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Parallel and Continuous Join Processing for Data Stream

Thèse pour l'obtention du grade de Docteur

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Part I: Data Driven Stream Join (kNN)

Outline

- Related Work
- Parallel Workflow
- Theoretical Analysis
- Continuous kNN
- Experiment Result
- Conclusion

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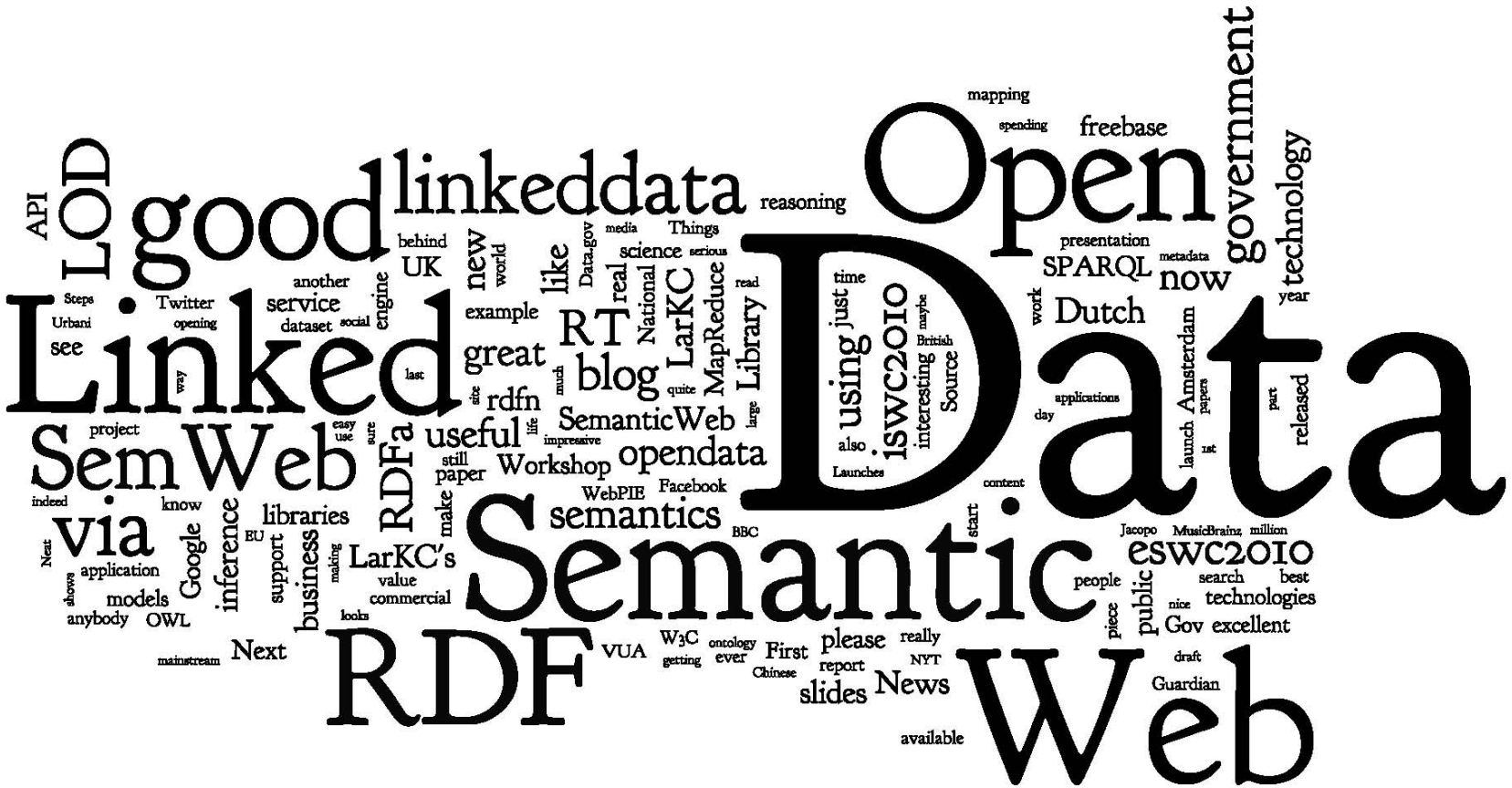
Definition: kNN

Given a set of query points $\mathbb{R}$ and a set of reference points $\mathbb{S}$, a $\mathbb{k}$ **nearest neighbor join** is an operation which, for each point in $\mathbb{R}$, discovers the $\mathbb{k}$ nearest neighbors in $\mathbb{S}$.

Part II: Query Driven Stream Join (RDF)



Outline

- Related Work
- Query Decomposition and Distribution
- Data Partition and Assignment
- Parallel and Distributed Query Plan
- Continuous Join
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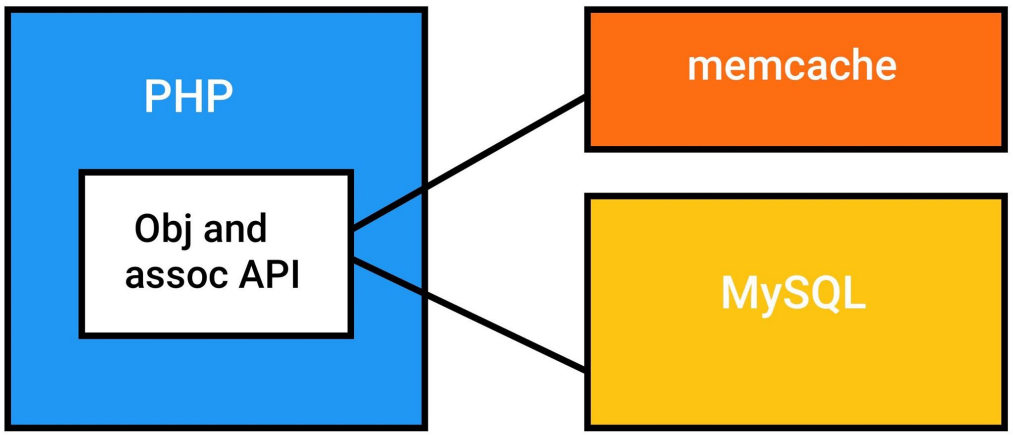
Architecture

Before Tao

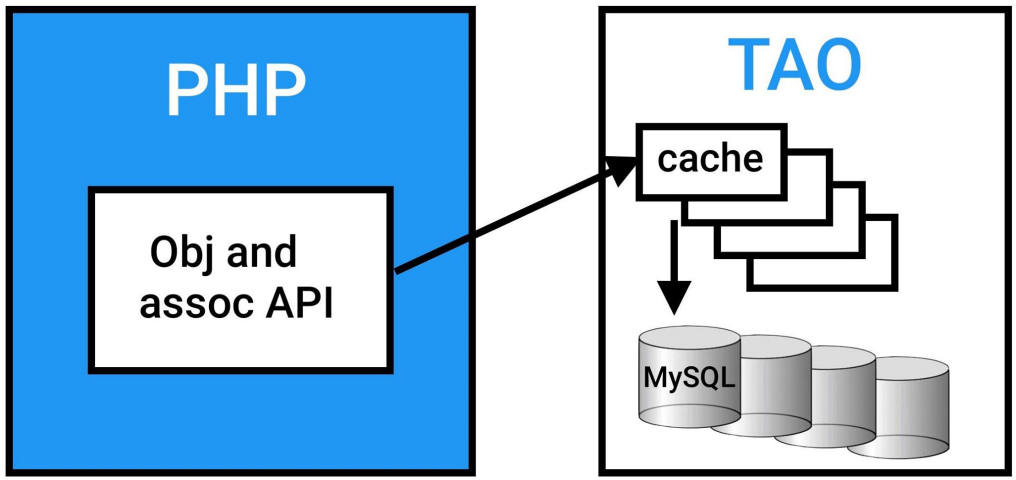


After Tao

Architecture

Before Tao

After Tao



Storage Layer

- Object and Associations are stored in MySql (before & with TAO)
- TAO API is mapped to a small set of SQL queries
- A single MySql server can't handle TAO volumes of data
  - We divide data into logical *shards*
  - *shards* are mapped to db
  - different servers are responsible for multiple shards
  - mapping is adjusted for load balancing
- Object are bounded to a *shard* for their entire lifetime
- Associations are stored in the *shard* of its `id1`

Cache Layer

TAO cache

- contains: Objects, Associations, Associations counts
- implement the complete API for clients
- handles all the communication with storage layer
- it's filled on demand end evict the least recently used items
- Understand the semantic of their contents

It consists of multiple servers forming a *tier*

- Request are forwarded to correct server by a *sharding* scheme as dbs
- For cache miss and write request, the server contacts other caches or db

Yet Another caching layer

Problem: A single caching layer divided into a *tier* is susceptible to *hot spot*

Solution: Split the caching layer in two levels

- A *Leader* tier
- Multiple *Followers* tiers

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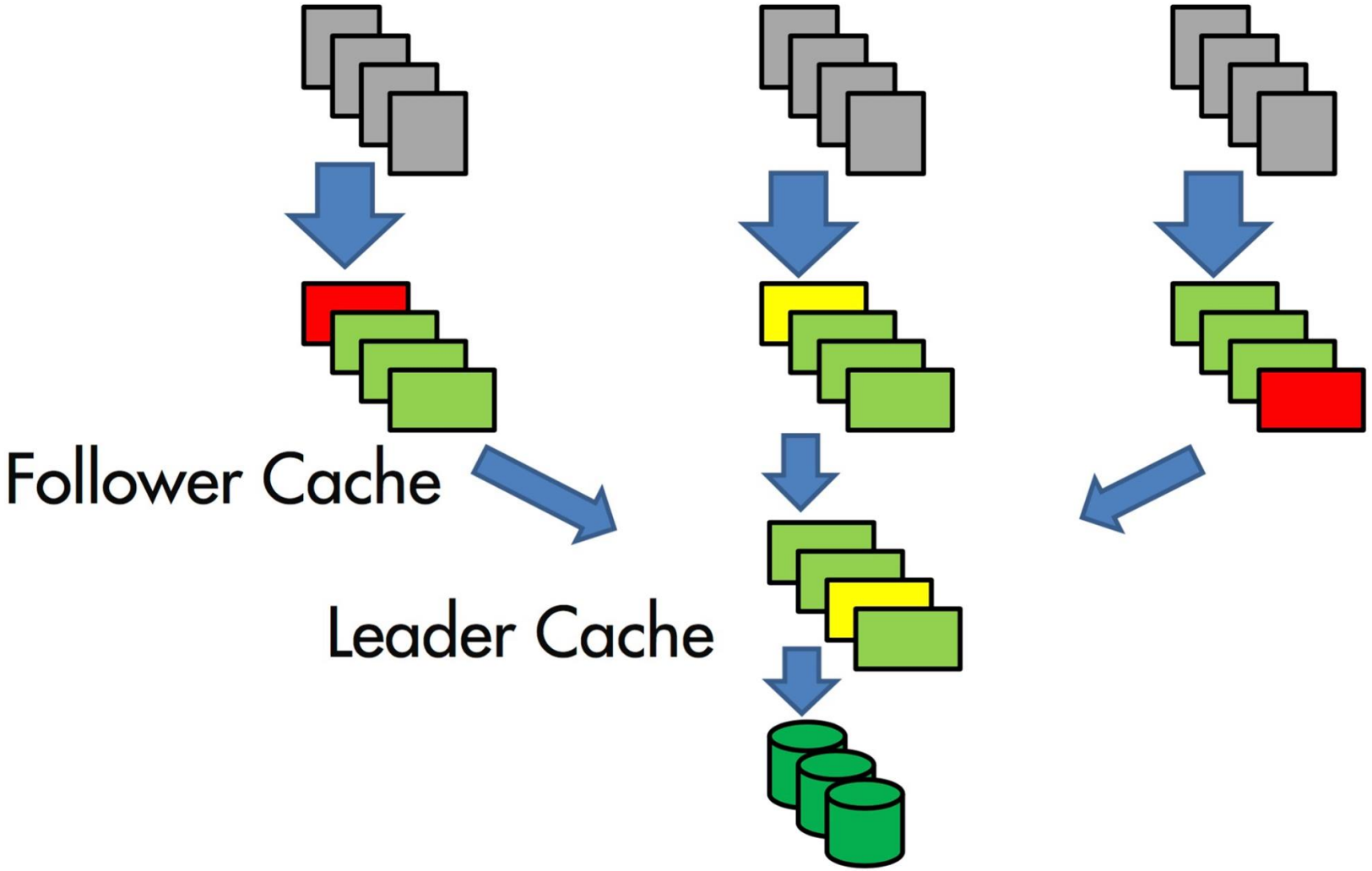
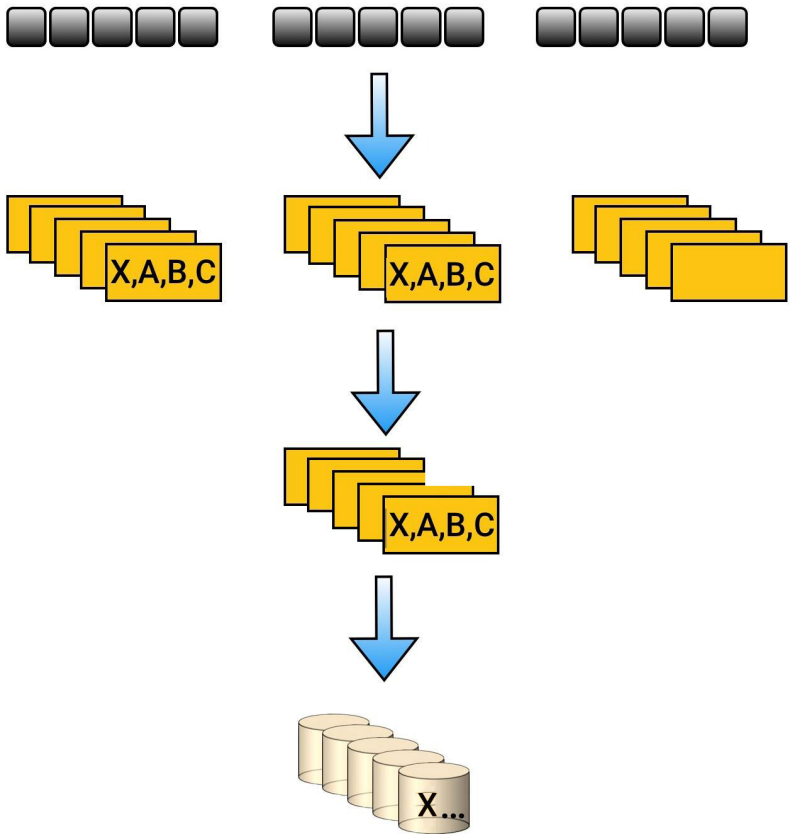
Leaders & Followers



Leaders & Followers

- Followers forward all writes and read cache misses to the leader tier
- Leader sends async cache maintenance messages to follower tier
  - Eventually Consistent
- If a follower issues a write, the follower's cache is updated synchronously
- Each update message has a version number
- Leader serializes writes

Leaders & Followers



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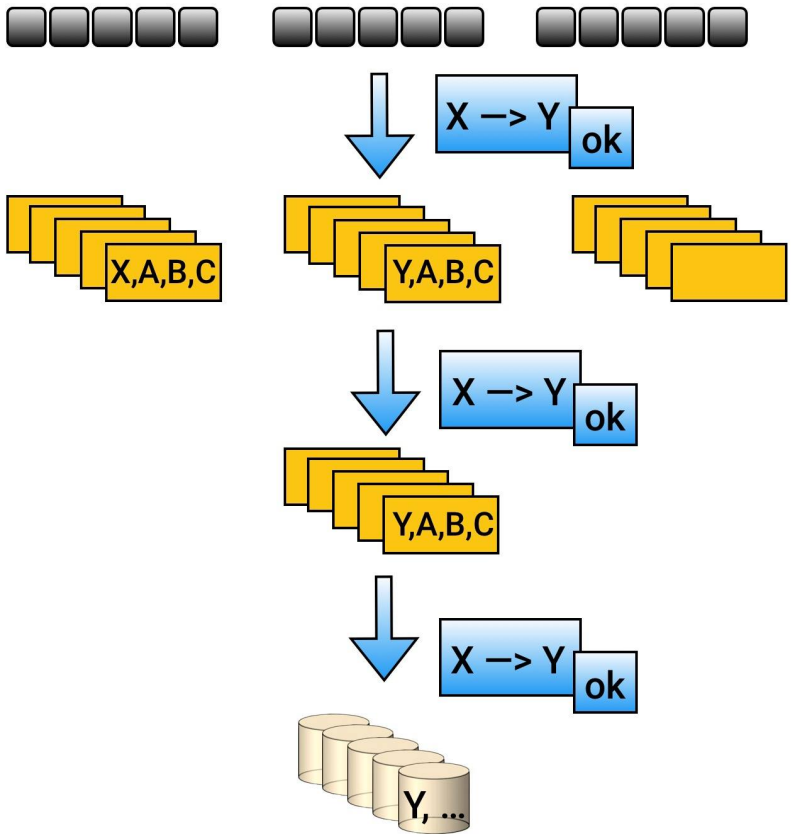

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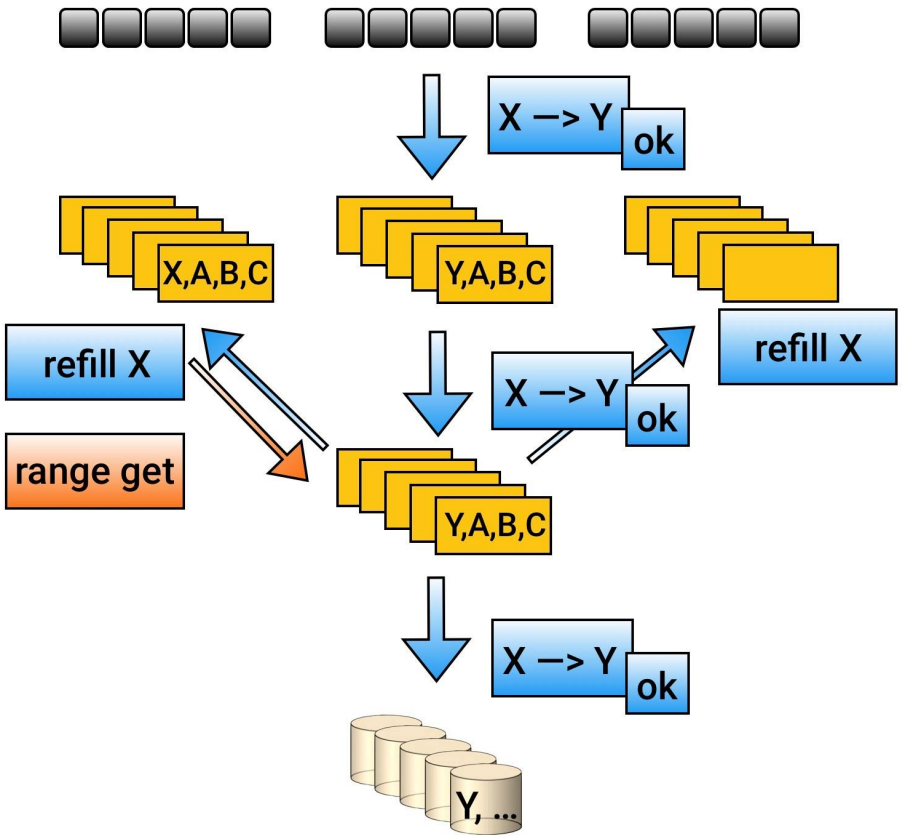

Scaling Geographically

Problem: Network latencies are not low in a multi Data Centers environment

Considering that read misses are more common than writes in the follower tier

Solution: Handles read cache miss locally

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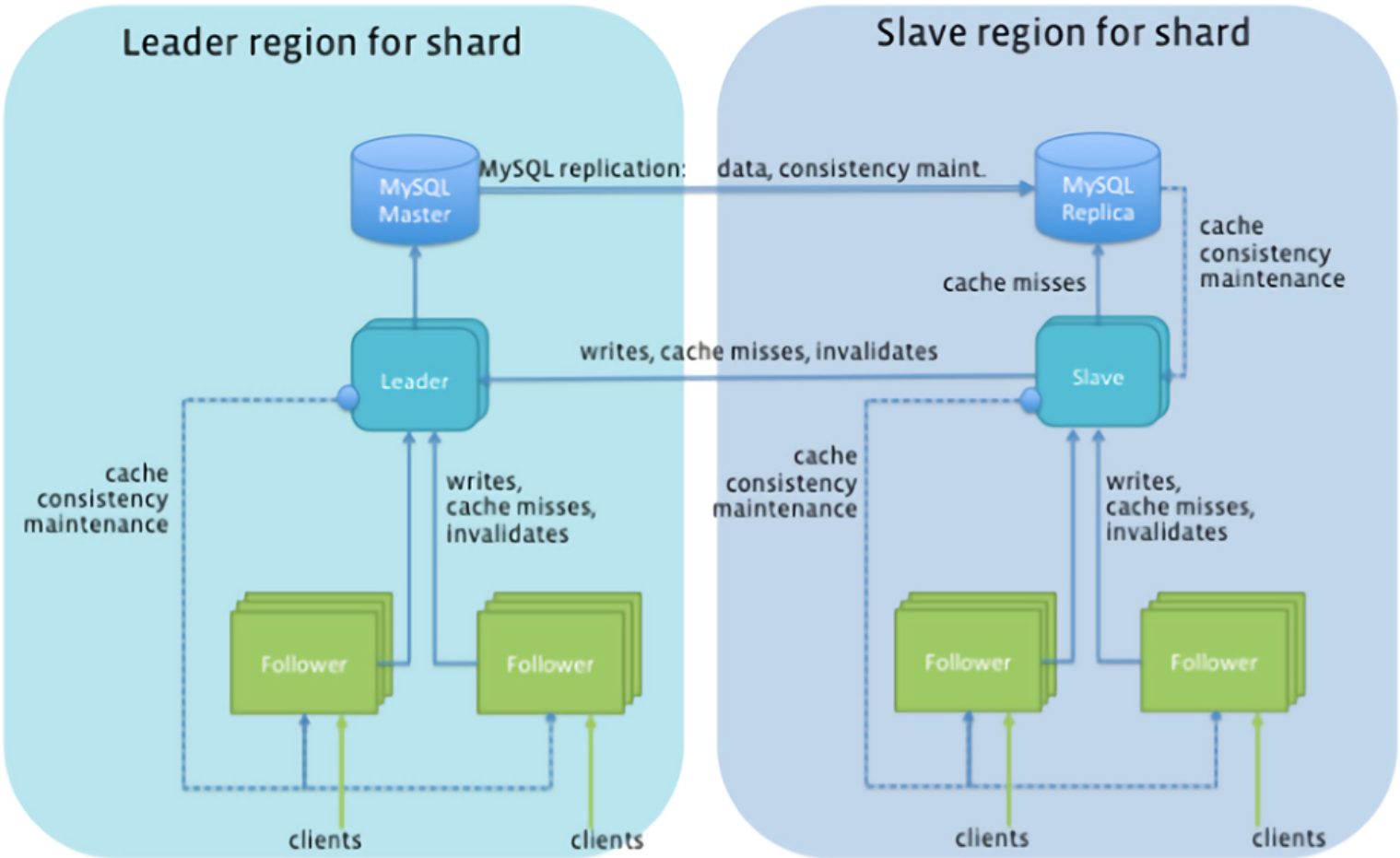
Master & Slave Regions

Fb cluster together DC in regions (with low intra region latency)

- Each region have a full copy of the social graph
- Region are defined master or slave for each shard
- Followers send read misses and write requests to the local leader
- Local leaders service read misses locally
- Slave leaders forward writes to the master shard
- Cache invalidation message are embedded into db replication stream
- Slave leader will update it’s cache as soon as write are forwarded to master

Overall Architecture



Implementation

To achieve performance and storage efficiency Fb have implemented some optimizations to servers.

Caching Servers

- Memory is partitioned into arenas by association type
  - This mitigates the issues of poorly behaved association types
  - They can also change the lifetime for important associations
- Small items with fixed size have a lot of pointer overhead
  - stored separately
  - Used for association counts

MySql Mapping

We divided the space of objects and associations into *shards*. Each *shard*:

- is assigned to a logical DB
- there is a table for objects and a table for associations
- all field of object are serialized in a single `data` column
- object of different size can be stored in the same column

Exceptions:

- Some object can benefit from being stored in a different table
- Associations counts are stored in a separate table

Cache Sharding

Shards are mapped to chache server using consistent hashing (like dynamo)

This can lead to *imbalances*, so TAO use shard cloning to rebalance the load

There are also *popular object* that can be queried a lot more often than others.

TAO says to the clients to cache them these objects

High-Degree Objects

Some object have a lot of associations (remember there were a limit of 6000?)

- TAO can't cache all associations list
- Requests will always end to Db

so

- For `assoc_count`, the edge direction is chosen using the lower degree between source and destination object
- For `assoc_get` query, only associations whose time > object's creation time

Thank You!