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TAO
Facebook's Distributed Data Store for the Social Graph

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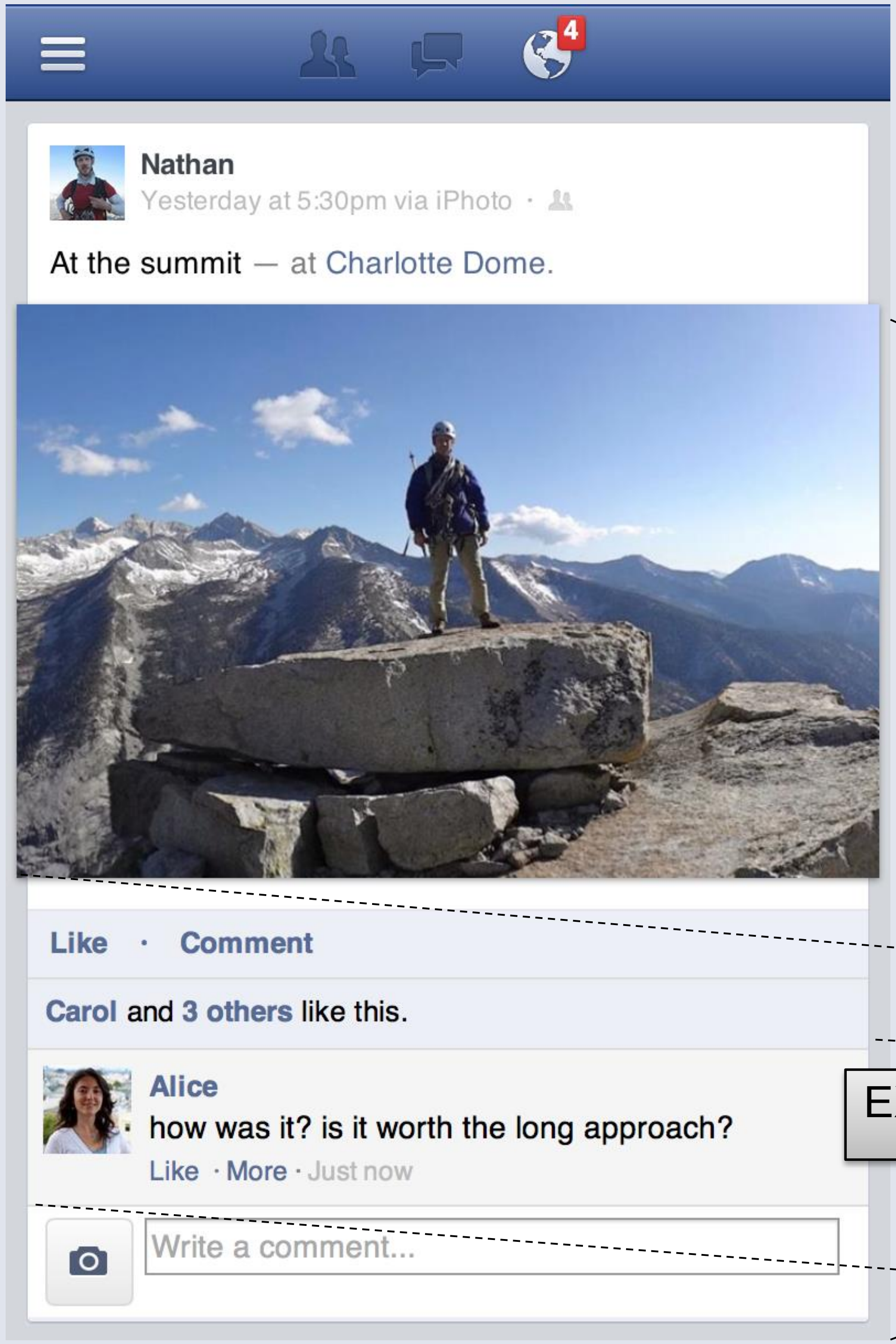
Presented at USENIX ATC – June 26, 2013

The Social Graph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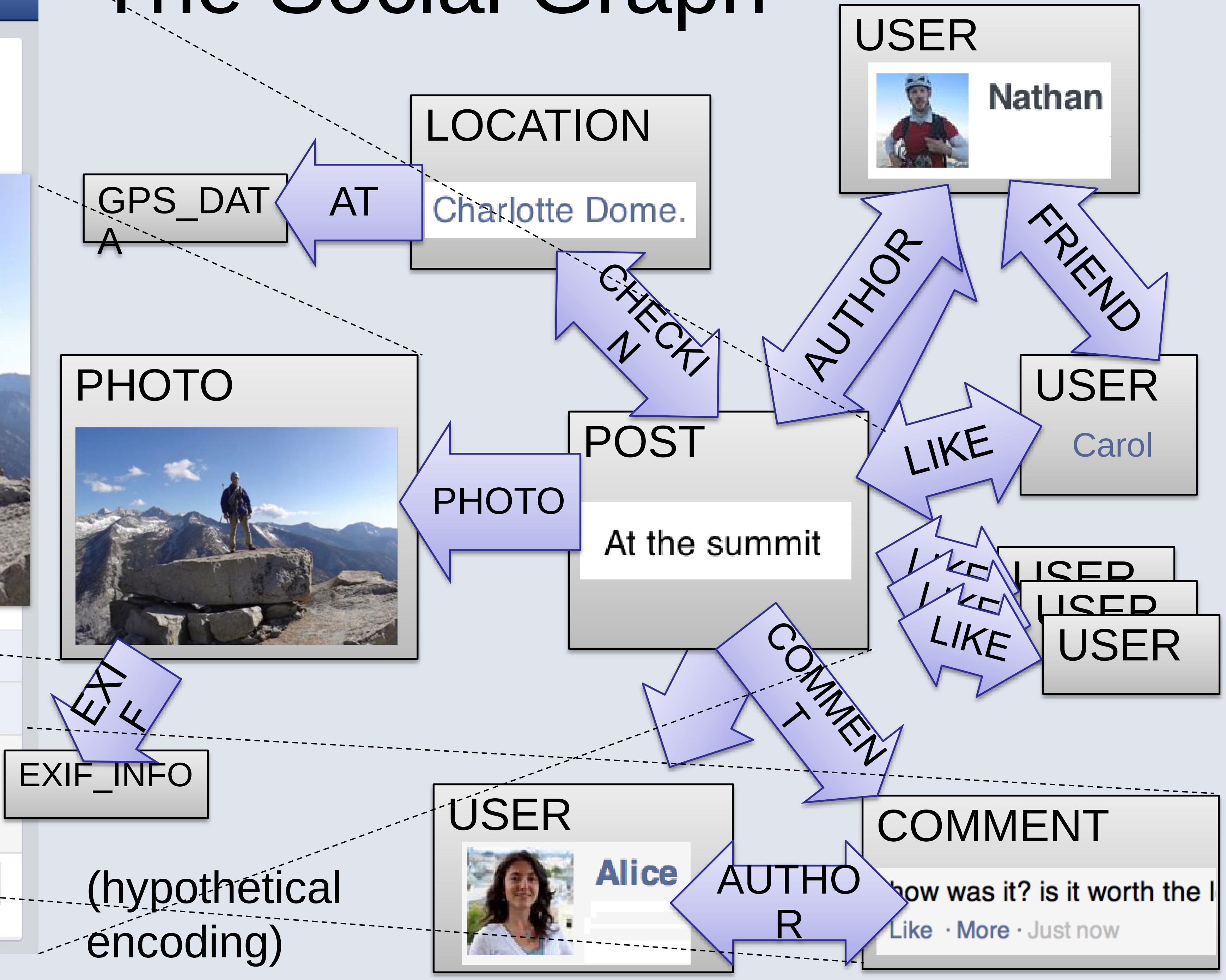
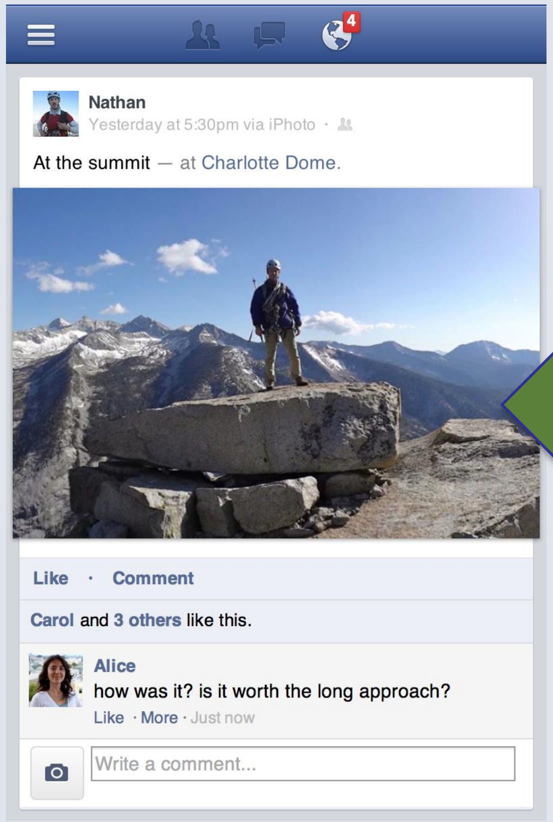


(hypothetical encoding)

Dynamically Rendering the Graph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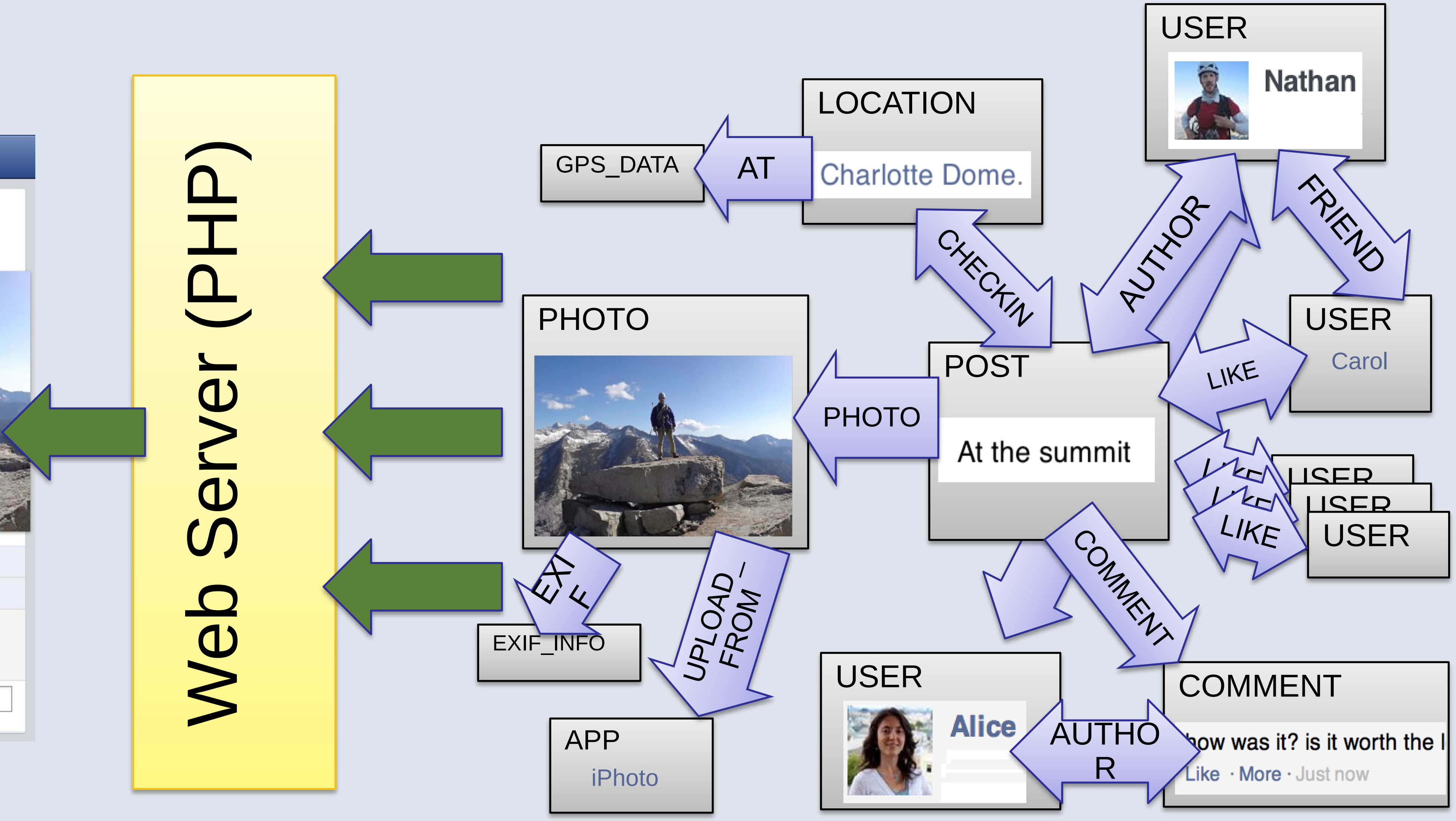

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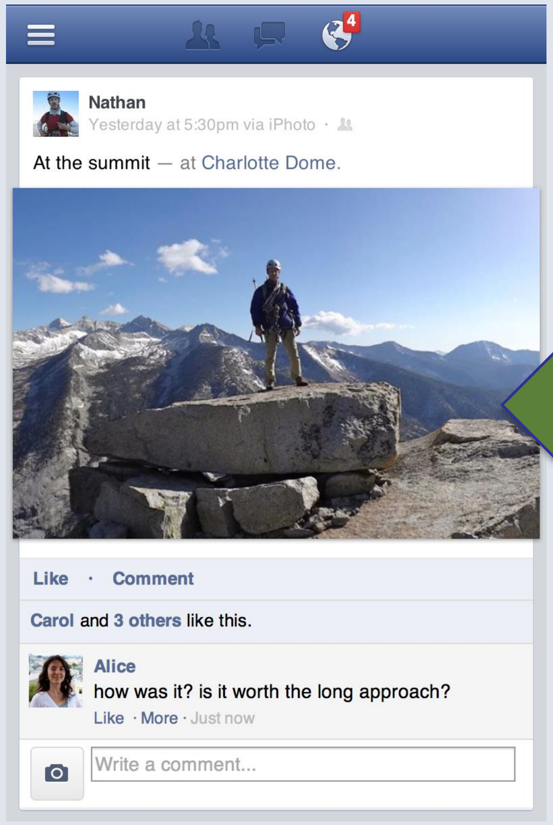
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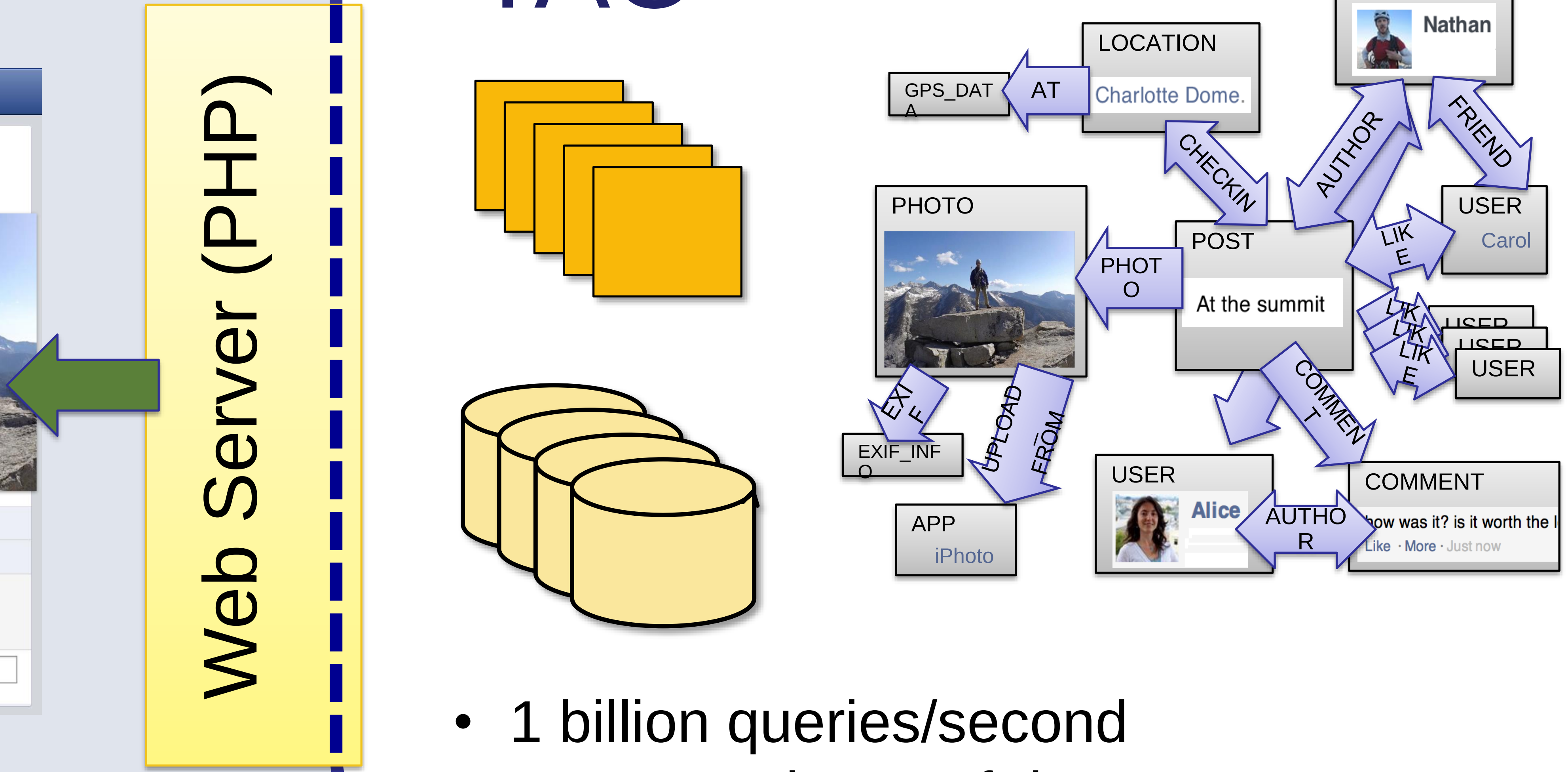
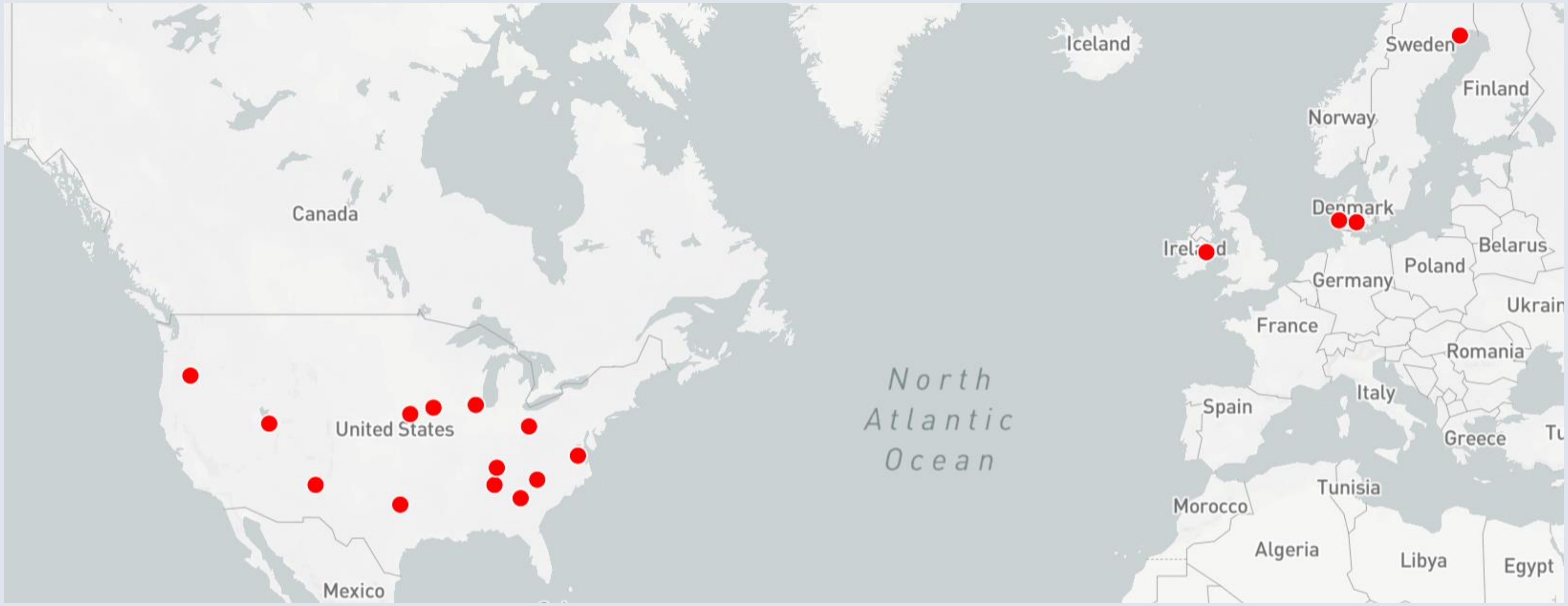


- 1 billion queries/second
- many petabytes of data

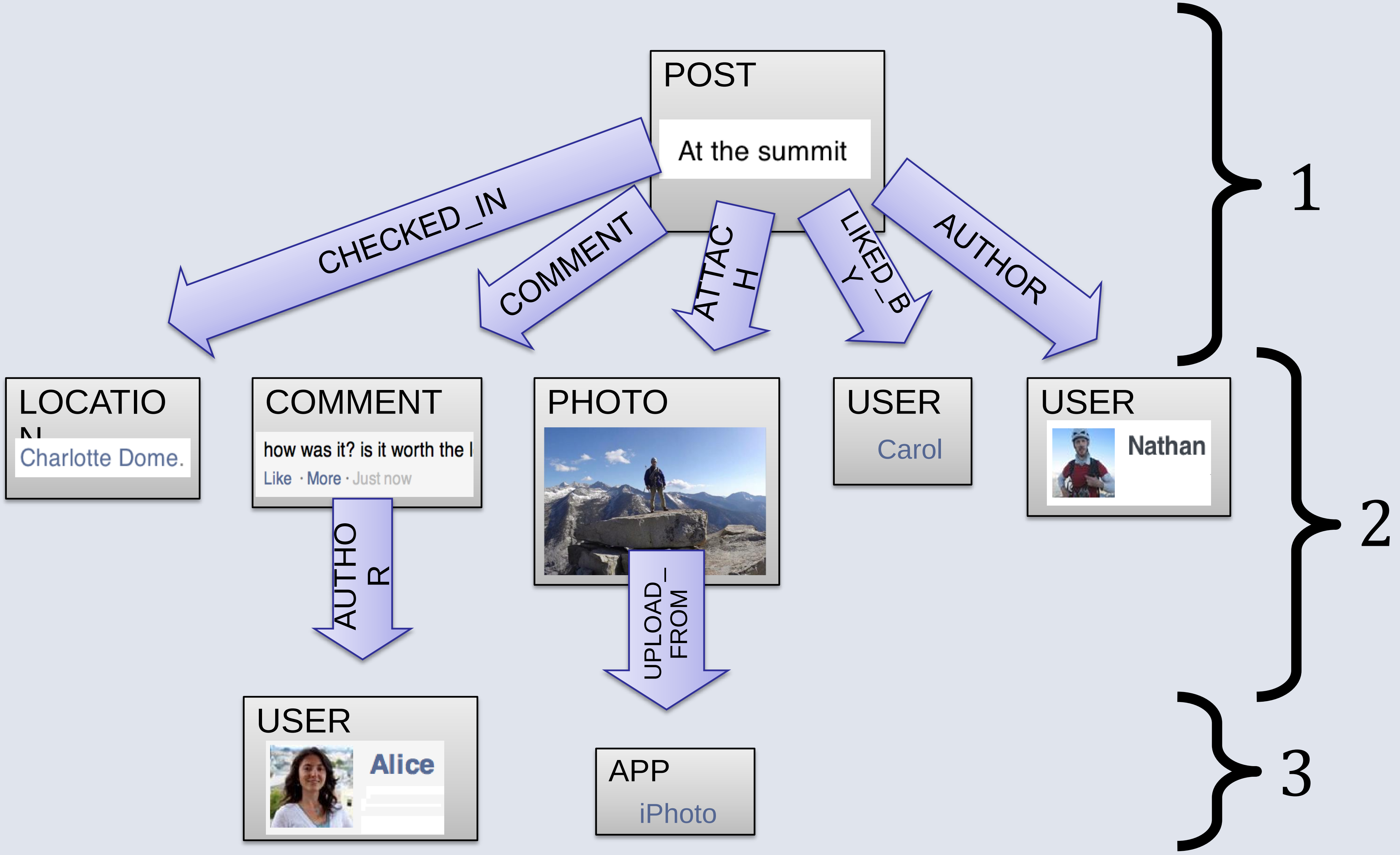
facebook data centers



What Are TAO's Goals/Challenges?

- Efficiency at scale

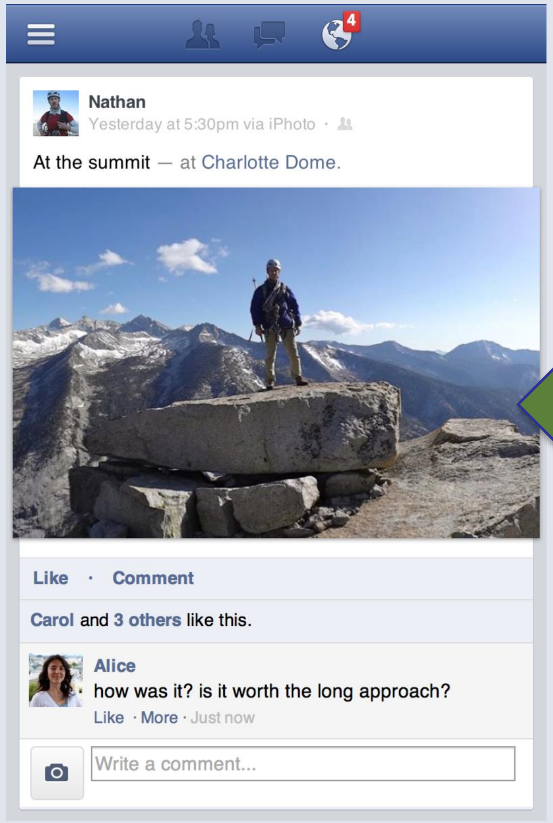
Dynamic Resolution of Data Dependencies



What Are TAO’s Goals/Challenges?

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

Graph in Memcache



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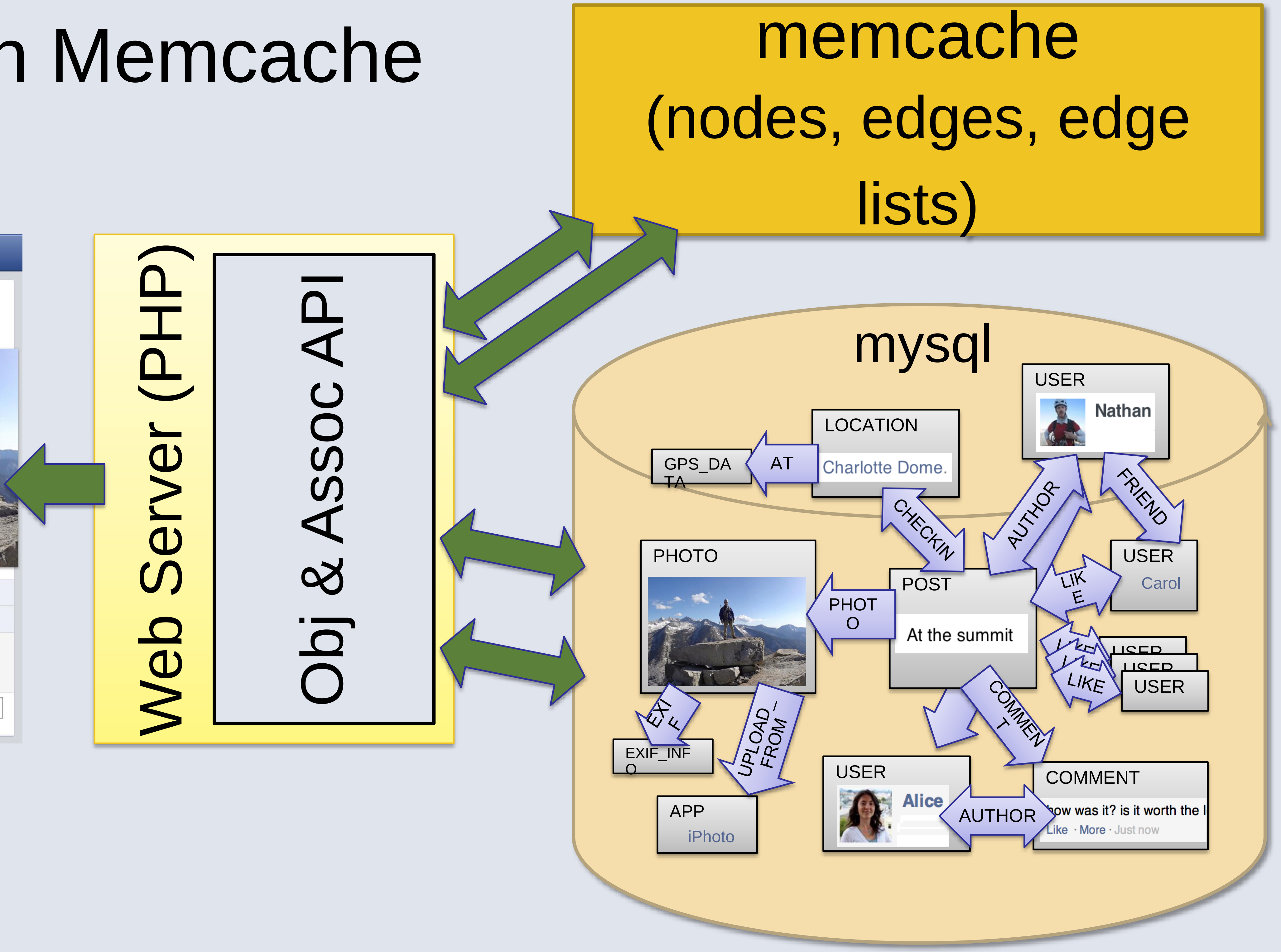
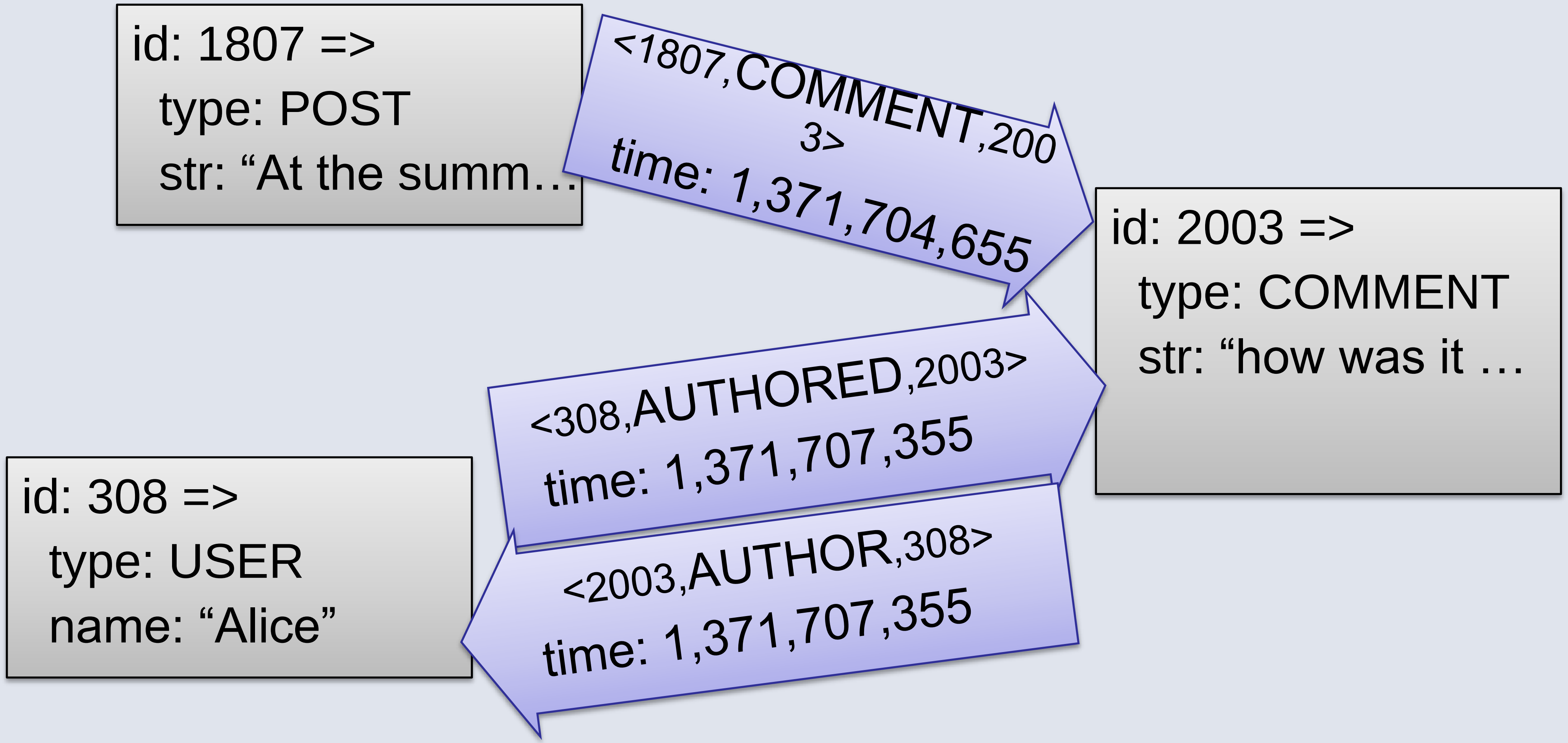


Objects = Nodes

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

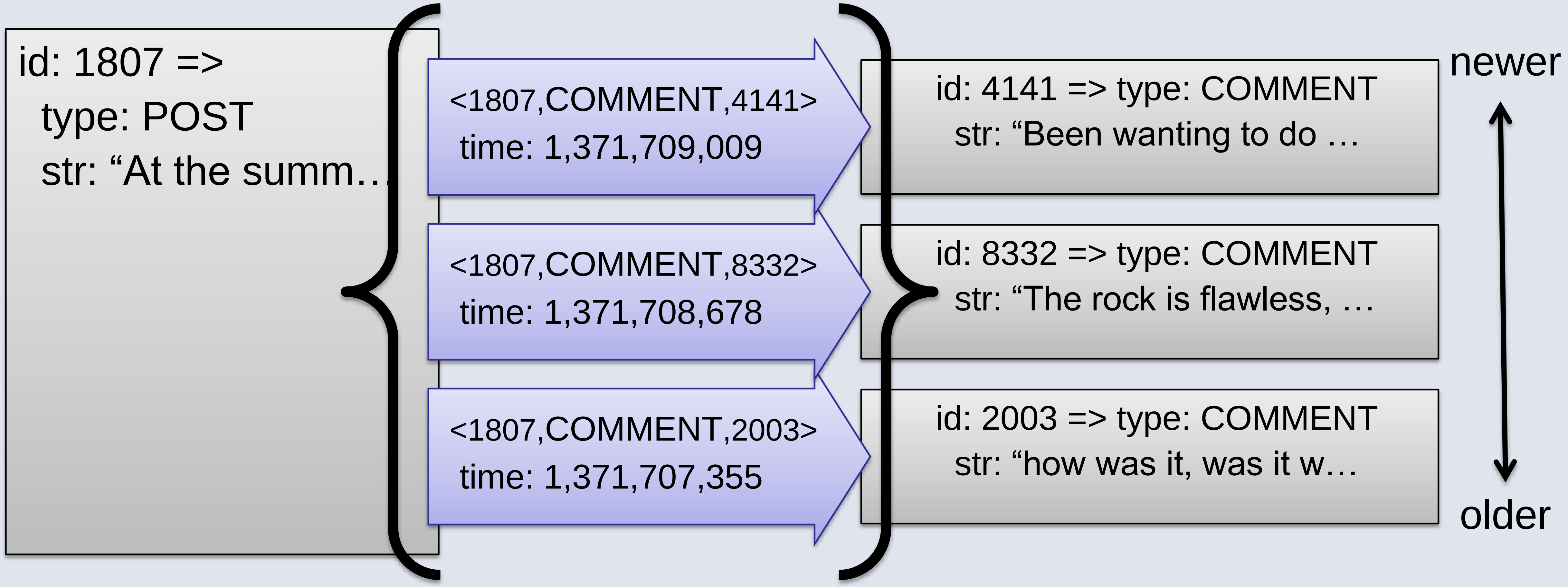
Associations = Edges

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



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?

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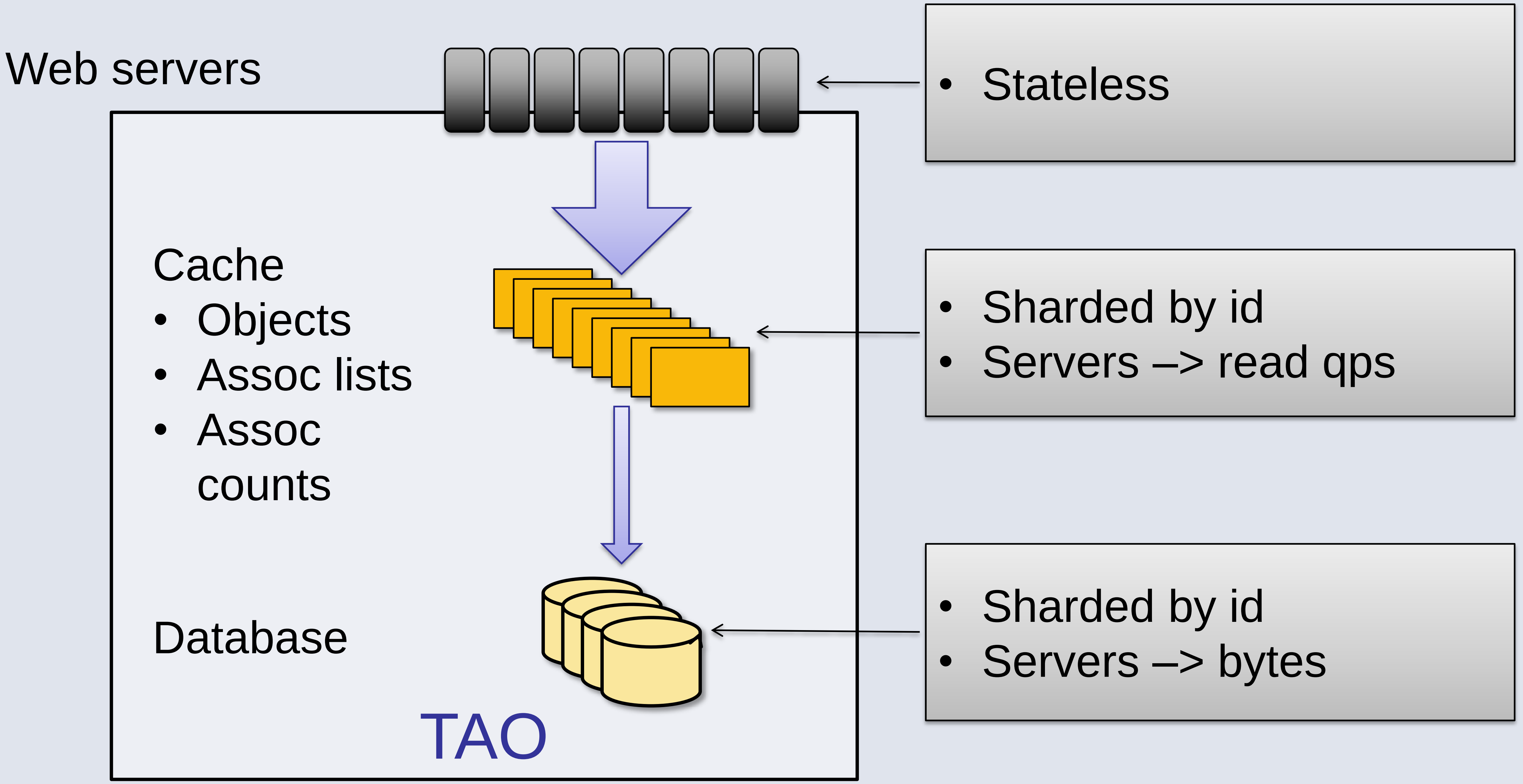
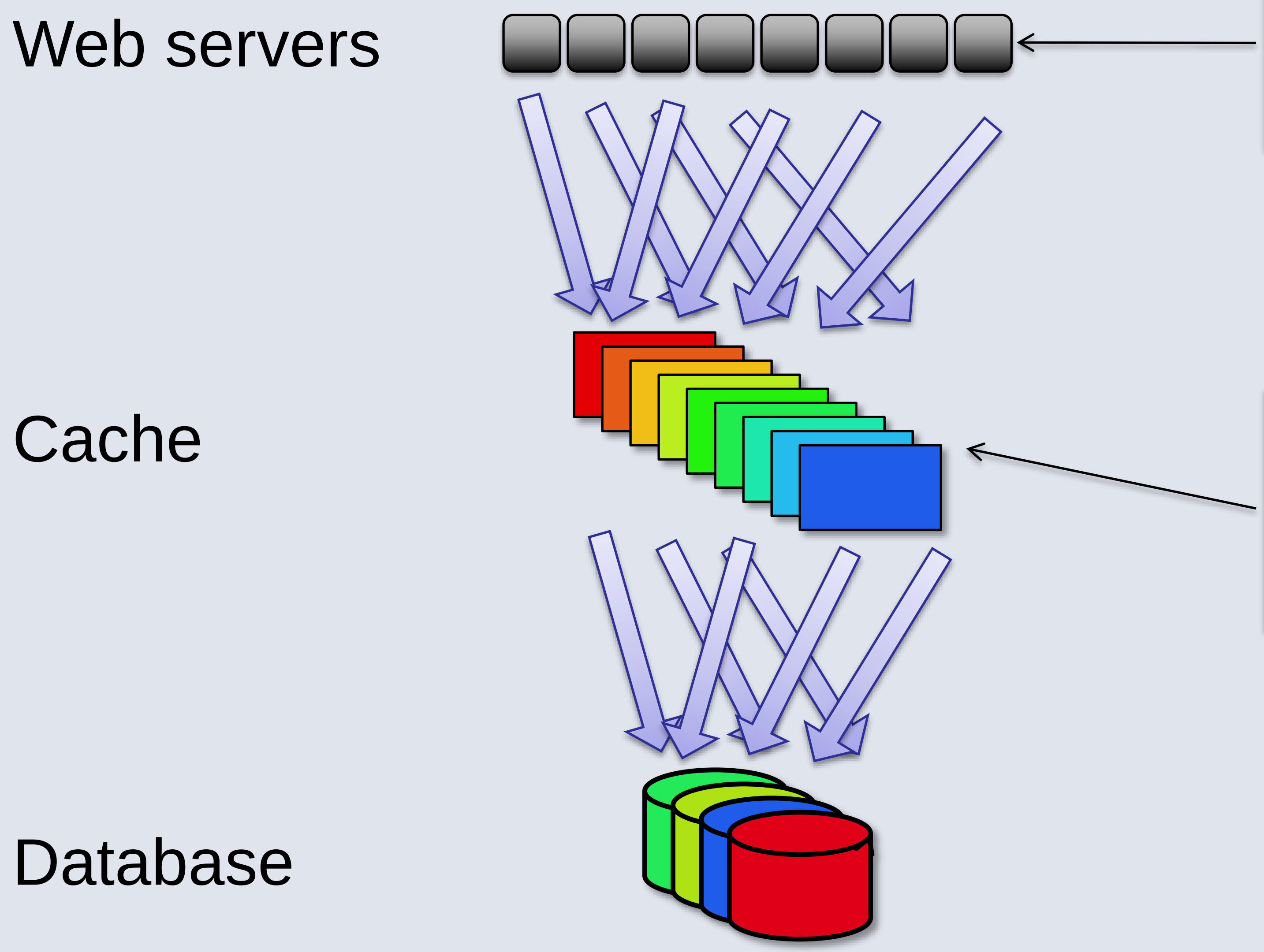
Independent Scaling by Separating Roles



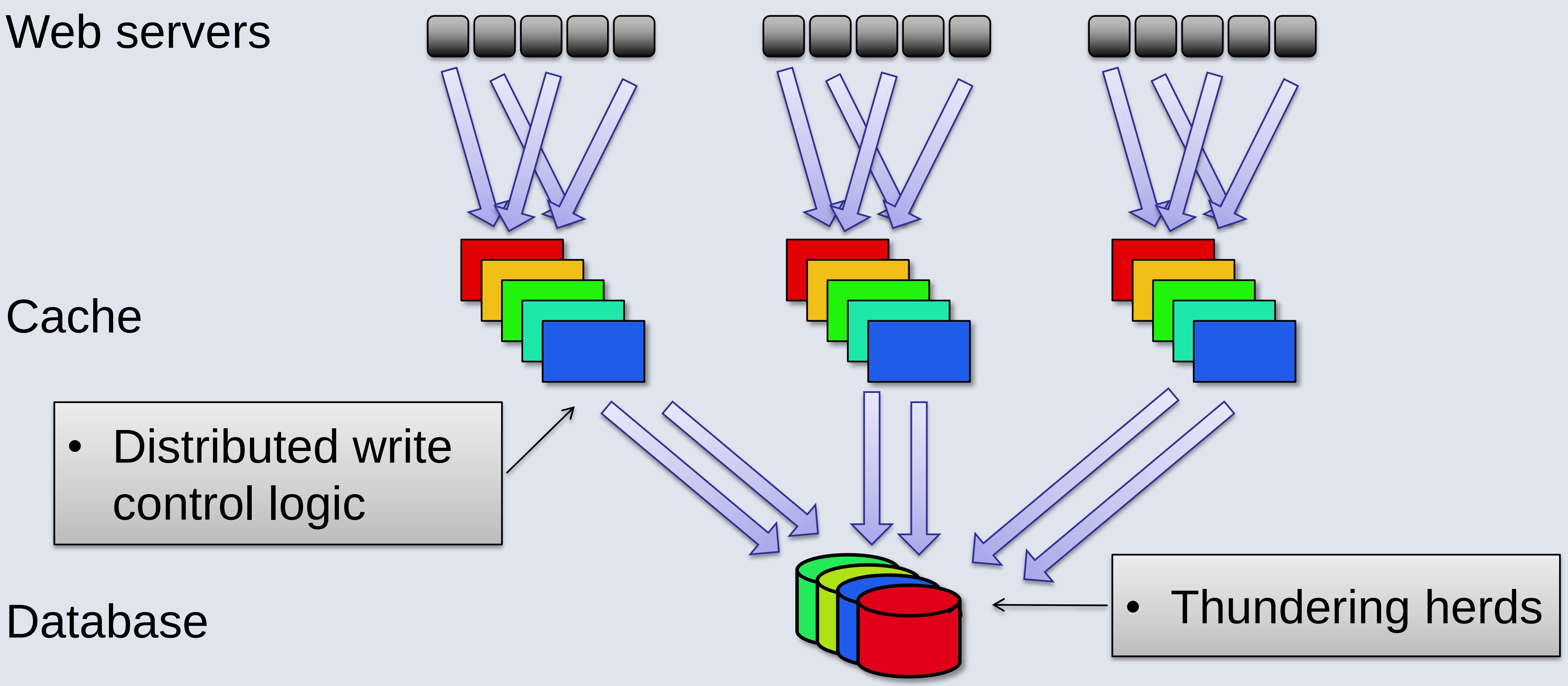
Subdividing the Data Center



- Inefficient failure detection
- Many switch traversals

- Many open sockets
- Lots of hot spots

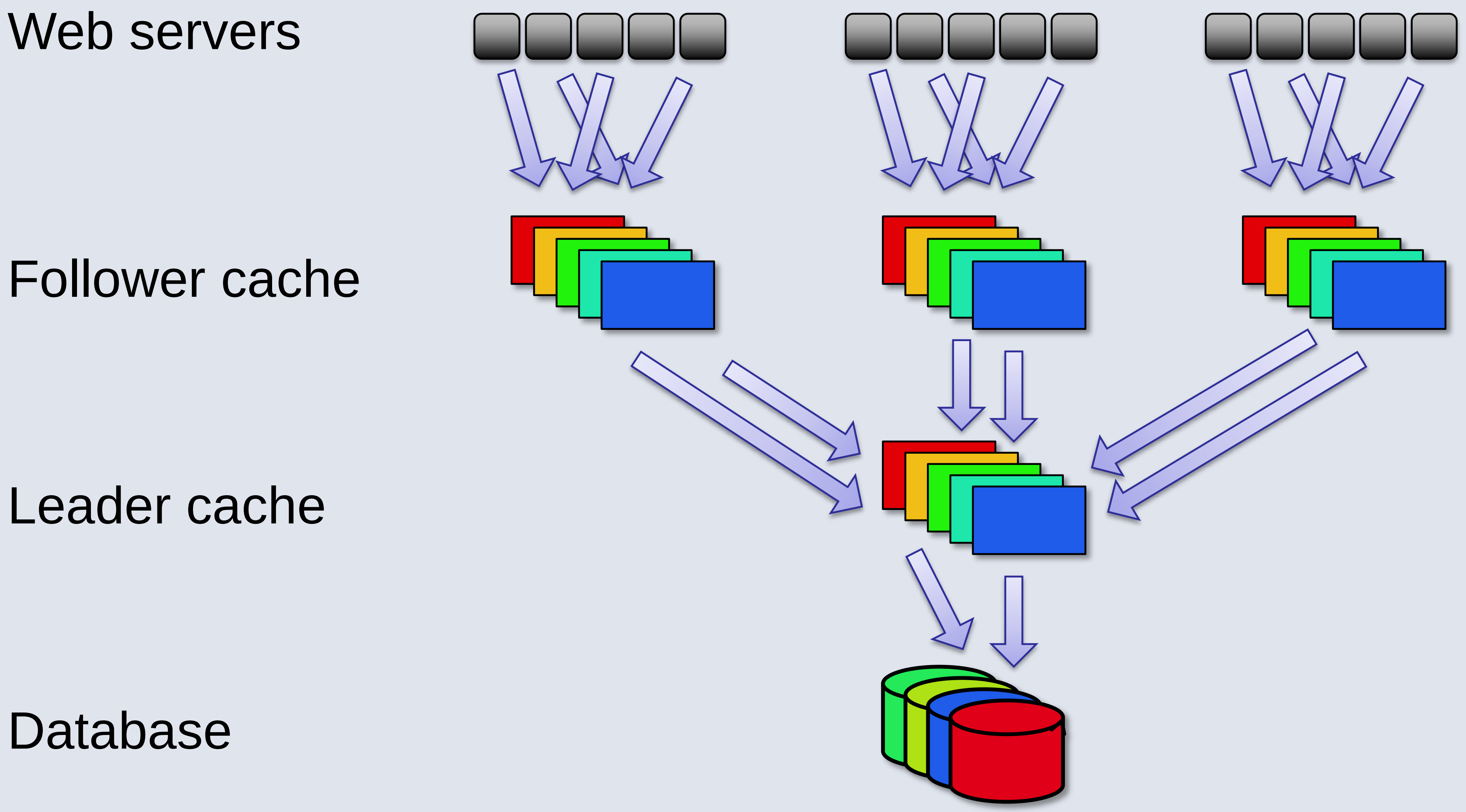
Subdividing the Data Center



- Distributed write control logic

- Thundering herds

Follower and Leader Caches



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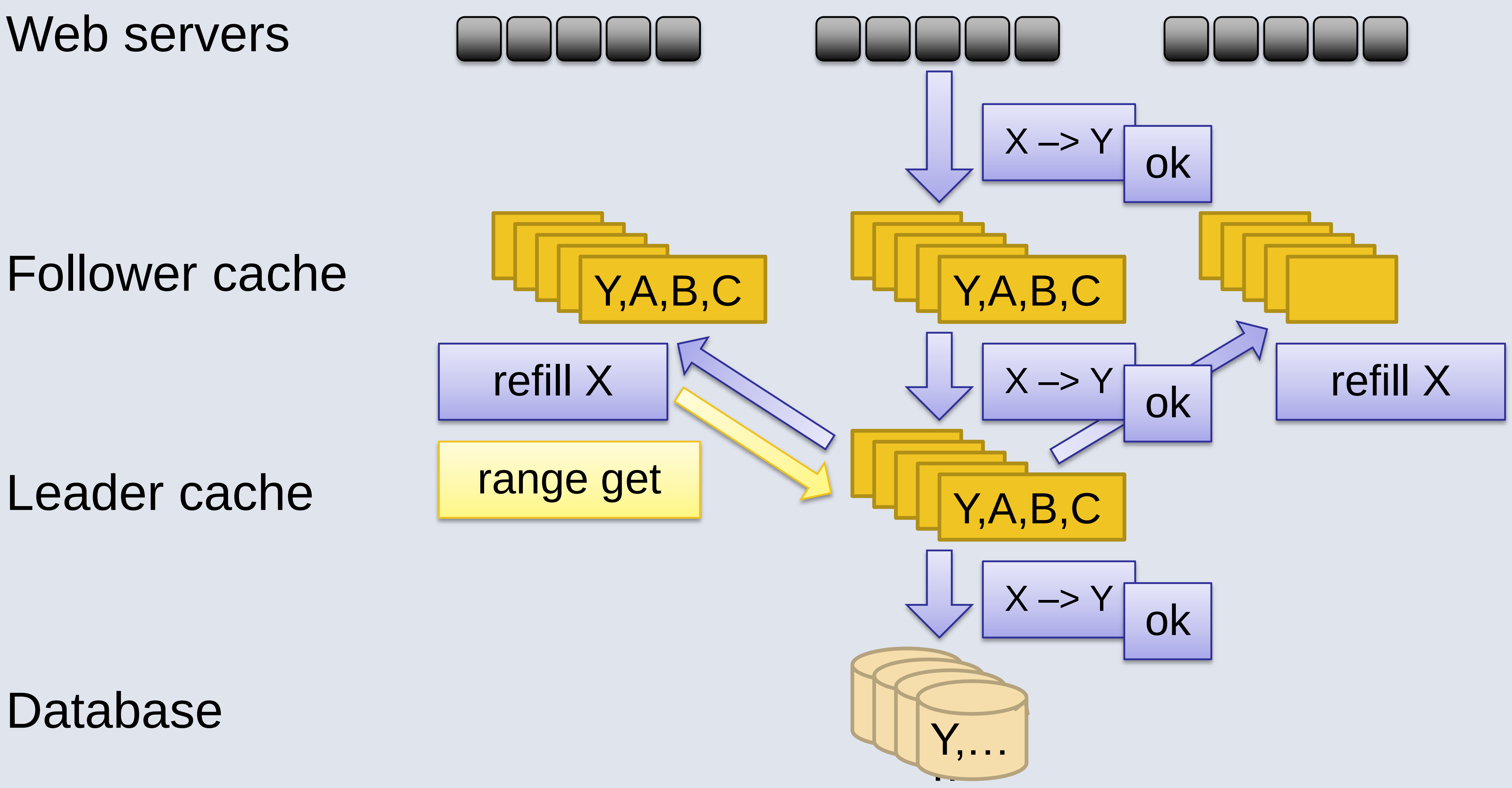
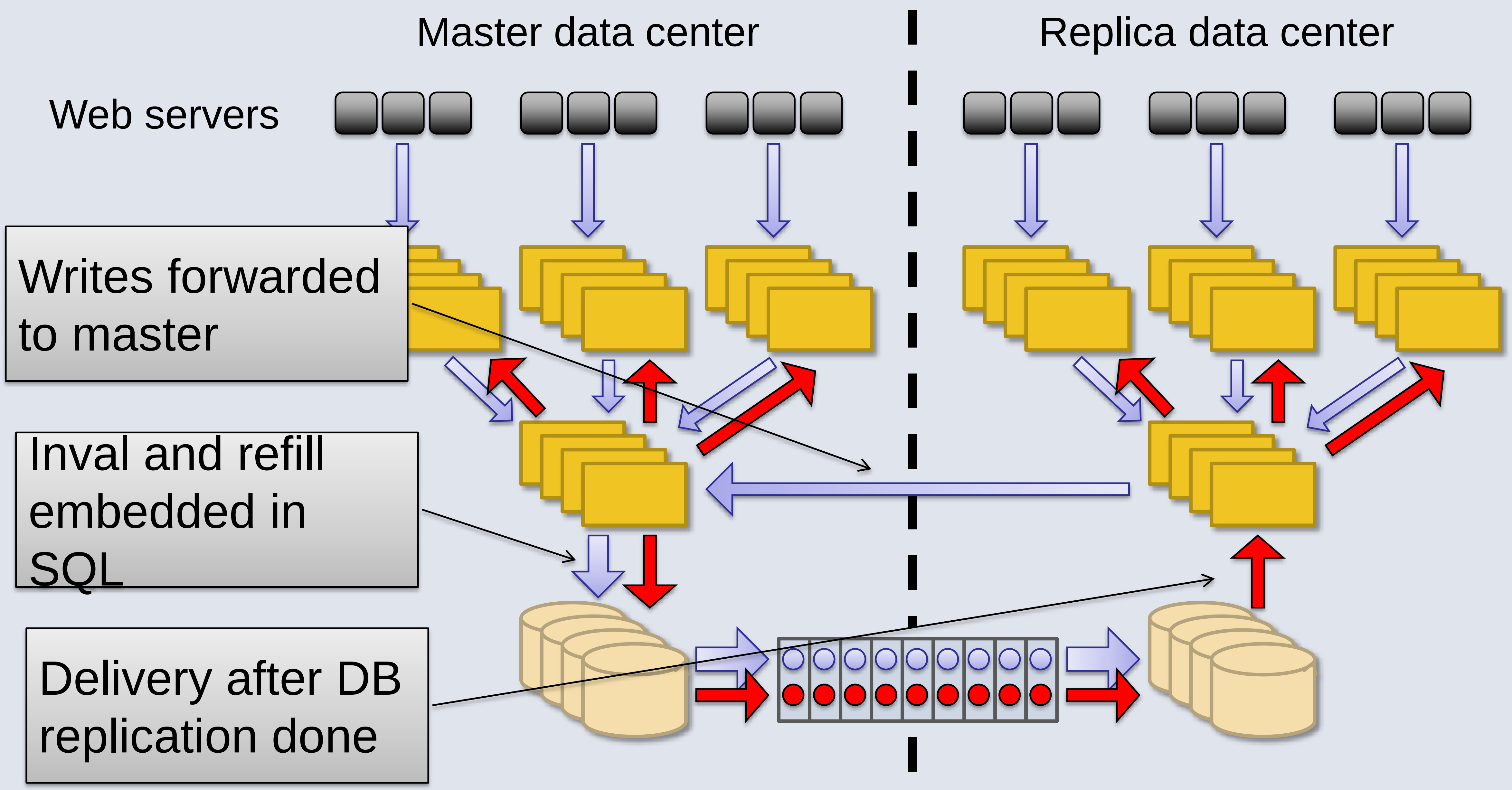
Write-through Caching – Association Lists



Asynchronous DB Replication



Writes forwarded to master

Inval and refill embedded in SQL

Delivery after DB replication done

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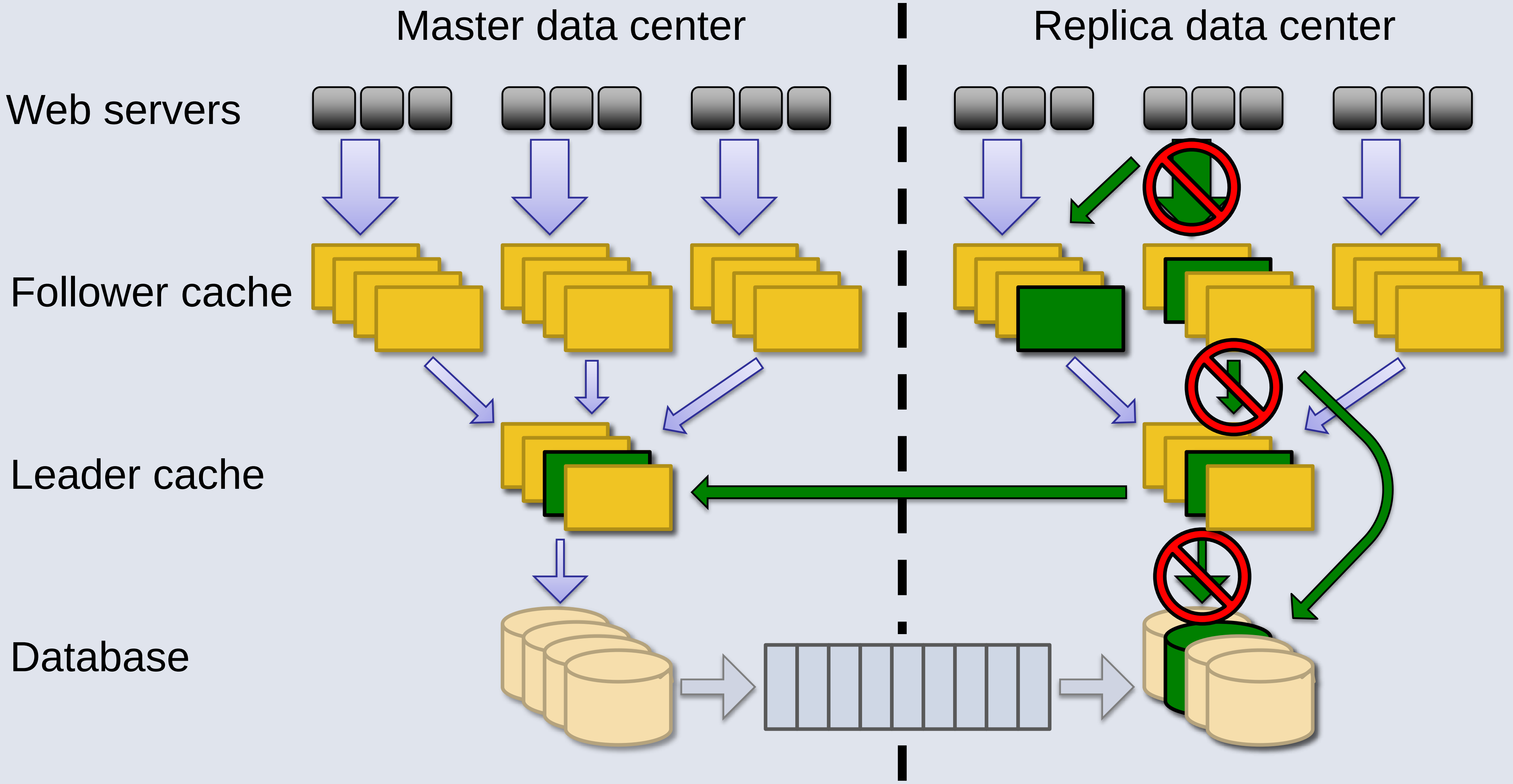
Improving Availability: Read Failover



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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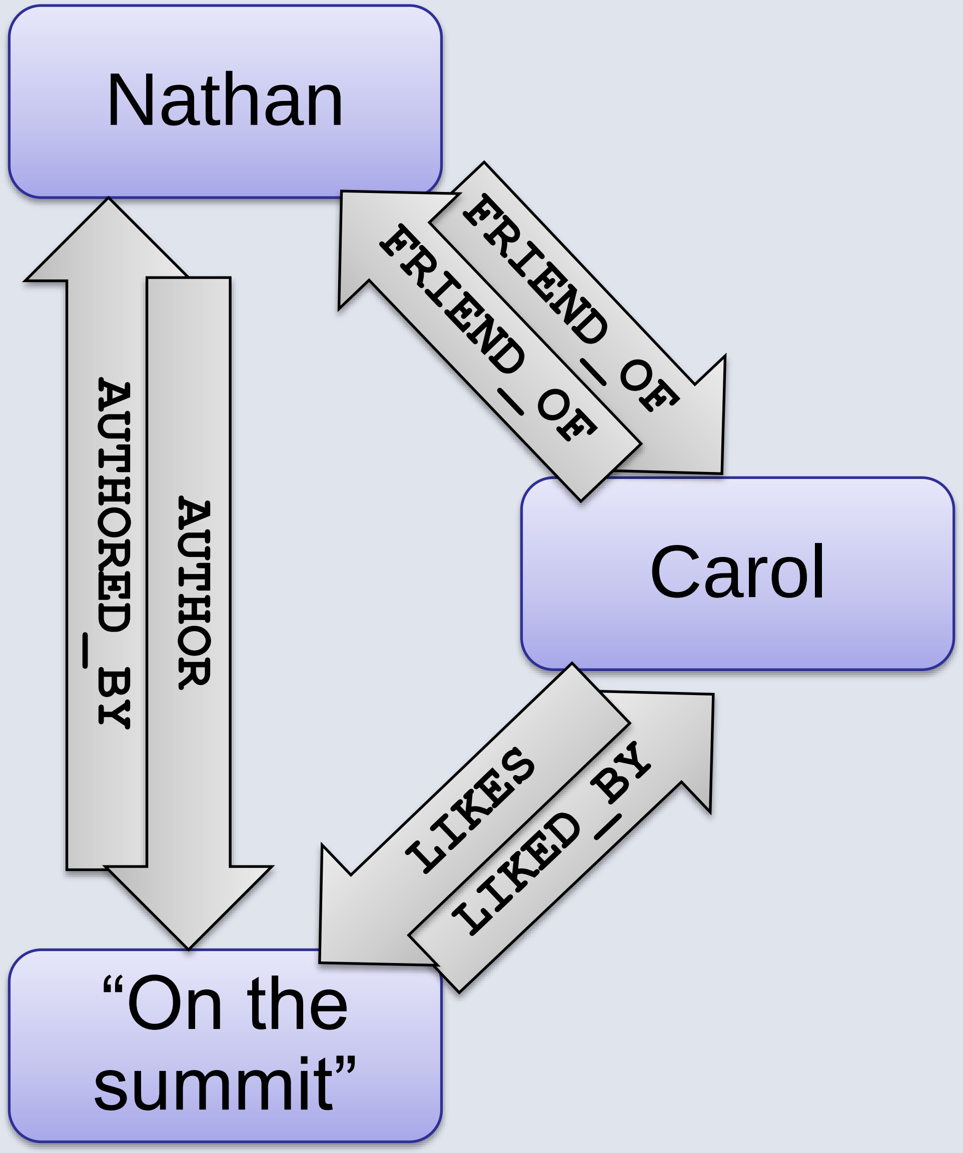
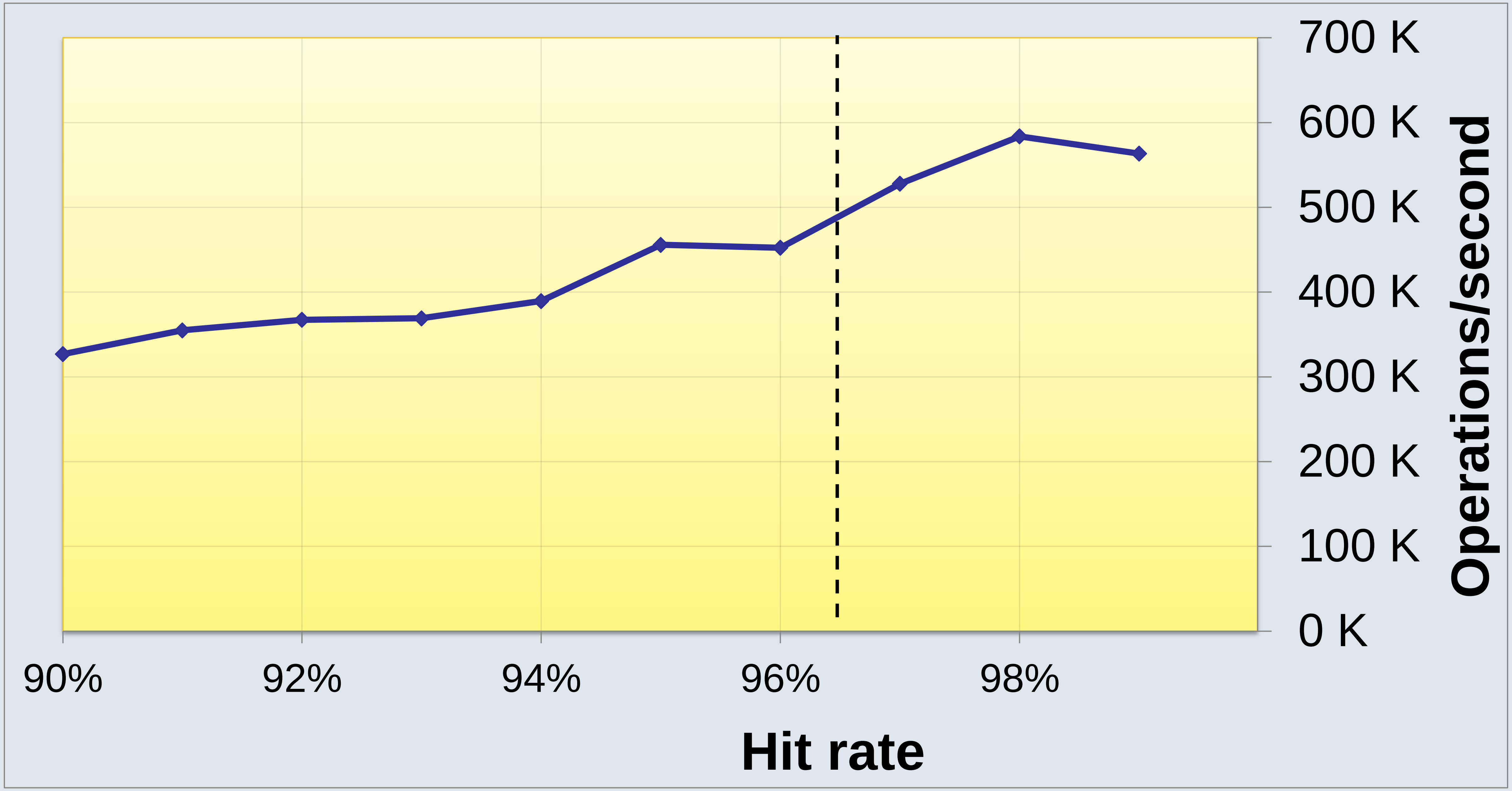
Inverse associations

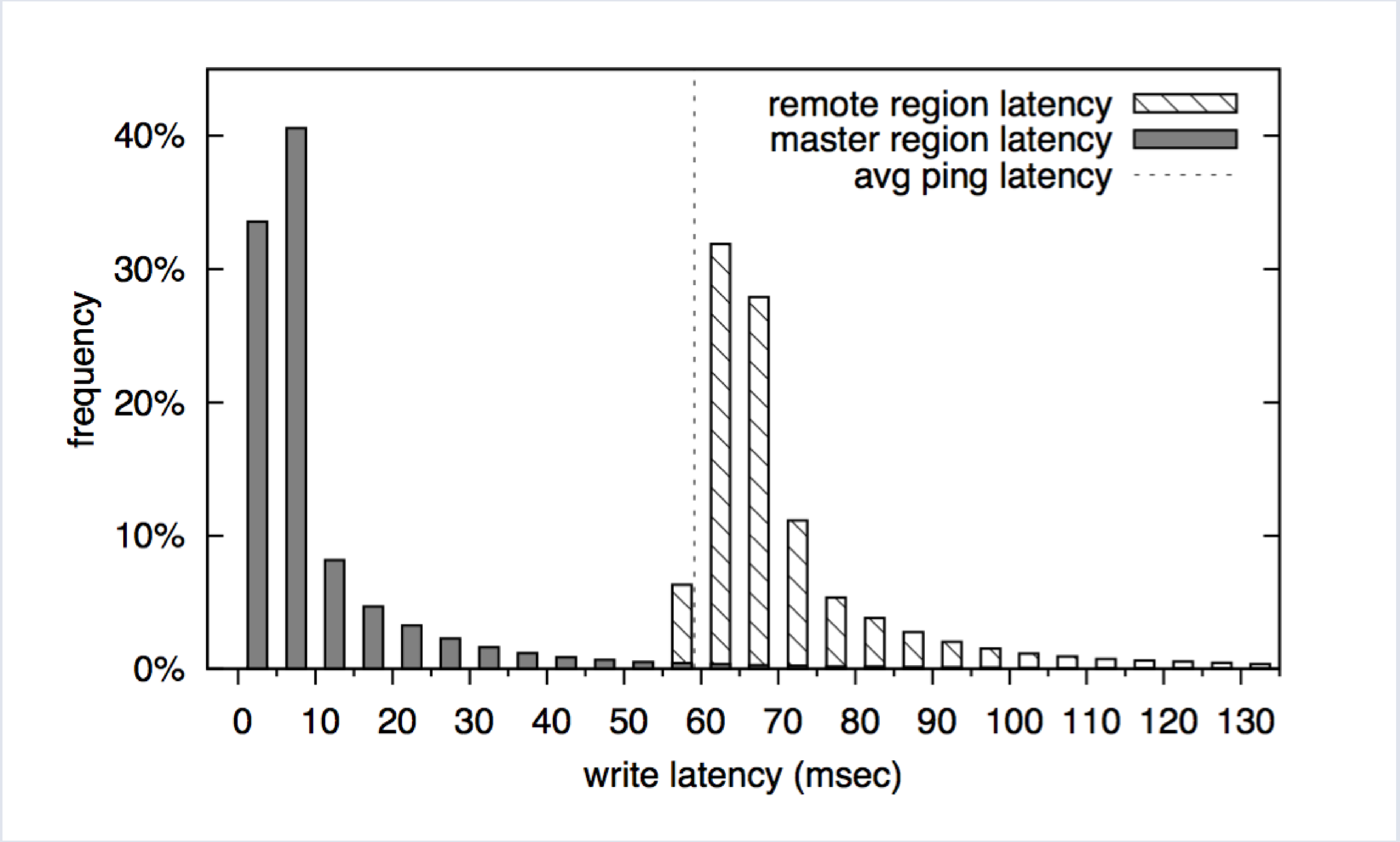
- Bidirectional relationships have separate *a*→*b* and *b*→*a* edges
  - inv_type(**`LIKES`**) = **`LIKED_BY`**
  - inv_type(**`FRIEND_OF`**) = **`FRIEND_OF`**
- Forward and inverse types linked only during write
  - TAO **`assoc_add`** will update both
  - Not atomic, but failures are logged and repaired



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