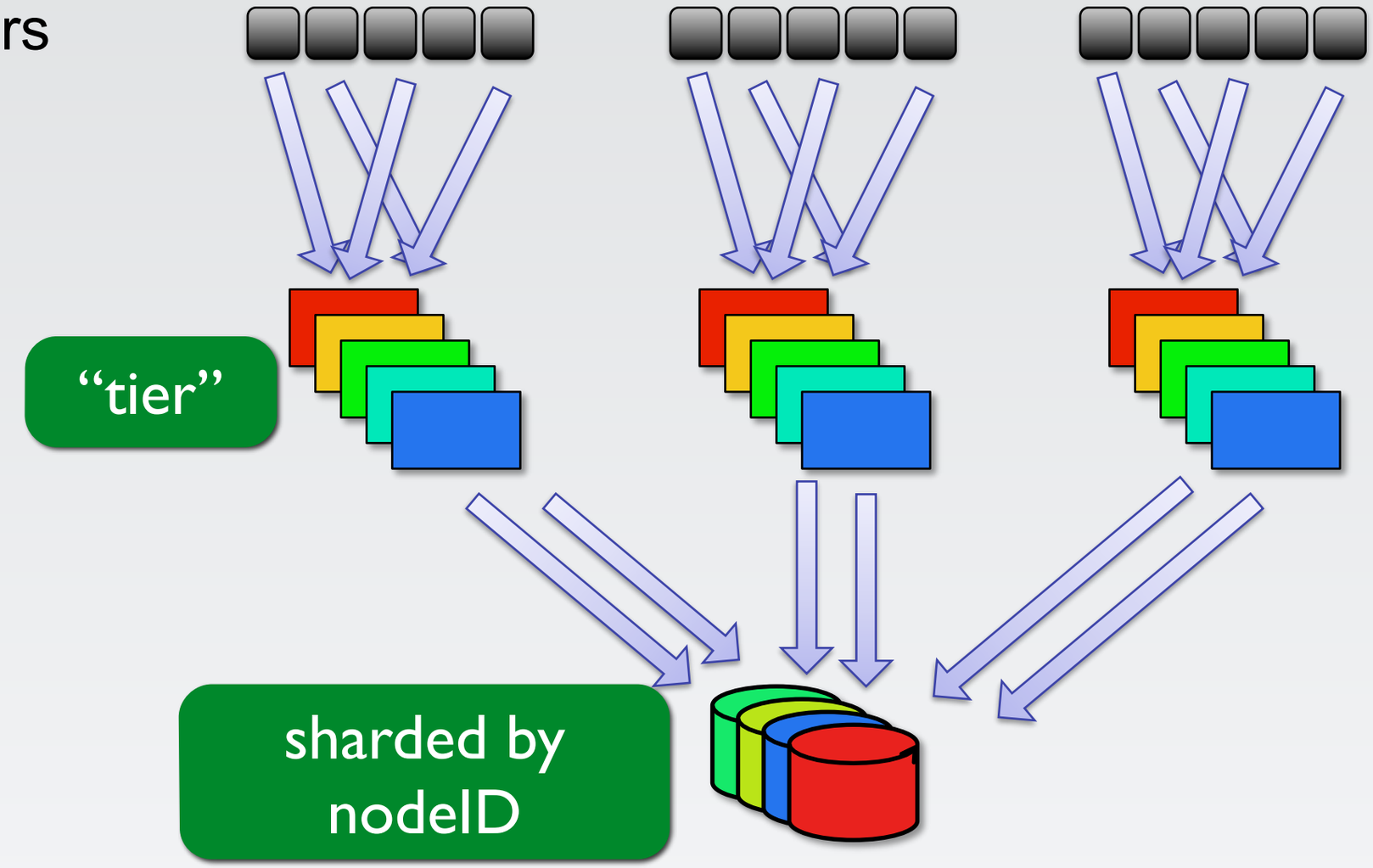

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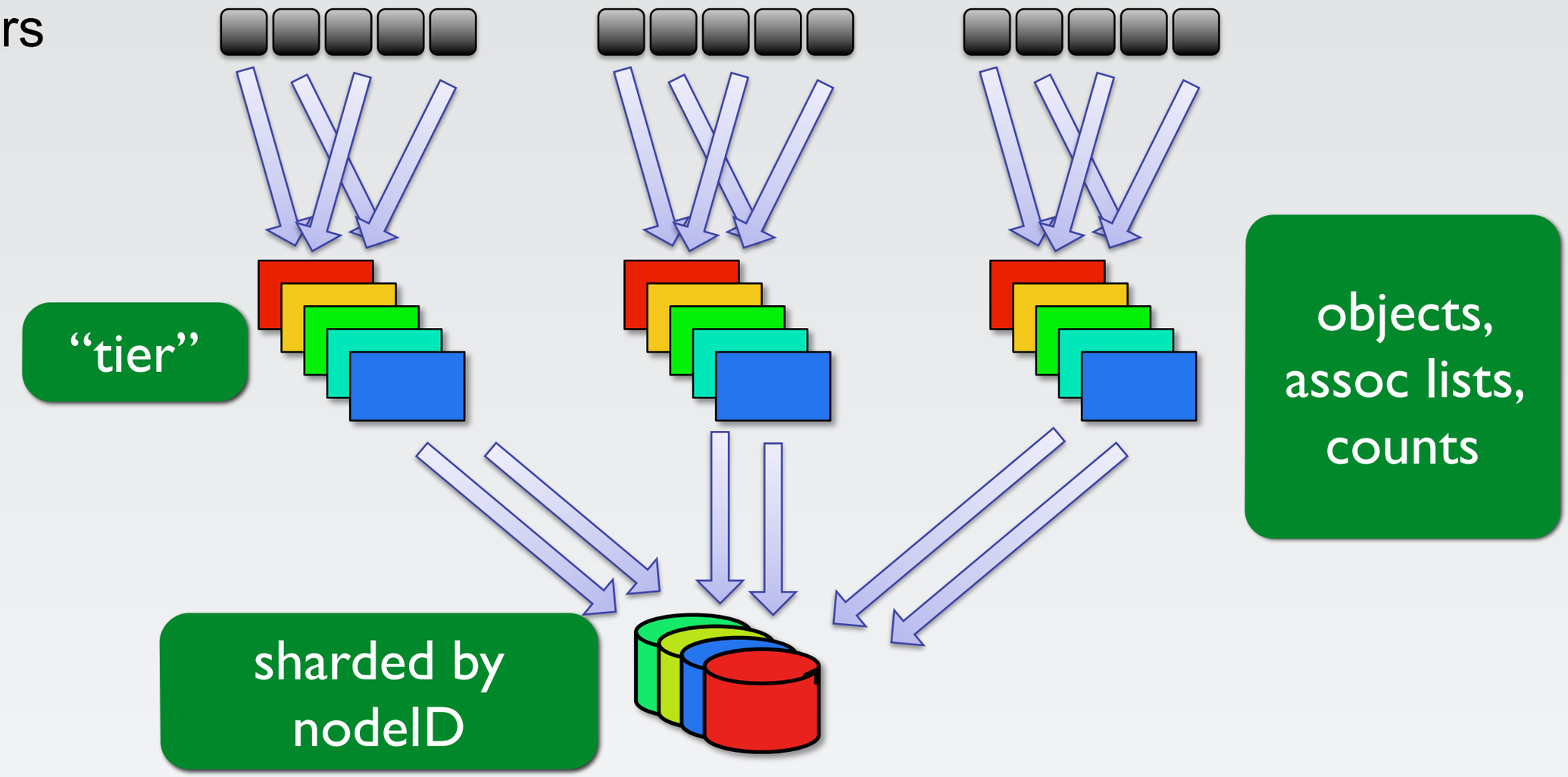

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Add more servers to the caching layer

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Two-layer hierarchical caching

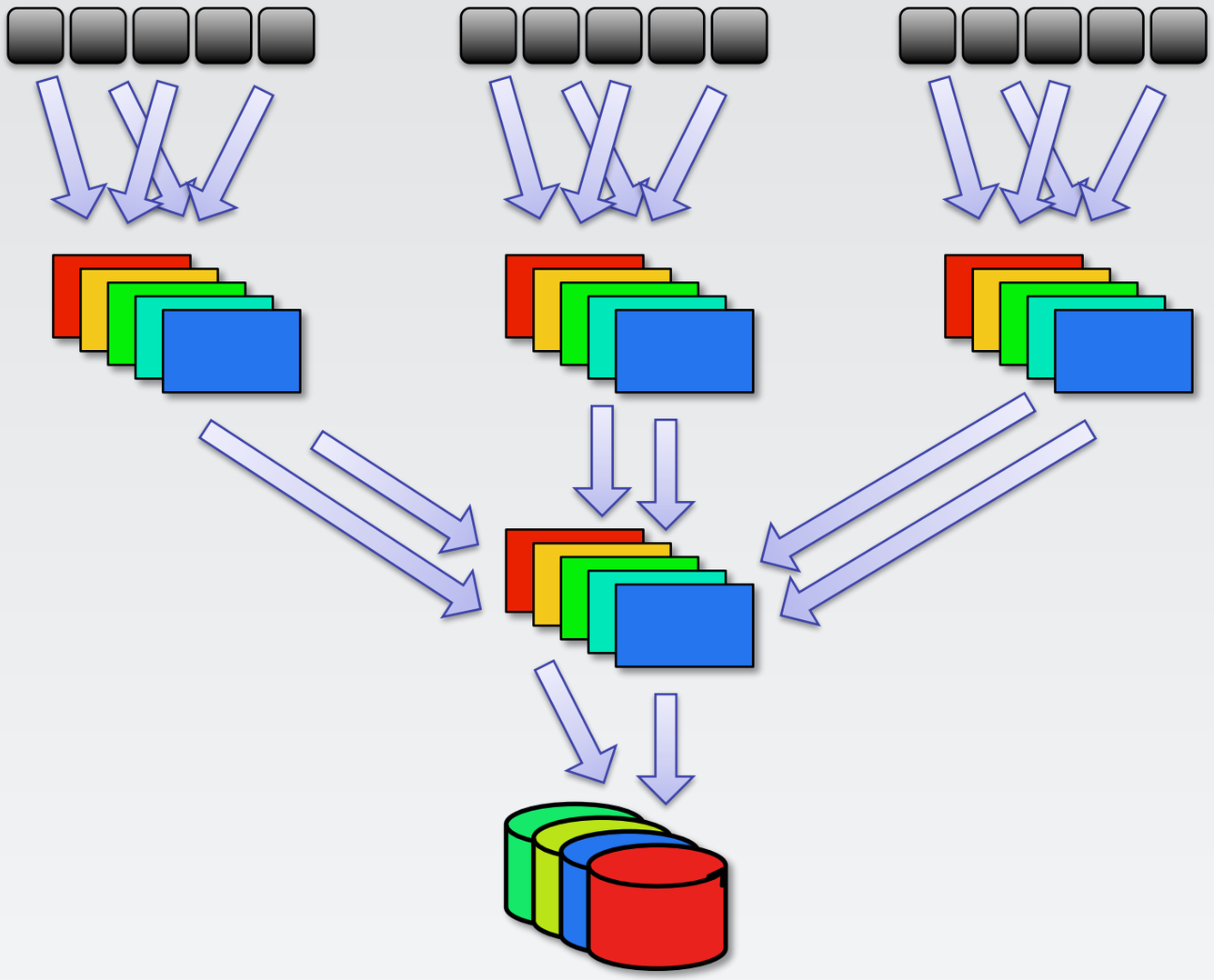
Two-layer caching

Web servers

Follower cache

Leader cache

Database



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Availability

- Key idea: a "tier" covers all ID space, can answer any query

- Follower failure: failover to another follower tier

- **Leader failure: follower talks directly to database**
  - 0.15% of follower cache misses

- **Database failure:**
  - If DB in master "region" down, promote a slave
    - 0.25% of a 90-day sample
  - If slave DB down: route to master

Write Path

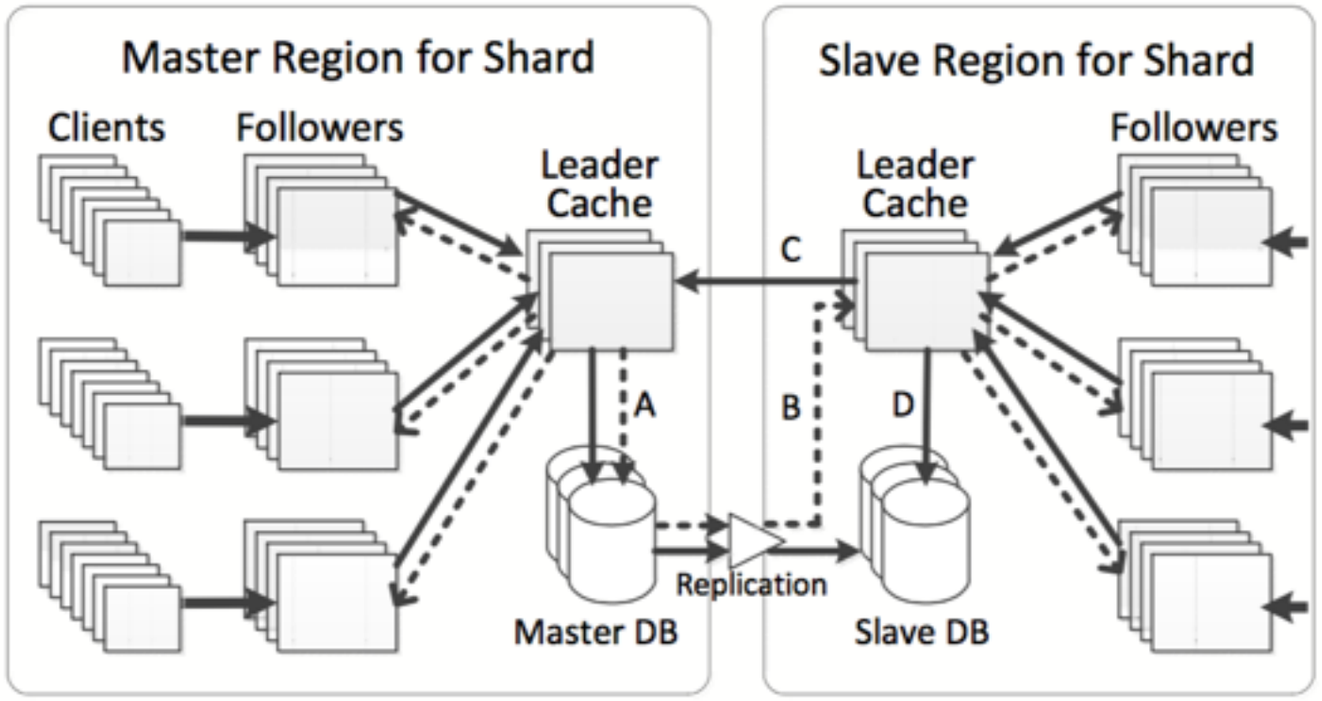
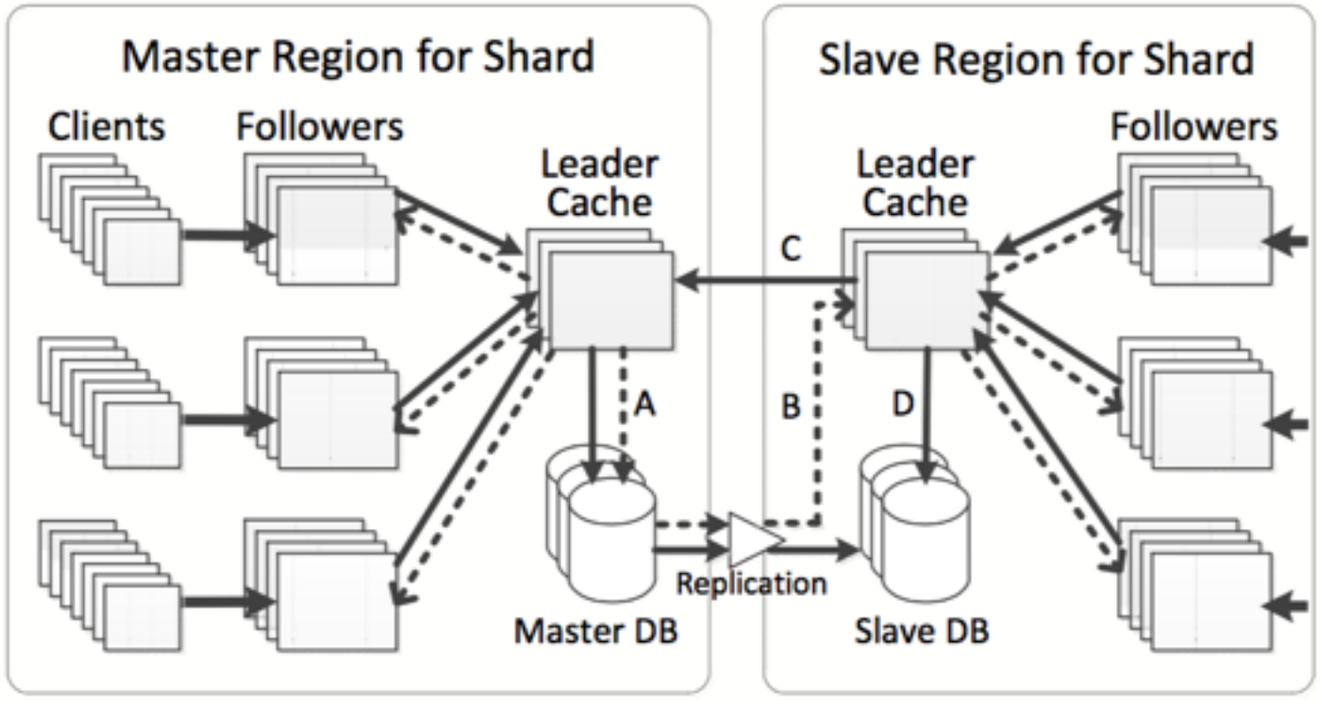


Figure 2: Multi-region TAO configuration. The master region sends read misses, writes, and embedded consistency messages to the master database (A). Consistency messages are delivered to the slave leader (B) as the replication stream updates the slave database. Slave leader sends writes to the master leader (C) and read misses to the replica DB (D). The choice of master and slave is made separately for each shard.

- **On write to node:**
  - leader sends <u>invalidate message</u> to other followers
- **On write to edge:**
  - leader sends <u>refill message</u> (why?)
- More complicated when inter-region repl. is involved (see Figure)

Consistency



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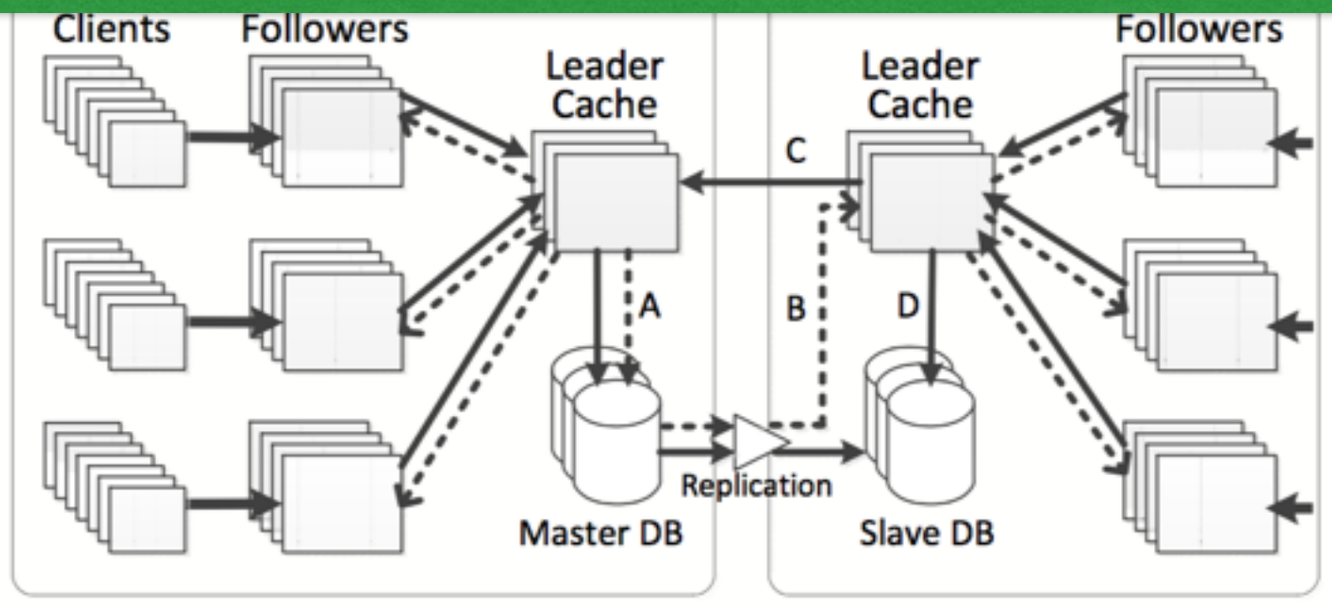
- As a whole, TAO is eventually consistent
- Within a tier, read-after-write consistency
- Trick: route critical queries to master region for strong consistency

But, with failures, if client writes N things…



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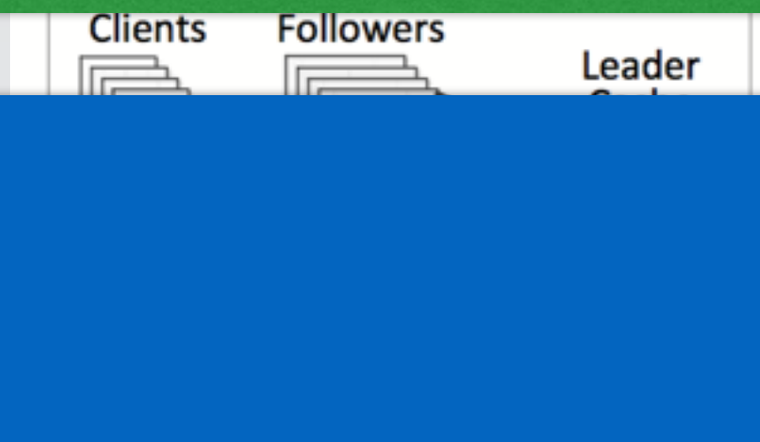
But, with failures, if client writes N things…

Can end up with 2^N states!



leader sends writes to the master leader (C) and read misses to the replica DB (D). The choice of master and slave is made separately for each shard.

Eval. Takeaway: API Frequency

Reads (99.8%)

```
40.9%  assoc_range(src, atype, off, len)
28.9%  obj_get(nodeId)
15.7%  assoc_get(src, atype, dstIdSet, tLow, tHigh)
11.7%  assoc_count(src, atype)
 2.8%  assoc_time_range(src, atype, tLow, tHigh, len)
```

Writes (0.2%)

```
52.5%  assoc_add
20.7%  obj_update
16.5%  obj_add
 8.3%  assoc_del
 2.0%  obj_del
 0.9%  assoc_change_type
```

Eval. Takeaway: Degree

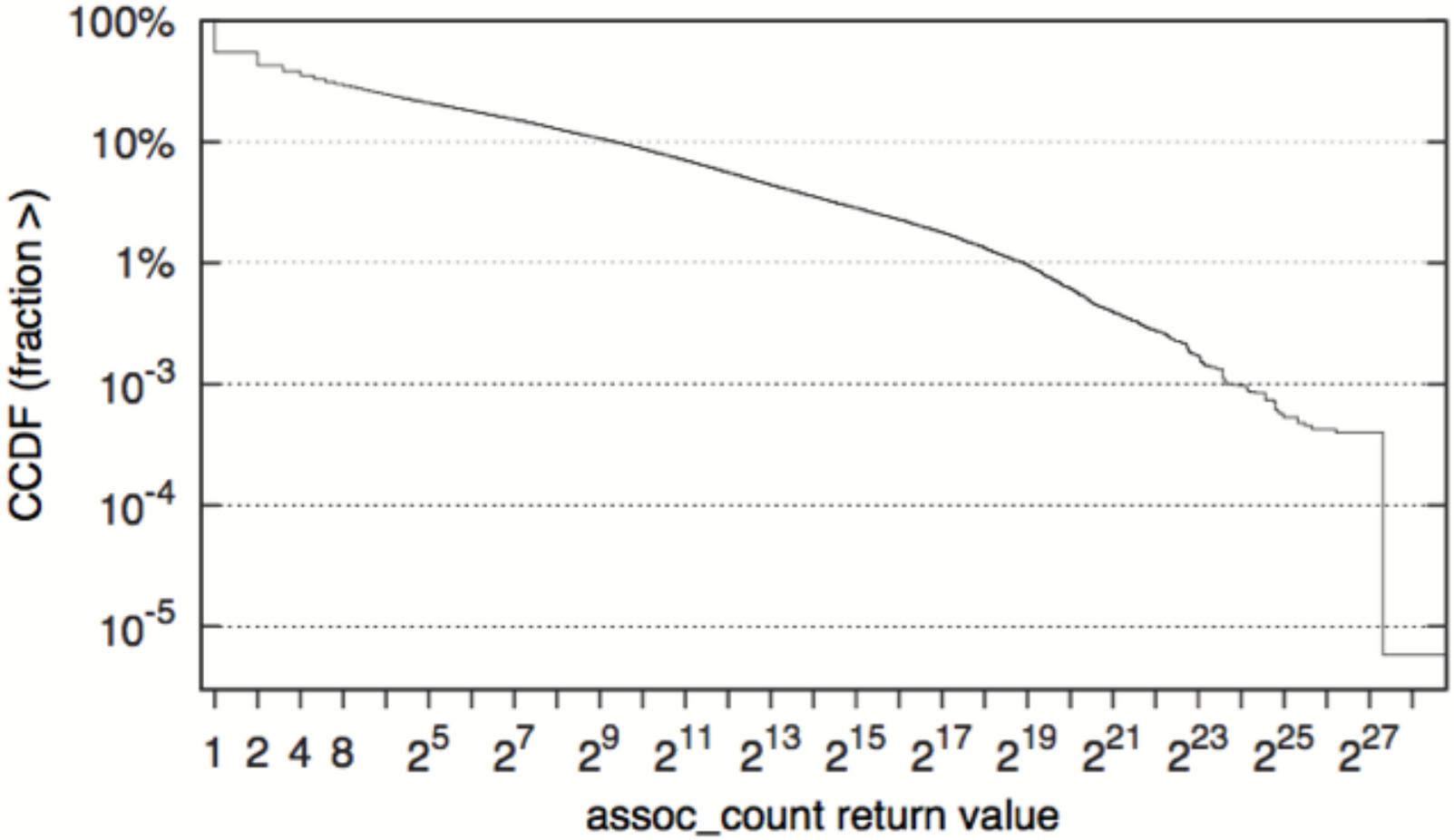


Figure 4: assoc_count frequency in our production environment. 1% of returned counts were ≥512K.

Takeaways:

1% supernodes

long tail

Discussion

- **TAO uses a relational storage backend, citing operational confidence**
  - Is a mature, full-fledged, performant, geographically distributed native graph store possible / preferable over TAO's architecture?
  - Is there something fundamentally difficult/different about the higher-level data model that prevents this (vs. relational)?

- **Is it possible to combine batch processing with online serving in a single graph system?**

- **Limitation: is stronger consistency worth the tradeoff in online graph serving?**