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

Data sharded across the databases
Why Separate Cache?
High fanout and multiple rounds of data fetching
Scaling memcache in 4 “easy” steps
10s of servers & millions of operations per second

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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

1. Read (A)
2. Updated to (B)
3. Read (B)
4. Set (B)
5. Set (A)

MC & DB Inconsistent
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

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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

- **Master**
- **Replica**
Writes in non-master
Database update directly in master

- Race between DB replication and subsequent DB read

1. Write to master
2. Delete from mc
3. Read from DB (get missed)
4. Set potentially state value to memcache
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

1. Set remote marker
2. Write to master
3. Delete from memcache
4. Mysql replication
5. Delete remote marker
Putting it all together

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
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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