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TAO
Facebook's Distributed Data Store for the Social Graph

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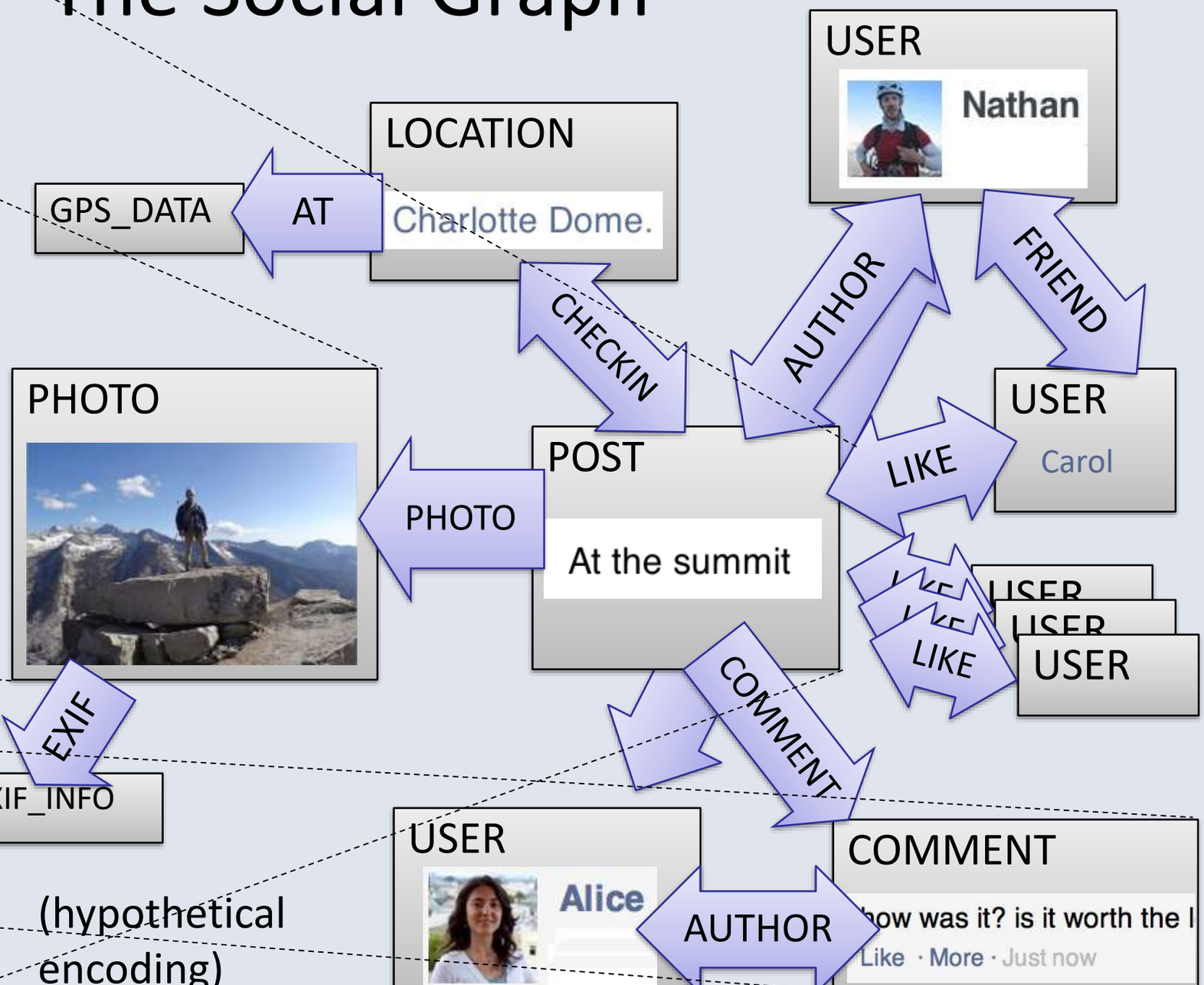
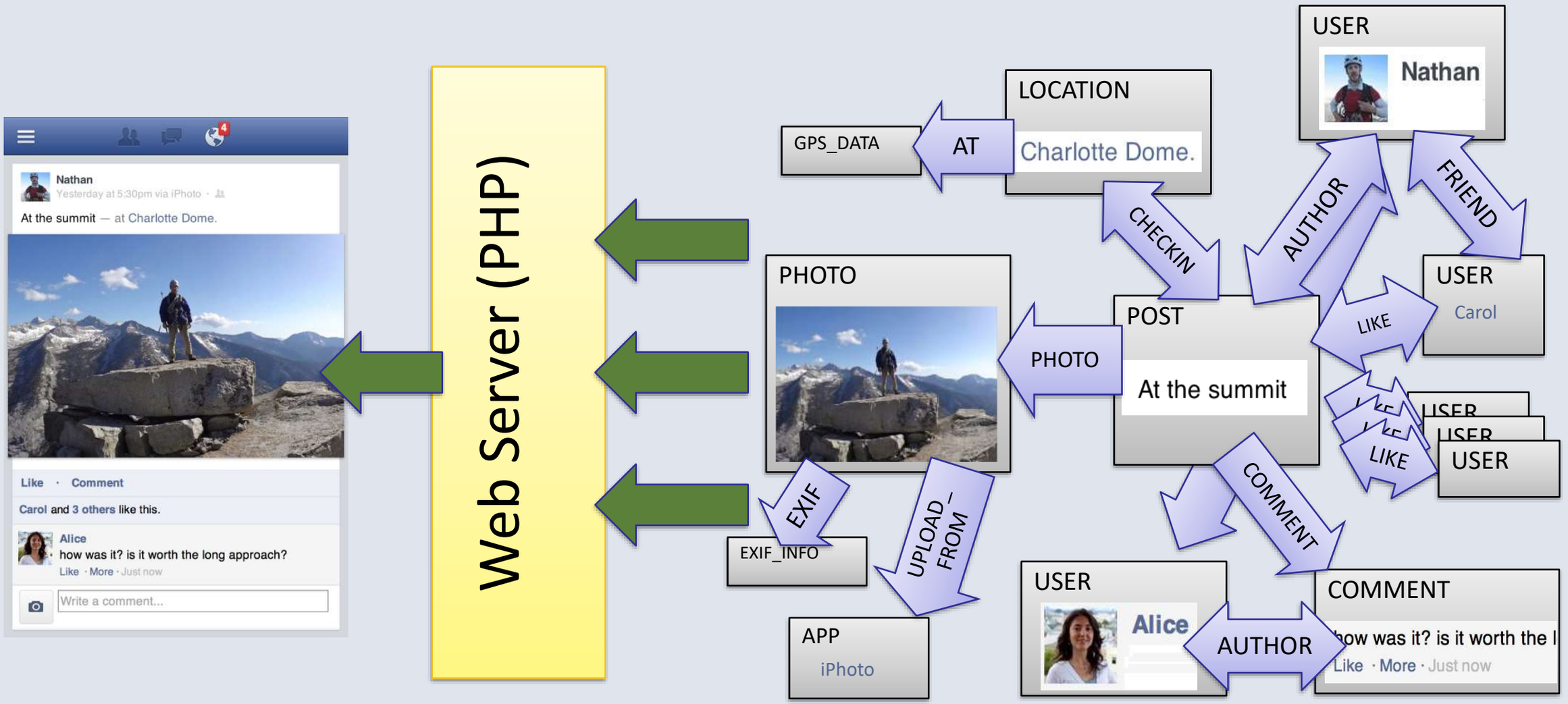
The Social Graph

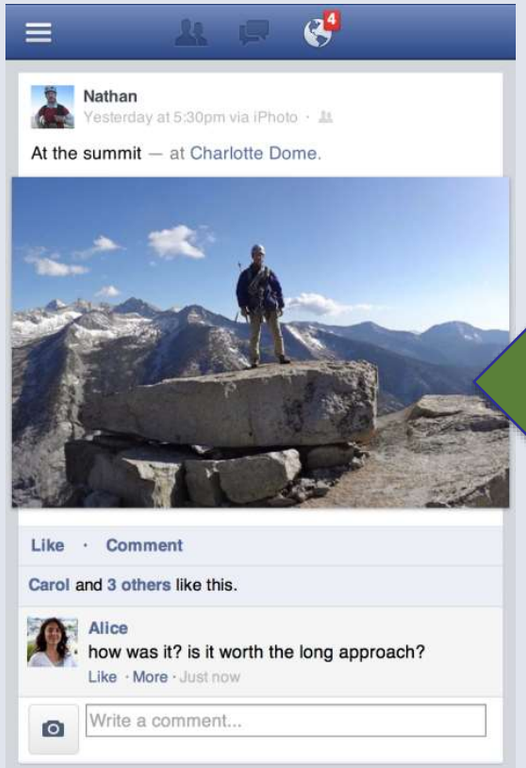


(hypothetical encoding)

Dynamically Rendering the Graph

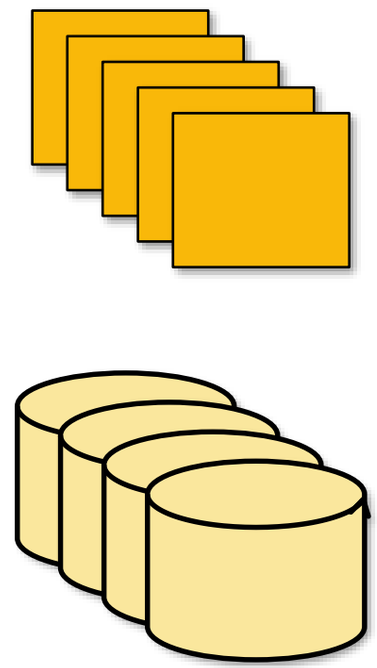


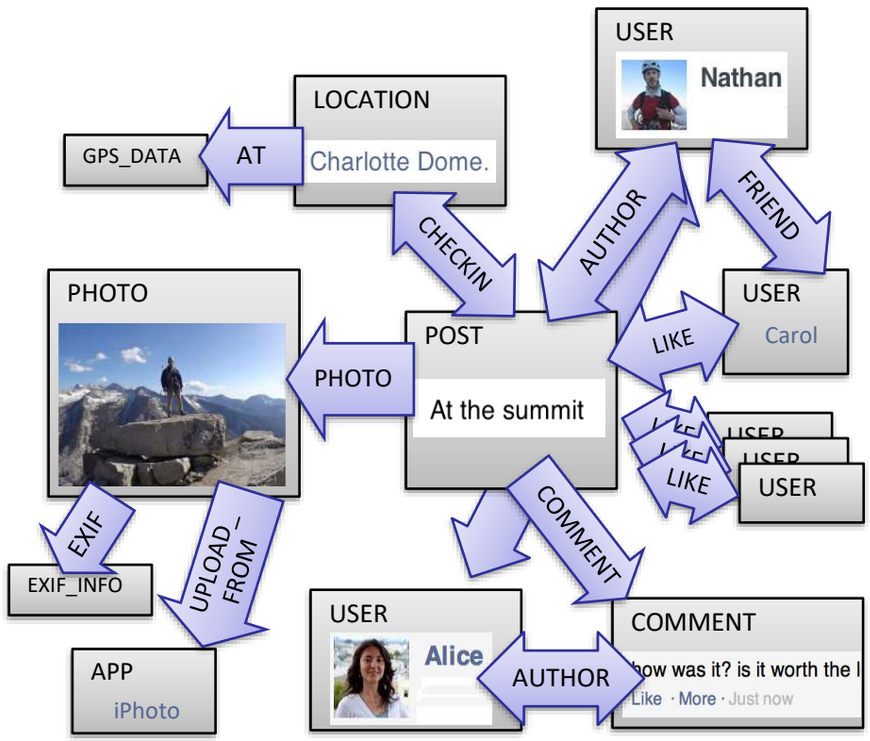
Dynamically Rendering the Graph



Web Server (PHP)

TAO





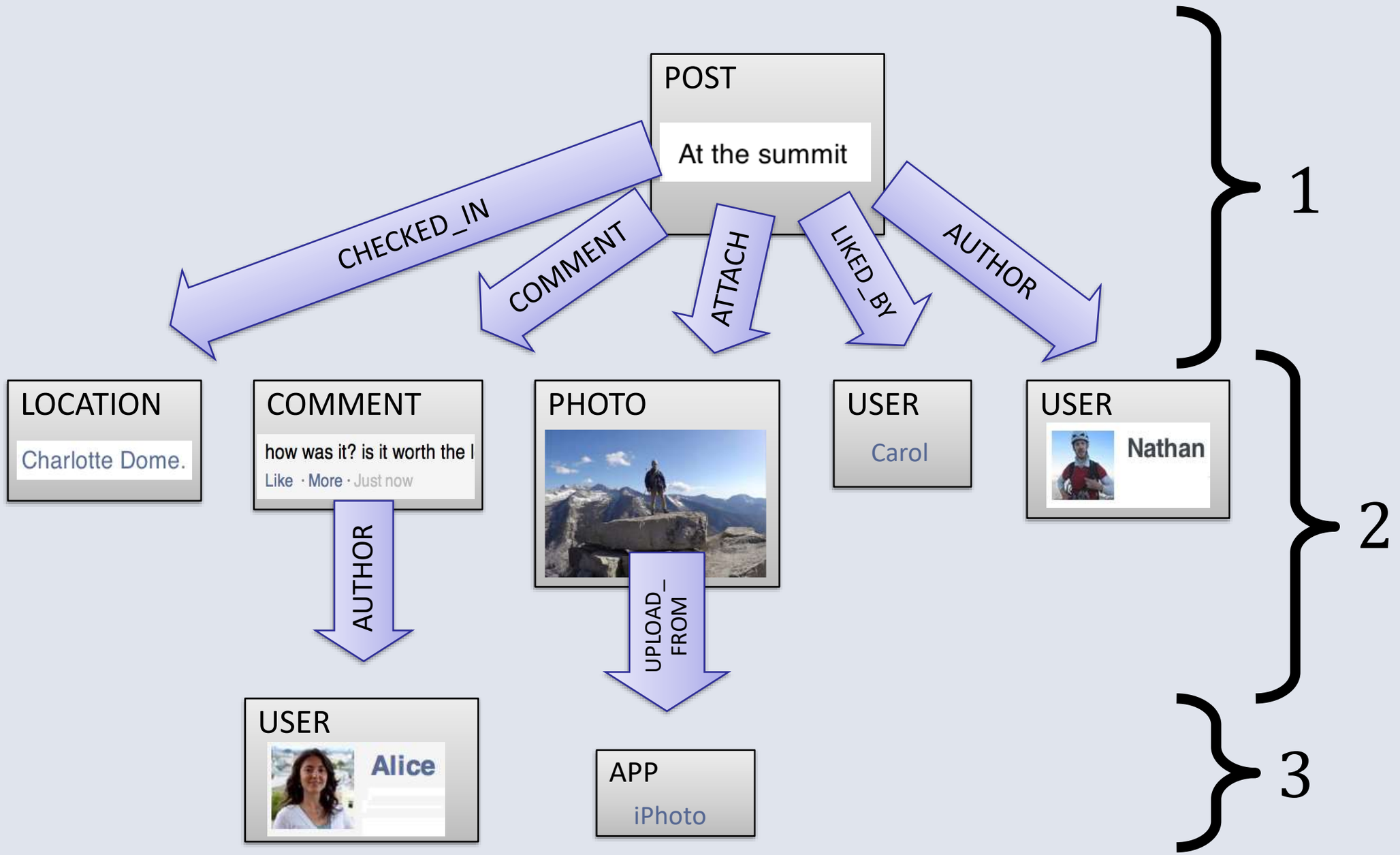
- 1 billion queries/second
- many petabytes of data

facebook data centers

What Are TAO's Goals/Challenges?

- Efficiency at scale

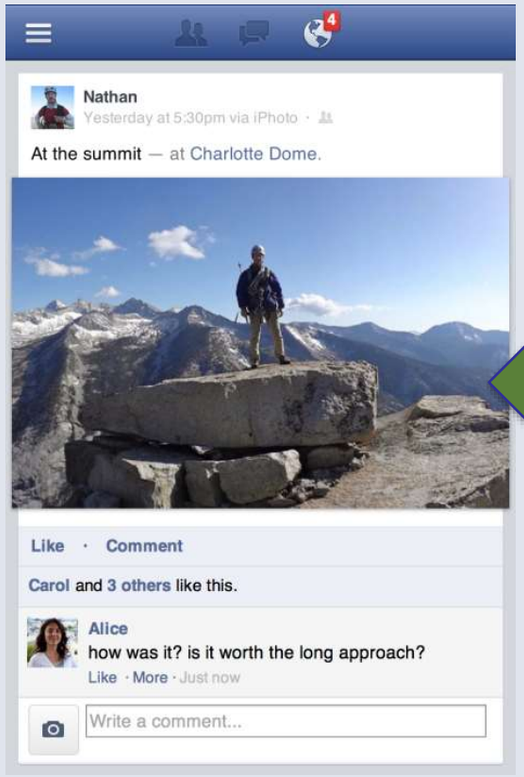
Dynamic Resolution of Data Dependencies



What Are TAO's Goals/Challenges?

- Efficiency at scale
- Low read latency
- Timeliness of writes
- High Read Availability

Graph in Memcache

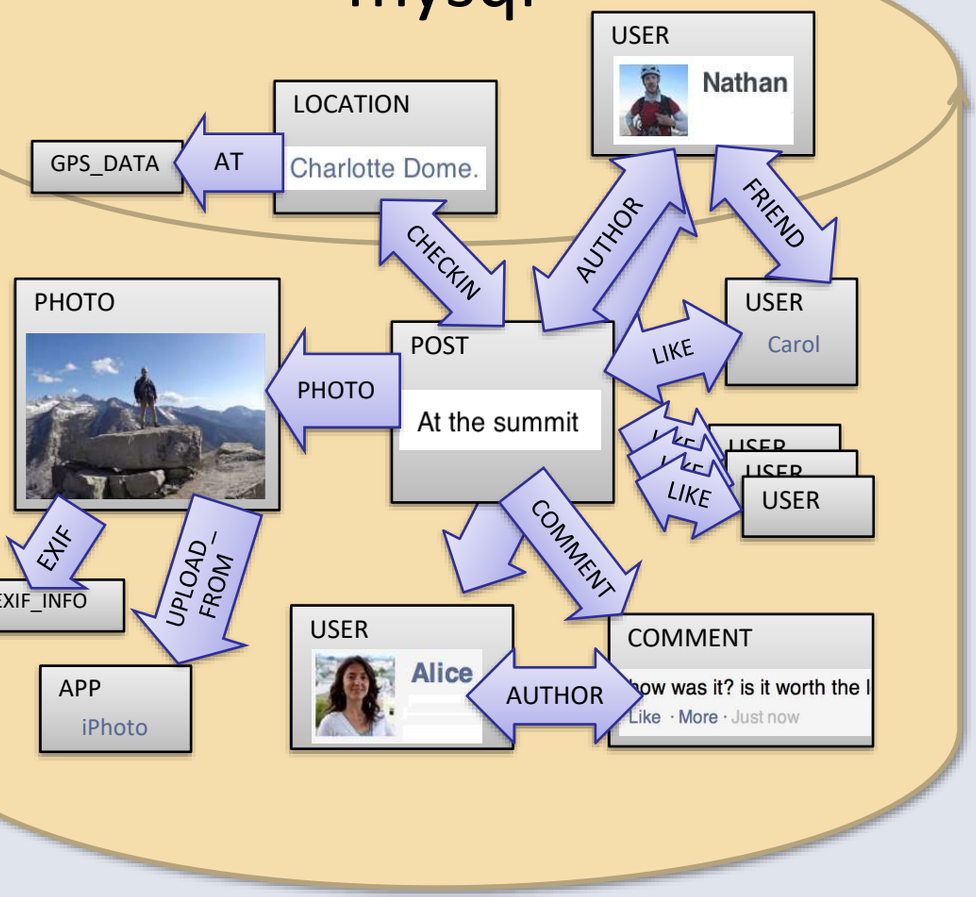


Web Server (PHP)

Obj & Assoc API

memcache
(nodes, edges, edge lists)

mysql

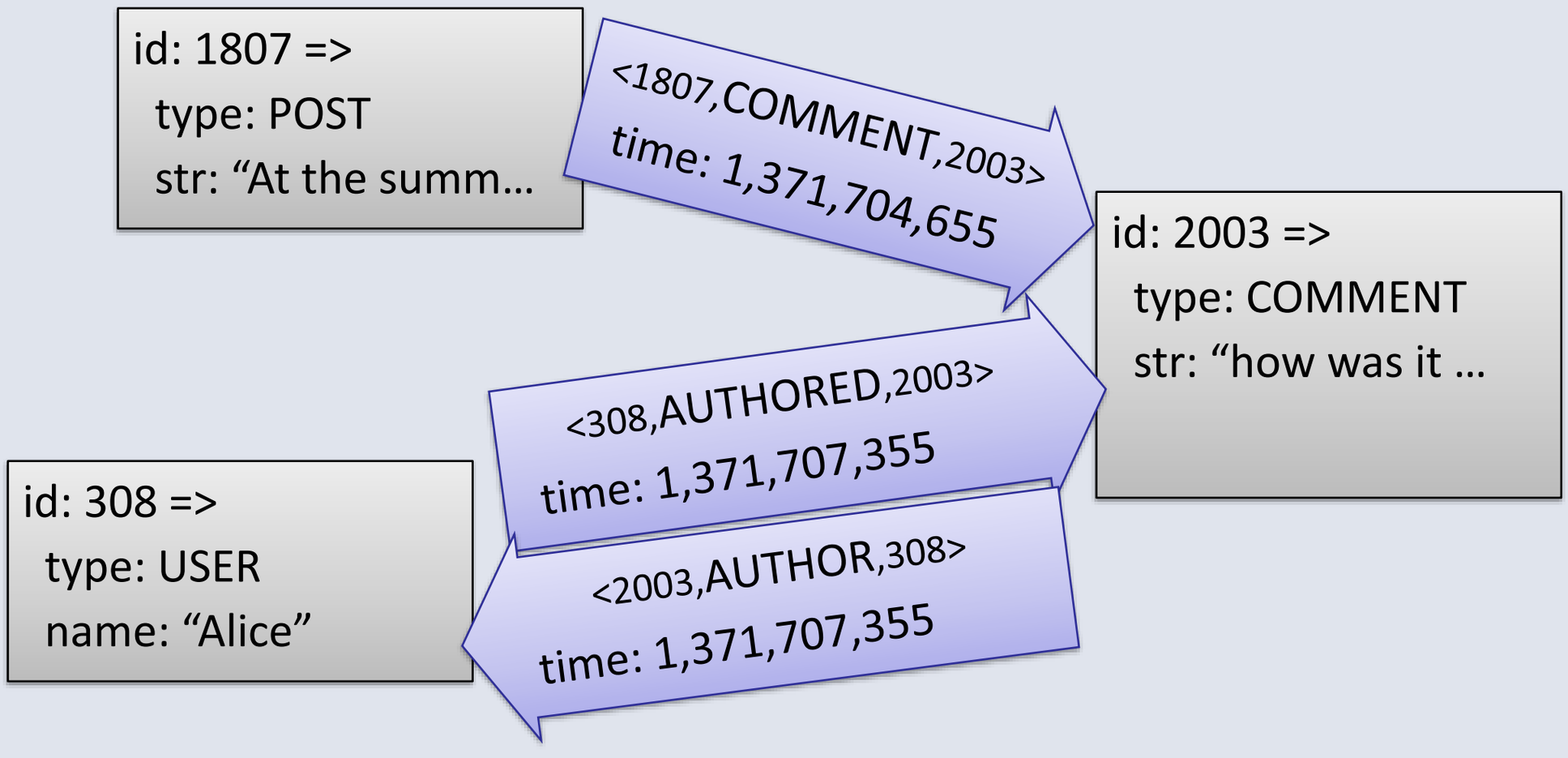


Objects = Nodes

- Identified by unique 64-bit IDs
- Typed, with a schema for fields

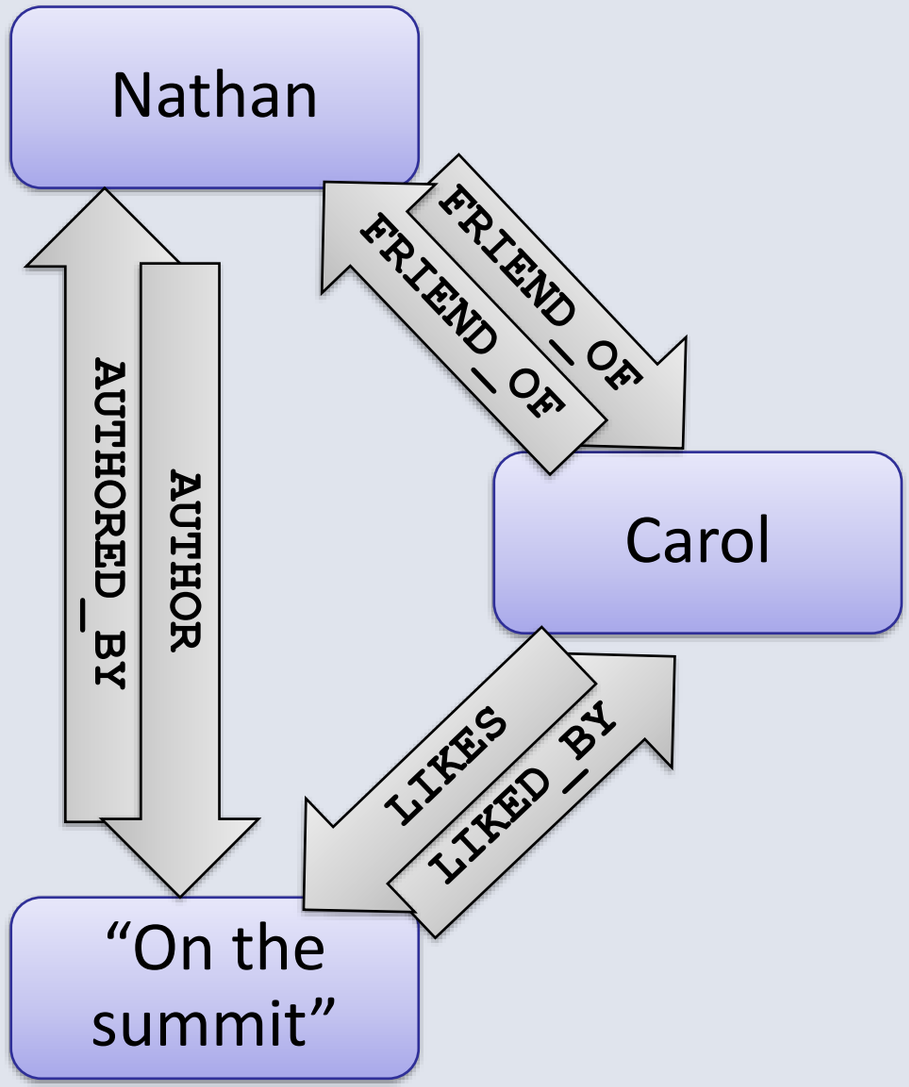
Associations = Edges

- Identified by <id1, type, id2>
- Bidirectional associations are two edges, same or different type



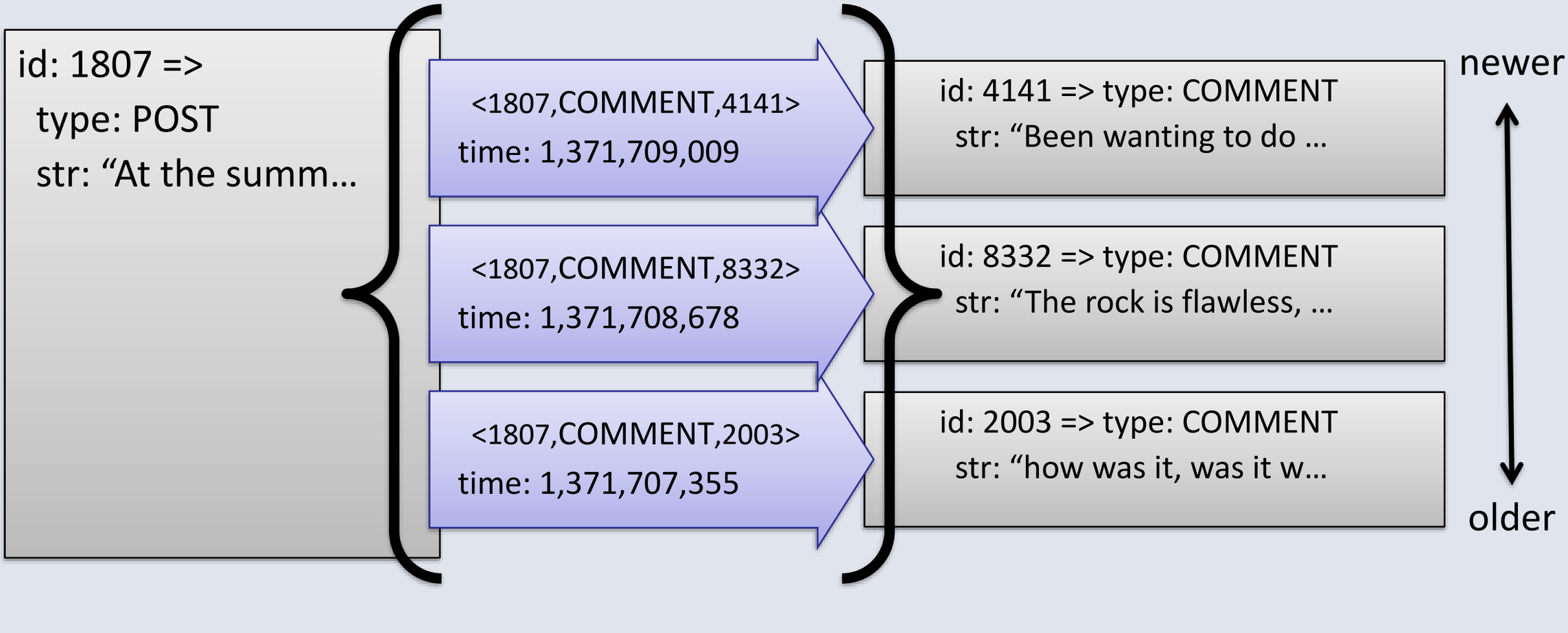
Inverse associations

- Bidirectional relationships have separate *a*→*b* and *b*→*a* edges
  - inv_type(**`LIKES`**) = **`LIKED_BY`**
  - inv_type(**`FRIEND_OF`**) = **`FRIEND_OF`**
- Forward and inverse types linked only during write
  - TAO **`assoc_add`** will update both
  - Not atomic, but failures are logged and repaired



Association Lists

- <id1, type, *>
- Descending order by time
- Query sublist by position or time
- Query size of entire list



Objects and Associations API

Reads – 99.8%

- Point queries
  - **obj_get** 28.9%
  - **assoc_get** 15.7%
- Range queries
  - **assoc_range** 40.9%
  - **assoc_time_range** 2.8%
- Count queries
  - **assoc_count** 11.7%

Writes – 0.2%

- Create, update, delete for objects
  - **obj_add** 16.5%
  - **obj_update** 20.7%
  - **obj_del** 2.0%
- Set and delete for associations
  - **assoc_add** 52.5%
  - **assoc_del** 8.3%

What Are TAO's Goals/Challenges?

- Efficiency at scale
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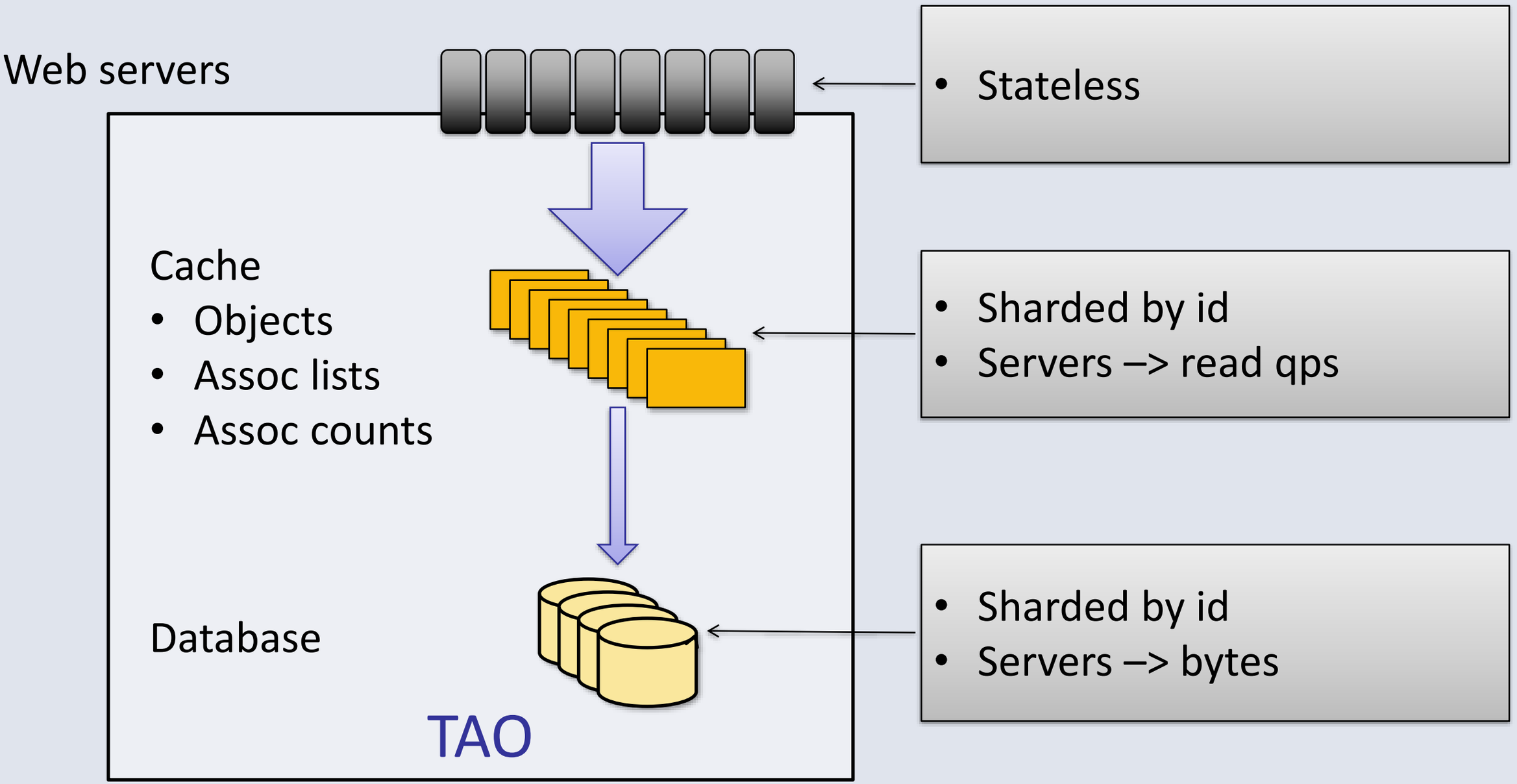
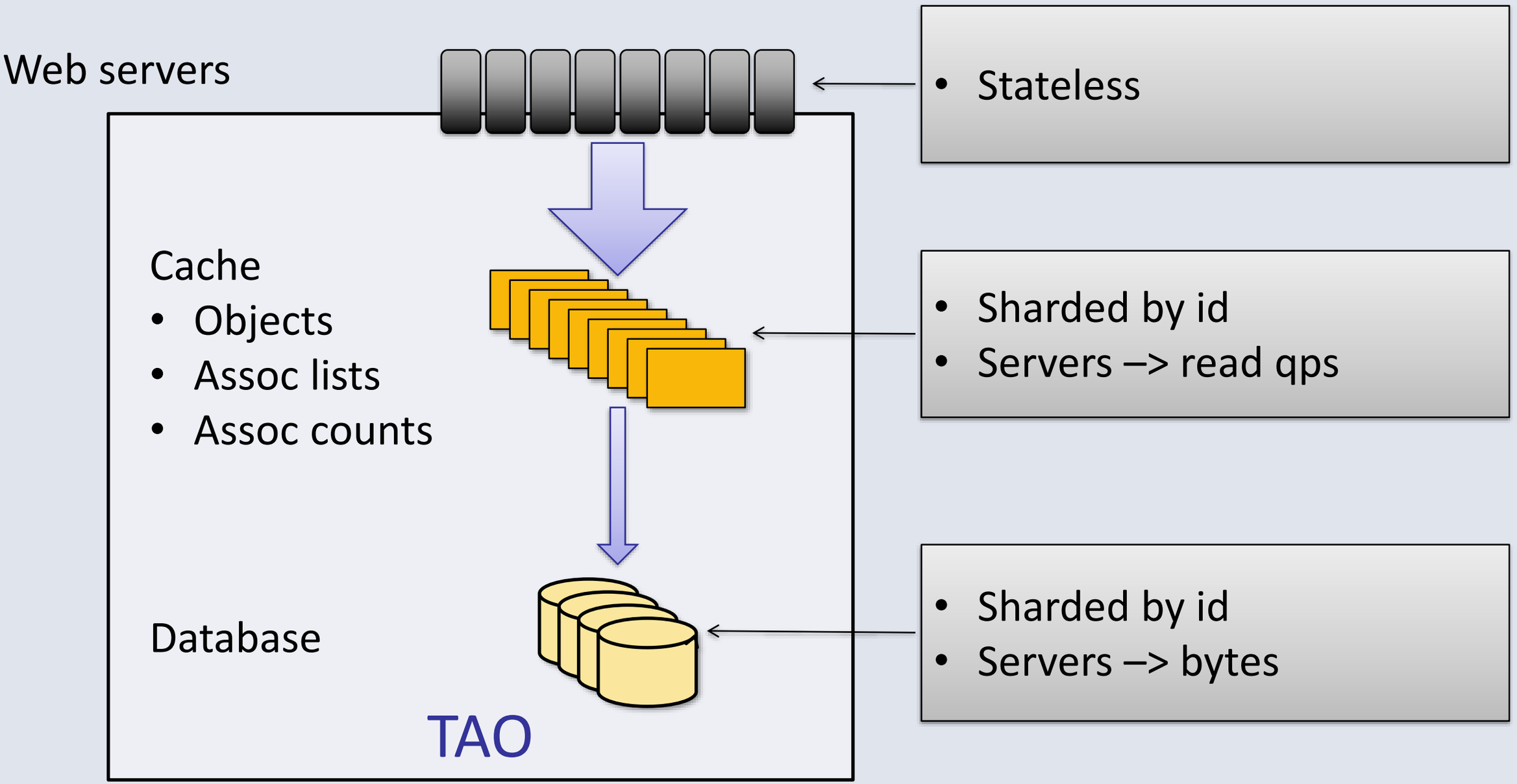
Independent Scaling by Separating Roles



Independent Scaling by Separating Roles



Object ID -> Shard -> Cache node

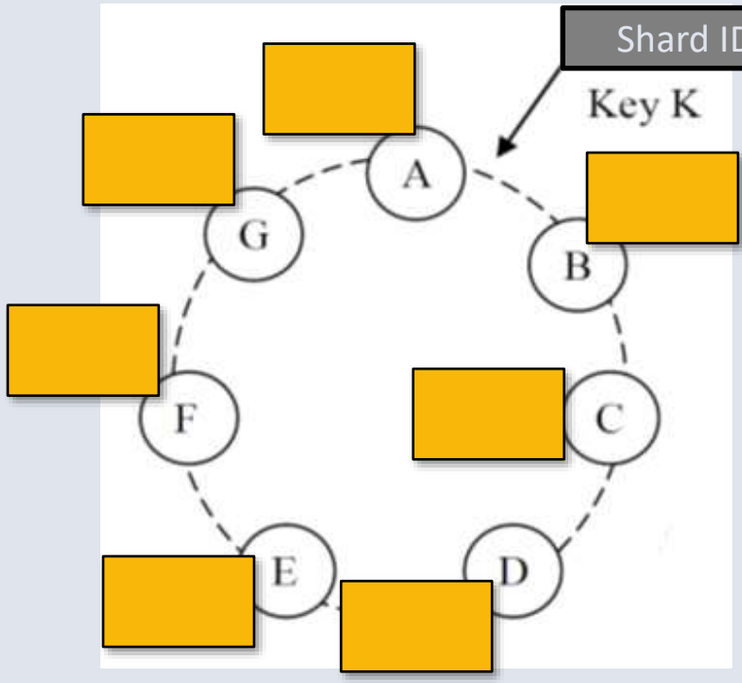
ObjID O_i

Assoc. O_i, type, O_j

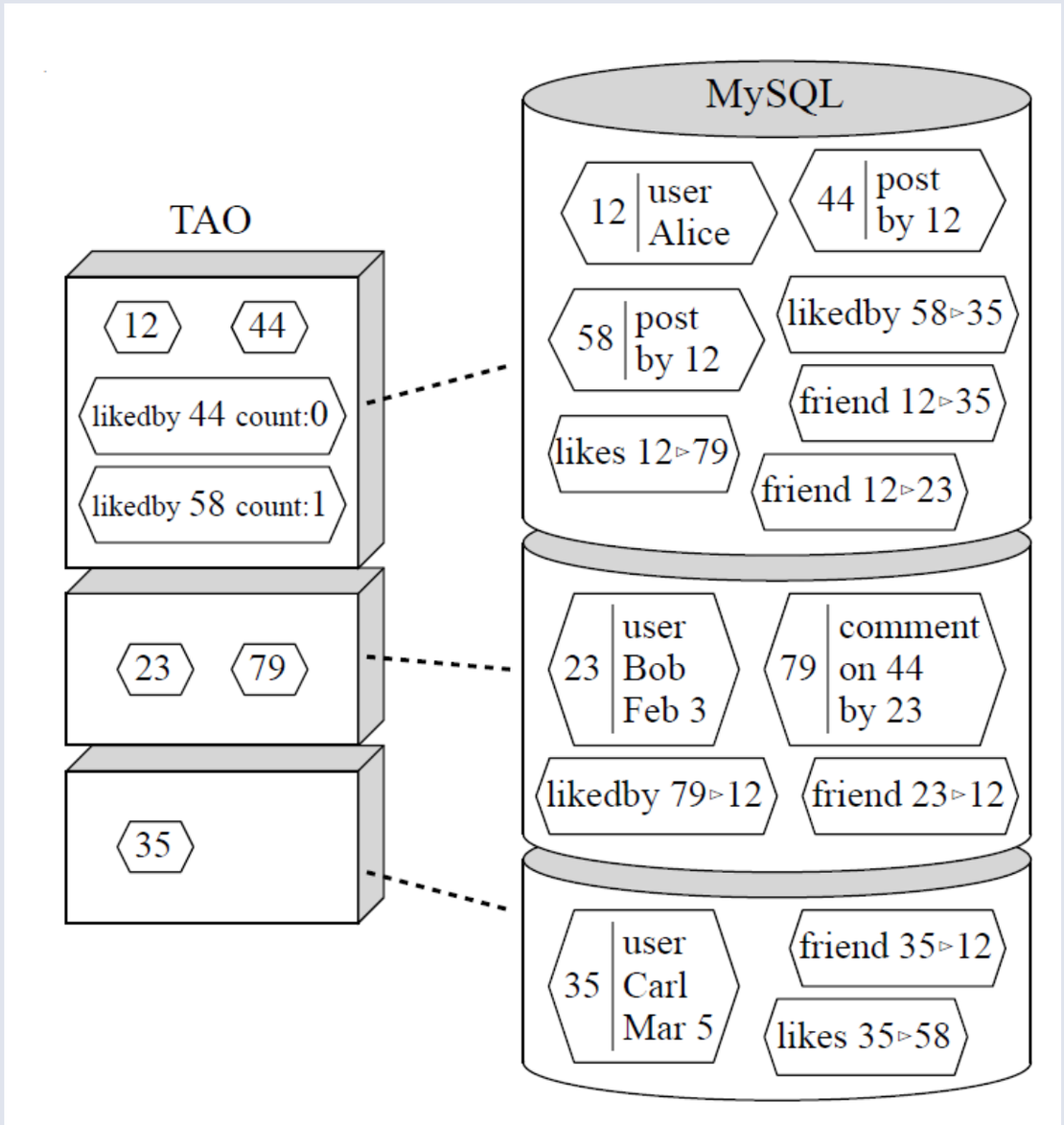
Static assignment, at creation time

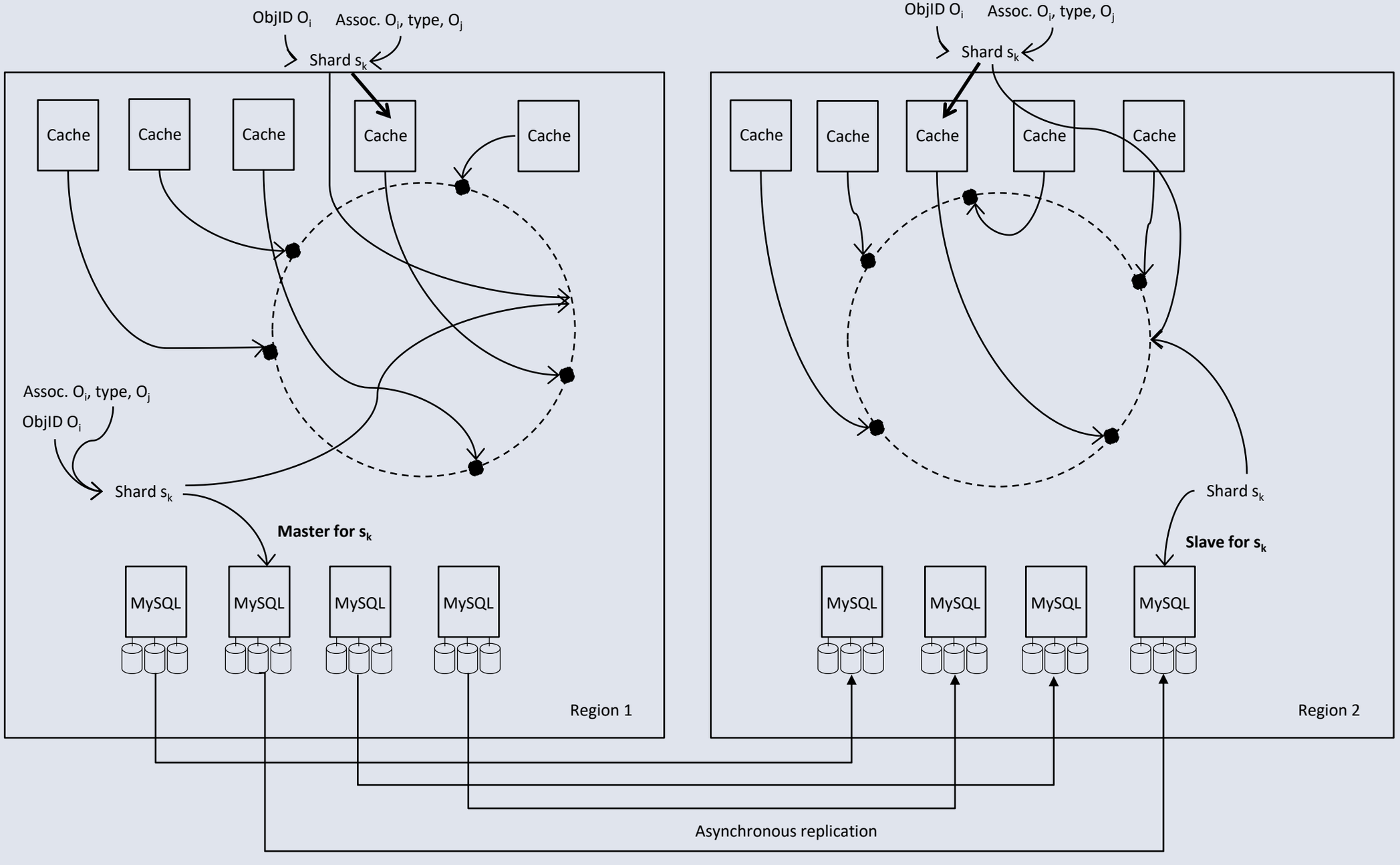
Shard ID

Consistent hashing



Sharding in Tao



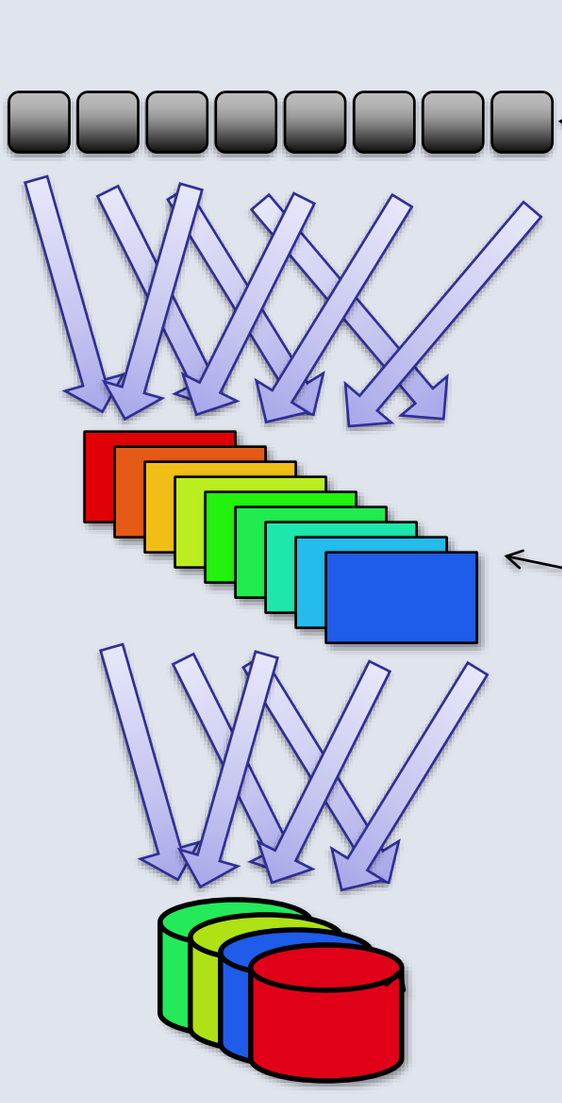

ObjID O_i
Assoc. O_i, type, O_j
Shard s_k
Cache
Cache
Cache
Cache
Cache
Assoc. O_i, type, O_j
ObjID O_i
Shard s_k
Master for s_k
MySQL
MySQL
MySQL
MySQL
Region 1
ObjID O_i
Assoc. O_i, type, O_j
Shard s_k
Cache
Cache
Cache
Cache
Cache
Shard s_k
Slave for s_k
MySQL
MySQL
MySQL
MySQL
Region 2
Asynchronous replication

Subdividing the Data Center

Web servers

Cache

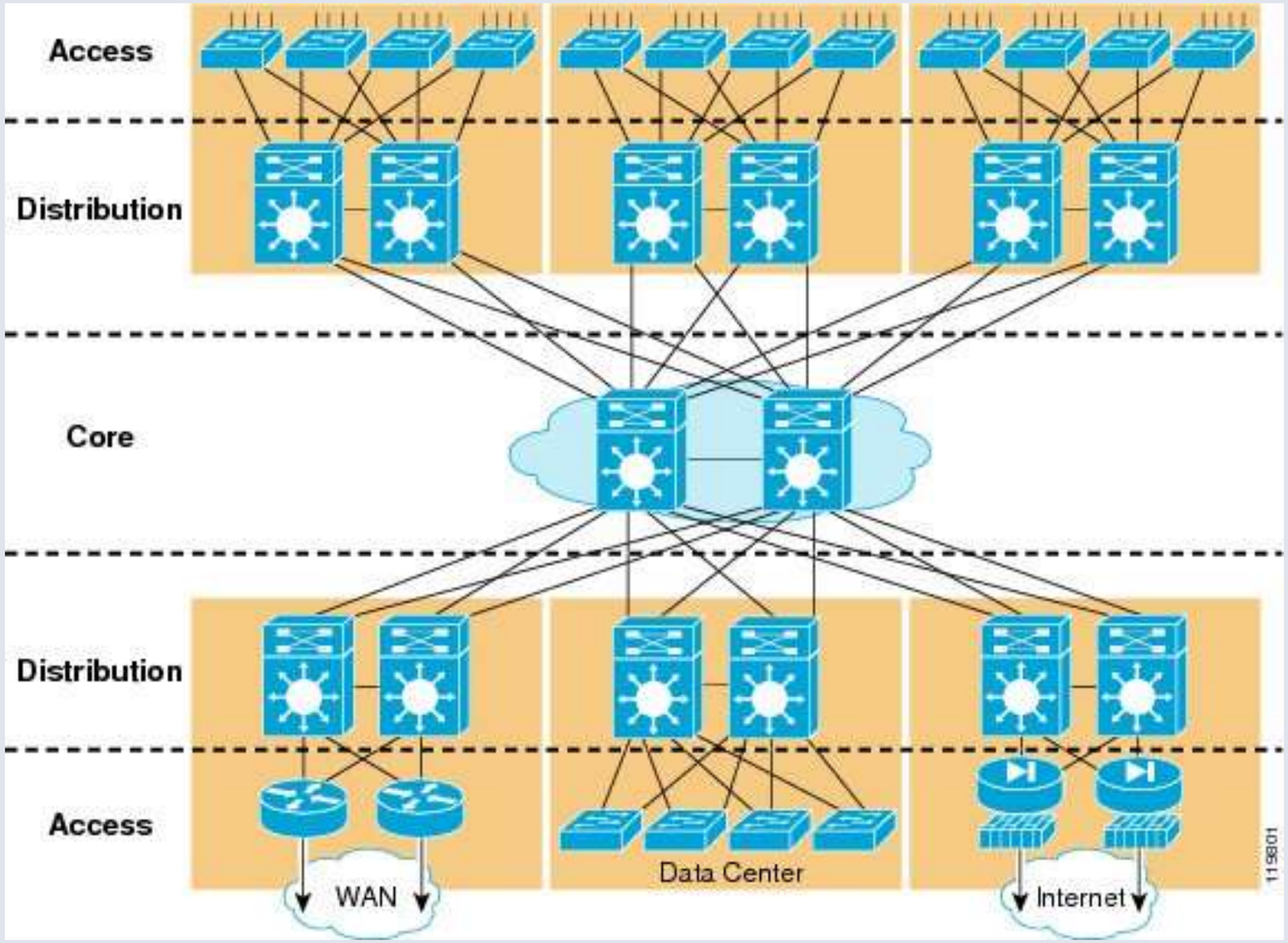
Database



- Inefficient failure detection
- Many switch traversals

- Many open sockets
- Lots of hot spots

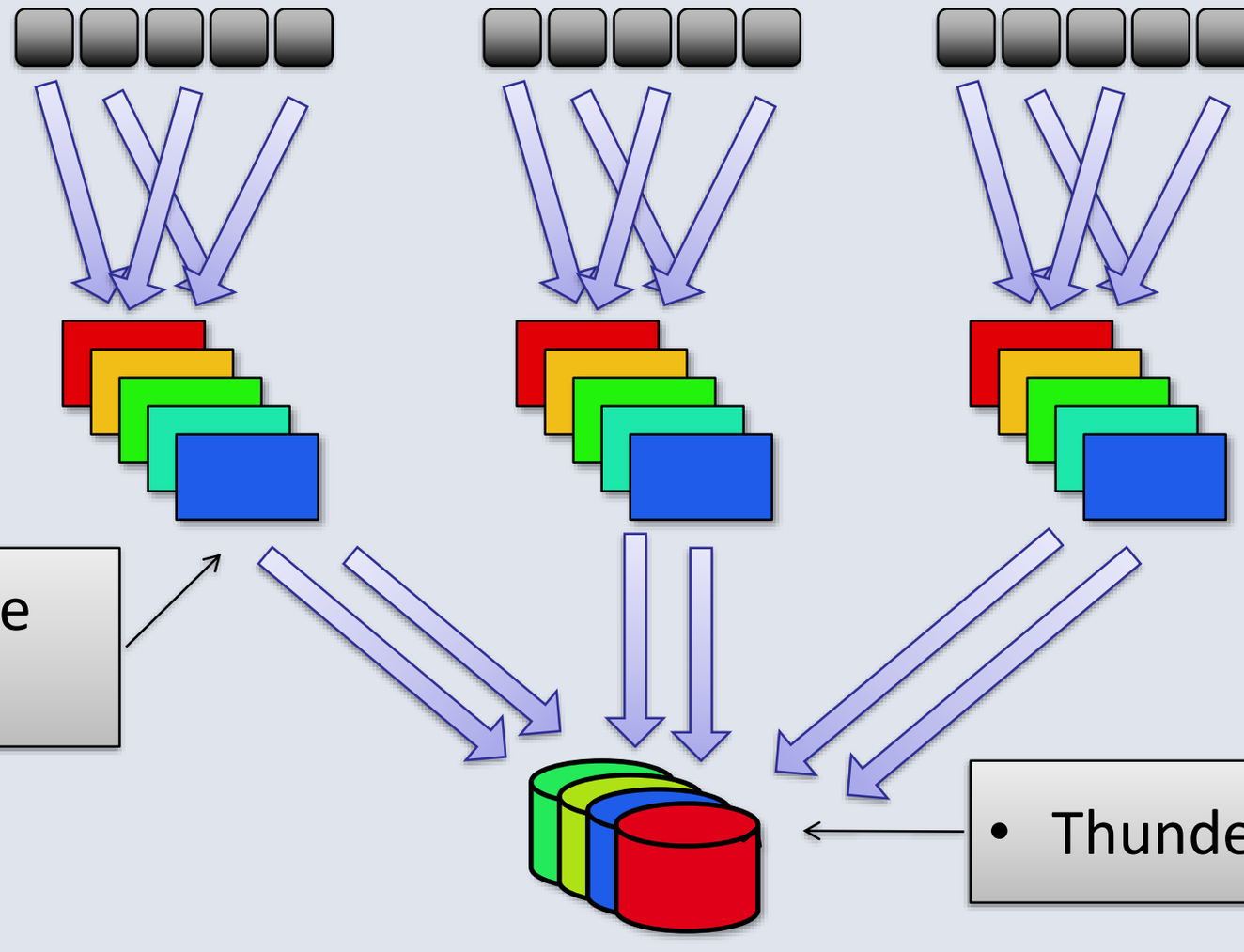
Network design



Source: http://www.cisco.com/c/en/us/td/docs/solutions/Enterprise/Campus/HA_campus_DG/hacampusdg.html

Subdividing the Data Center

Web servers



Cache

- Distributed write control logic

Database

- Thundering herds

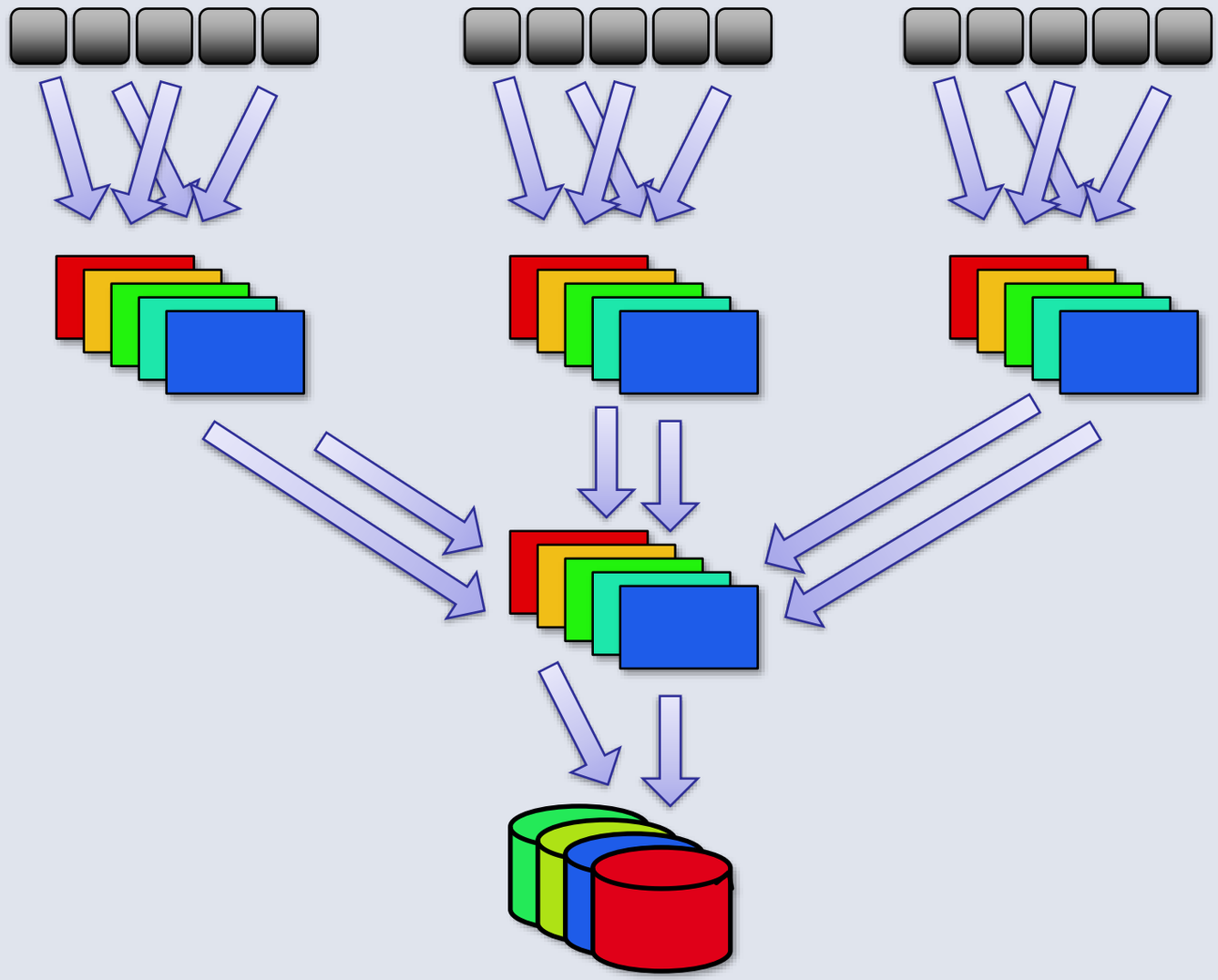
Follower and Leader Caches

Web servers

Follower cache

Leader cache

Database



What Are TAO's Goals/Challenges?

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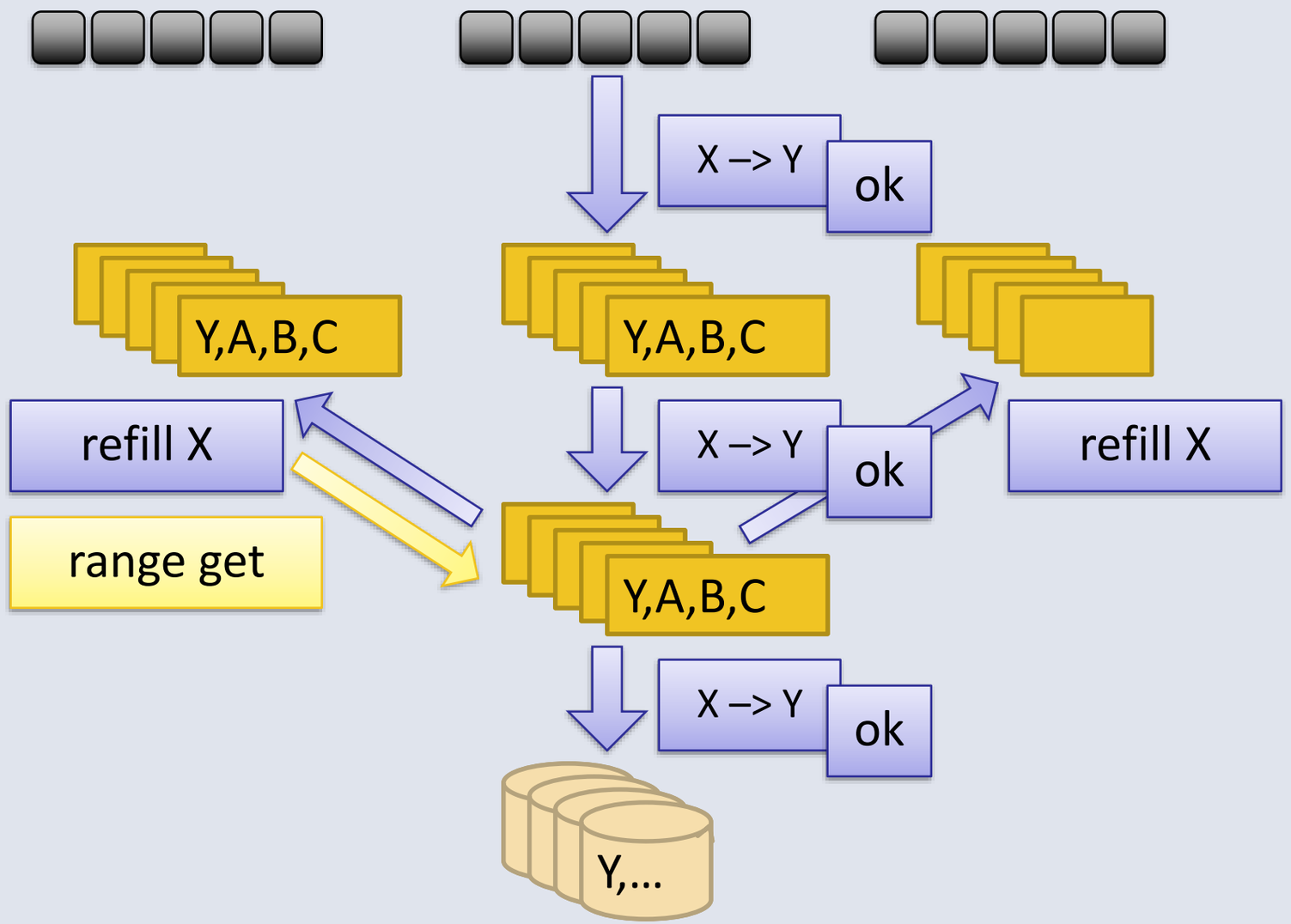
Write-through Caching – Association Lists

Web servers

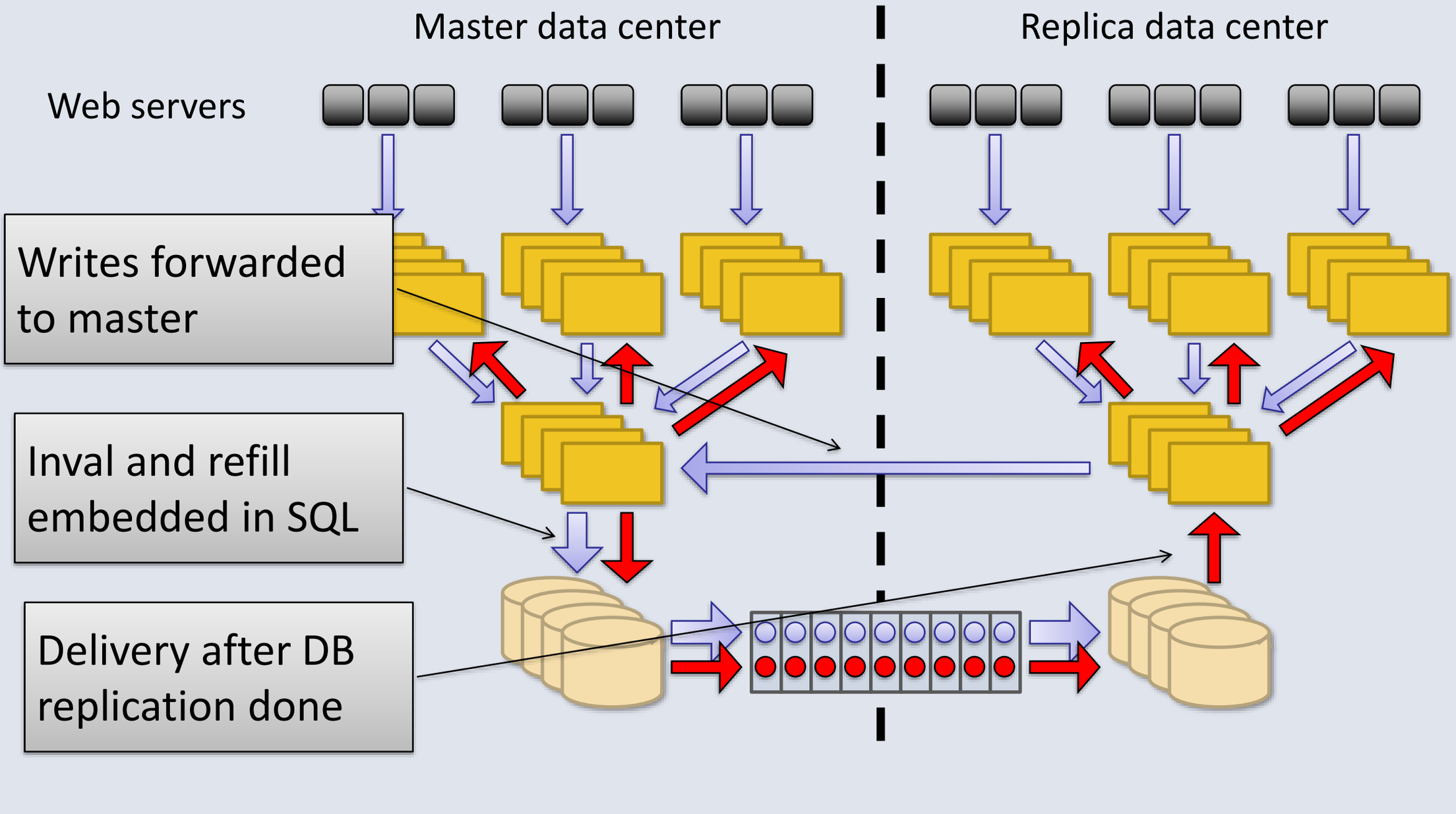
Follower cache

Leader cache

Database



Asynchronous DB Replication



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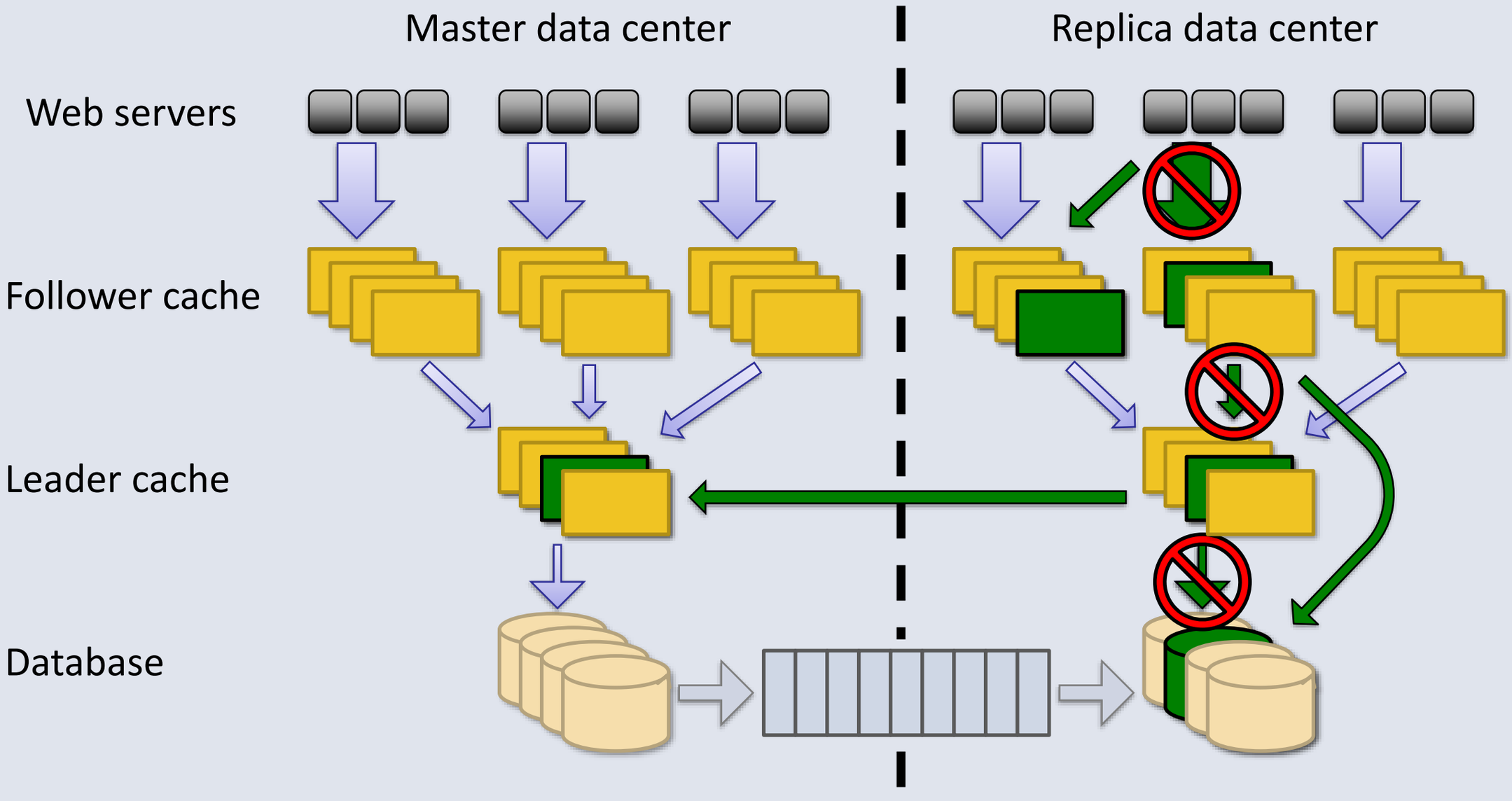
Improving Availability: Read Failover



TAO Summary

Efficiency at scale Read latency	• Separate cache and DB • Graph-specific caching • Subdivide data centers
Write timeliness	• Write-through cache • Asynchronous replication
Read availability	• Alternate data sources

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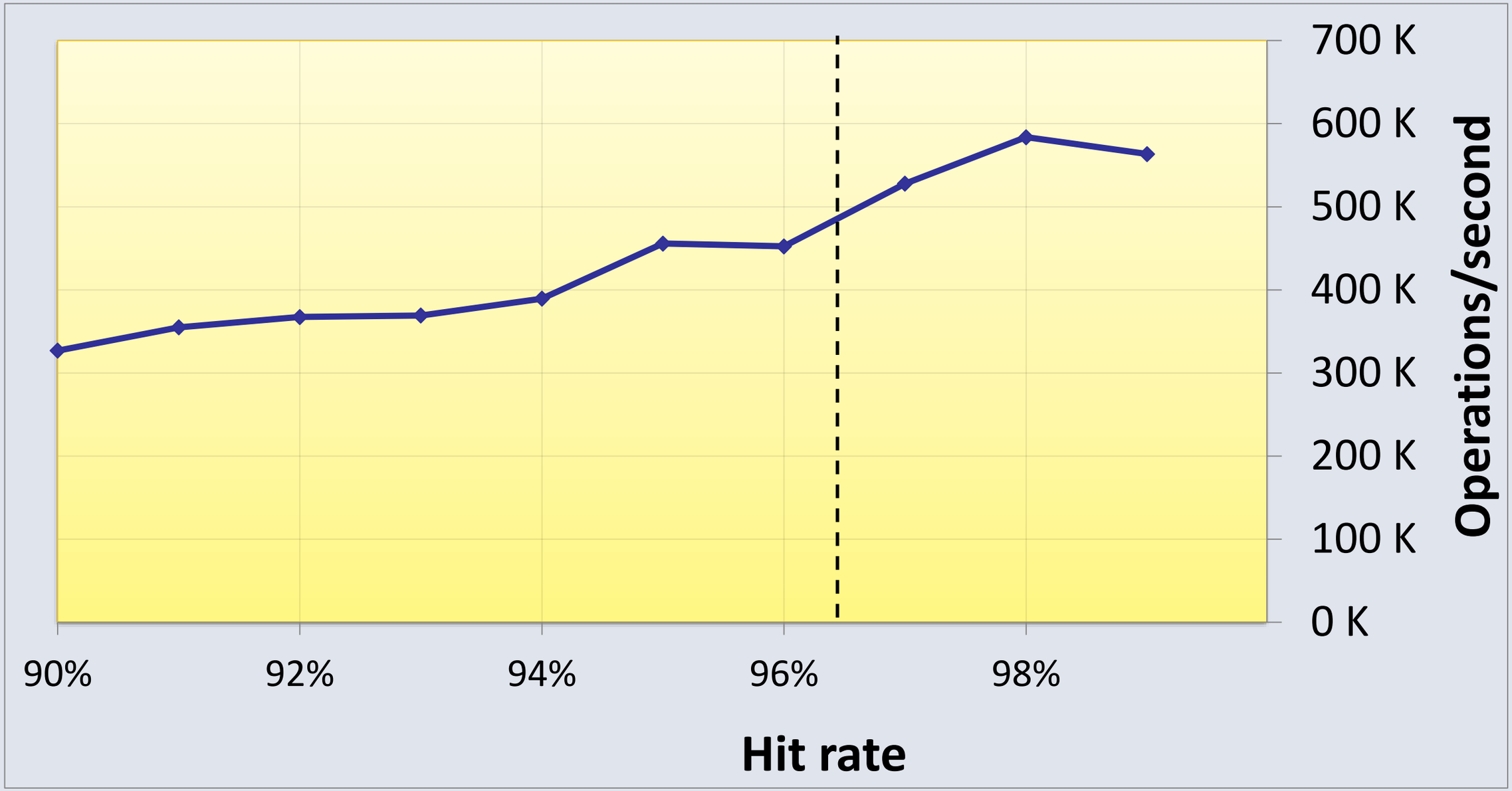
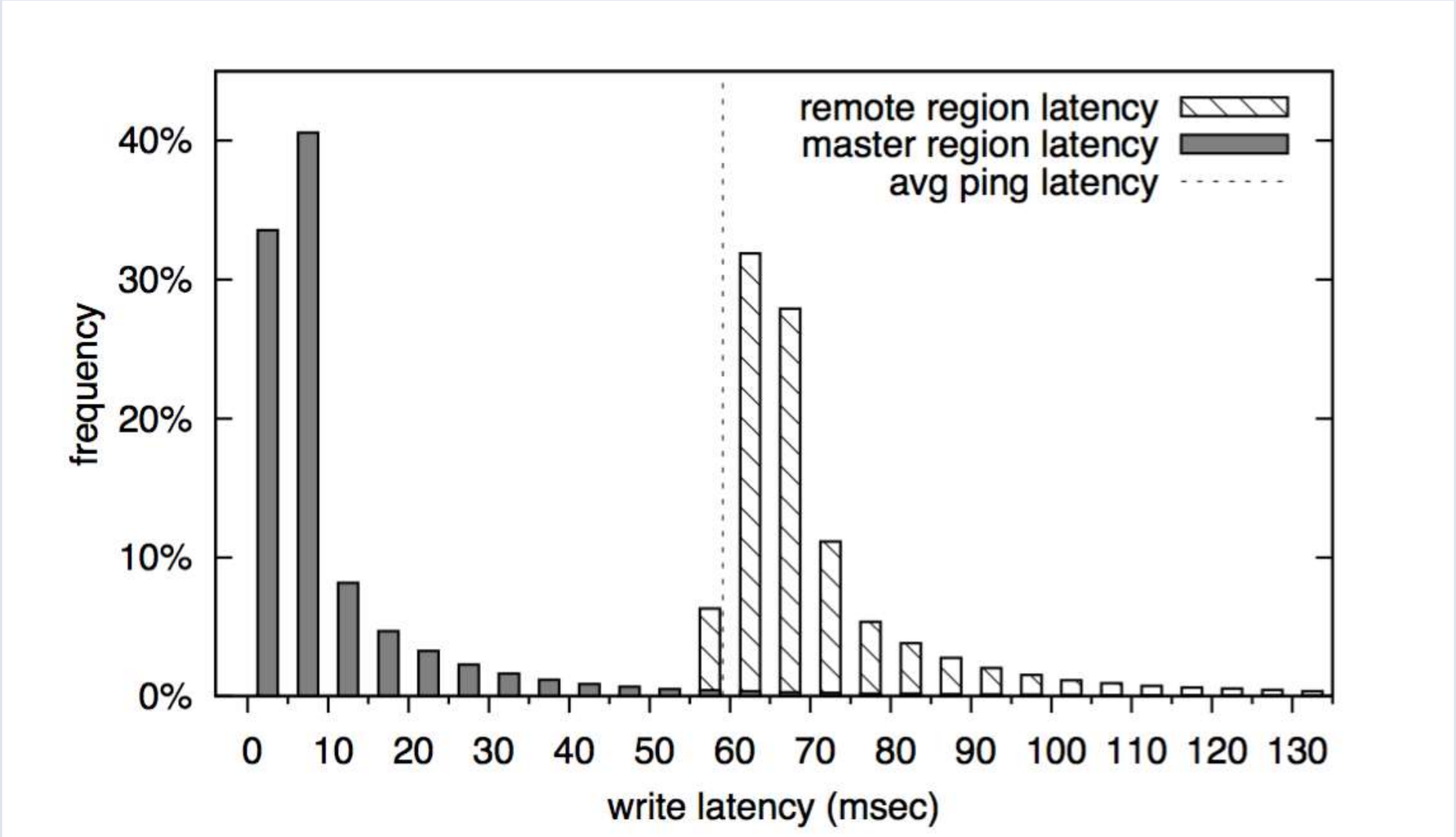
Single-server Peak Observed Capacity

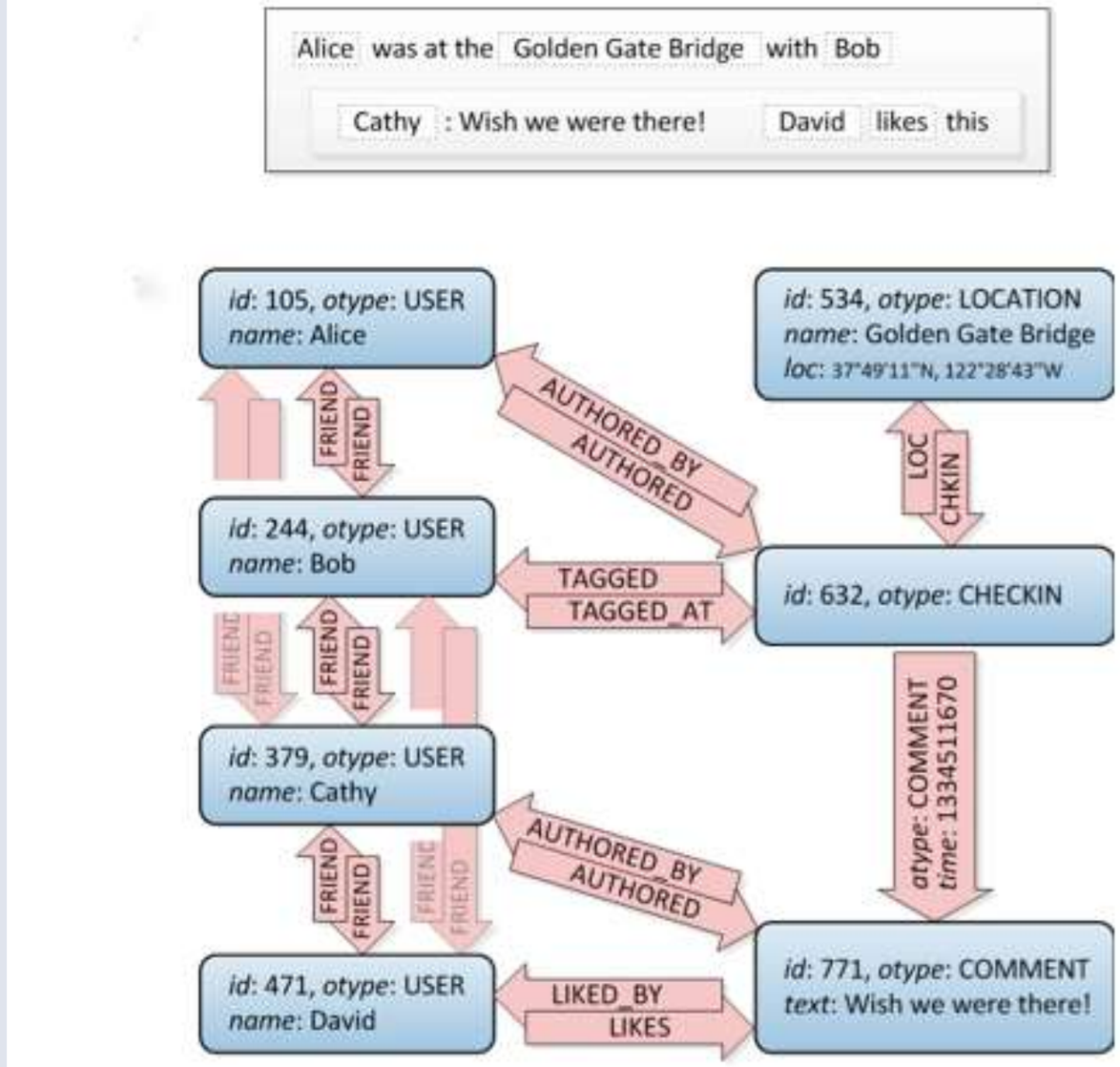


Write latency



More In the Paper

- The role of association time in optimizing cache hit rates
- Optimized graph-specific data structures
- Write failover
- Failure recovery
- Workload characterization


Alice was at the Golden Gate Bridge with Bob
Cathy : Wish we were there! David likes this
id: 105, otype: USER
name: Alice
id: 534, otype: LOCATION
name: Golden Gate Bridge
loc: 37°49'11"N, 122°28'43"W
FRIEND
FRIEND
AUTHORED_BY
AUTHORED
LOC
CHKIN
id: 244, otype: USER
name: Bob
TAGGED
TAGGED_AT
id: 632, otype: CHECKIN
FRIEND
FRIEND
FRIEND
FRIEND
id: 379, otype: USER
name: Cathy
atype: COMMENT
time: 1334511670
AUTHORED_BY
AUTHORED
FRIEND
FRIEND
FRIEND
FRIEND
id: 471, otype: USER
name: David
LIKED_BY
LIKES
id: 771, otype: COMMENT
text: Wish we were there!