Tao: Facebook's Distributed Data Store For The Social Graph

Bronson et. al., ATC 2013

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CMU 15-799 : Paper Presentation

Carnegie Mellon

Talk Overview

- Graph-aware cache backed by a database
  - Efficiency vs. consistency

Motivation

- Memcached
  - Distributed in-memory key-value store
  - Memory object caching system
  - Data mapping in client code (PHP API)

Limitations

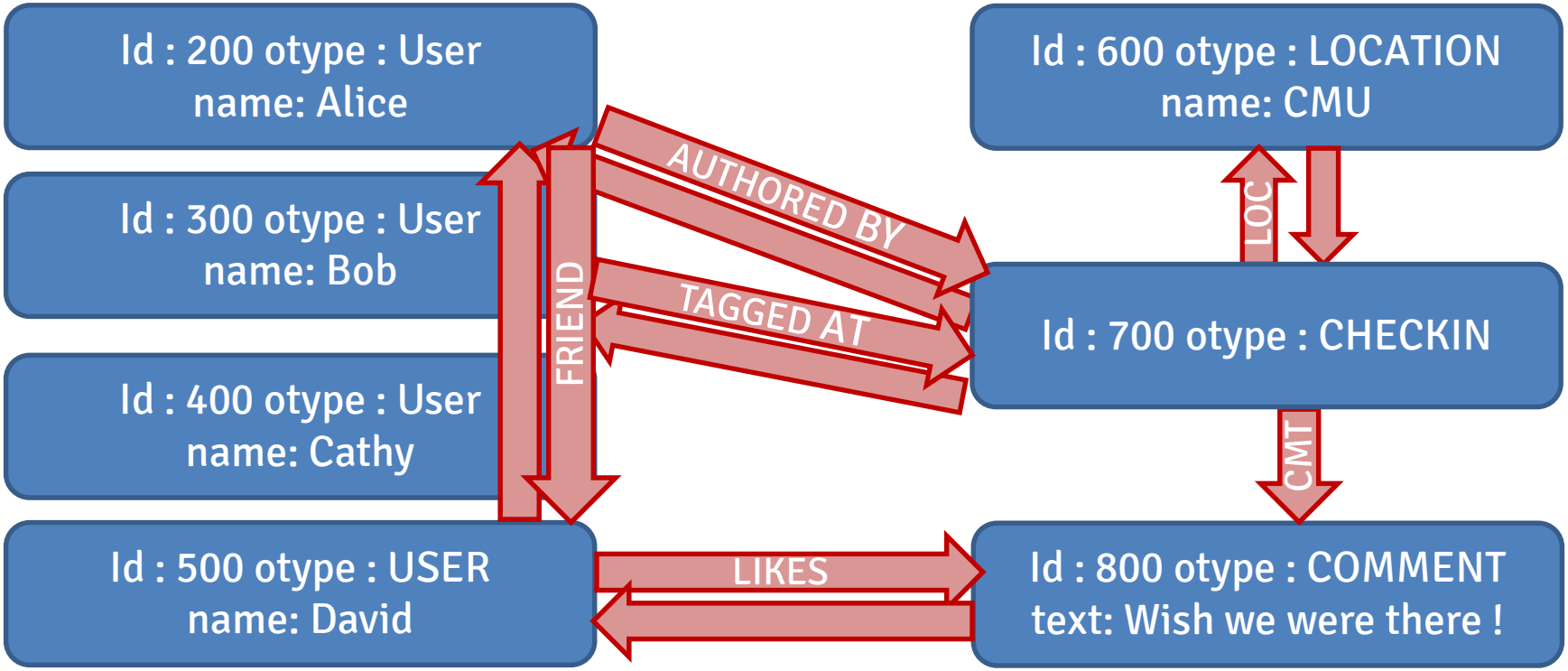
- Association lists
  - Get entire list to update one edge
- Control logic
  - Clients manage lookaside cache
  - But, only have a local perspective
- Expensive read-after-write consistency
  - Writes forwarded to master
  - Local state updated asynchronously

Problem Statement

- Need a "smart" caching layer
  - Graph-aware
  - Distributed cache management
  - Provides read-my-write consistency
- Solution
  - Fix the API and leverage its constraints !

Example

Alice was at *CMU* with *Bob*
Cathy: Wish we were there !
David likes this



Data Model

- Object
  - (id) -> (otype, (key->value)*)
  - Entities, repeatable actions
  - Ex: users, comments
- Association
  - (id1, atype, id2) -> (time, (key->value)*)
  - Relationships, actions that model state transitions
  - Ex: tagged at, likes

Data Model

- Association List
  - (id1, atype) -> [a_{new},…,a_{old}]
  - Supports the Association Query API
  - Ex: (“CMU”, “COMMENT”)

API

- Association API
  - assoc_add(id1, atype, id2, time, (k->v)*)
  - assoc_delete(id1, atype, id2)

- Association Query API
  - [POINT] assoc_get(id1, atype, id2)
  - [RANGE] assoc_range(id1, atype, pos, limit)
  - [COUNT] assoc_count(id1, atype)

Client Queries

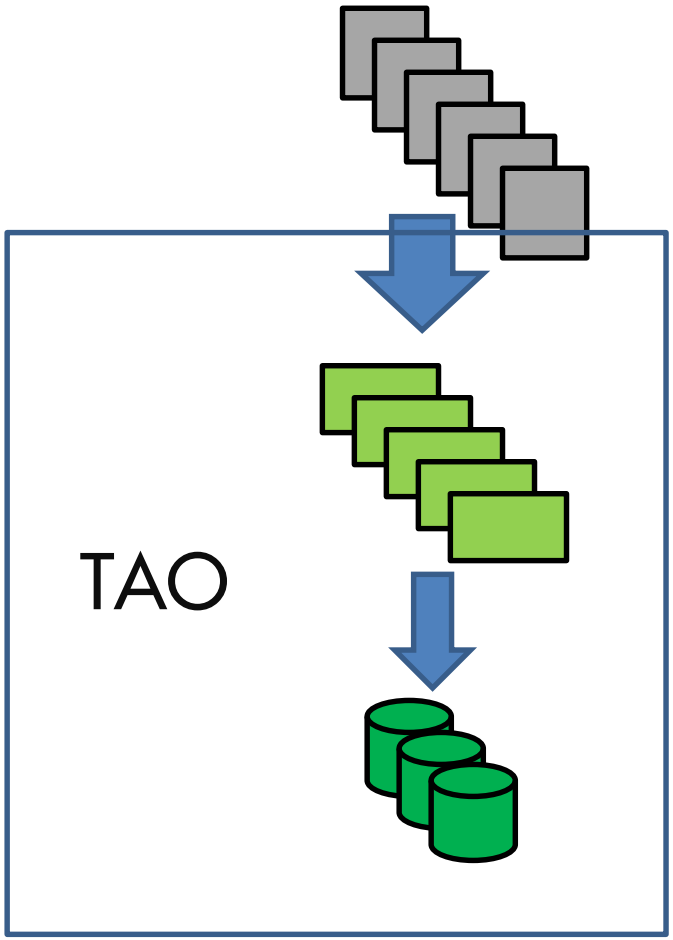
- All queries start from an <id, atype>

- 5 most recent comments on Alice's checkin
  - assoc_range("Alice", "COMMENT", 0, 5)
- Number of friends of Bob
  - assoc_count("Bob", "FRIEND")

Tao's Goals

- Low read latency
- Write consistency
- High read availability

Basic Architecture

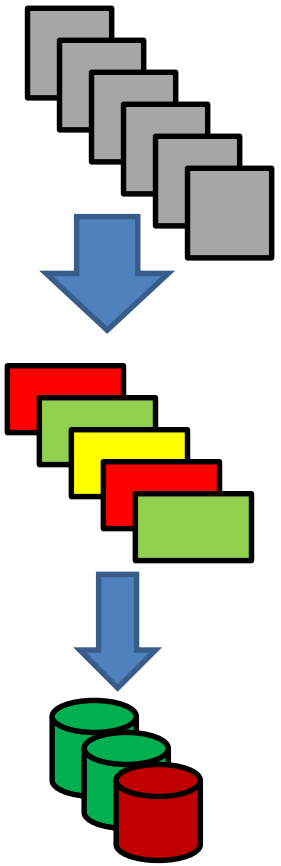


Webservers
- Stateless

Cache servers
- Objects, Association Lists
- Partitioned based on <id>

Database
- Partitioned based on <id>

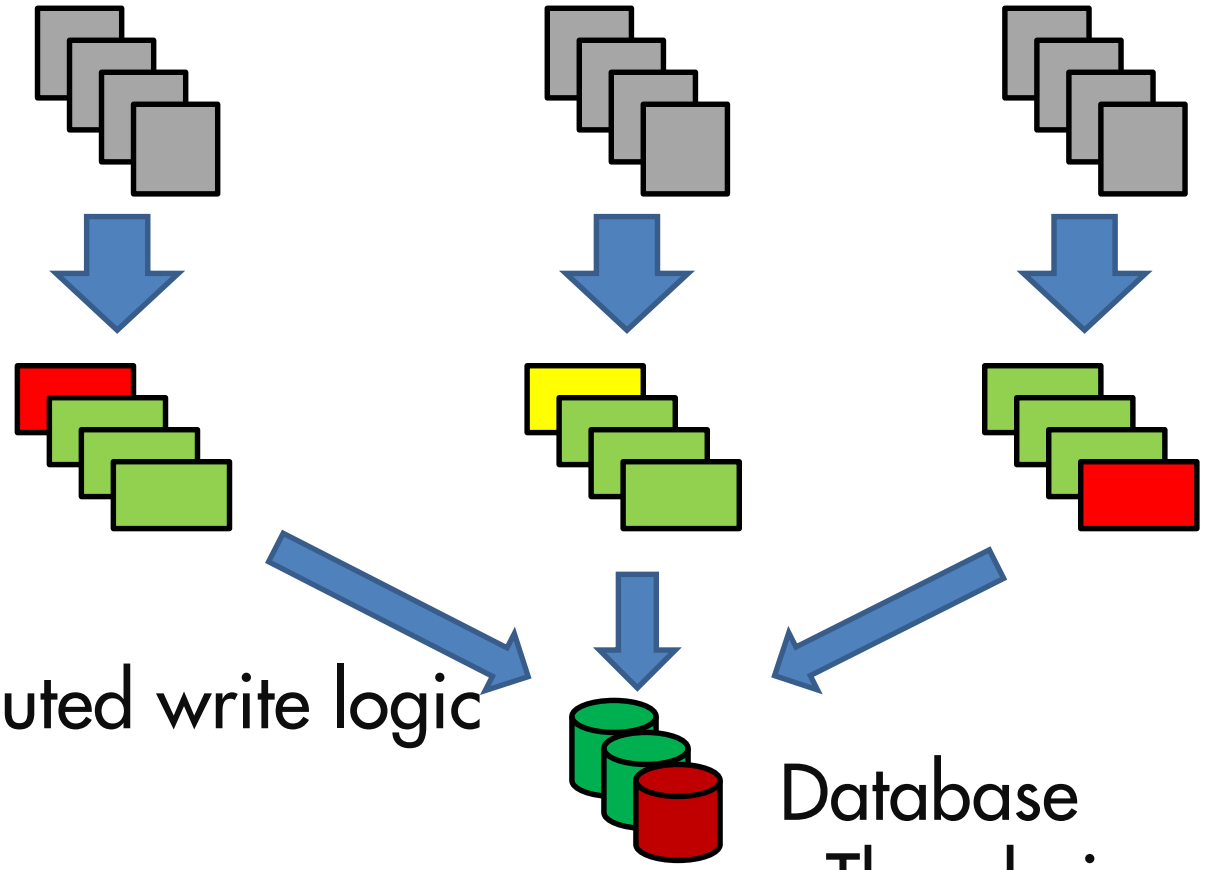
Low Read Latency



Webservers
- Too many network hops

Cache servers
- Hotspots with smaller shards

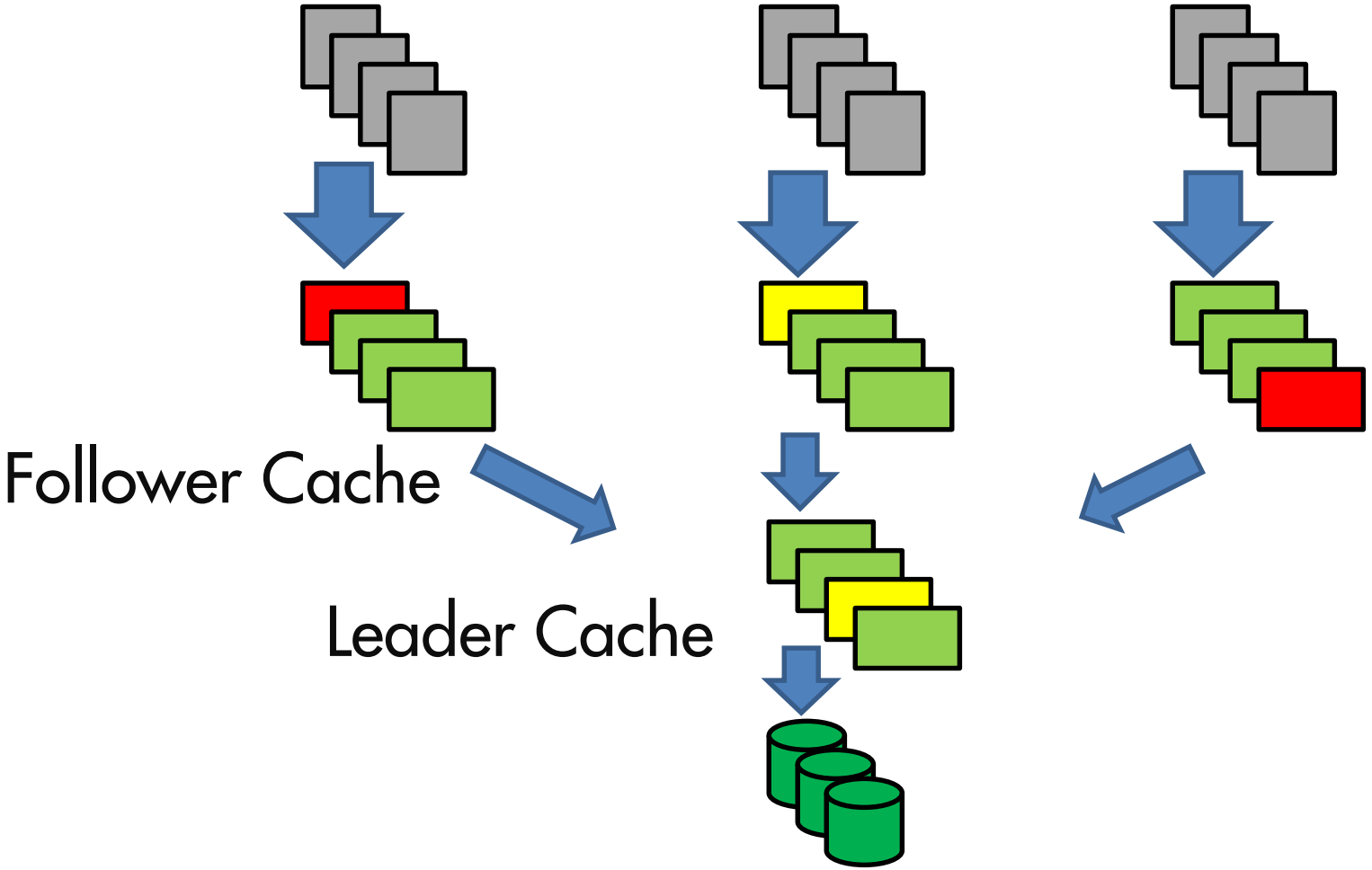
Datacenter-level Scalability



Tiers
- Distributed write logic

Database
- Thundering herds

Splitting the cache layer



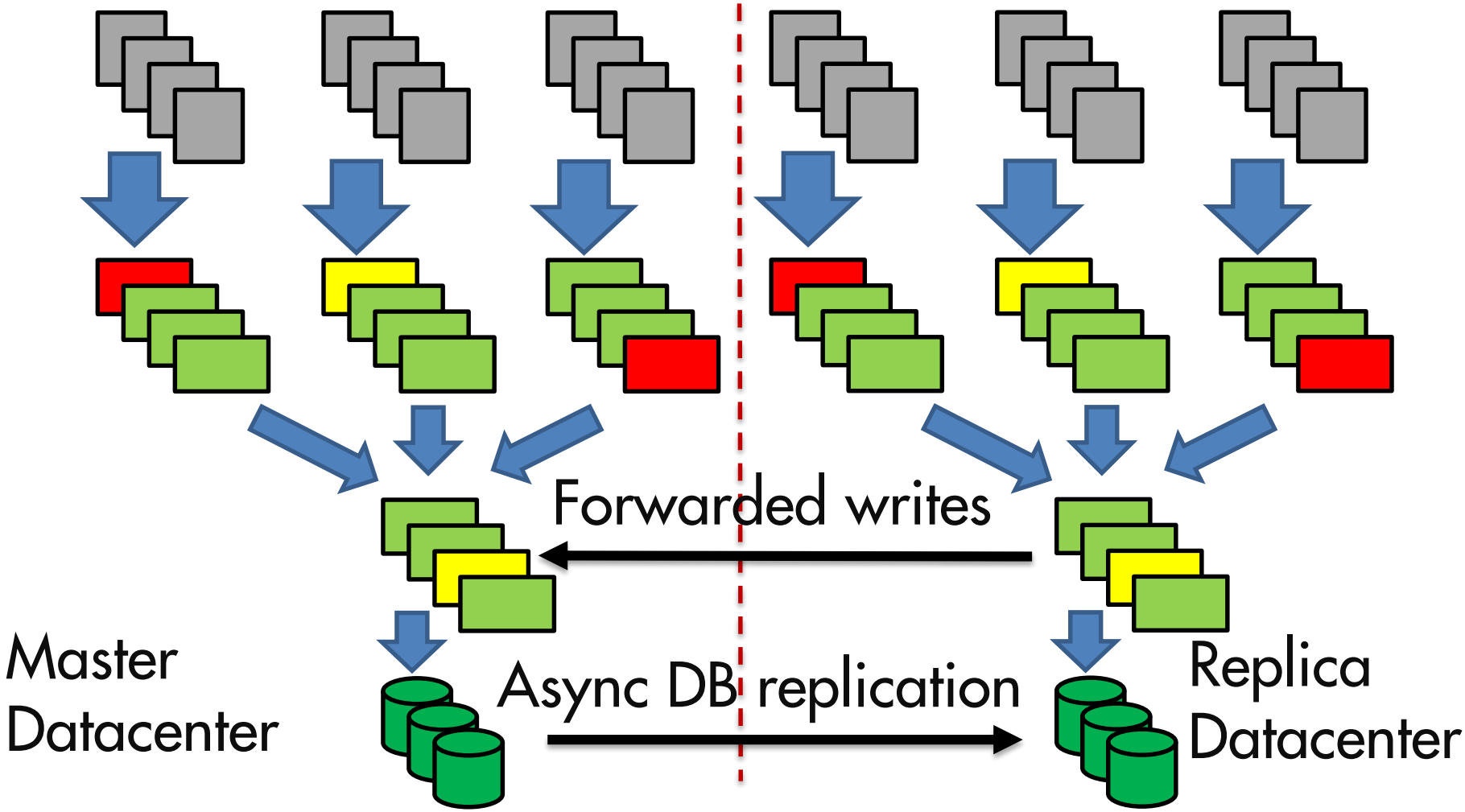
Write Consistency

- Followers
  - Absorb read hits
  - Forward read misses and writes to leaders
  - Write-through cache
- Leader updates
  - Synchronously sent in reply to writer
  - Asynchronously sent to other followers

Write consistency

- Leaders
  - Serialize concurrent writes
  - Can prevent "thundering herds"
- Association list updates
  - Refills instead of invalidates
  - Idempotent pull-based incremental updates

Multi-datacenter Scalability



High Read Availability

- Follower failure
  - Client contacts backup follower tier
  - May break read-after-write consistency
- Leader failure
  - Follower tiers reroute read misses directly to DB
  - Writes sent to another member of leader tier

Handling Hot Spots

- Consistent hashing
  - Simplifies cluster expansion
  - Request rerouting
- Load balancing
  - Shard cloning
  - Small client-side cache

Results

- Reads dominate writes
  - 99.8% read requests
  - 40% of requests are range queries
- Most edge queries have empty results
  - Tao can use cached assoc_count
  - Key advantage of app-aware caching

Results

- Availability
  - Fraction of failed queries : $4.9*10^{-6}$
- Follower Throughput
  - 8 core Xeon + 144GB RAM + 10Gb Ethernet
  - 30-60K requests/sec

Tao Summary

- Low read latency
  - Application-aware cache layer
- Write consistency
  - Replication model
- High read availability
  - Fault-tolerance

Talk Summary

- Graph-aware cache backed by a database
  - Efficiency vs. consistency
- Why did they not use a graph database ?
  - They trust MySQL
  - Tao's cache layer handles their demands

Thanks !