Sharding

Jason Zucchetto

Consulting Engineer, 10gen

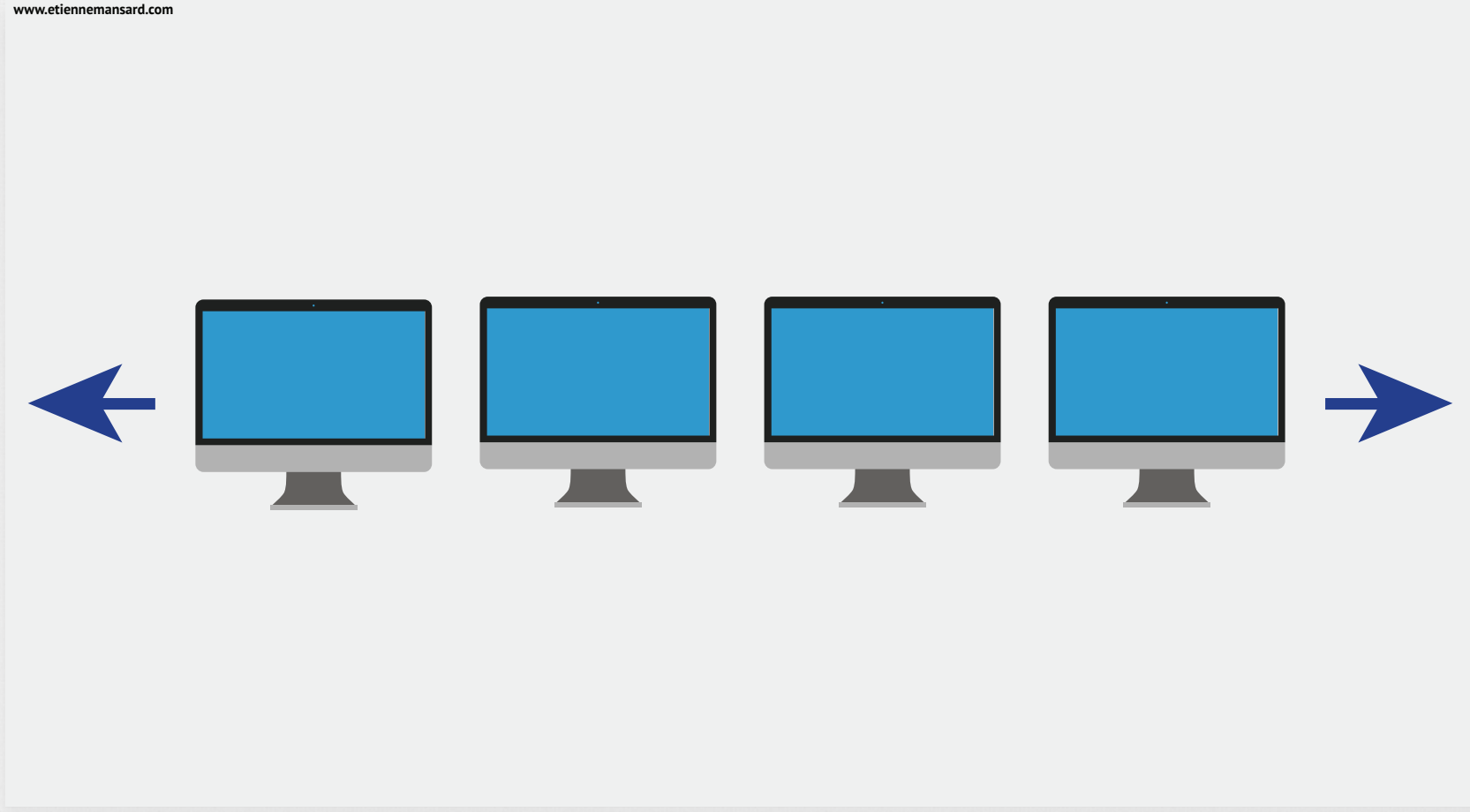
10gen | the MongoDB company

Agenda

- Short history of scaling data
- Why shard
- MongoDB's approach
- Architecture
- Configuration
- Mechanics
- Solutions

The story of scaling data

1970 - 2000: Vertical Scalability (scale up)



Google, ~2000: Horizontal Scalability (scale out)

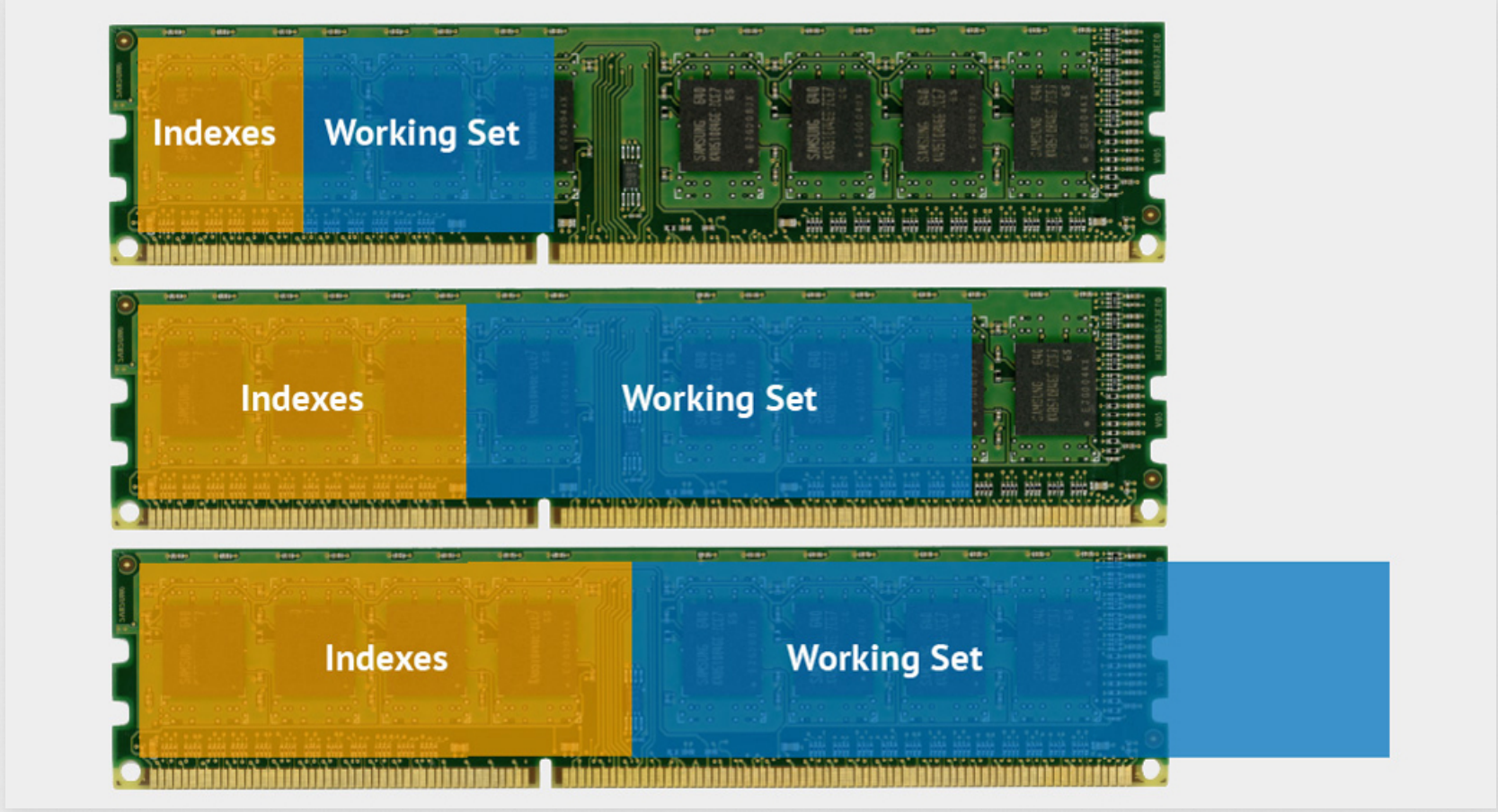
Data Store Scalability in 2005

- Custom Hardware
  - Oracle
- Custom Software
  - Facebook + MySQL

Data Store Scalability Today

- MongoDB auto-sharding available in 2009
- A data store that is
  - Free
  - Publicly available
  - Open source (https://github.com/mongodb/mongo)
  - Horizontally scalable
  - Application independent

Why shard?



Working Set Exceeds Physical Memory

Read/Write Throughput Exceeds I/O

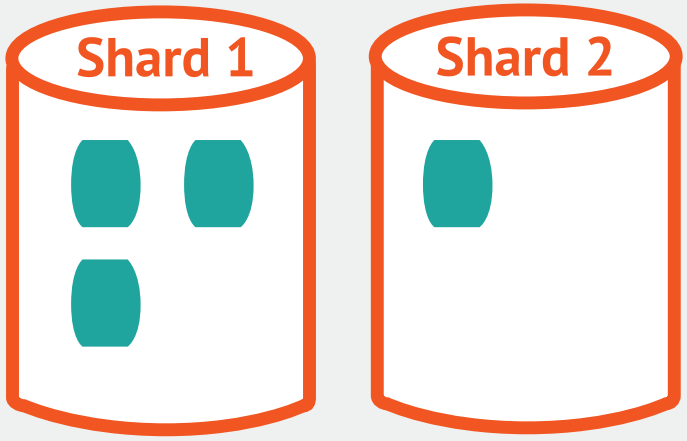
MongoDB's approach to sharding

Partition data based on ranges

- User defines shard key
- Shard key defines range of data
- Key space is like points on a line
- Range is a segment of that line

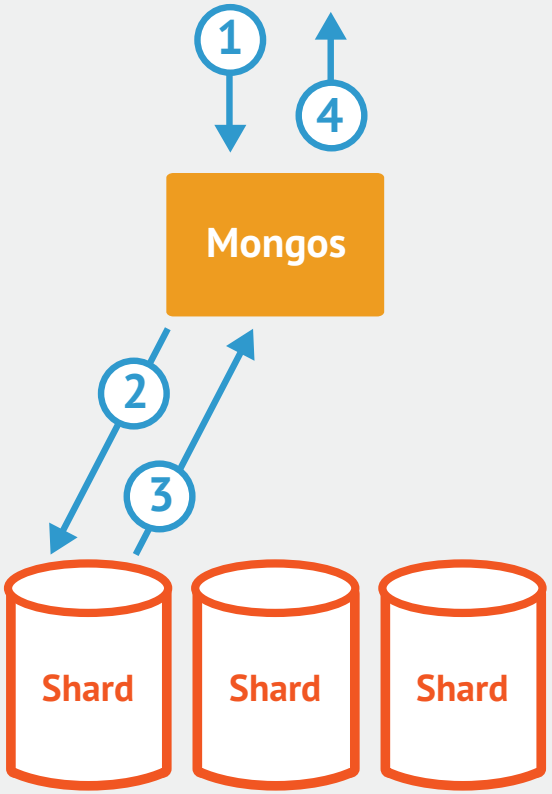
Distribute data in chunks across nodes

- Initially 1 chunk
- Default max chunk size: 64mb
- MongoDB automatically splits & migrates chunks when max reached



MongoDB manages data

- Queries routed to specific shards
- MongoDB balances cluster
- MongoDB migrates data to new nodes



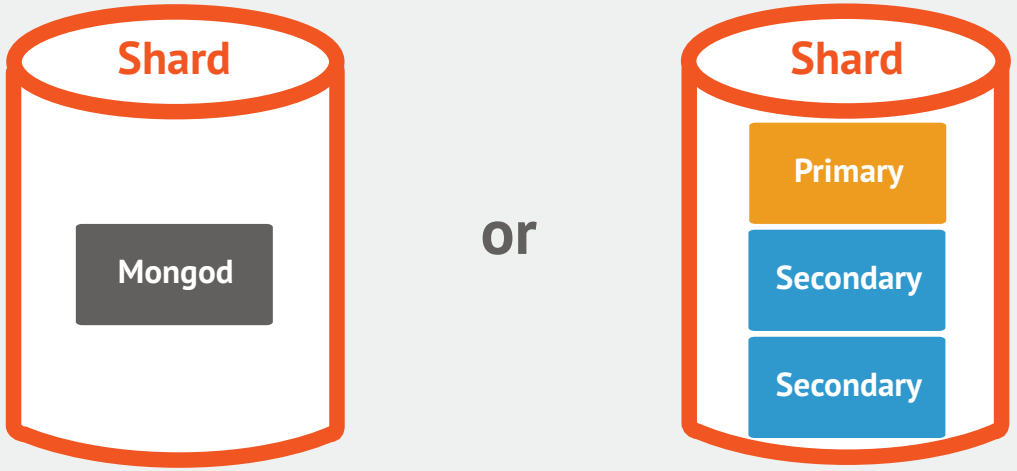
MongoDB Auto-Sharding

- Minimal effort required
  - Same interface as single mongod
- Two steps
  - Enable Sharding for a database
  - Shard collection within database

Architecture

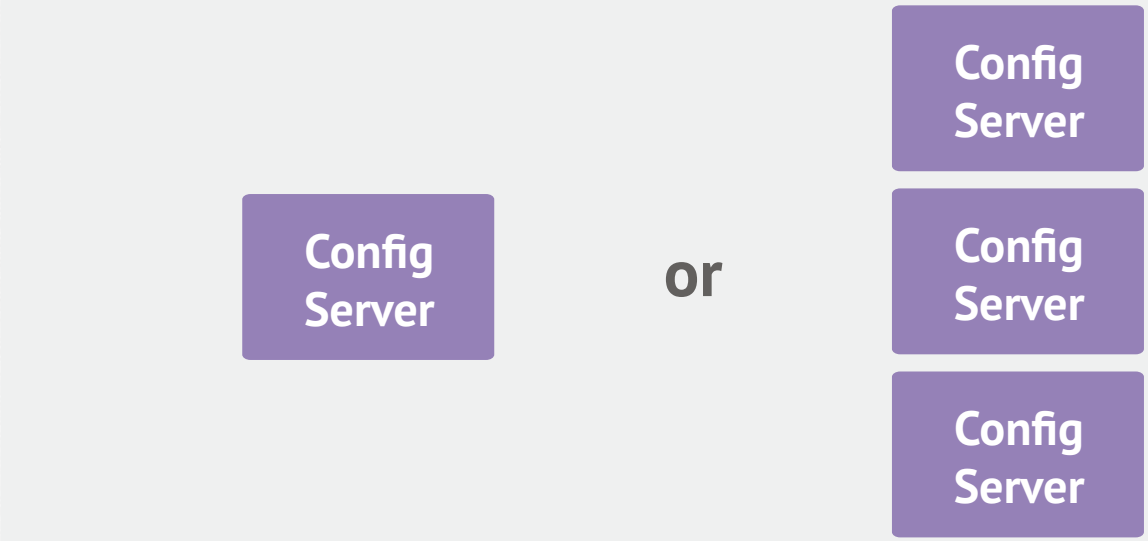
Data stored in shard

- Shard is a node of the cluster
- Shard can be a single mongod or a replica set



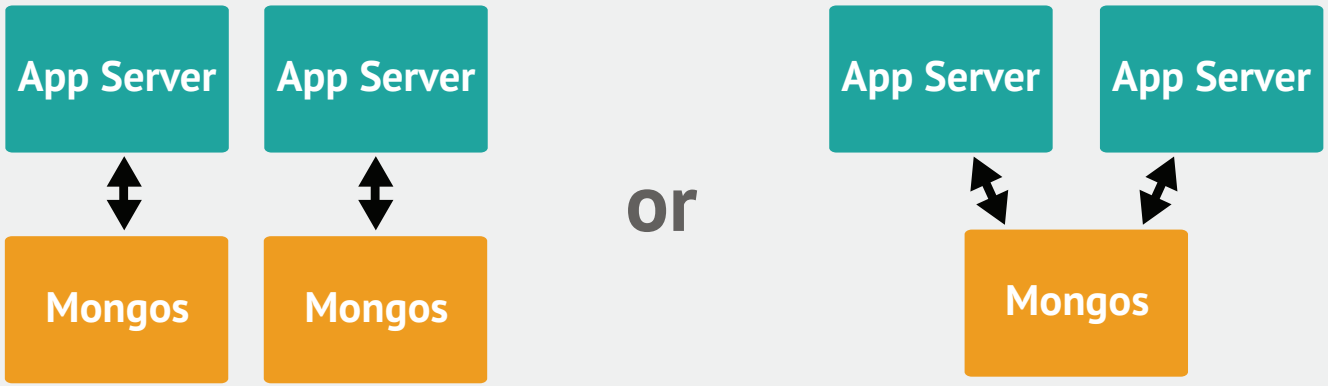
Config server stores meta data

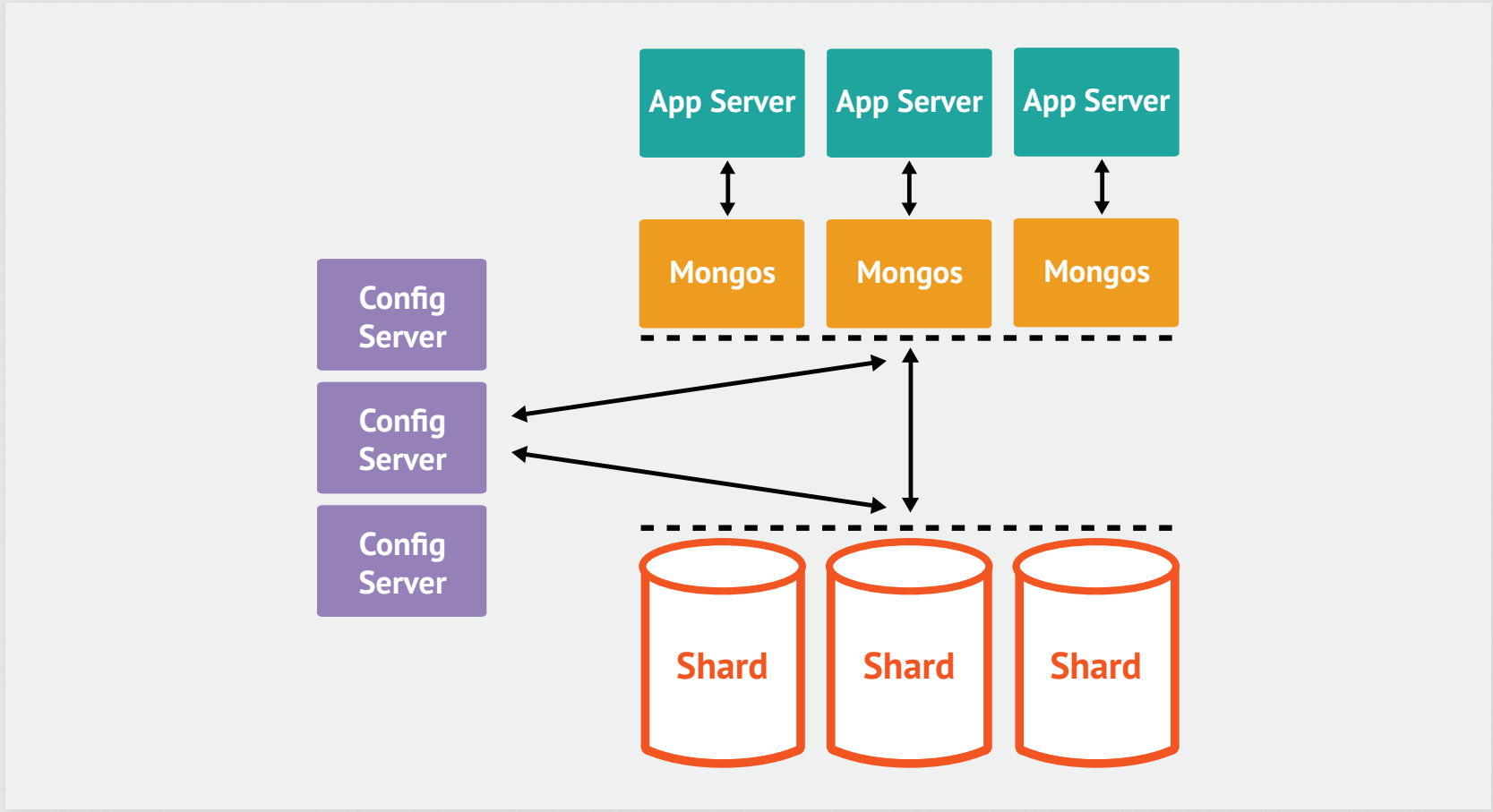
- Config Server
  - Stores cluster chunk ranges and locations
  - Can have only 1 or 3 (production must have 3)
  - Two phase commit (not a replica set)



MongoS manages the data

- Mongos
  - Acts as a router / balancer
  - No local data (persists to config database)
  - Can have 1 or many

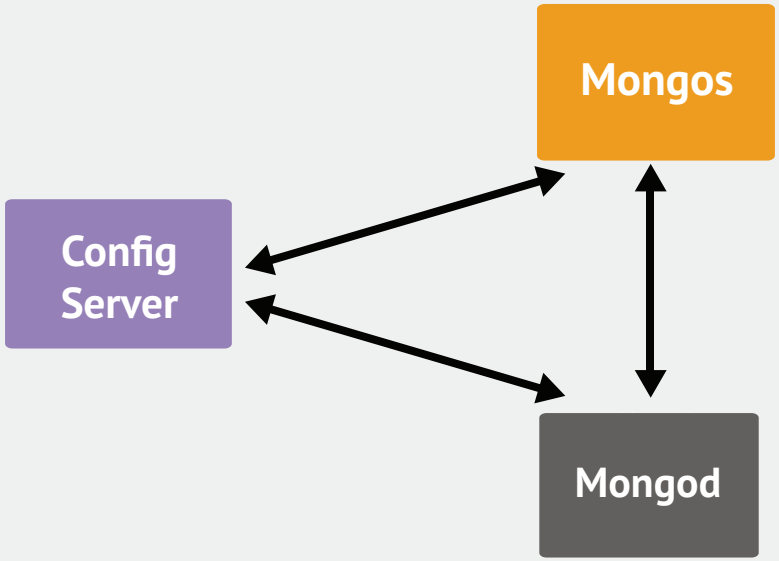




Sharding infrastructure

Configuration

Example cluster setup

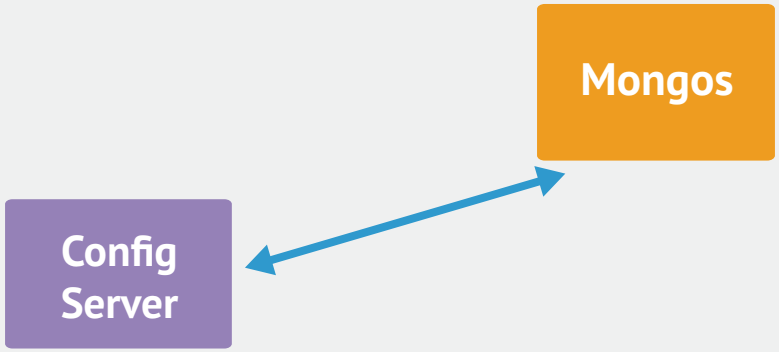


- ***Don't use this setup in production!***
  - Only one Config server (No Fault Tolerance)
  - Shard not in a replica set (Low Availability)
  - Only one Mongos and shard (No Performance Improvement)
  - Useful for development or demonstrating configuration mechanics

Start the config server

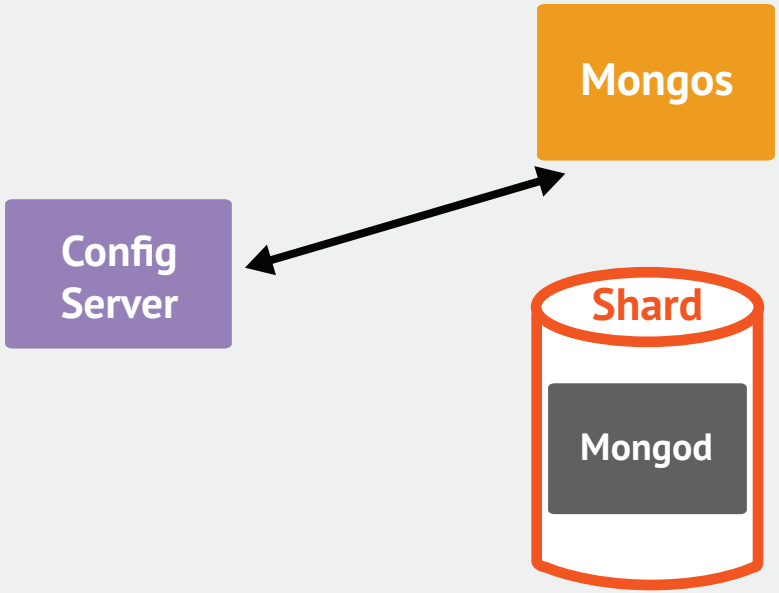
- "mongod --configsvr"
- Starts a config server on the default port (27019)

Start the mongos router



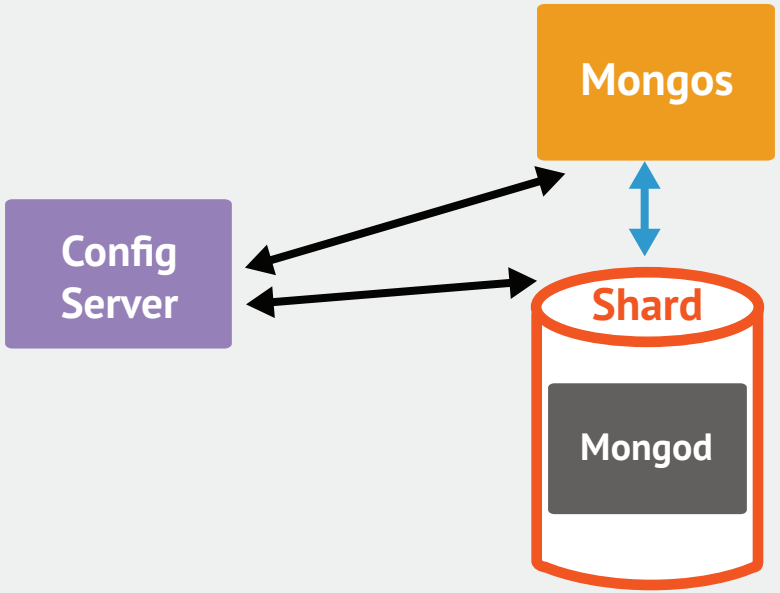
- "mongos --configdb <hostname>:27019"
- For 3 config servers: "mongos --configdb <host1>:<port1>,<host2>:<port2>,<host3>:<port3>"
- This is always how to start a new mongos, even if the cluster is already running

Start the shard database



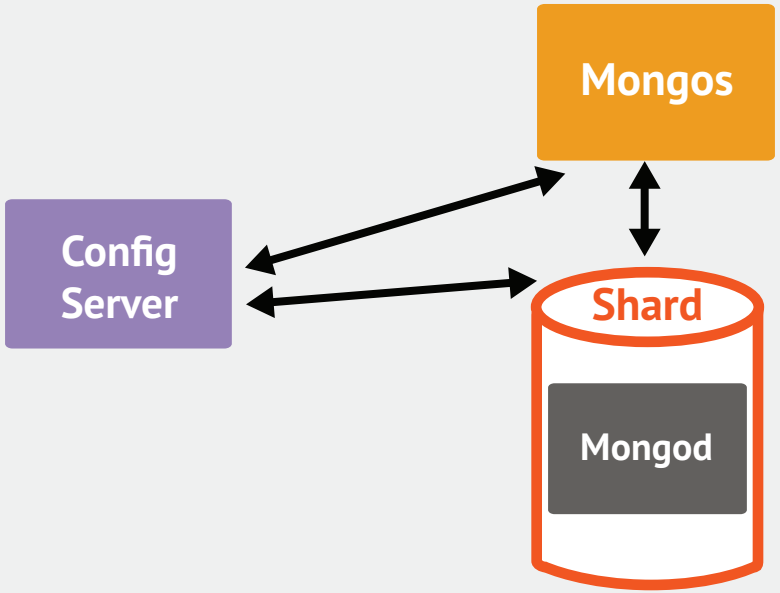
- "mongod --shardsvr"
- Starts a mongod with the default shard port (27018)
- Shard is not yet connected to the rest of the cluster
- Shard may have already been running in production

Add the shard



- On mongos: "sh.addShard('<host>:27018')"
- Adding a replica set: "sh.addShard('<rsname>/<seedlist>')
- In 2.2 and later can use sh.addShard('<host>:<port>')

Verify that the shard was added



- db.runCommand({ listshards:1 })
- { "shards" :
  [{ "_id":"shard0000", "host":"<hostname>:27018" }],
  "ok" : 1
  }

Enabling Sharding

- Enable sharding on a database
  - sh.enableSharding("<dbname>")
- Shard a collection with the given key
  - sh.shardCollection("<dbname>.people",{"country":1})
- Use a compound shard key to prevent duplicates
  - sh.shardCollection("<dbname>.cars",{"year":1,"uniqueid":1})

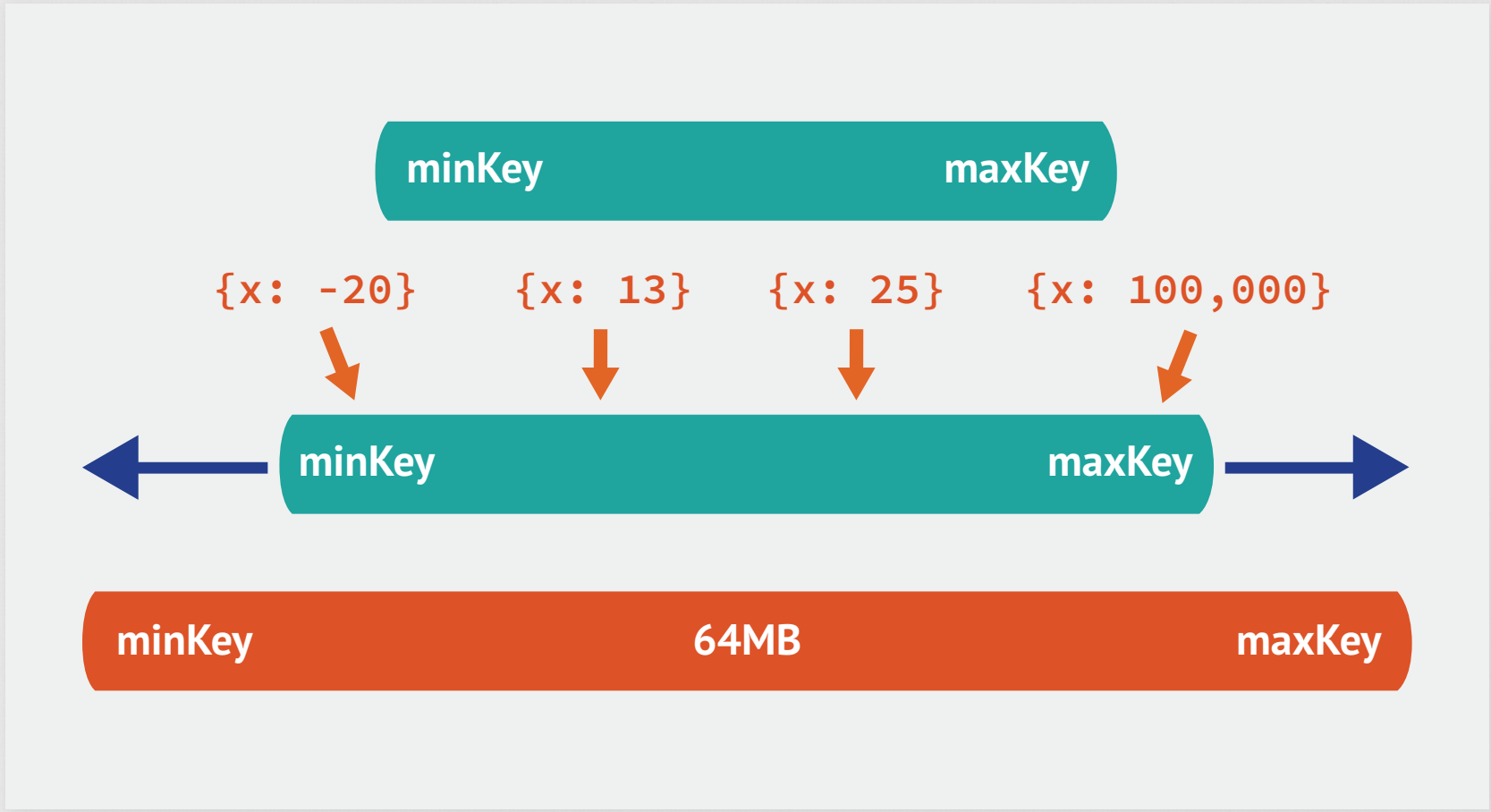
Tag Aware Sharding

- Tag aware sharding allows you to control the distribution of your data
- Tag a range of shard keys
  - sh.addTagRange(<collection>,<min>,<max>,<tag>)
- Tag a shard
  - sh.addShardTag(<shard>,<tag>)

Mechanics

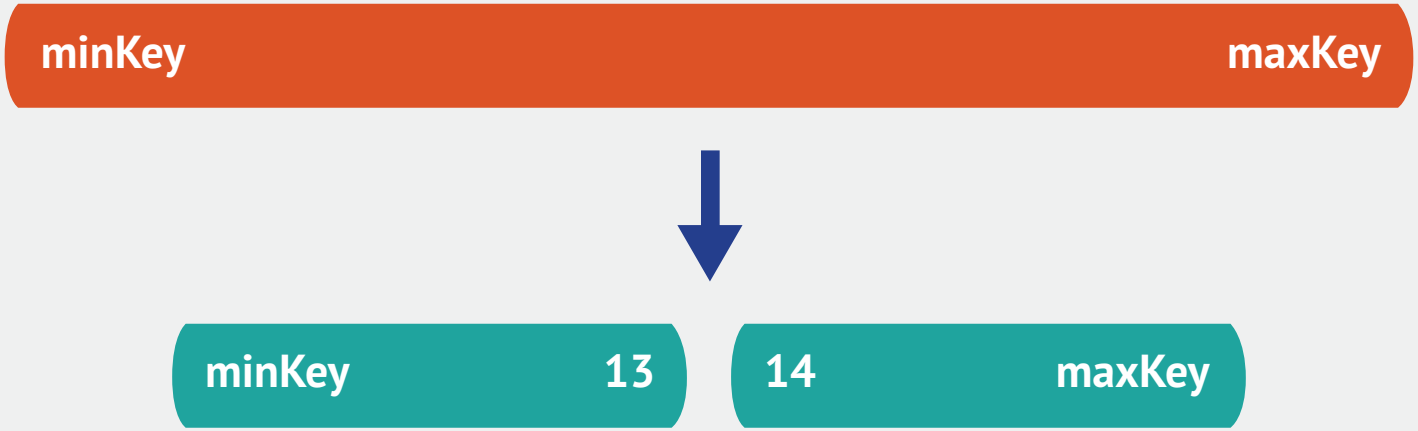
Partitioning

- Remember it's based on ranges



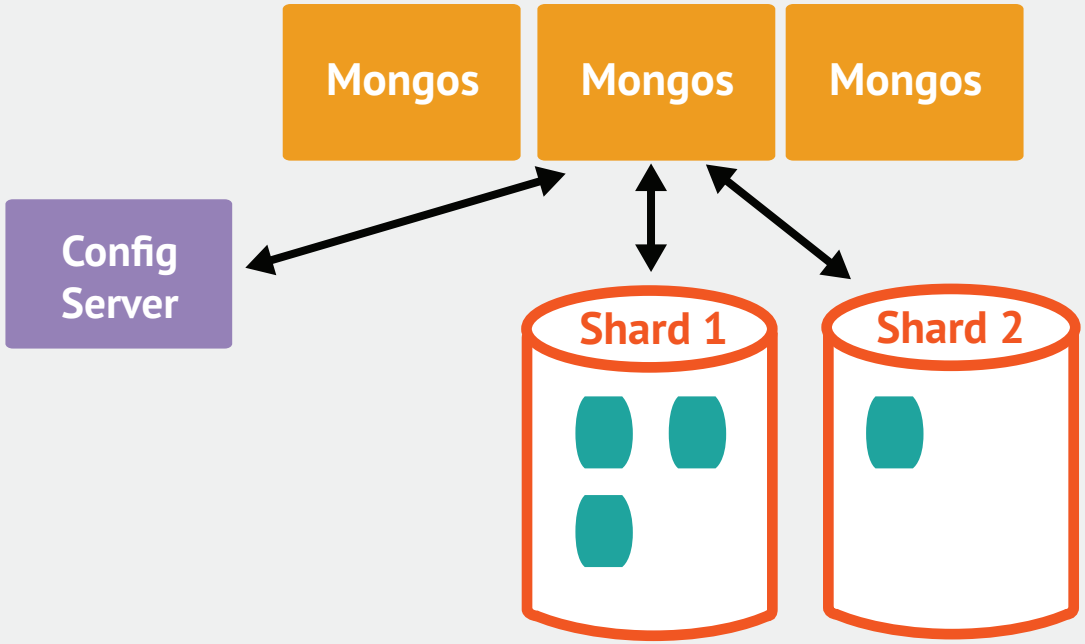
Chunk is a section of the entire range

Chunk splitting



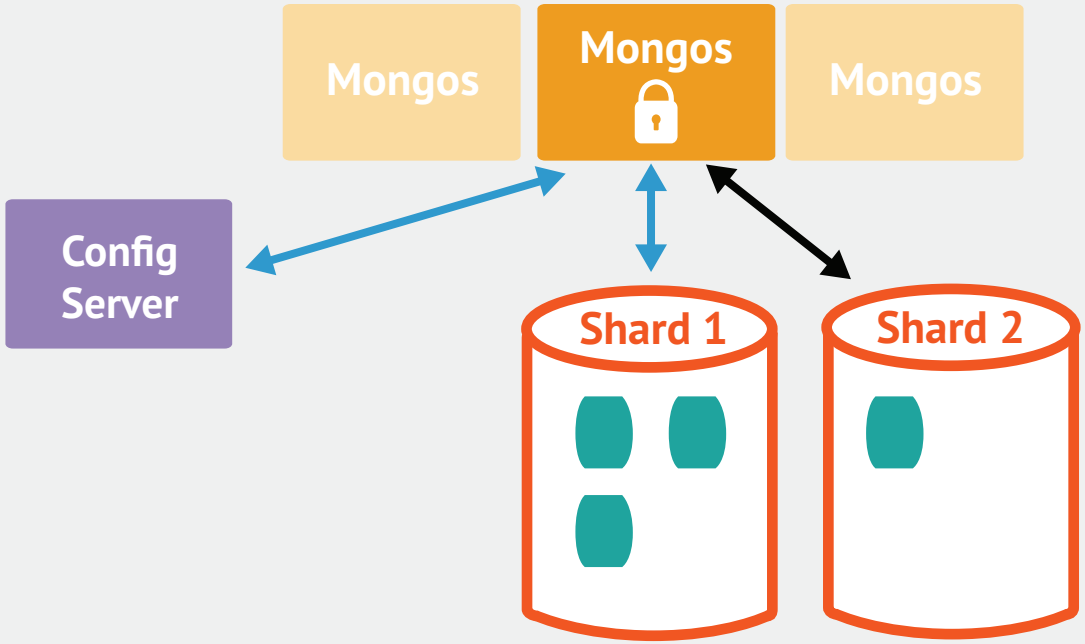
- A chunk is split once it exceeds the maximum size
- There is no split point if all documents have the same shard key
- Chunk split is a logical operation (no data is moved)
- If split creates too large of a discrepancy of chunk count across cluster a balancing round starts

Balancing



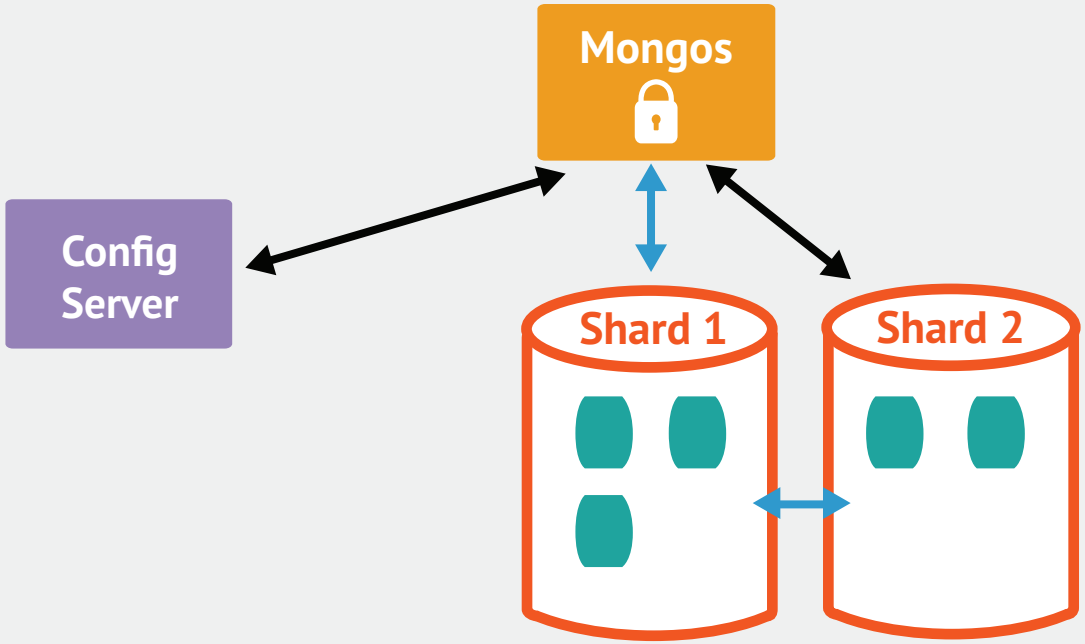
- Balancer is running on mongos
- Once the difference in chunks between the most dense shard and the least dense shard is above the migration threshold, a balancing round starts

Acquiring the Balancer Lock



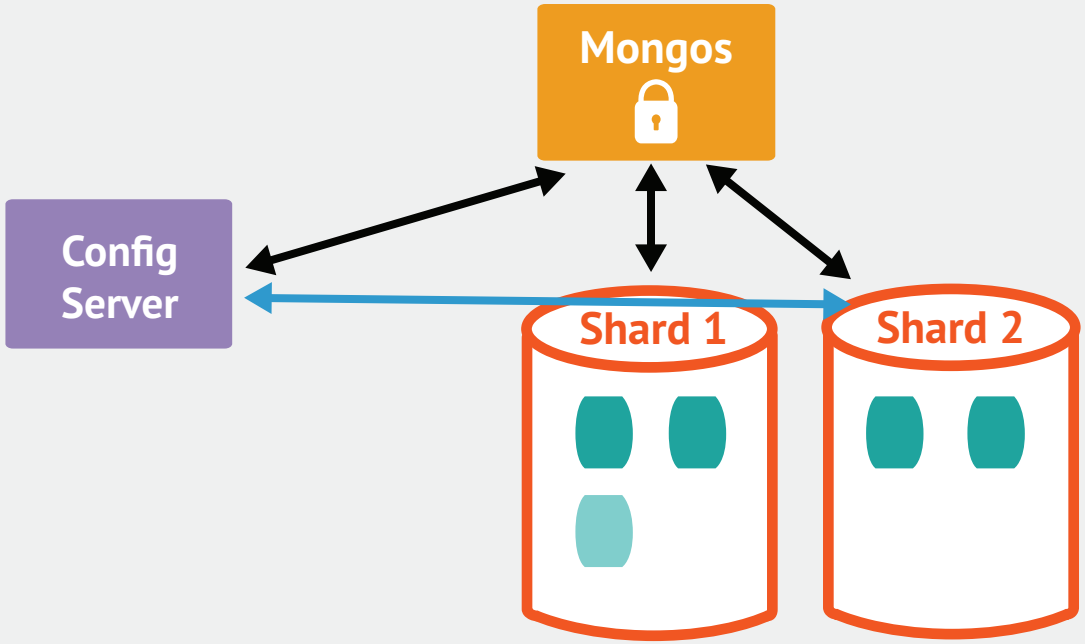
- The balancer on mongos takes out a "balancer lock"
- To see the status of these locks:
  - use config
  - db.locks.find({ _id: "balancer" })

Moving the chunk



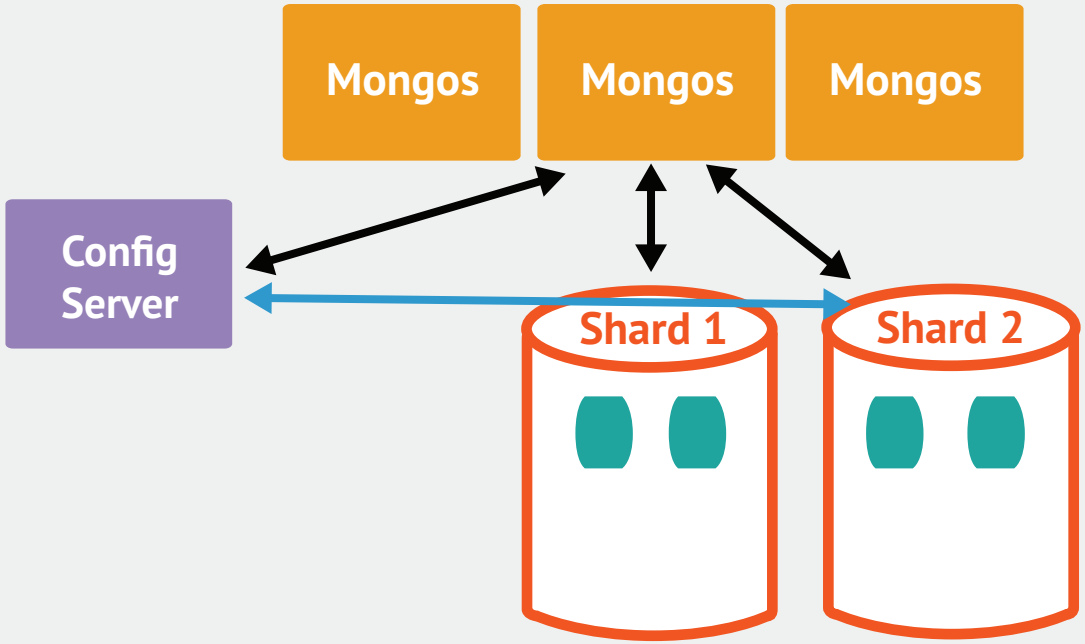
- The mongos sends a "moveChunk" command to source shard
- The source shard then notifies destination shard
- The destination claims the chunk shard-key range
- Destination shard starts pulling documents from source shard

Committing Migration



- When complete, destination shard updates config server
  - Provides new locations of the chunks

Cleanup

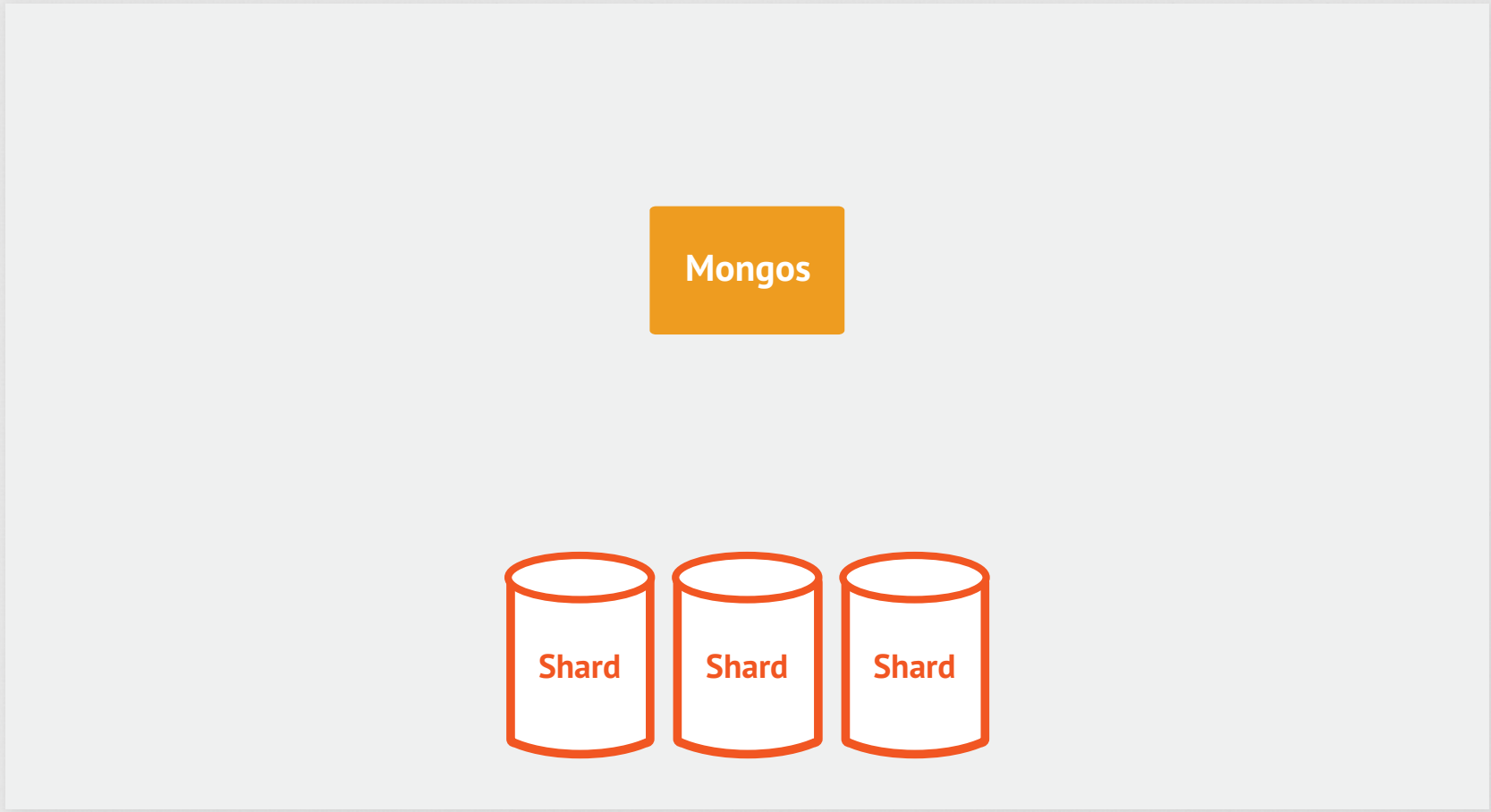


- Source shard deletes moved data
  - Must wait for open cursors to either close or time out
  - NoTimeout cursors may prevent the release of the lock
- Mongos releases the balancer lock after old chunks are deleted

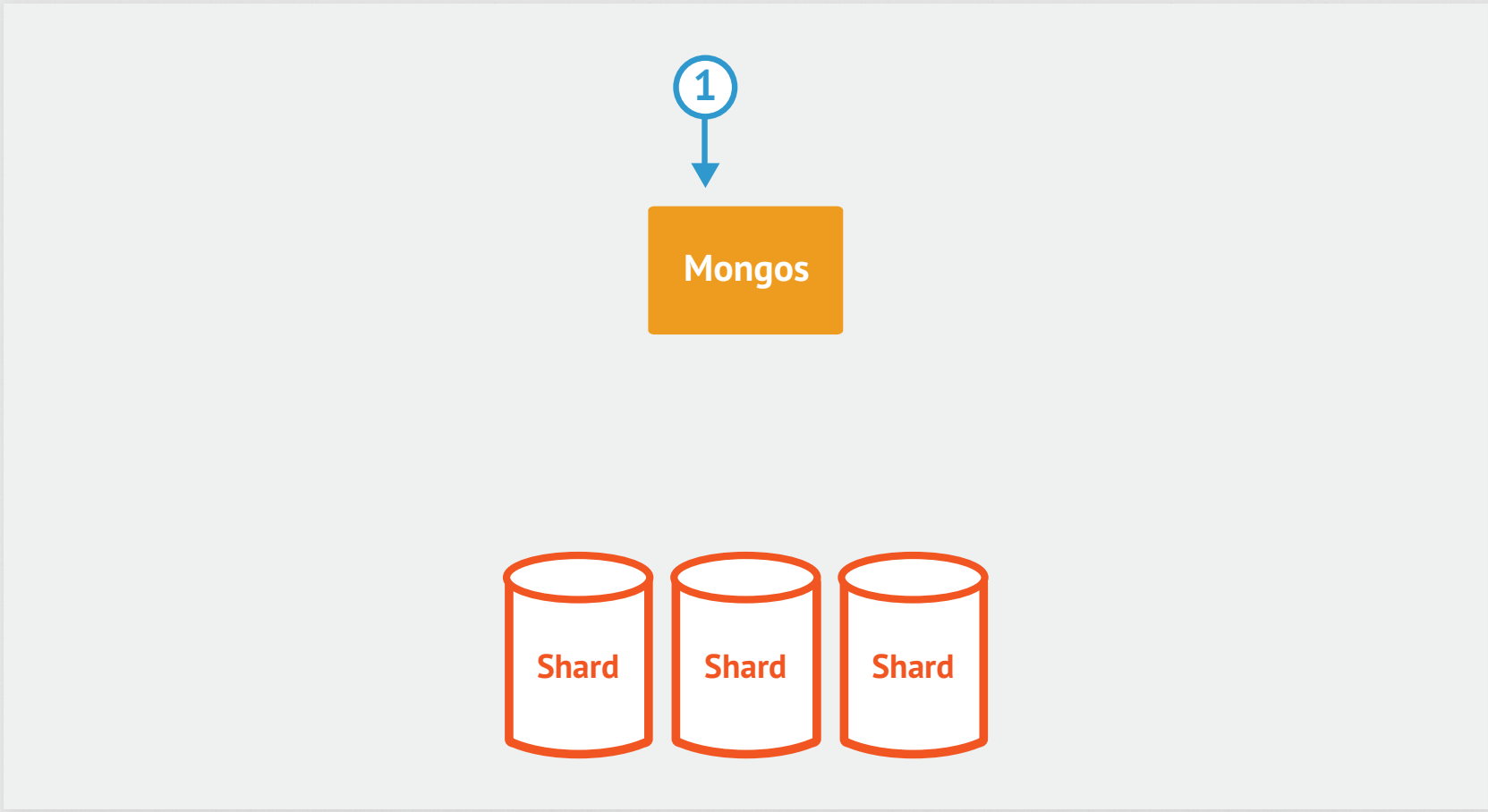
Routing Requests

Cluster Request Routing

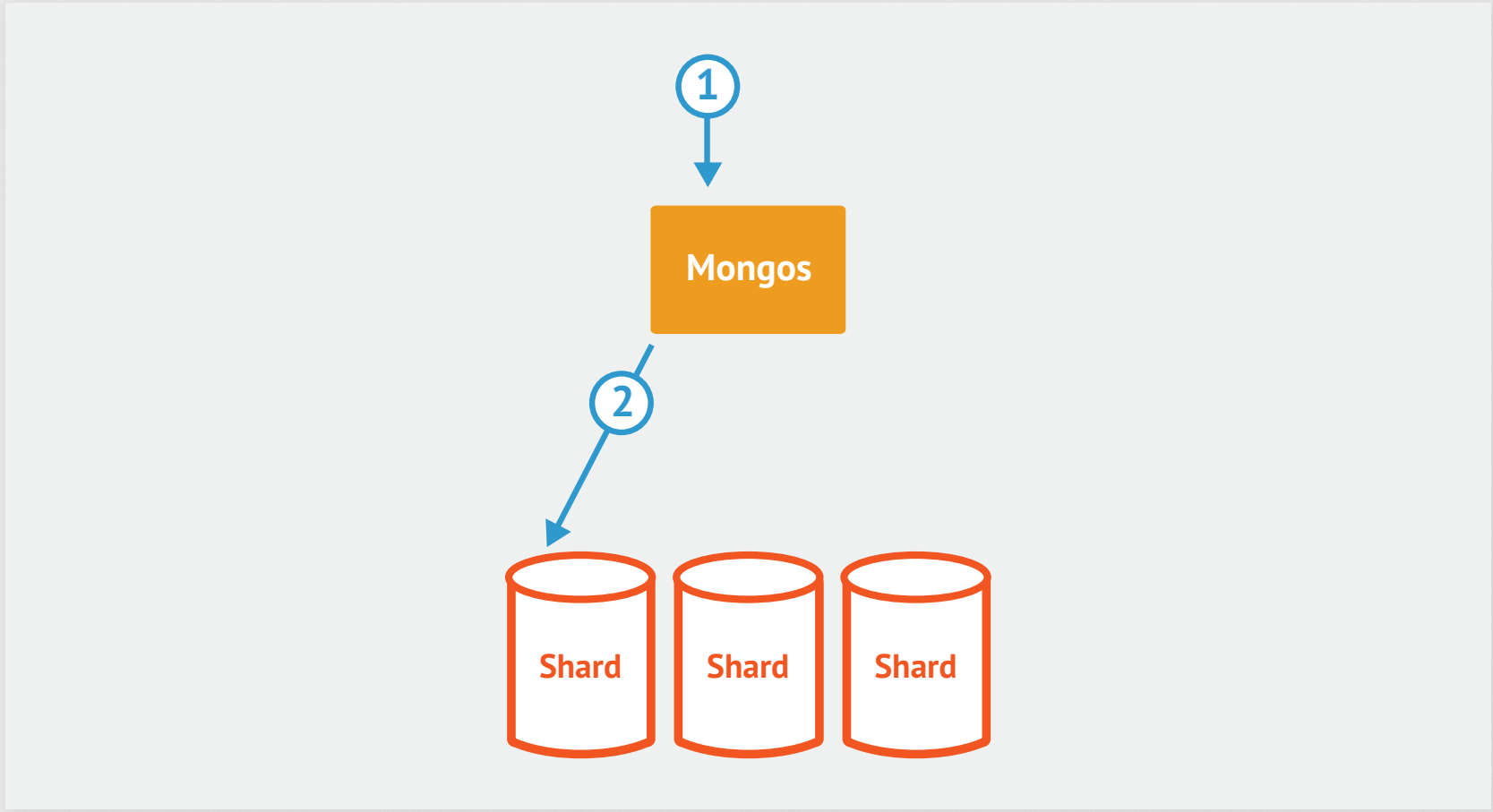
- Targeted Queries
- Scatter Gather Queries
- Scatter Gather Queries with Sort



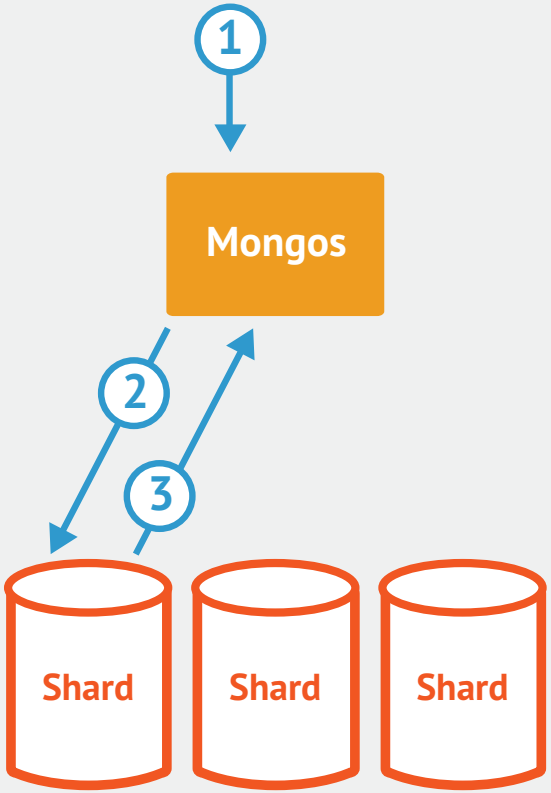
Cluster Request Routing: Targeted Query



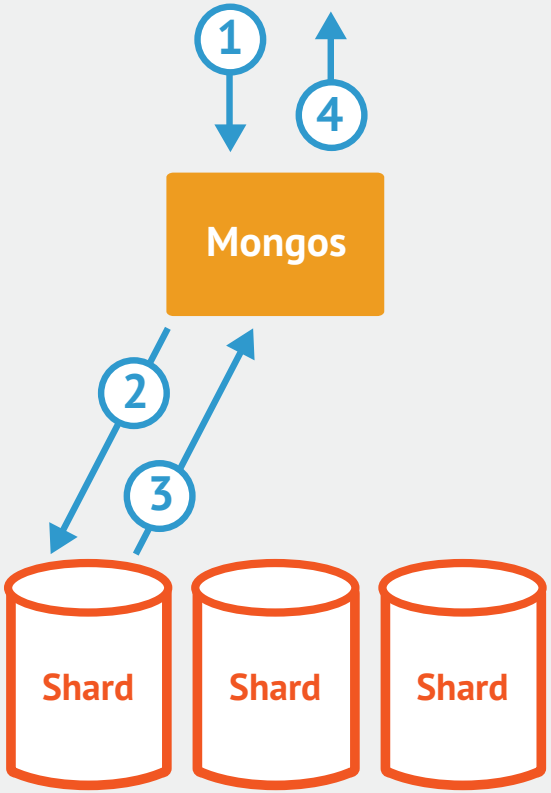
Routable request received



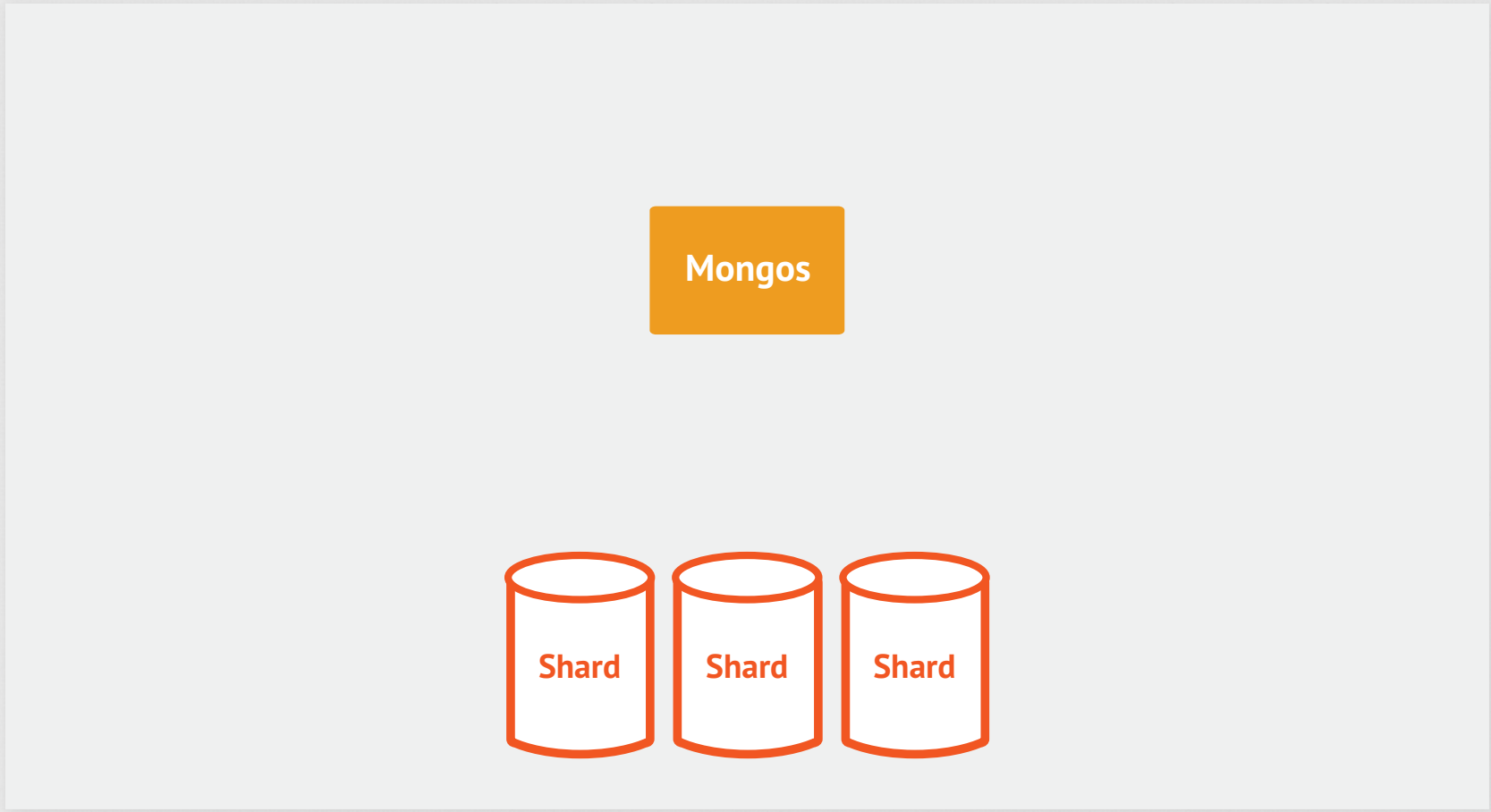
Request routed to appropriate shard



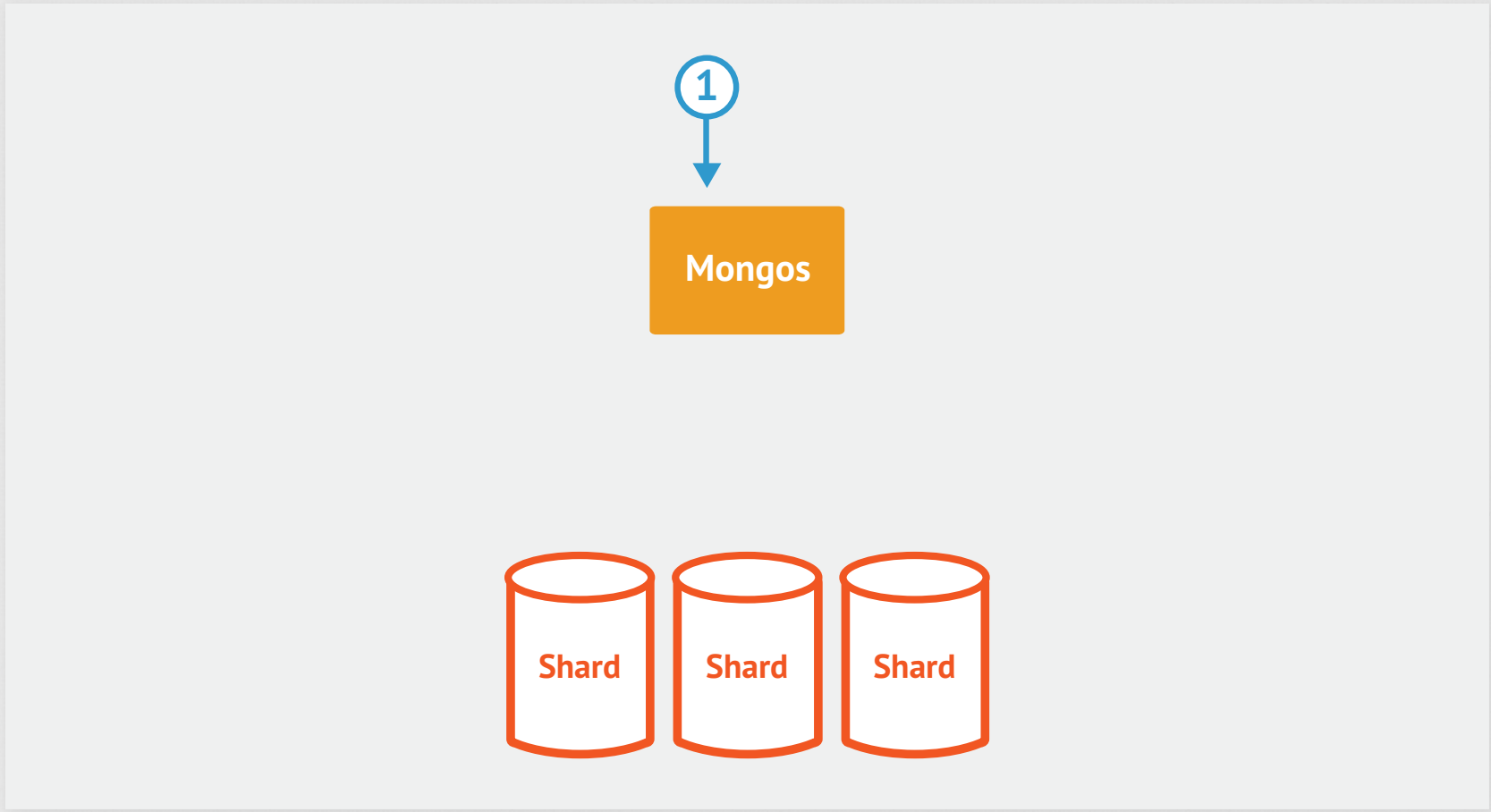
Shard returns results



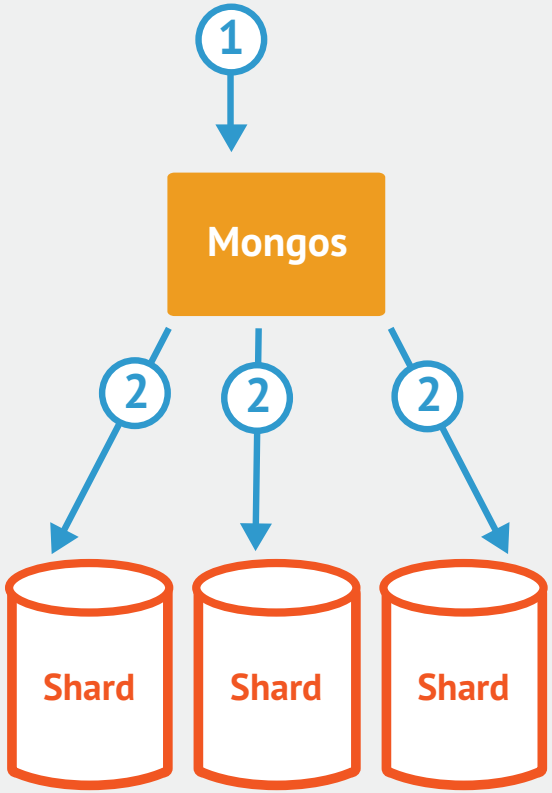
Mongos returns results to client



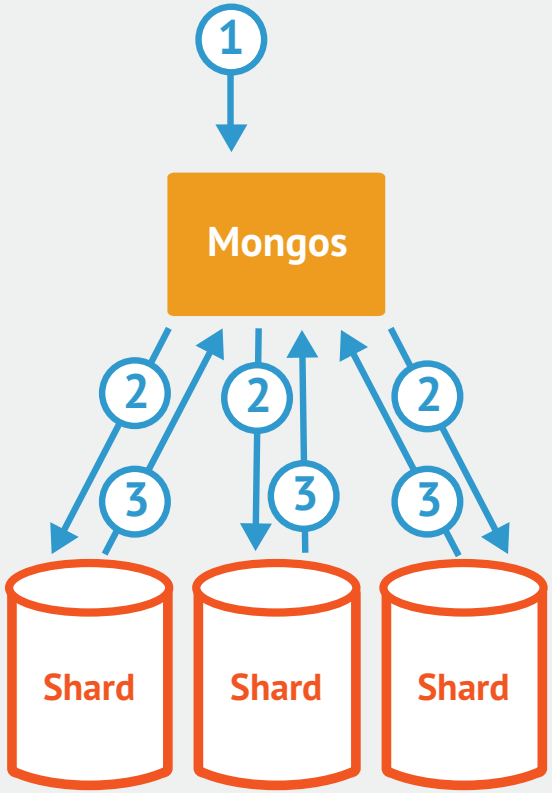
Cluster Request Routing: Non-Targeted Query



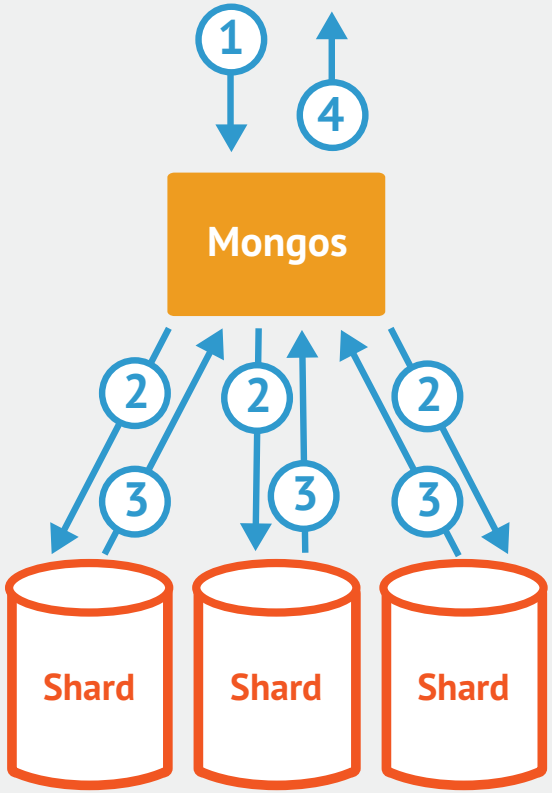
Non-Targeted Request Received



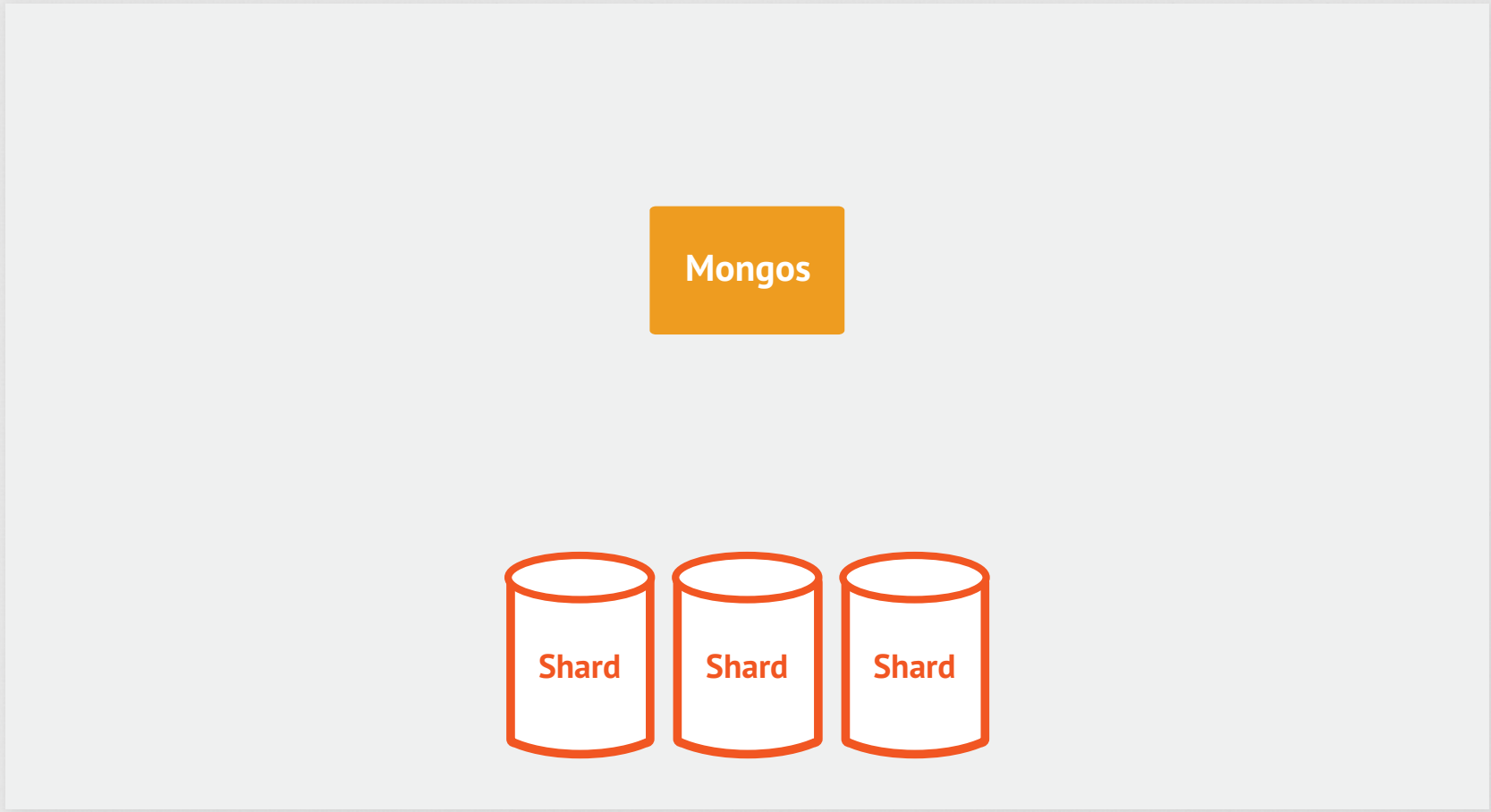
Request sent to all shards



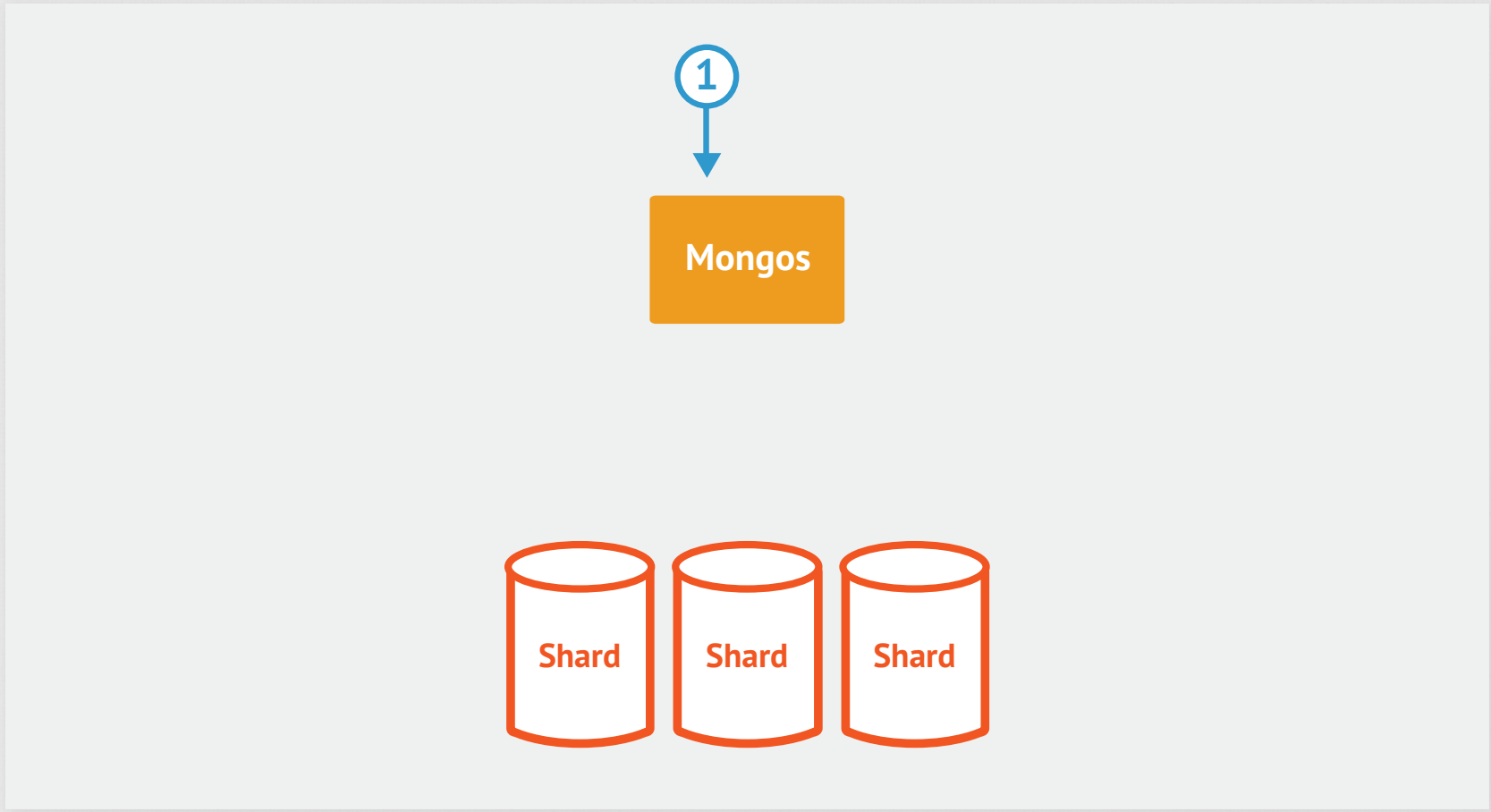
Shards return results to mongos



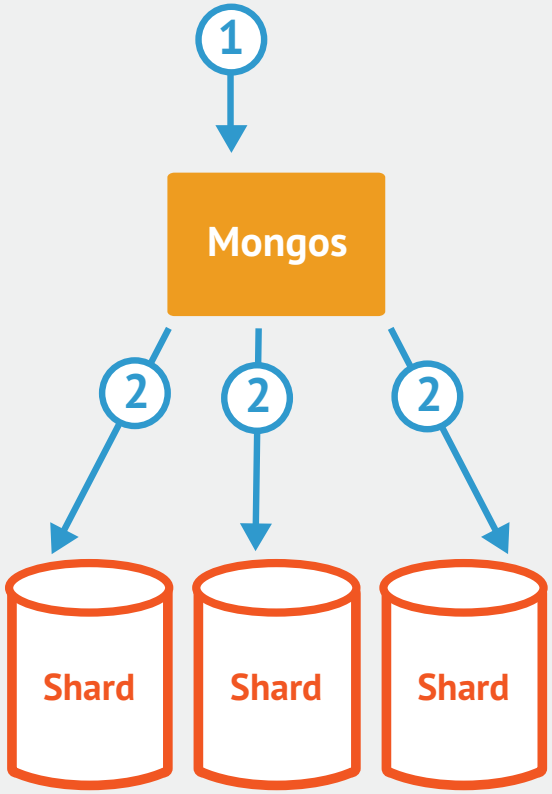
Mongos returns results to client



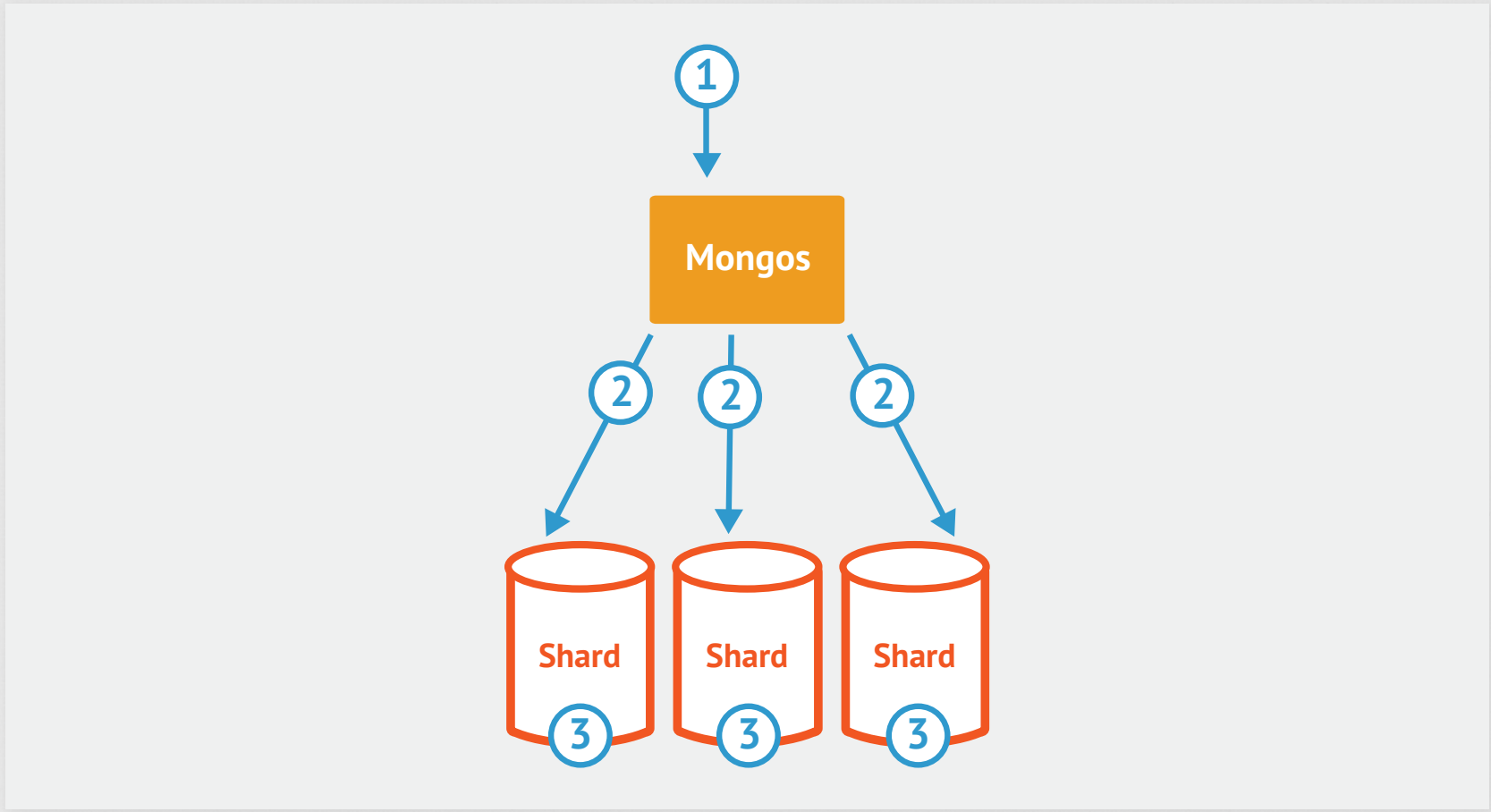
Cluster Request Routing: Non-Targeted Query with Sort



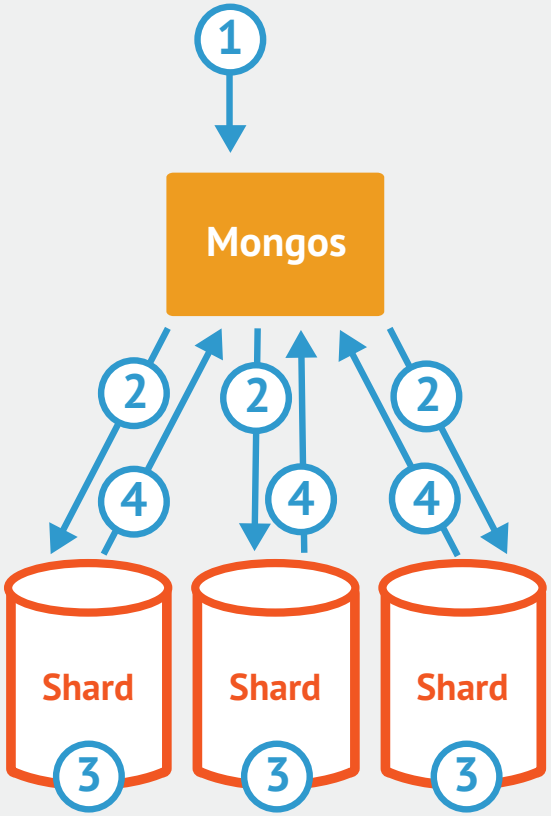
Non-Targeted request with sort received



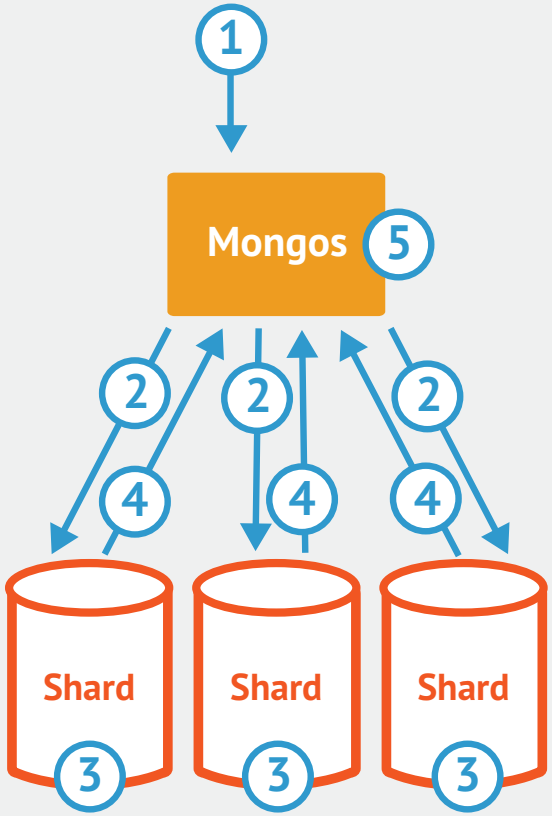
Request sent to all shards



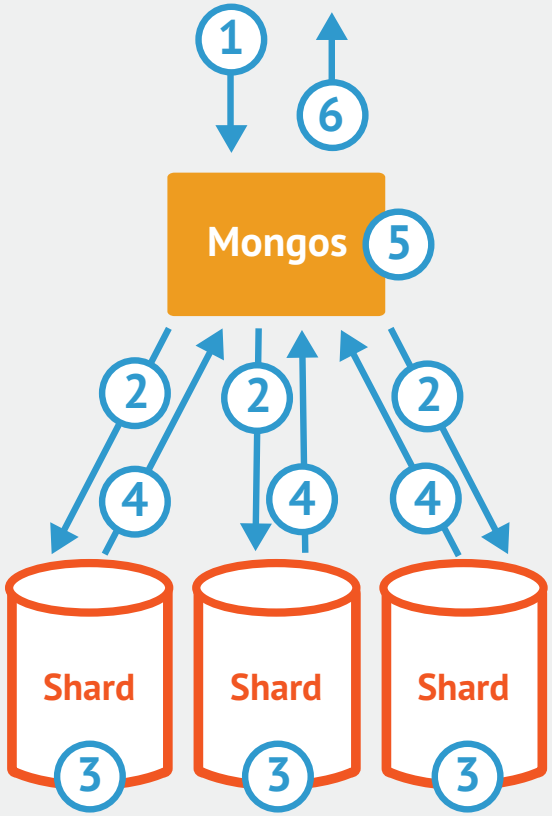
Query and sort performed locally



Shards return results to mongos



Mongos merges sorted results



Mongos returns results to client

Shard Key

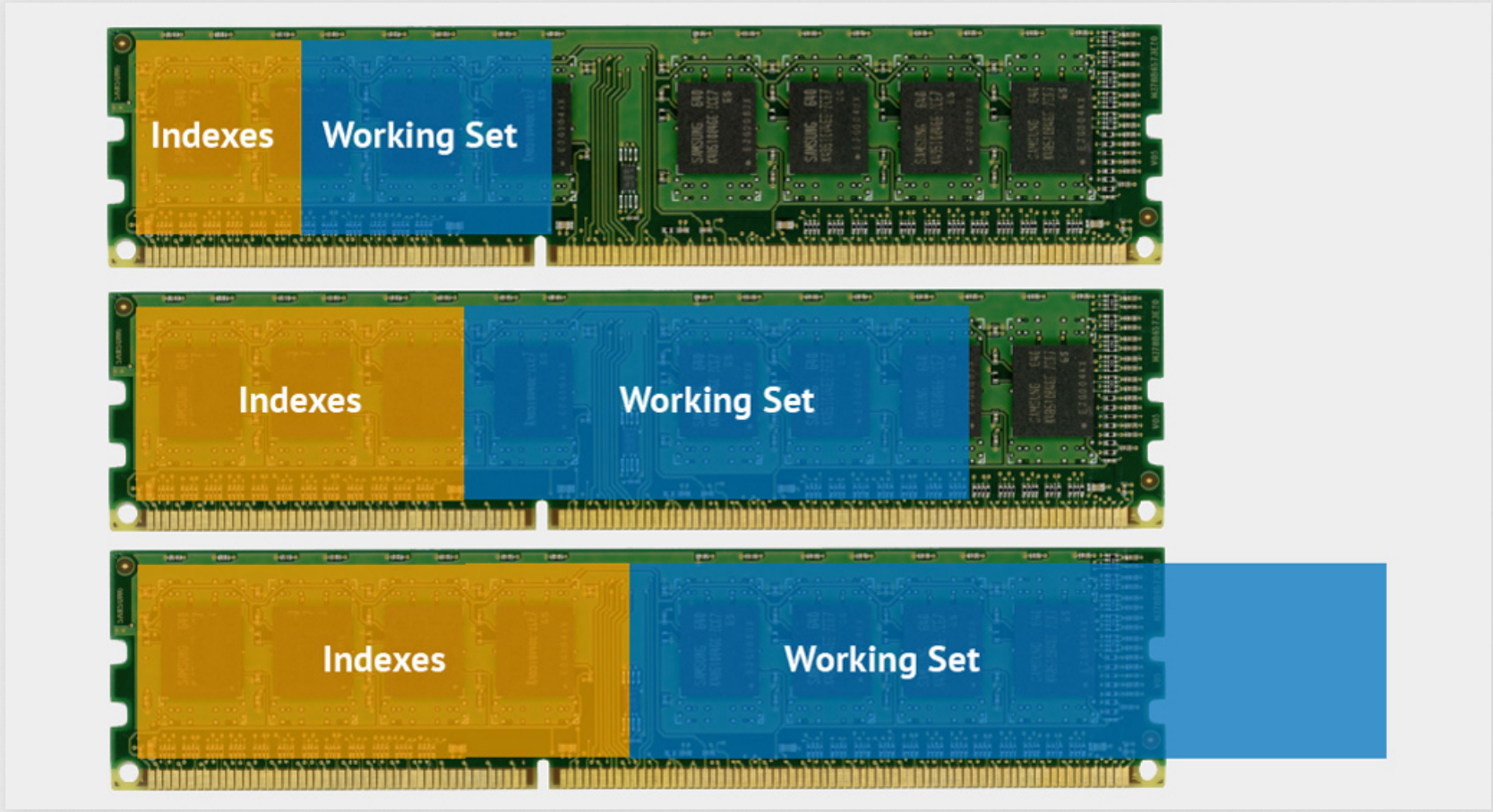
Shard Key

- Choose a field common used in queries
- Shard key is **immutable**
- Shard key values are **immutable**
- Shard key requires index on fields contained in key
- Uniqueness of `_id` field is only guaranteed within individual shard
- Shard key limited to 512 bytes in size

Shard Key Considerations

- Cardinality
- Write distribution
- Query isolation
- Data Distribution

Sharding enables scale



Working Set Exceeds Physical Memory

Read/Write throughput exceeds I/O

Thank You

Jason Zucchetto

Consulting Engineer, 10gen

10gen | the MongoDB company