facebook

Scaling Memcache at Facebook

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Infrastructure Requirements for Facebook

1. Near real-time communication
2. Aggregate content on-the-fly from multiple sources
3. Be able to access and update very popular shared content
4. Scale to process millions of user requests per second

Design Requirements

Support a very heavy read load

- Over 1 billion reads / second
- Insulate backend services from high read rates

Geographically Distributed

Support a constantly evolving product

- System must be flexible enough to support a variety of use cases
- Support rapid deployment of new features

Persistence handled outside the system

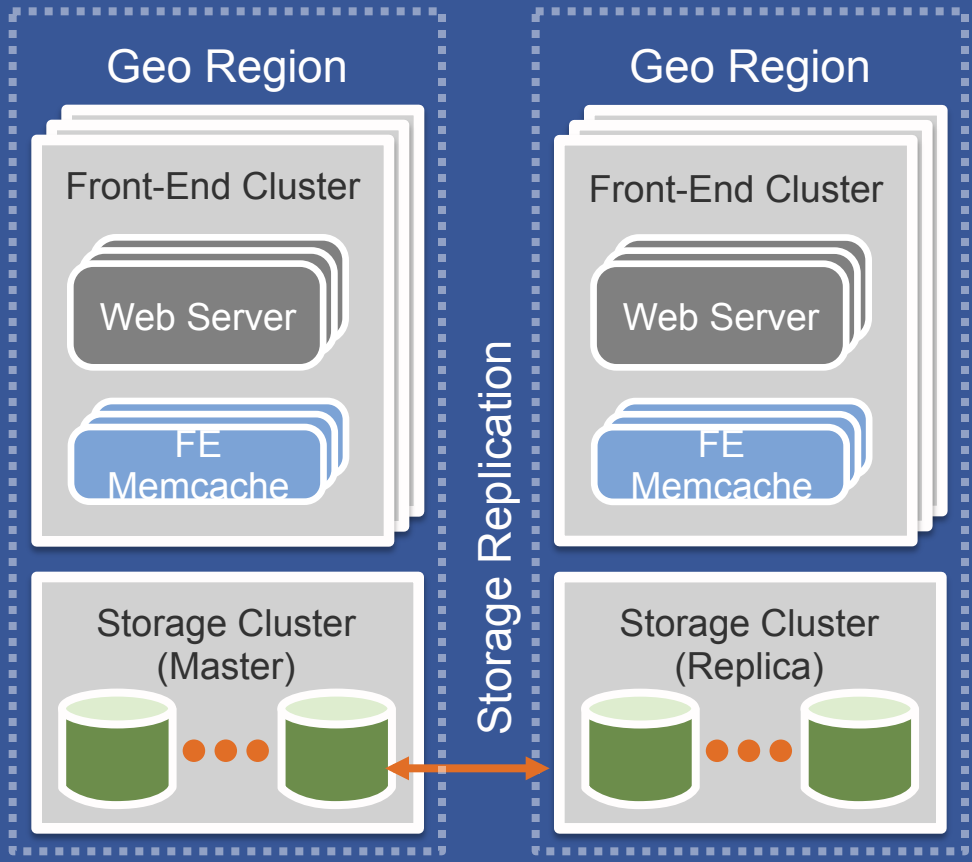
- Support mechanisms to refill after updates

memcached

- Basic building block for a distributed key-value store for Facebook
  - Trillions of items
  - Billions of requests / second
- Network attached in-memory hash table
  - Supports LRU based eviction

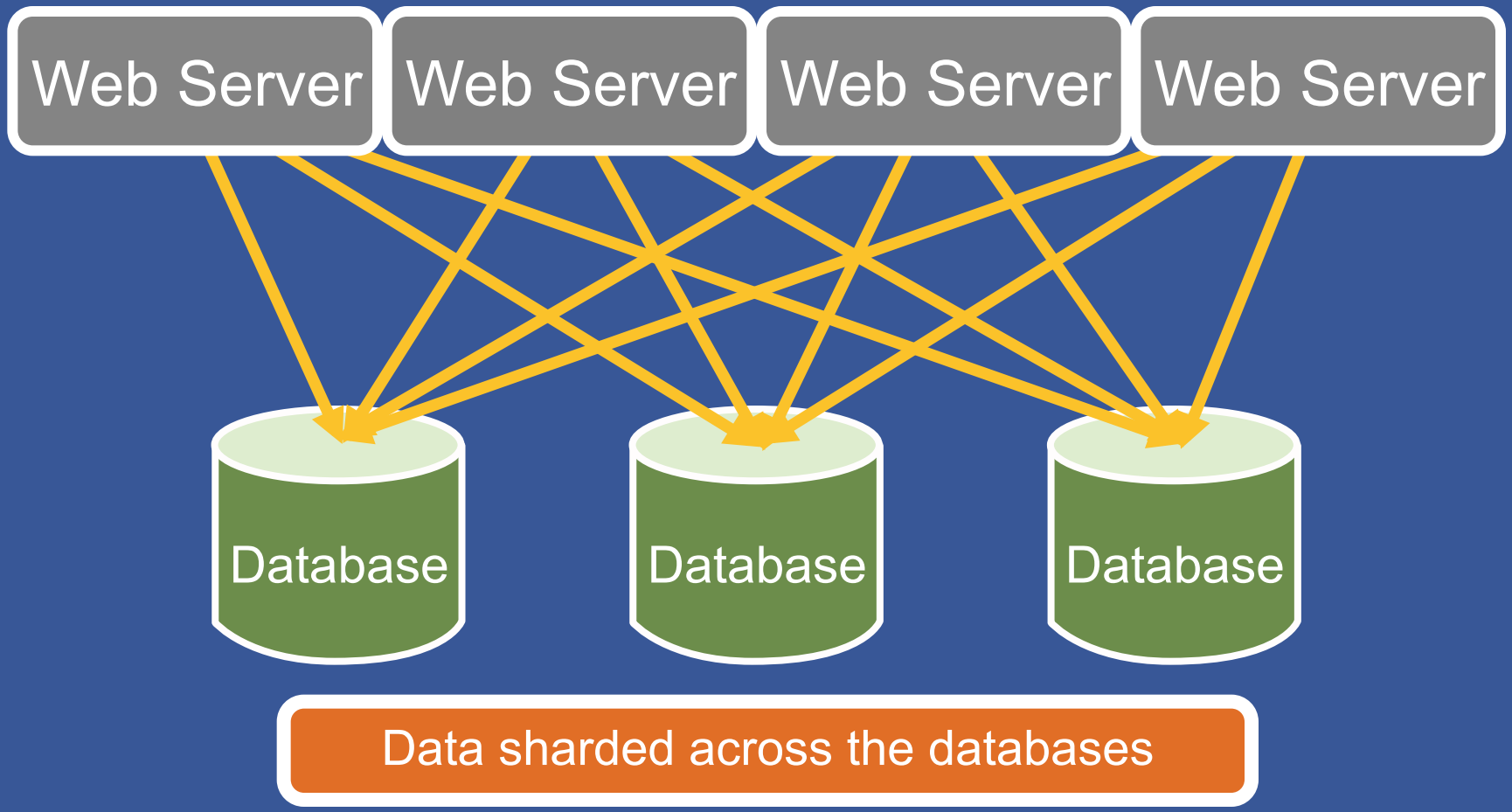
Roadmap

1. Single front-end cluster
   - Read heavy workload
   - Wide fanout
   - Handling failures
2. Multiple front-end clusters
   - Controlling data replication
   - Data consistency
3. Multiple Regions
   - Data consistency



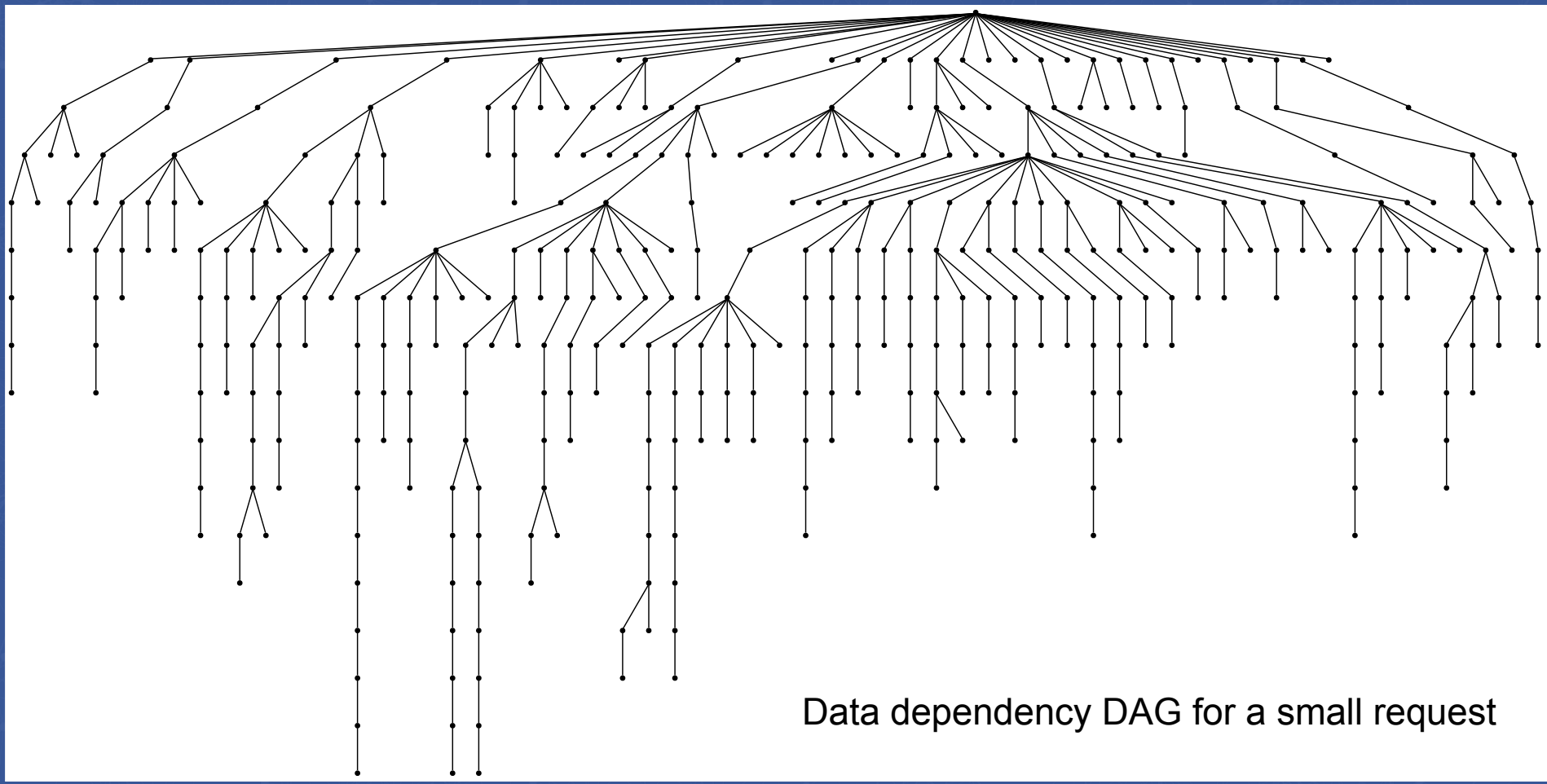
Pre-memcache

Just a few databases are enough to support the load



Why Separate Cache?

High fanout and multiple rounds of data fetching



Data dependency DAG for a small request

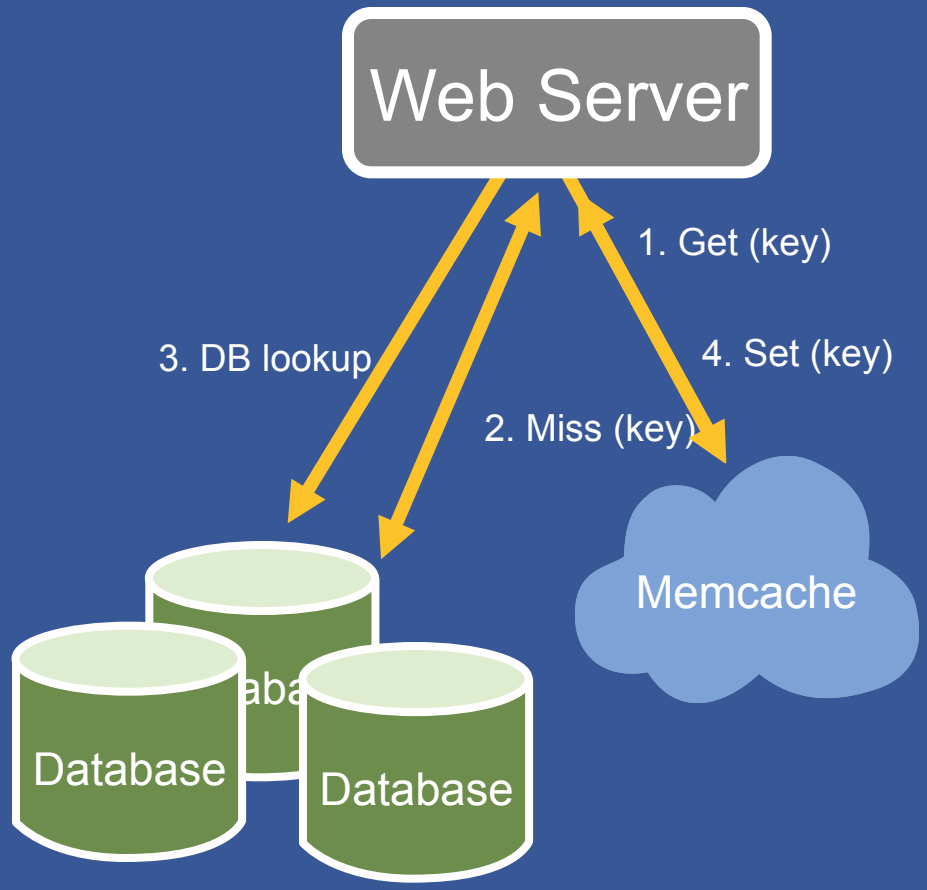
Scaling memcache in 4 “easy” steps

10s of servers & millions of operations per second

0	No memcache servers
1	A few memcache servers
2	Many memcache servers in one cluster
3	Many memcache servers in multiple clusters
4	Geographically distributed clusters

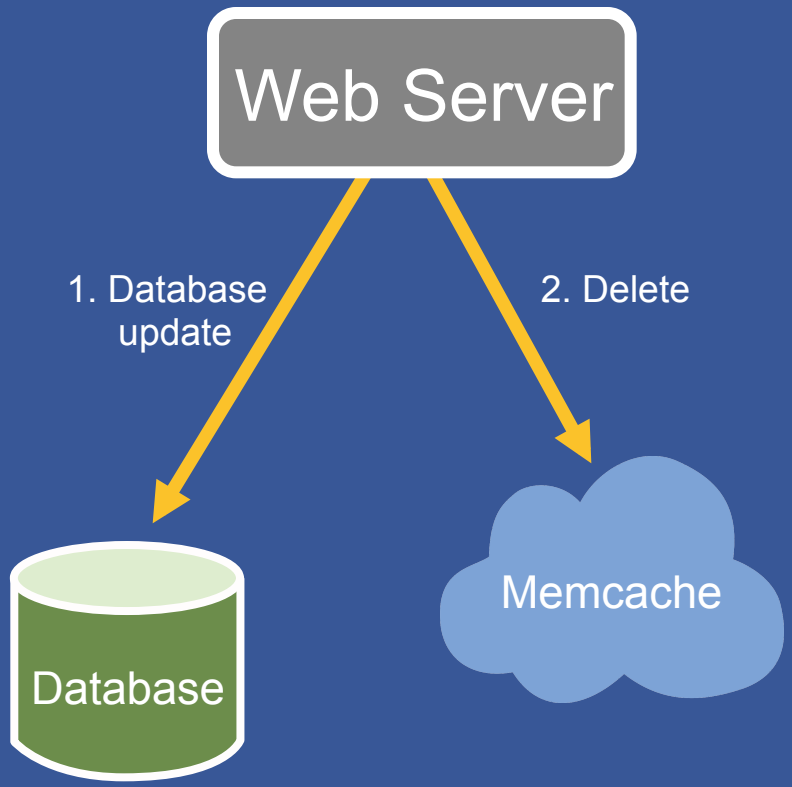
Need more read capacity

- Two orders of magnitude more reads than writes
- Solution: Deploy a few memcache hosts to handle the read capacity
- How do we store data?
  - Demand-filled look-aside cache
  - Common case is data is available in the cache

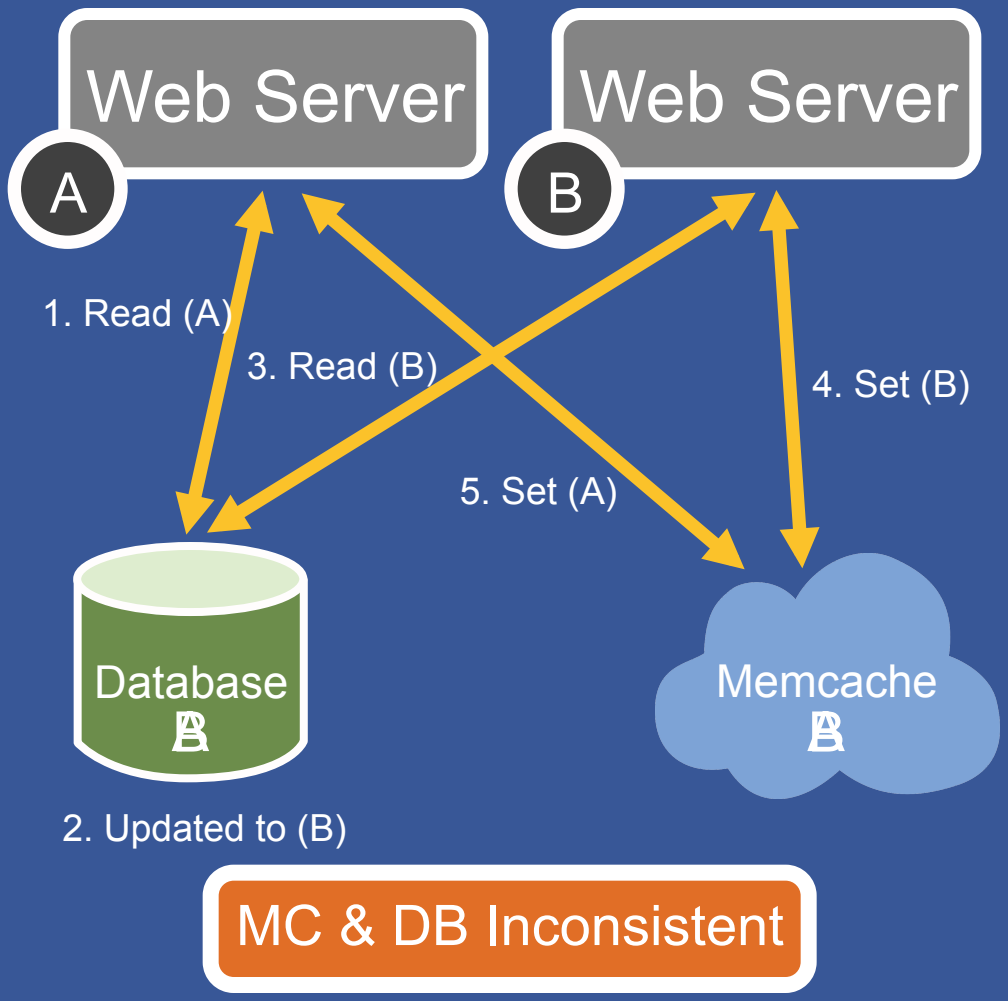


Handling updates

- Memcache needs to be invalidated after DB write
- Prefer deletes to sets
  - Idempotent
  - Demand filled
- Up to web application to specify which keys to invalidate after database update

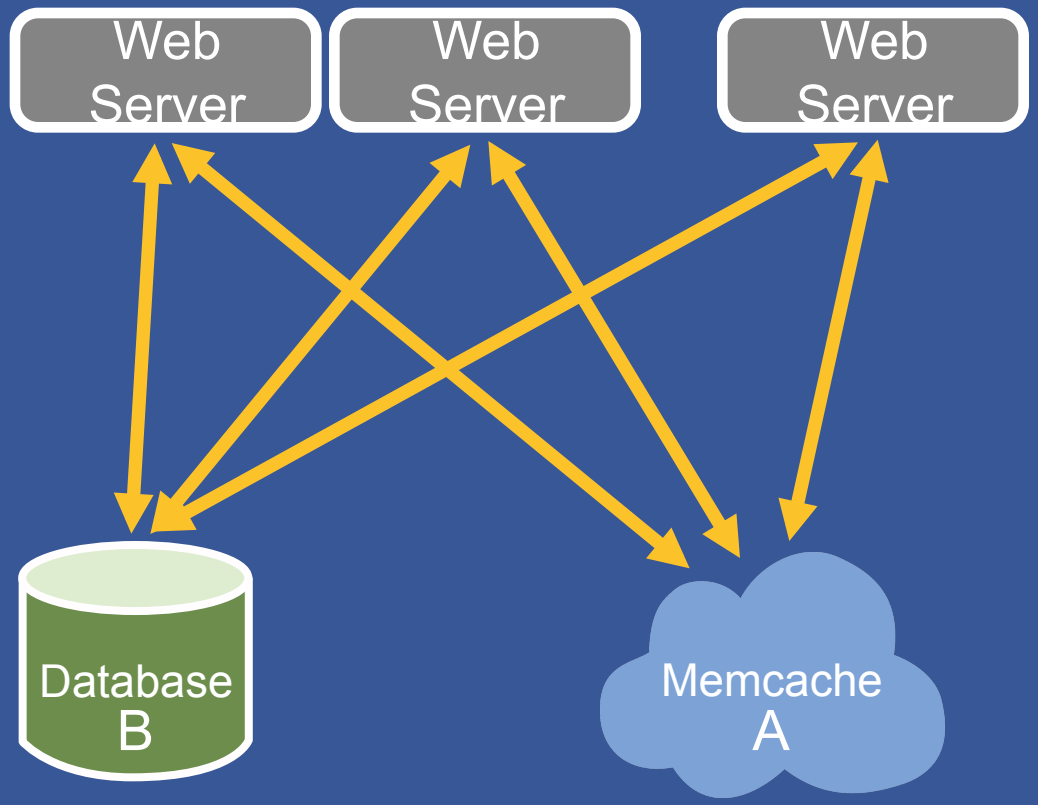


Problems with look-aside caching
Stale Sets



- Extend memcache protocol with “leases”
  - Return and attach a lease-id with every miss
  - Lease-id is invalidated inside server on a delete
  - Disallow set if the lease-id is invalid at the server

Problems with look-aside caching
Thundering Herds



- Memcache server arbitrates access to database
  - Small extension to leases
- Clients given a choice of using a slightly stale value or waiting

Scaling memcache in 4 “easy” steps

100s of servers & 10s of millions of operations per second

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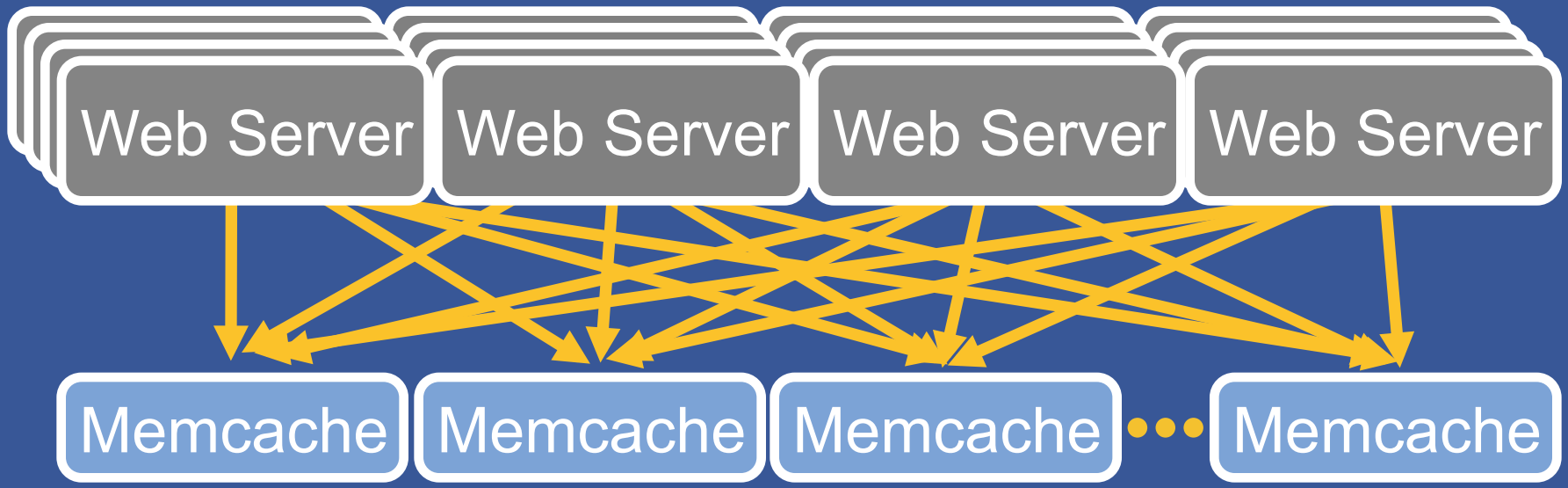
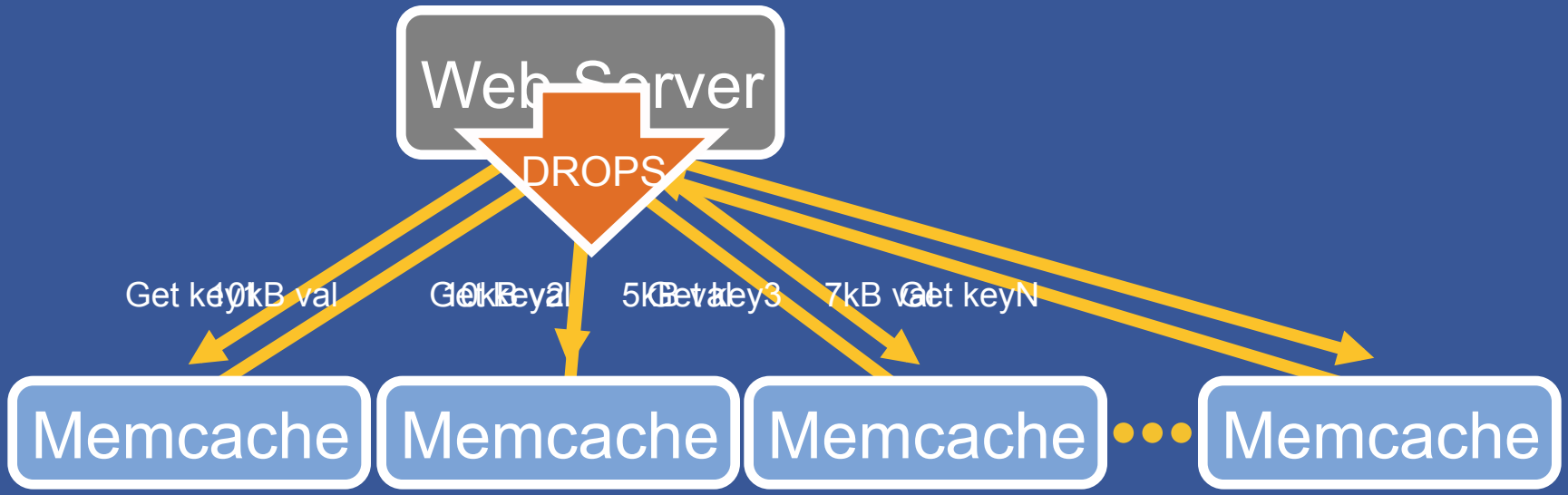
Need even more read capacity



- Items are distributed across memcache servers by using consistent hashing on the key
  - Individual items are rarely accessed very frequently so over replication doesn't make sense
- All web servers talk to all memcache servers
  - Accessing 100s of memcache servers to process a user request is common

Incast congestion



- Many simultaneous responses overwhelm shared networking resources
- Solution: Limit the number of outstanding requests with a sliding window
  - Larger windows cause result in more congestion
  - Smaller windows result in more round trips to the network

Scaling memcache in 4 “easy” steps

1000s of servers & 100s of millions of operations per second

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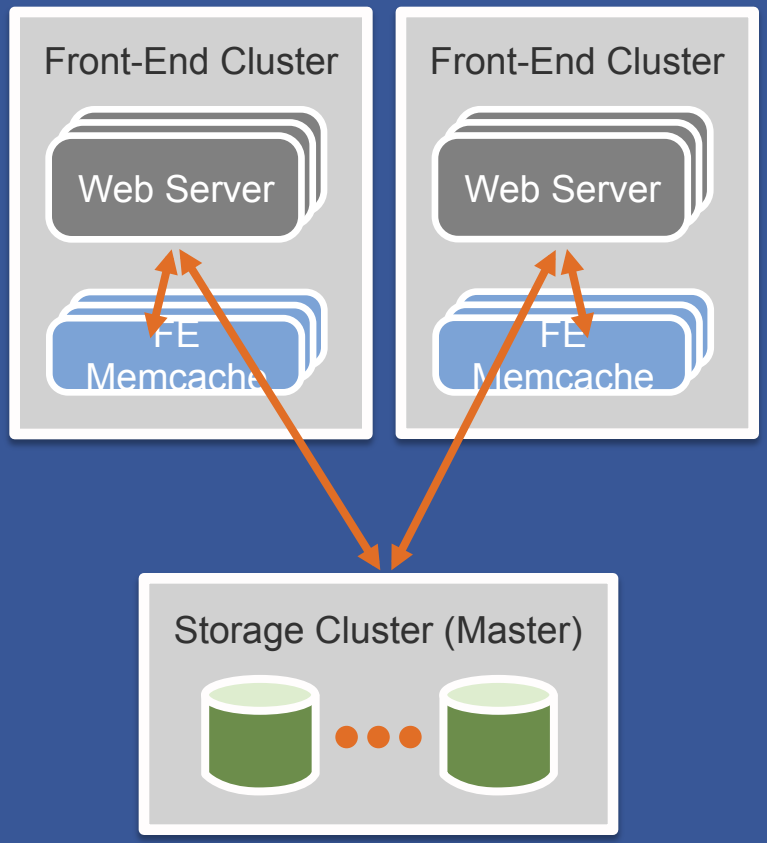
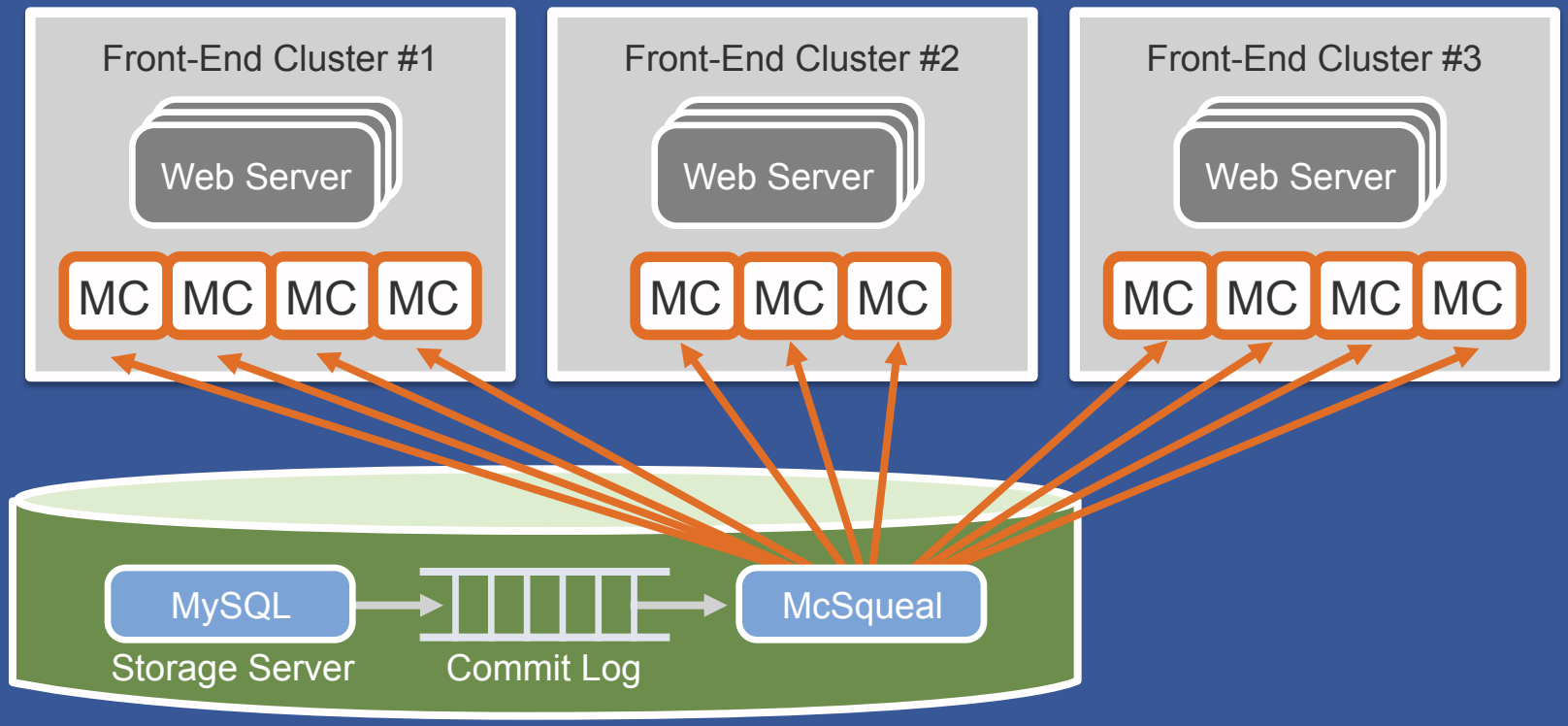
Multiple clusters

- All-to-all limits horizontal scaling
- Multiple memcache clusters front one DB installation
  - Have to keep the caches consistent
  - Have to manage over-replication of data



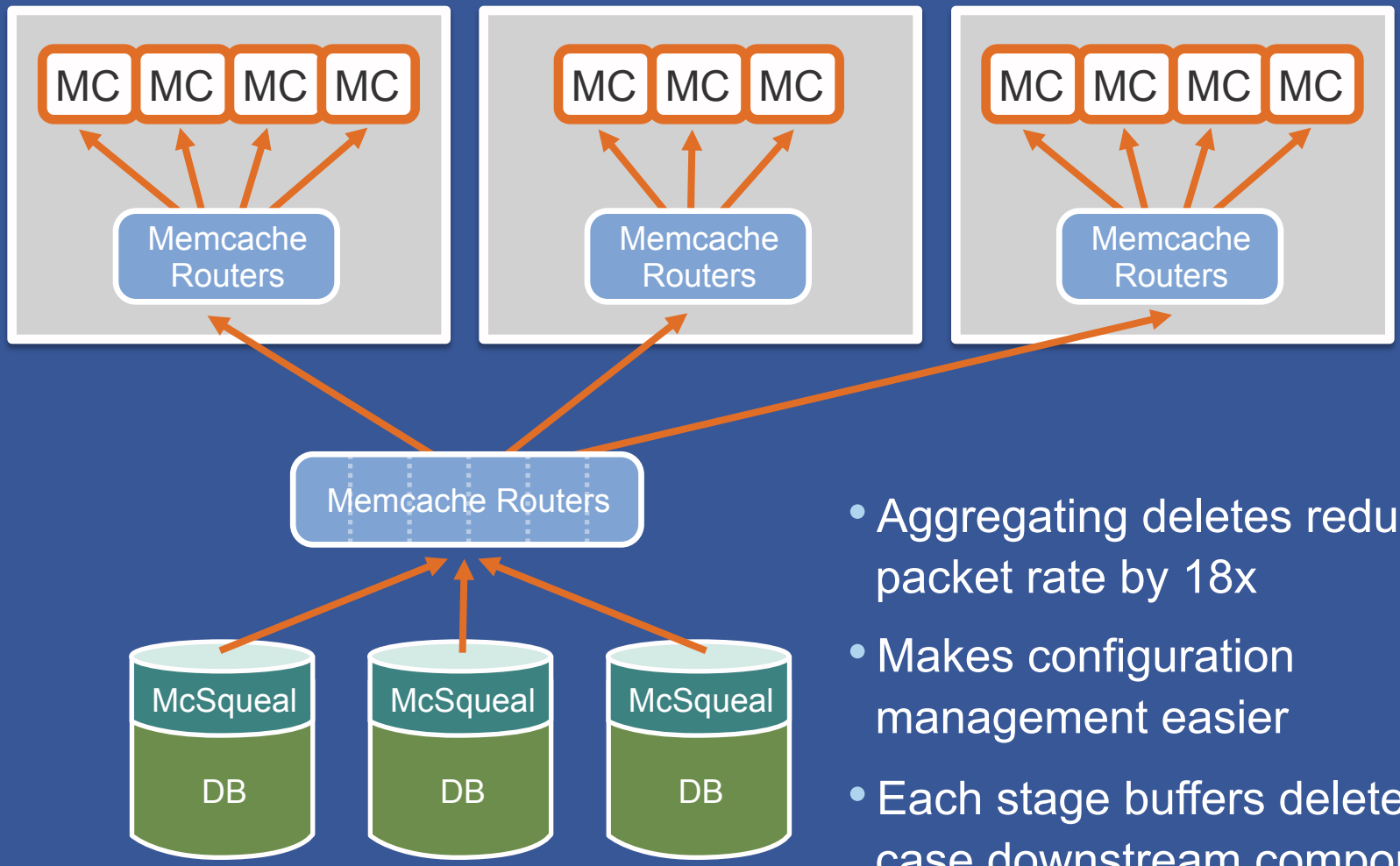
Databases invalidate caches



- Cached data must be invalidated after database updates
- Solution: Tail the mysql commit log and issue deletes based on transactions that have been committed
  - Allows caches to be resynchronized in the event of a problem

Invalidation pipeline

Too many packets



- Aggregating deletes reduces packet rate by 18x
- Makes configuration management easier
- Each stage buffers deletes in case downstream component is down

Scaling memcache in 4 “easy” steps

1000s of servers & > 1 billion operations per second

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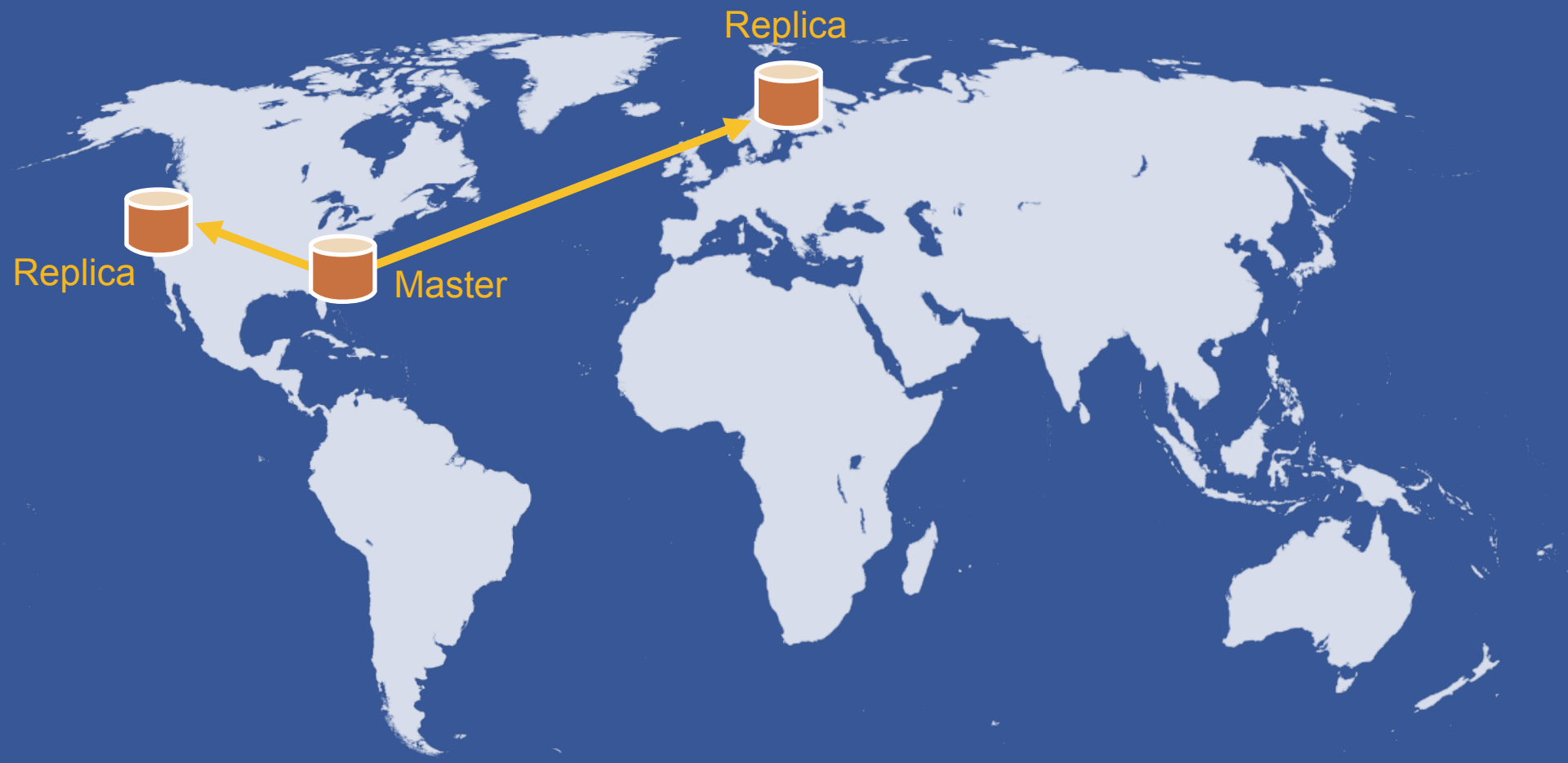
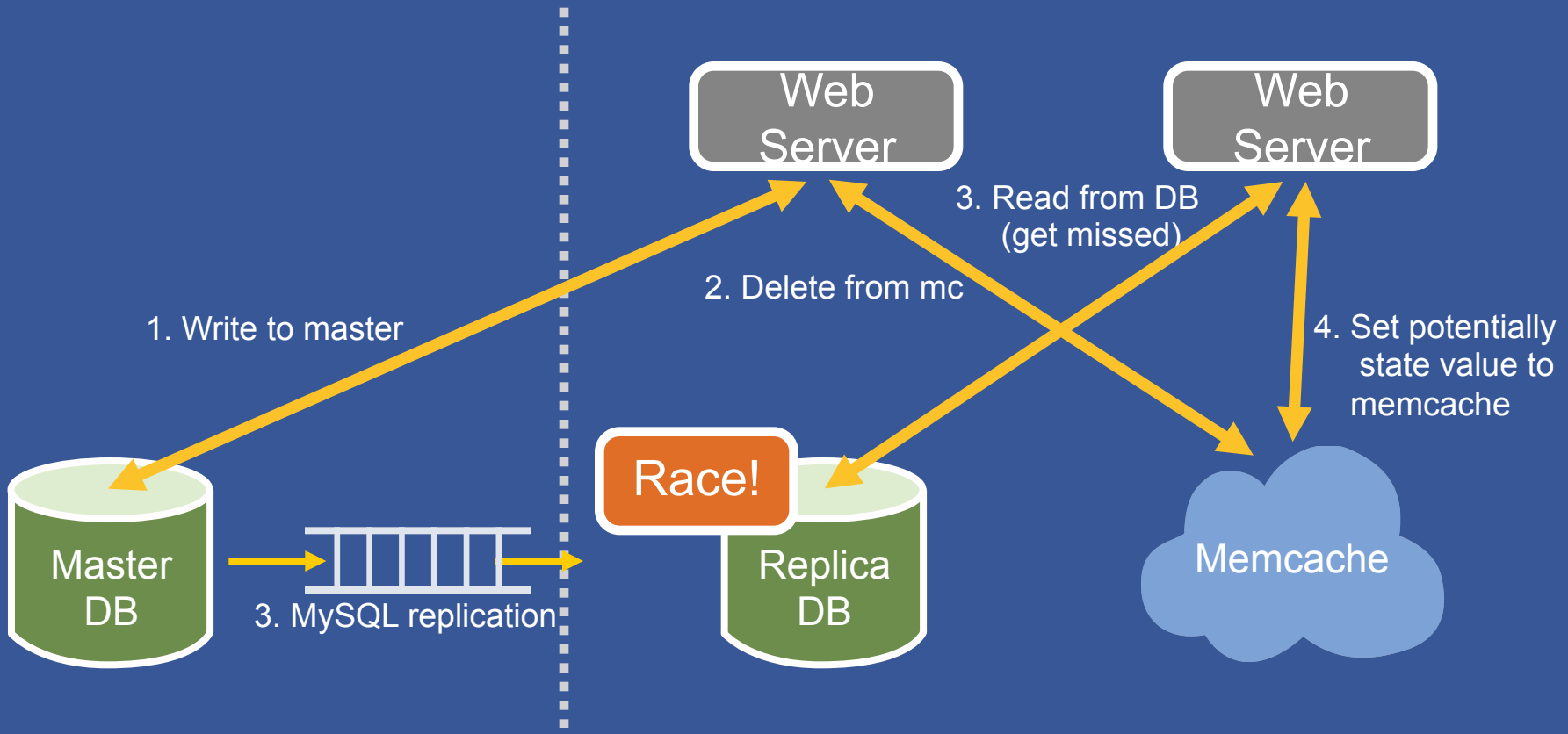
Geographically distributed clusters



Writes in non-master

Database update directly in master

- Race between DB replication and subsequent DB read

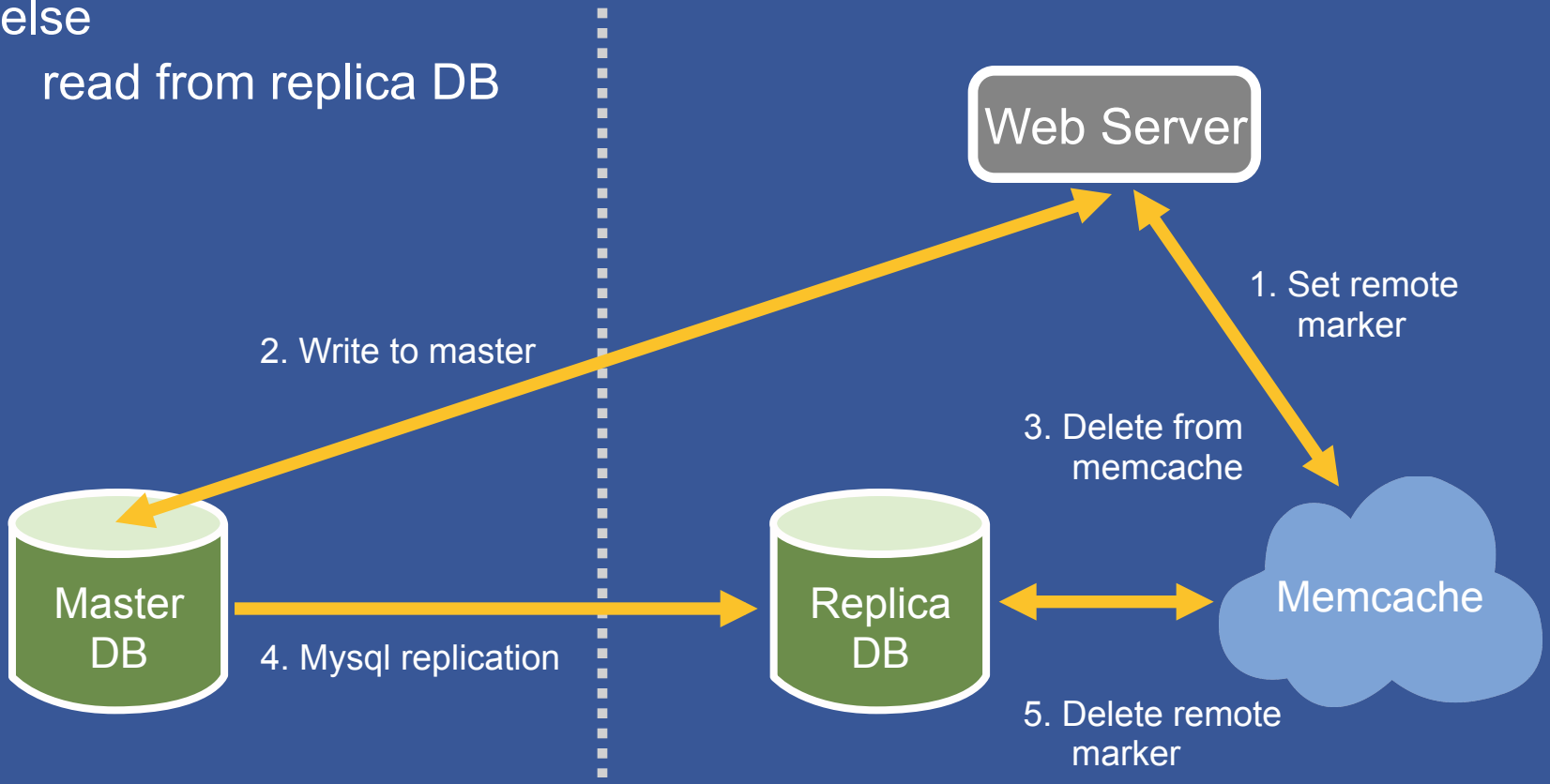


Remote markers

Set a special flag that indicates whether a race is likely

Read miss path:

If marker set
  read from master DB
else
  read from replica DB



Putting it all together

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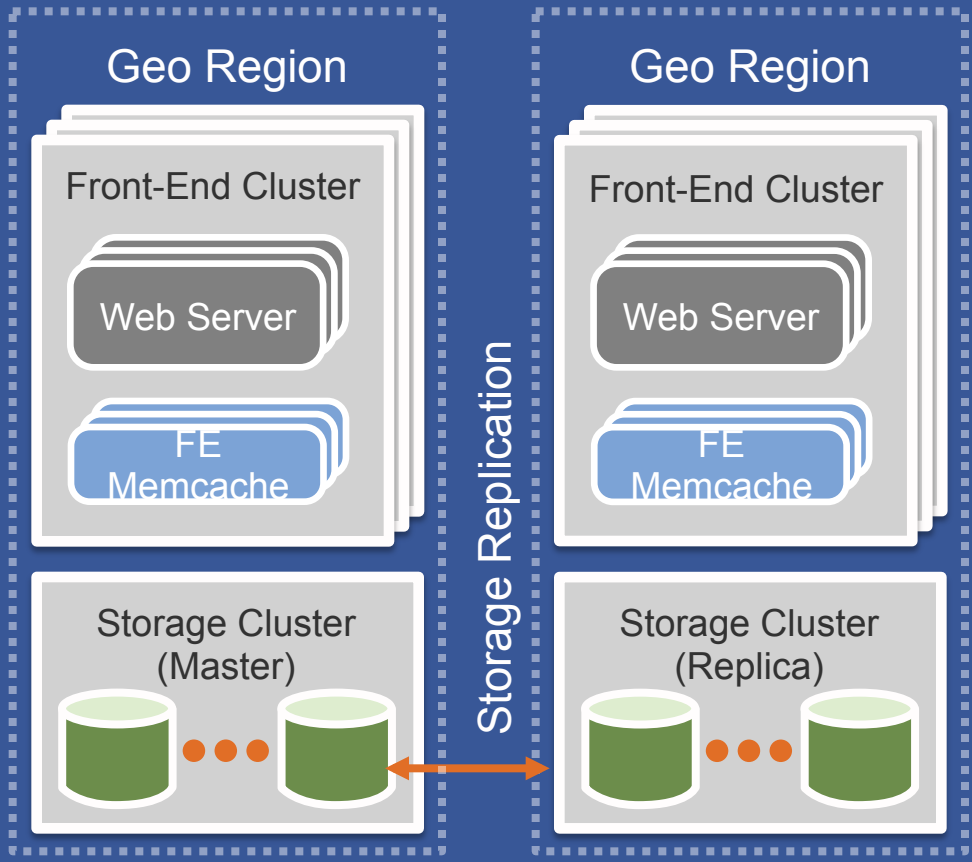

Lessons Learned

- Push complexity into the client whenever possible
- Operational efficiency is as important as performance
- Separating cache and persistent store allows them to be scaled independently

Thanks! Questions?

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