#CodeMash

Sharding

Sridhar Nanjundeswaran

Engineer, 10gen

@snanjund

10gen | the MongoDB company

mongoDB

Agenda

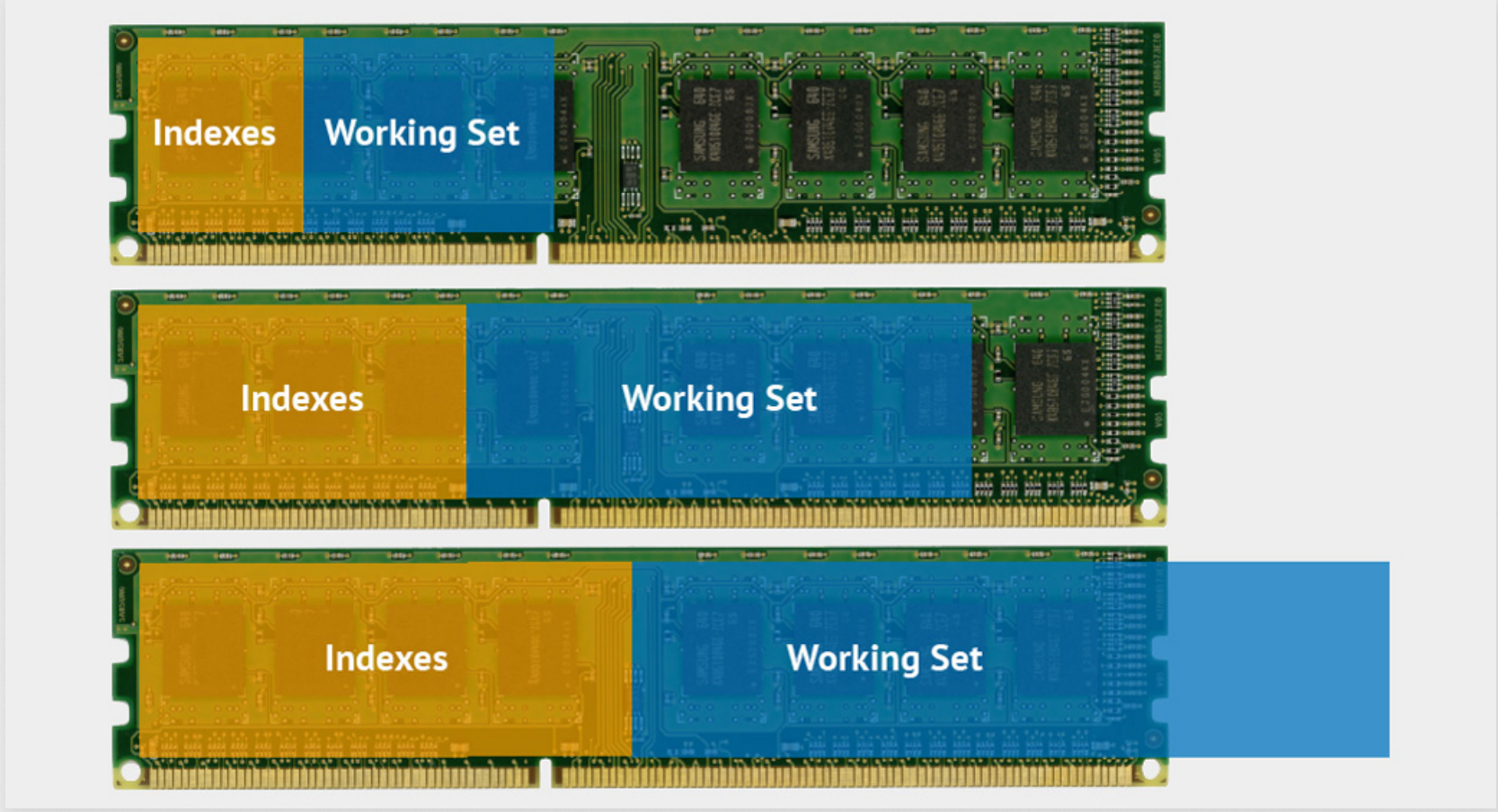
- Scaling Data
- MongoDB's Approach
- Architecture
- Configuration
- Mechanics
- https://github.com/sridharn/codemash_2013/tree/master/sharding

Scaling Data

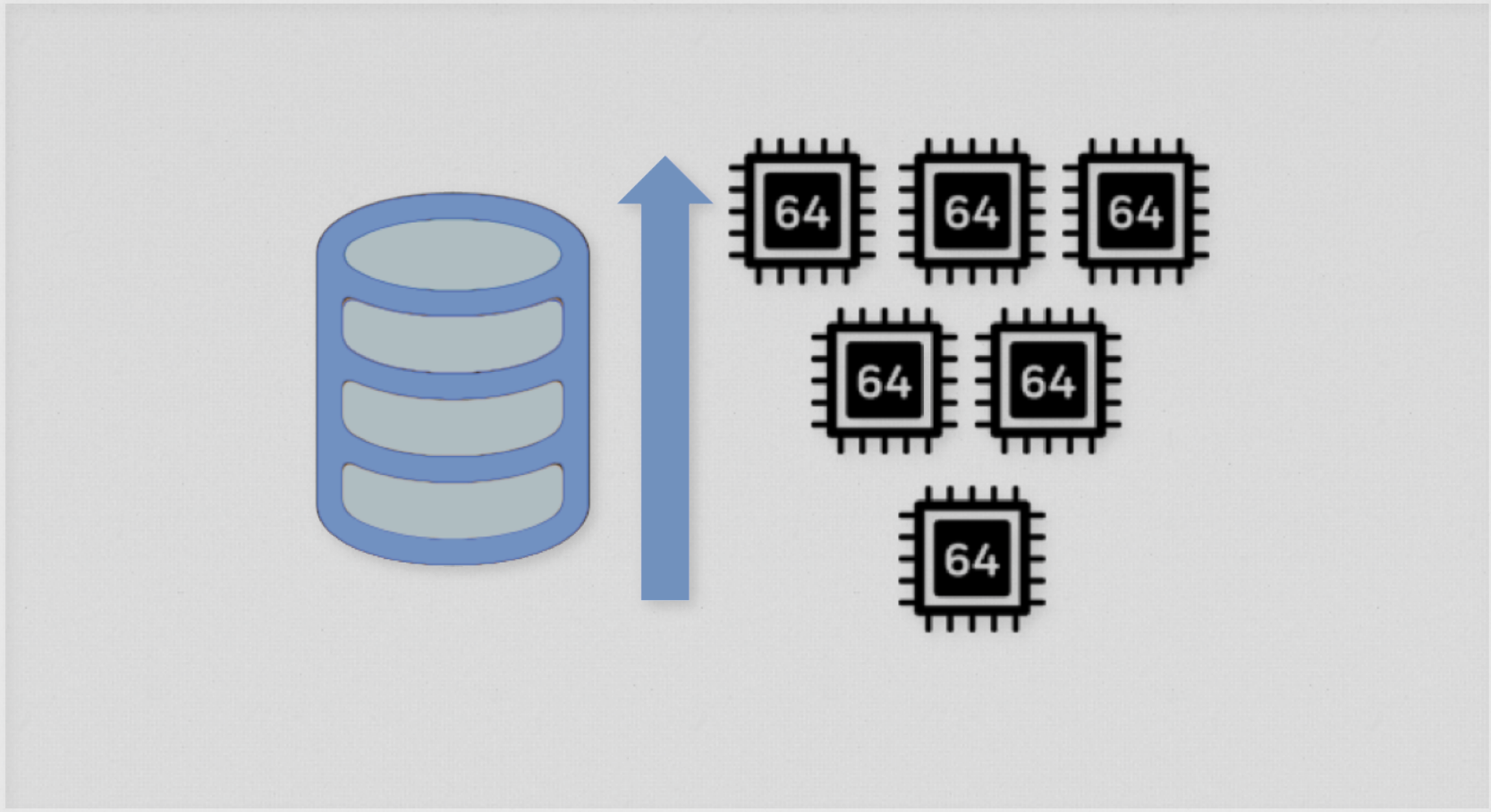
Examining Growth

- More Users
  - 1995: 0.4% of the world's population
  - Today: 30% of the world is online (~2.2B)
  - Emerging Markets & Mobile
- More Data
  - Facebook's data set is around 100 petabytes
  - 4 billion photos taken in the last year (4x a decade ago)

Read/Write Throughput Exceeds I/O



Working Set Exceeds Physical Memory



Vertical Scalability (Scale Up)

Horizontal Scalability (Scale Out)

Data Store Scalability

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

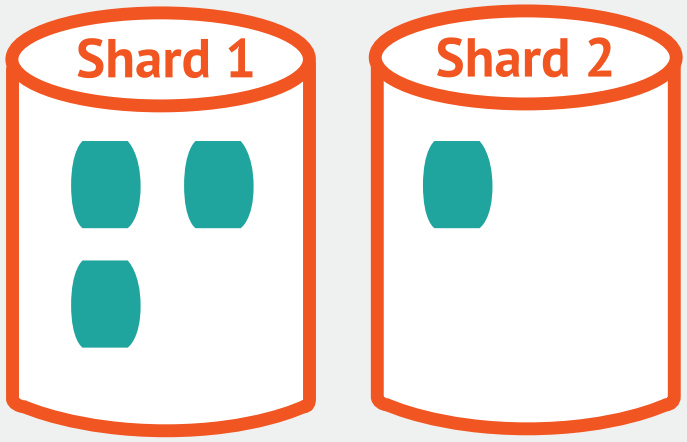
MongoDB's Approach to Sharding

Partitioning

- 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

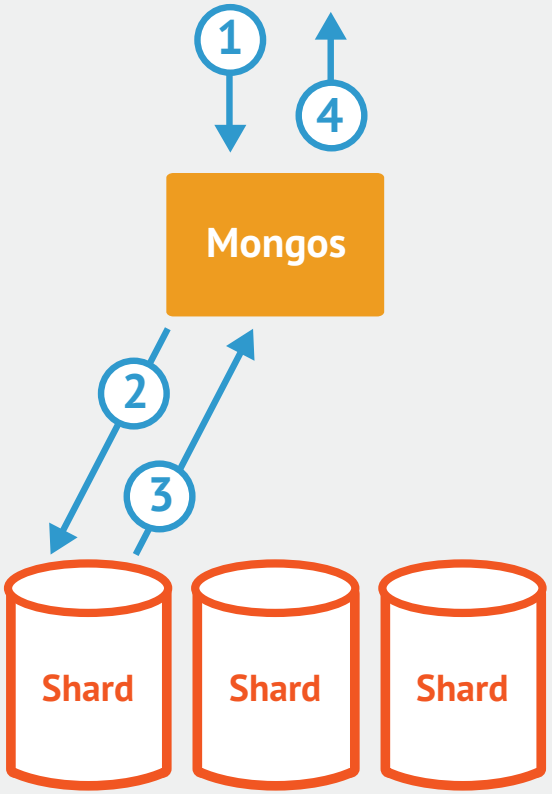
Data Distribution

- Initially 1 chunk
- Default max chunk size: 64mb
- Default imbalance is 8 chunks
- MongoDB automatically splits & migrates chunks when max r



Routing and Balancing

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



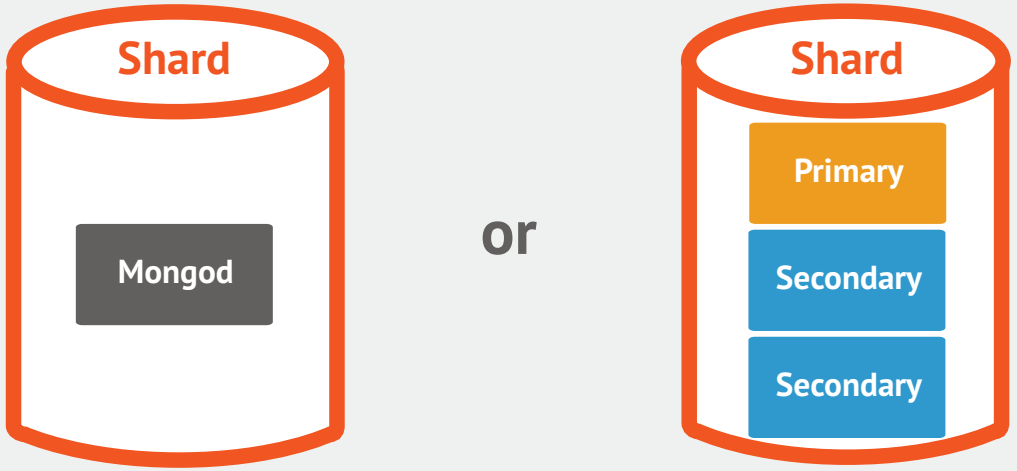
MongoDB Auto-Sharding

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

Architecture

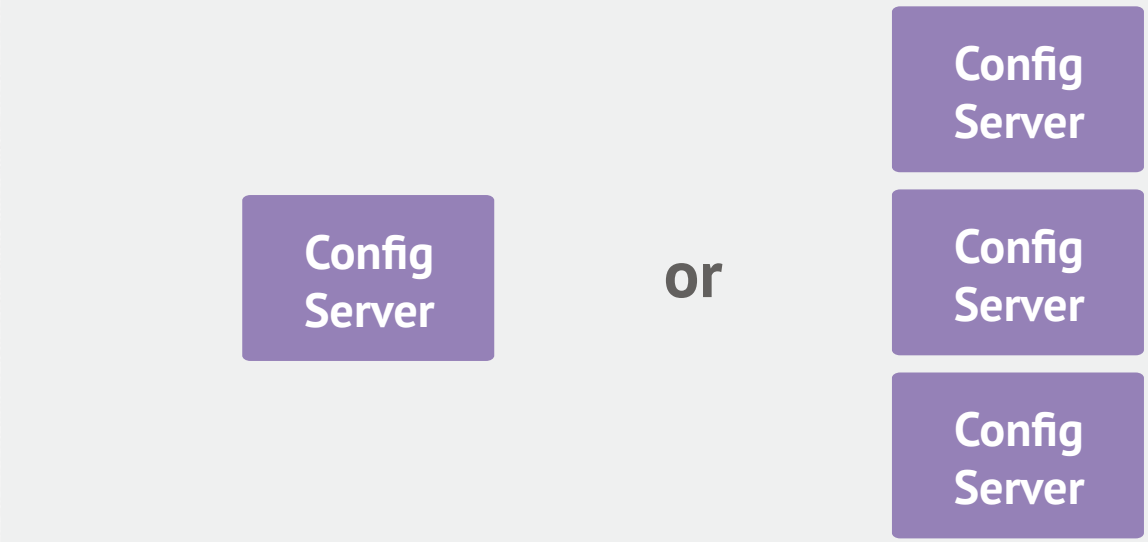
What is a Shard?

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



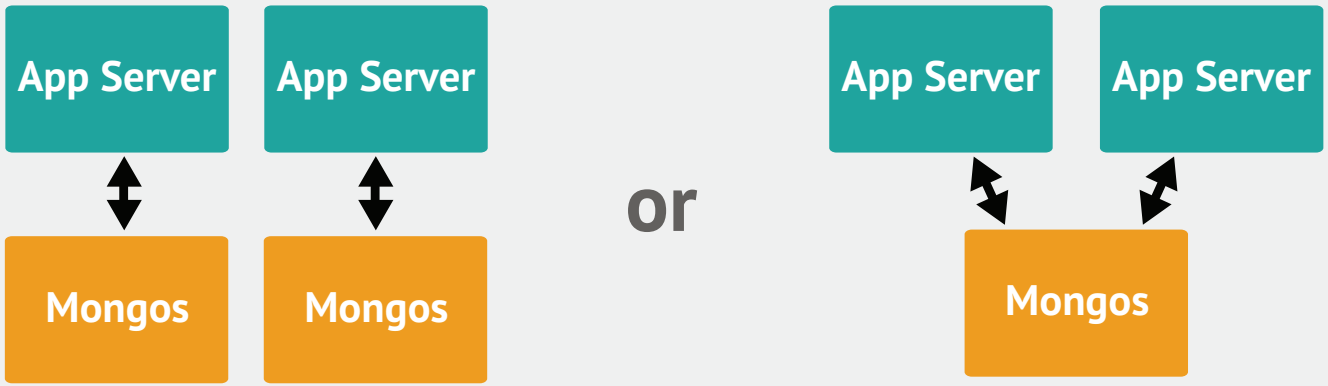
Meta Data Storage

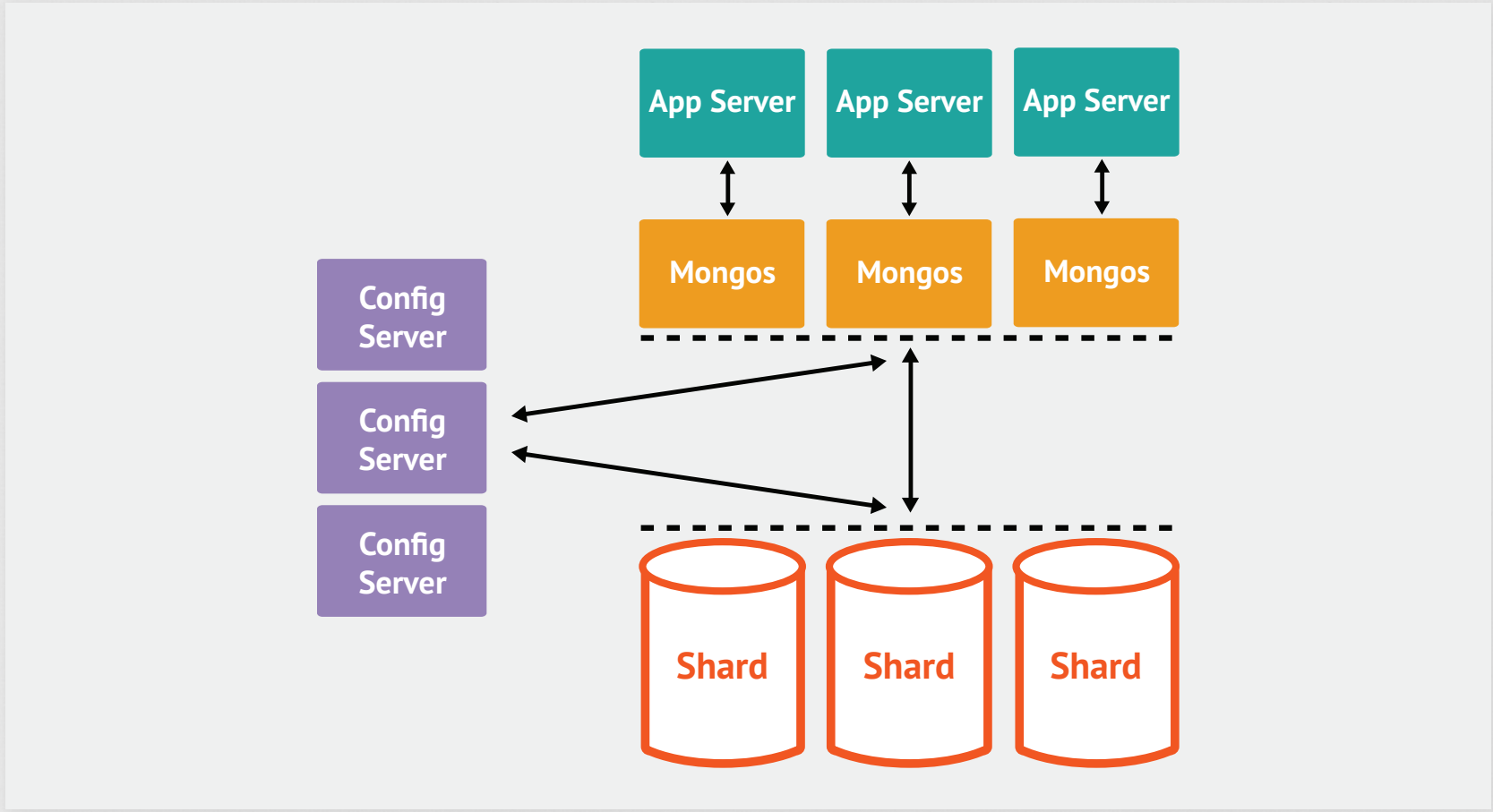
- Config Server
  - Stores cluster chunk ranges and locations
  - Can have only 1 or 3 (production must have 3)
  - Not a replica set



Routing and Managing Data

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

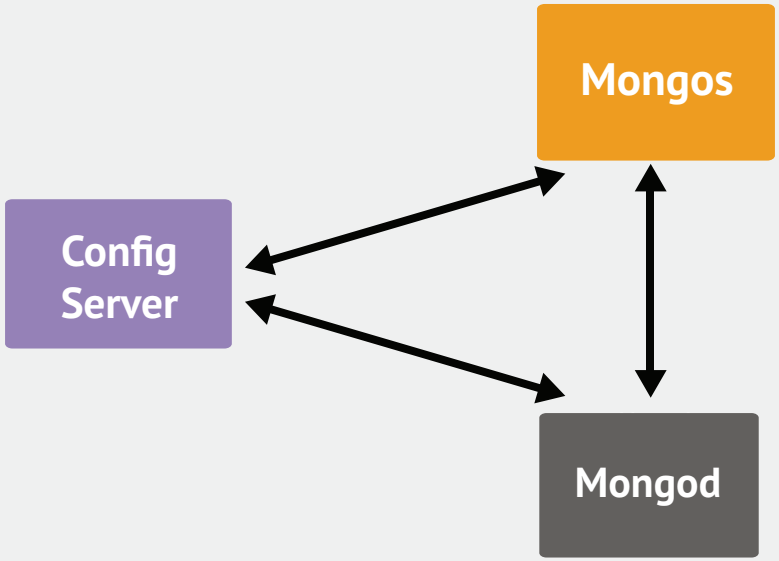




Sharding infrastructure

Configuration

Example Cluster

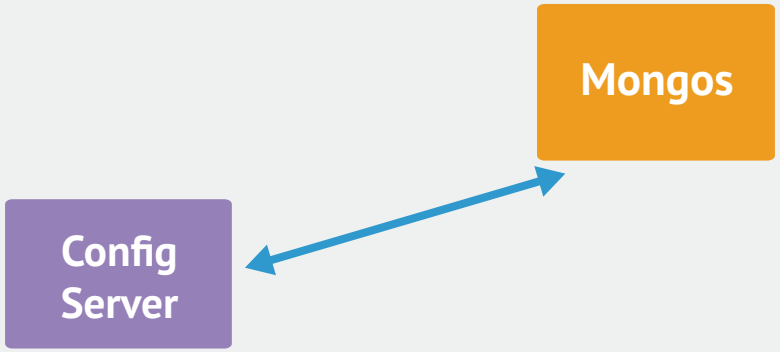


- ***Don't use this setup in production!***
  - Only one Config server (No Fault Tolerance)
  - Shard not in a replica set (No data safety and Low Availability)
  - Only one `mongos` and shard (No Performance Improvement)
  - Useful for development or demonstrating configuration mechanics

Starting the Configuration Server

- `mongod --configsvr`
- Starts a configuration server on the default port (27019)

Start the `mongos` Router

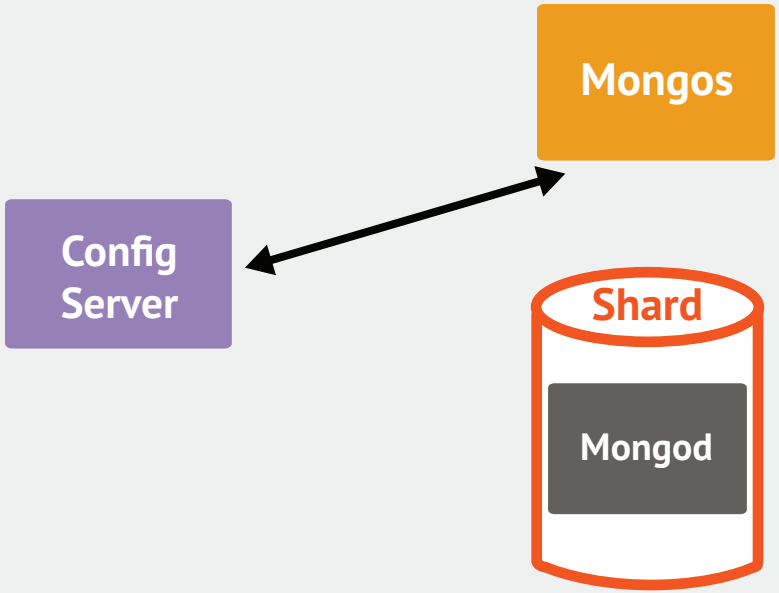


- `mongos --configdb <hostname>:27019`
- For 3 configuration servers:

  ```
  mongos --configdb
  <host1>:<port1>,<host2>:<port2>,<host3>:<port3>
  ```

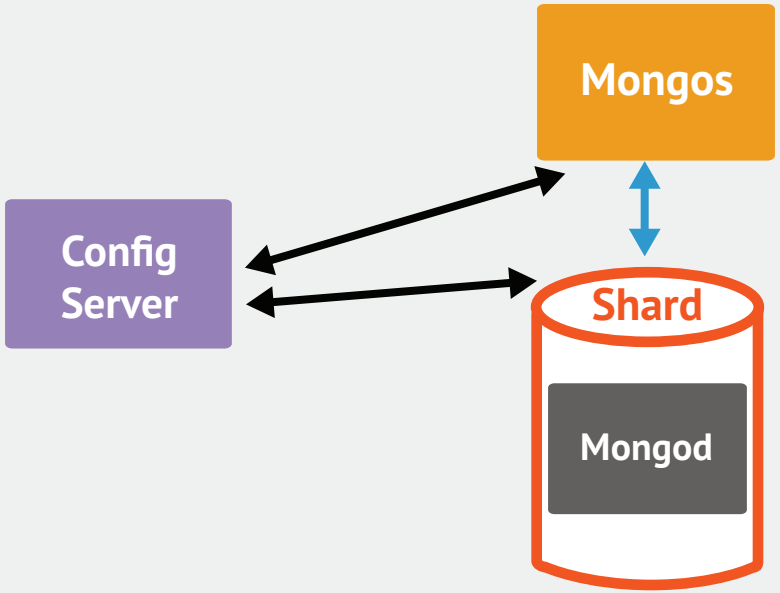
- This is always how to start a new `mongos`, even if the cluster is already running

Start the shard database



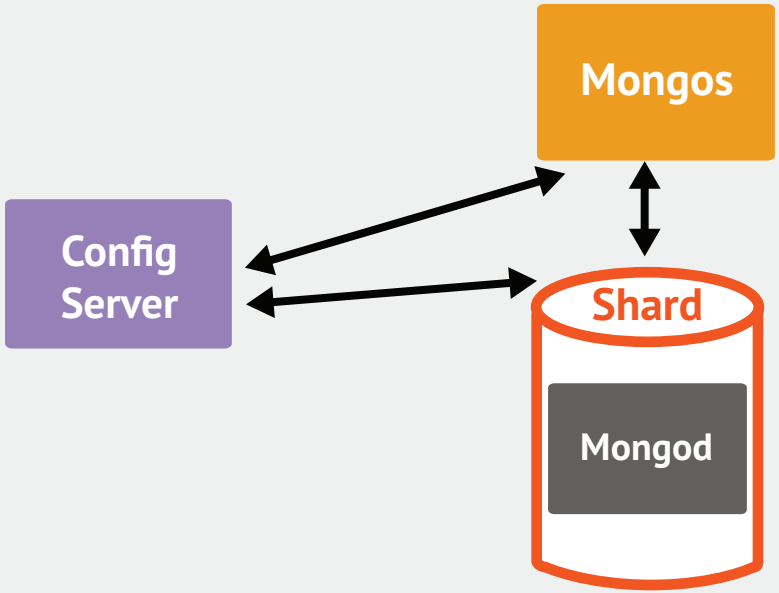
- `mongod --shardsvr`
- Starts a `mongod` with the default shard port (27018)
- Shard is not yet connected to the rest of the cluster
- Shard may have already been running in production

Add the Shard



- On mongos:
  - `sh.addShard('<host>:27018')`
- Adding a replica set:
  - `sh.addShard('<rsname>/<seedlist>')`

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})
```

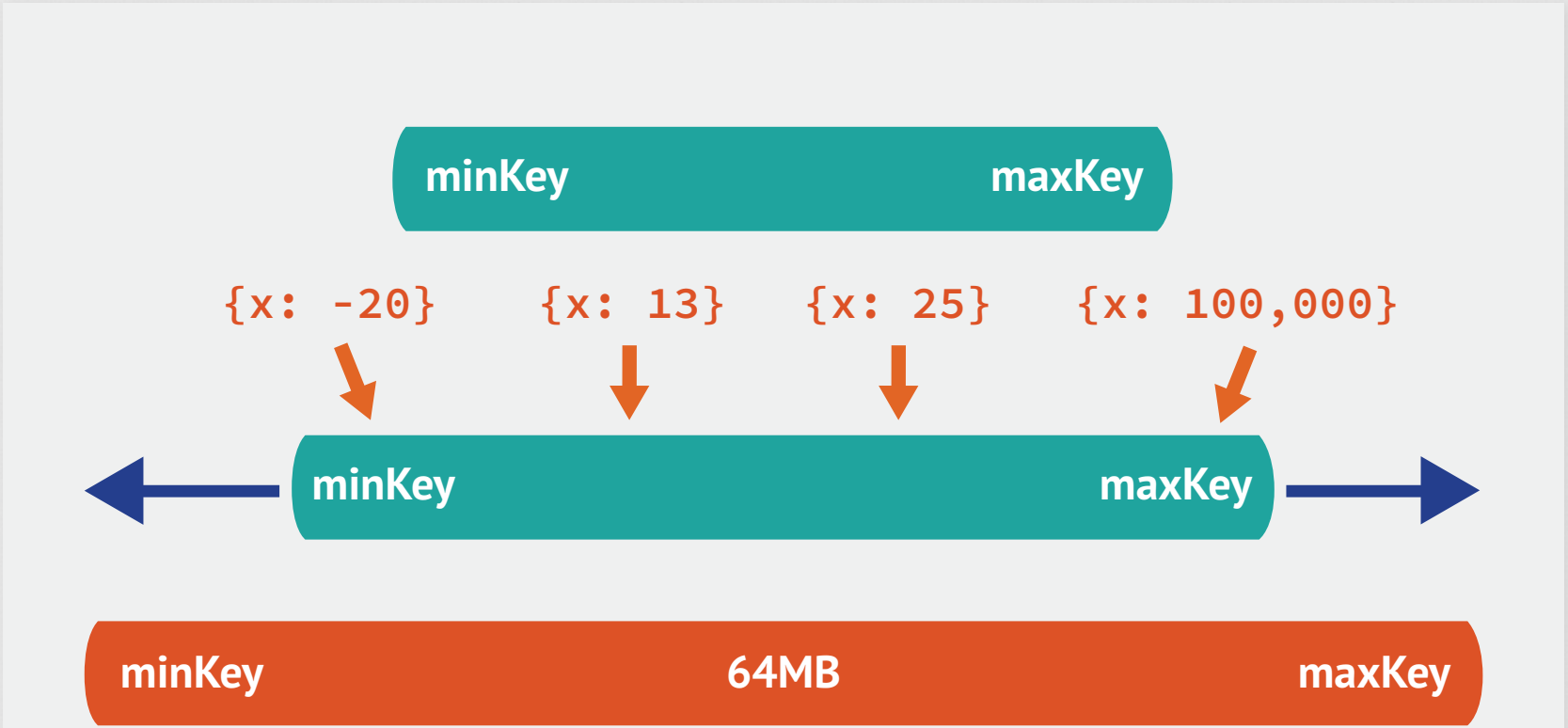
- Use a compound shard key to prevent duplicates

```
sh.shardCollection("<dbname>.cars",{"year":1, "uniqueid":1})
```

Mechanics

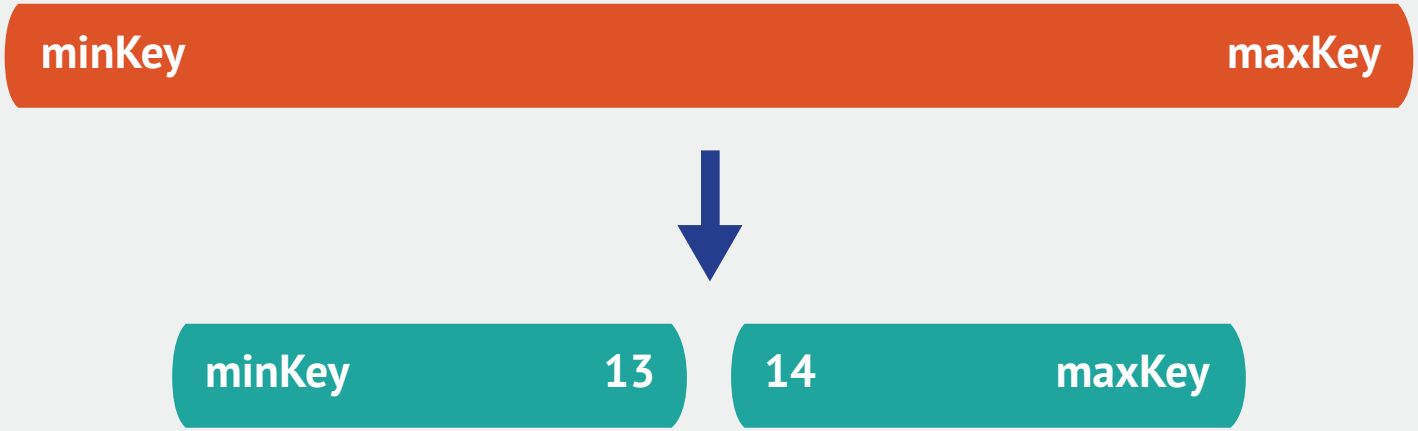
Partitioning

- Remember it's based on ranges



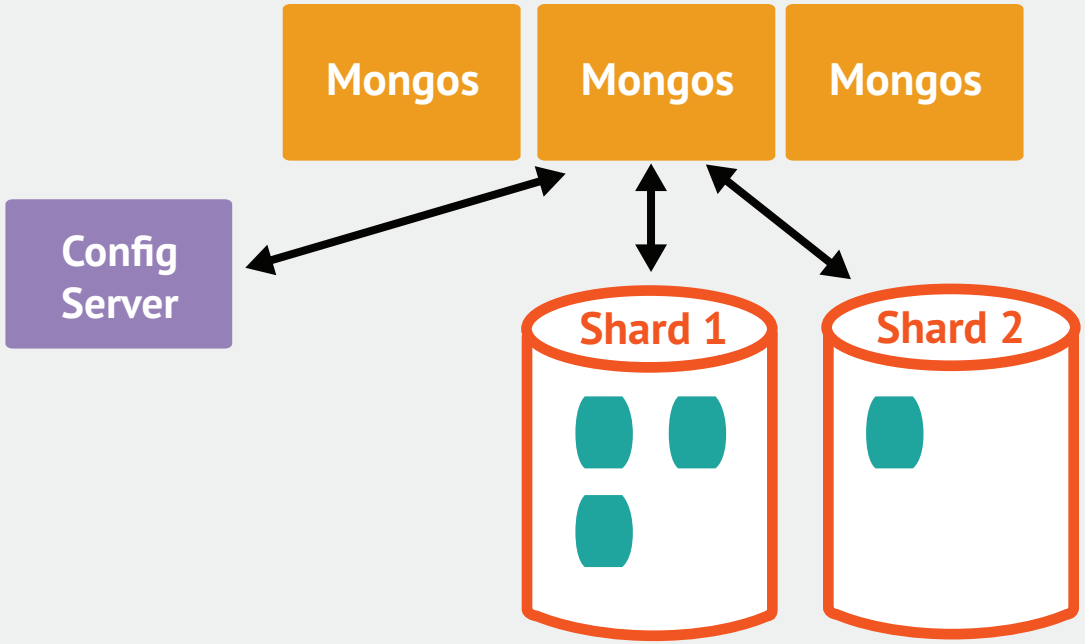
Chunk is a section of the entire range

Chunk splitting



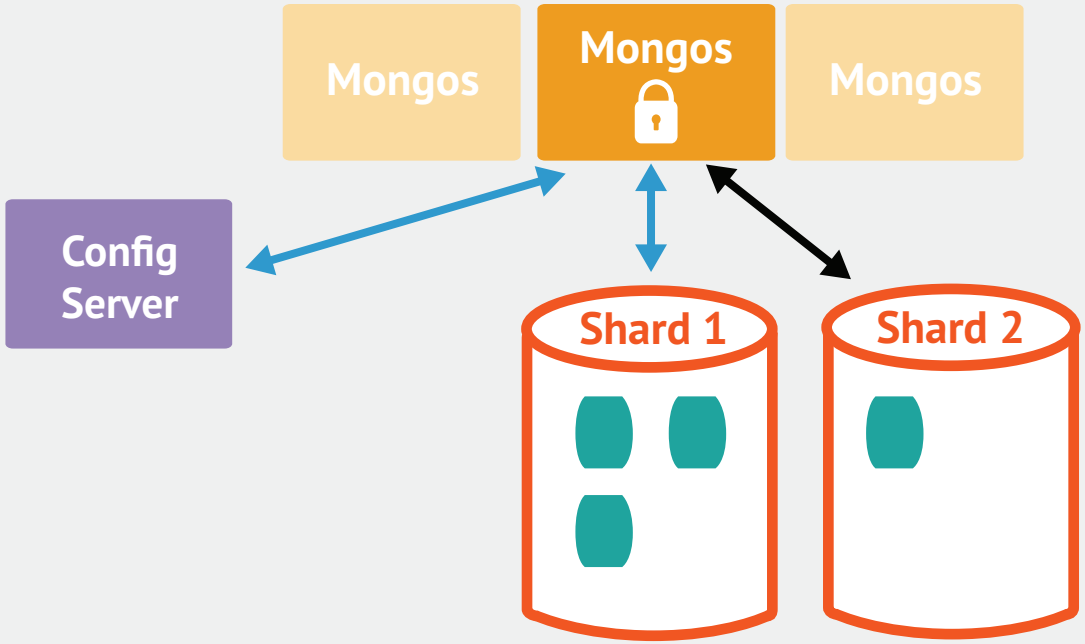
- A chunk is split once it exceeds the maximum size
- There is no split point if all documents have the same shard key
- Chunk split is a logical operation (no data is moved)

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

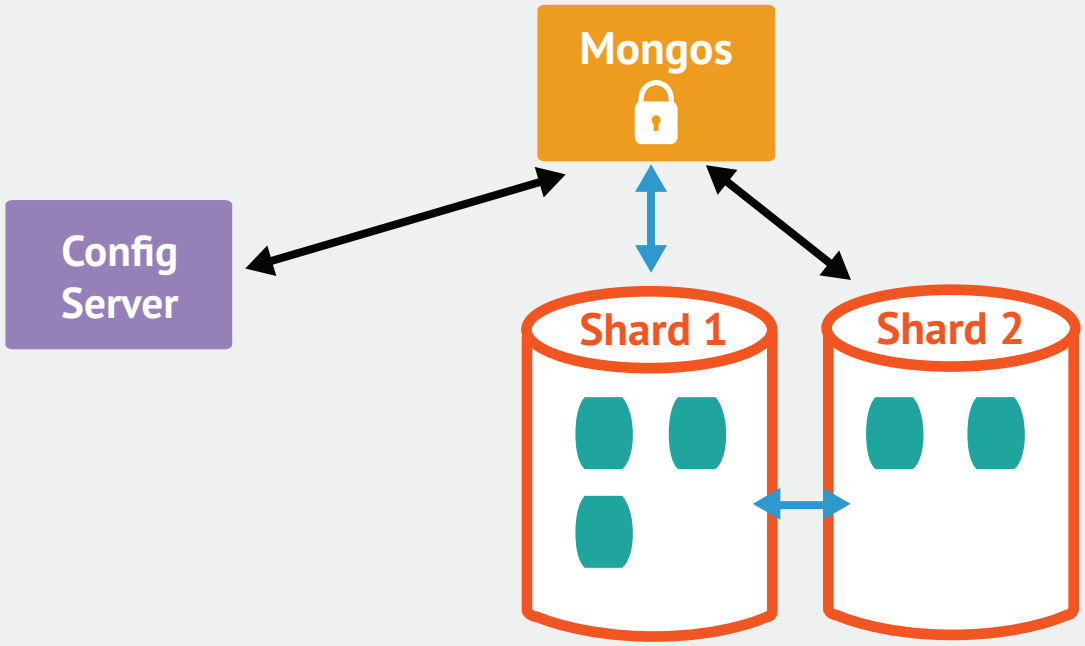
Acquiring the Balancer Lock



- The balancer on mongos takes out a "balancer lock"
- To see the status of these locks:

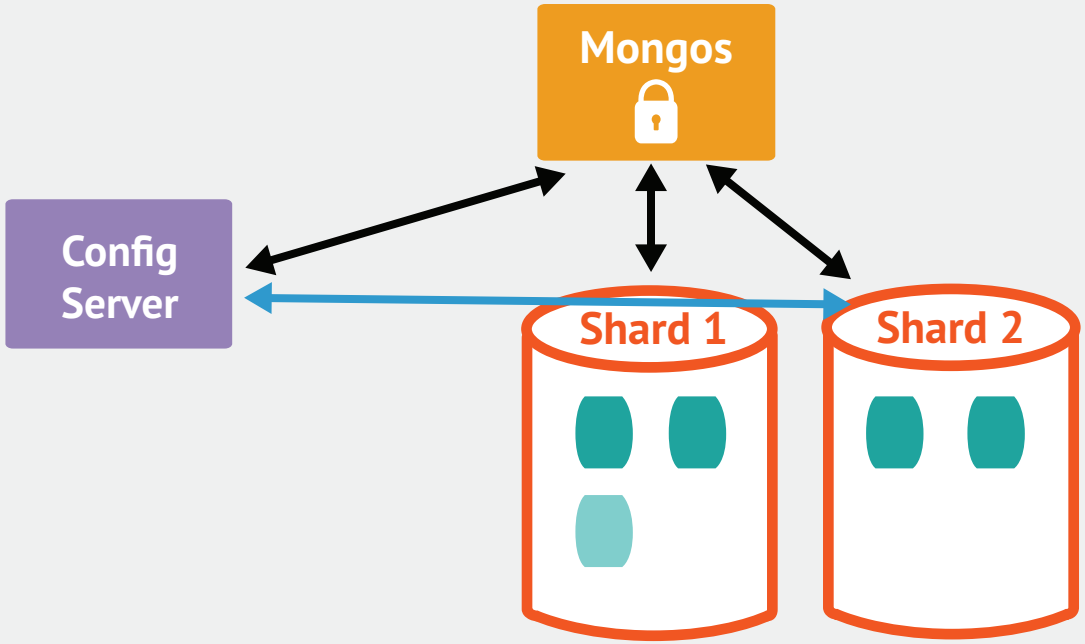
```
use config
db.locks.find({ _id: "balancer" })
```

Moving the chunk



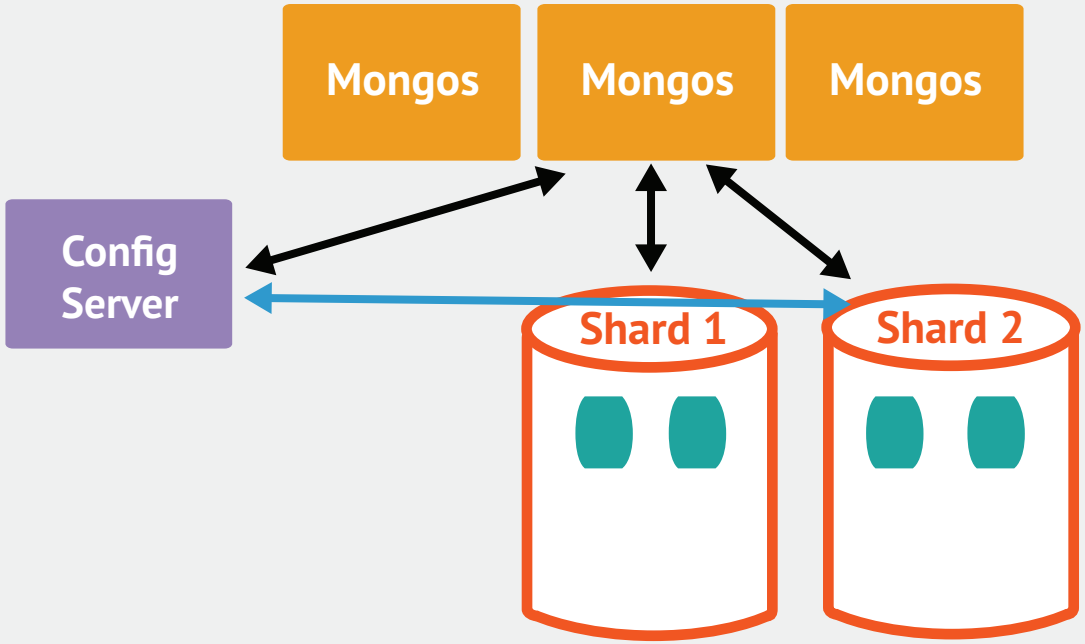
- The mongos sends a `moveChunk` command to source shard
- The source shard then notifies destination shard
- Destination shard starts pulling documents from source shard

Committing Migration



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

Cleanup

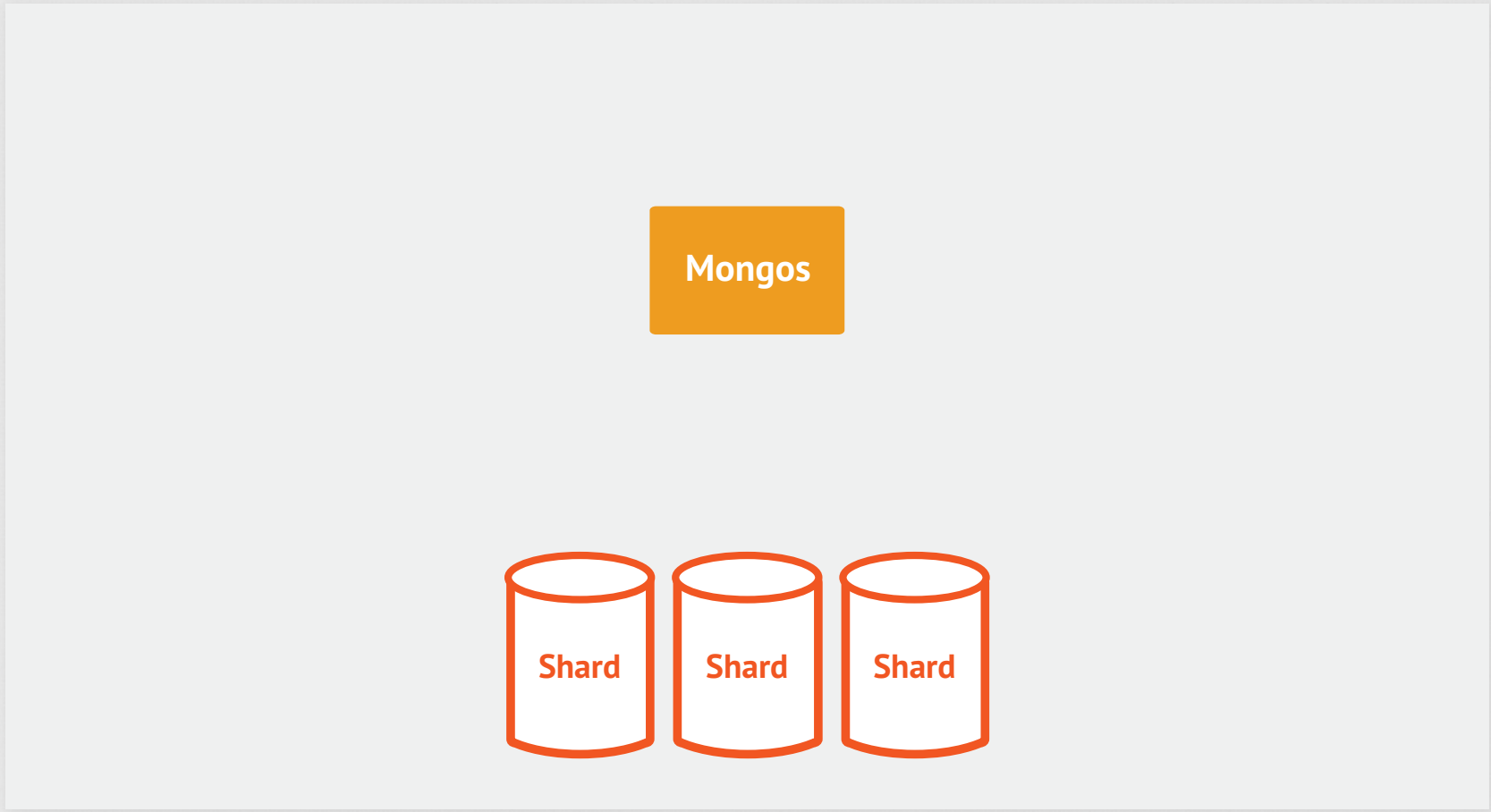


- Source shard deletes moved data
  - Must wait for open cursors to either close or time out
  - `NoTimeout` cursors may prevent the release of the lock
- The `mongos` releases the balancer lock after old chunks are deleted

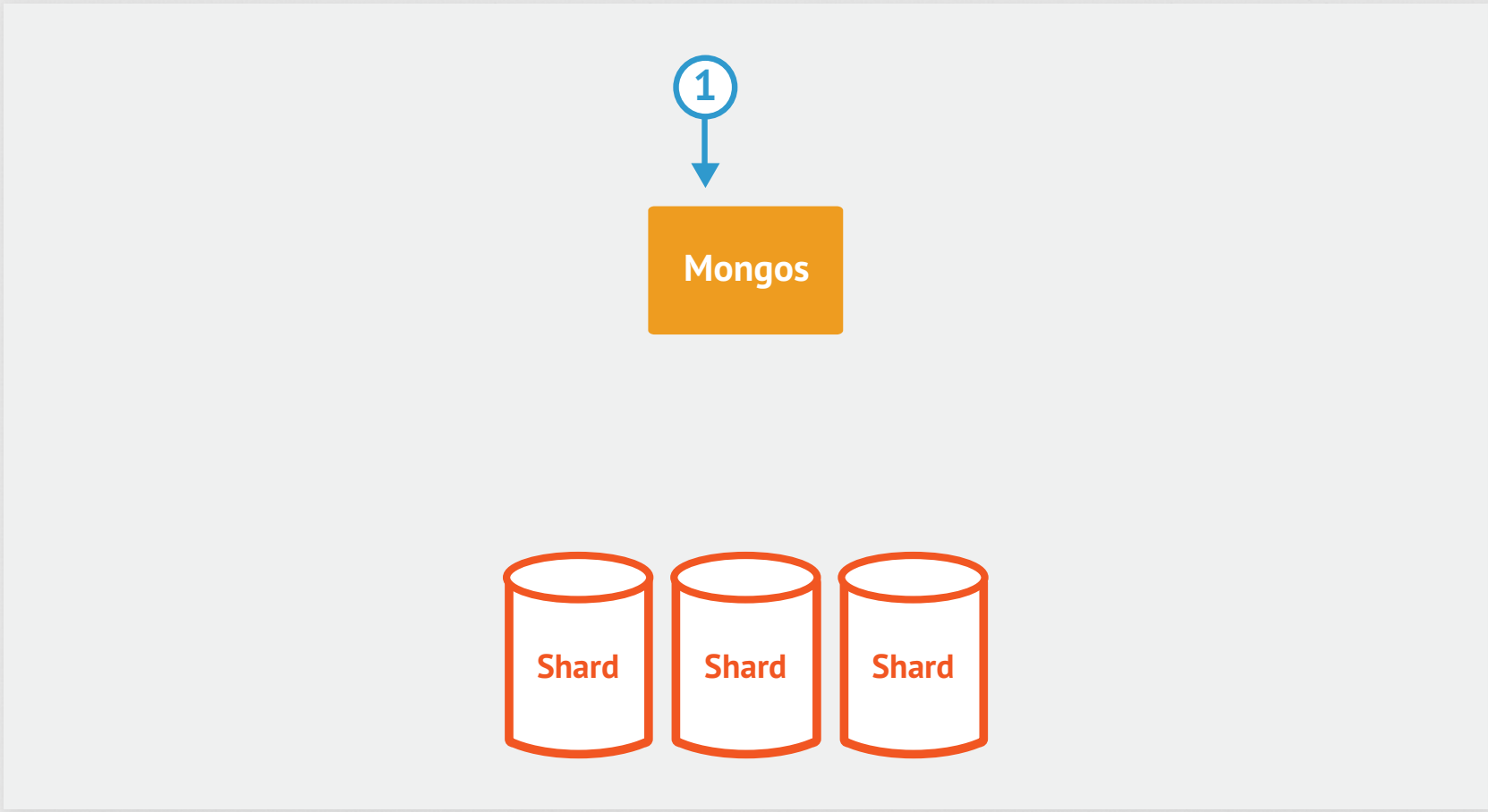
Routing Requests

Cluster Request Routing

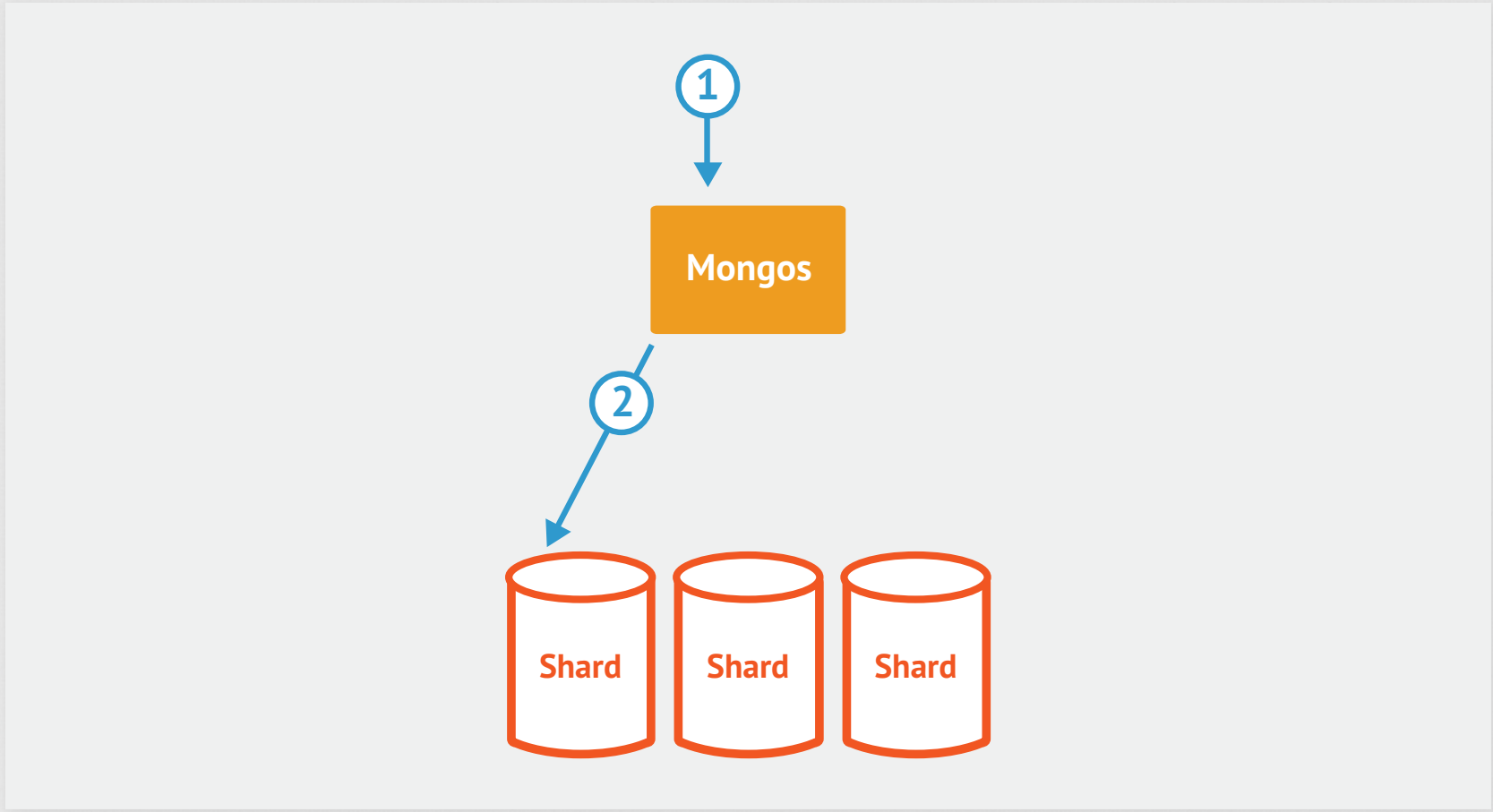
- Targeted Queries
- Scatter Gather Queries
- Scatter Gather Queries with Sort



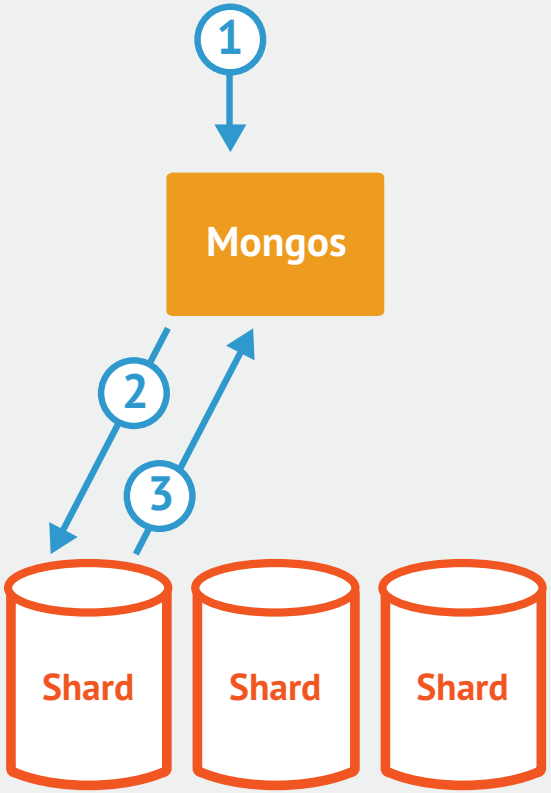
Cluster Request Routing: Targeted Query



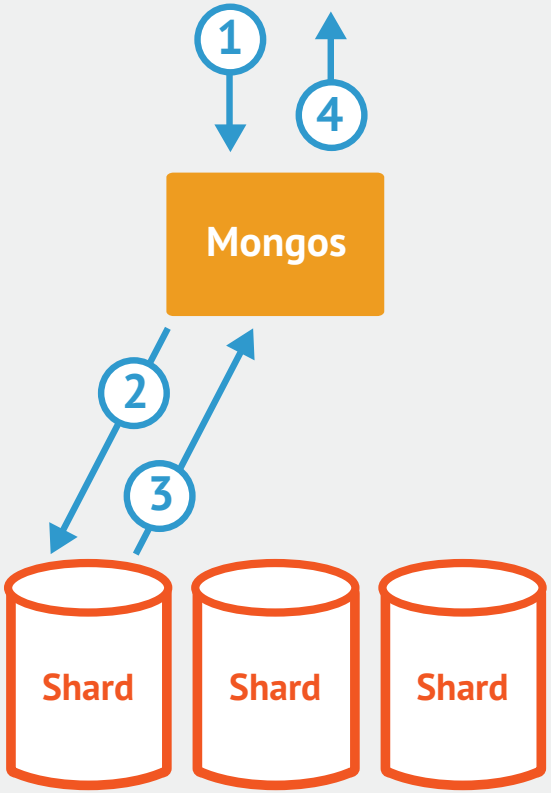
Routable request received



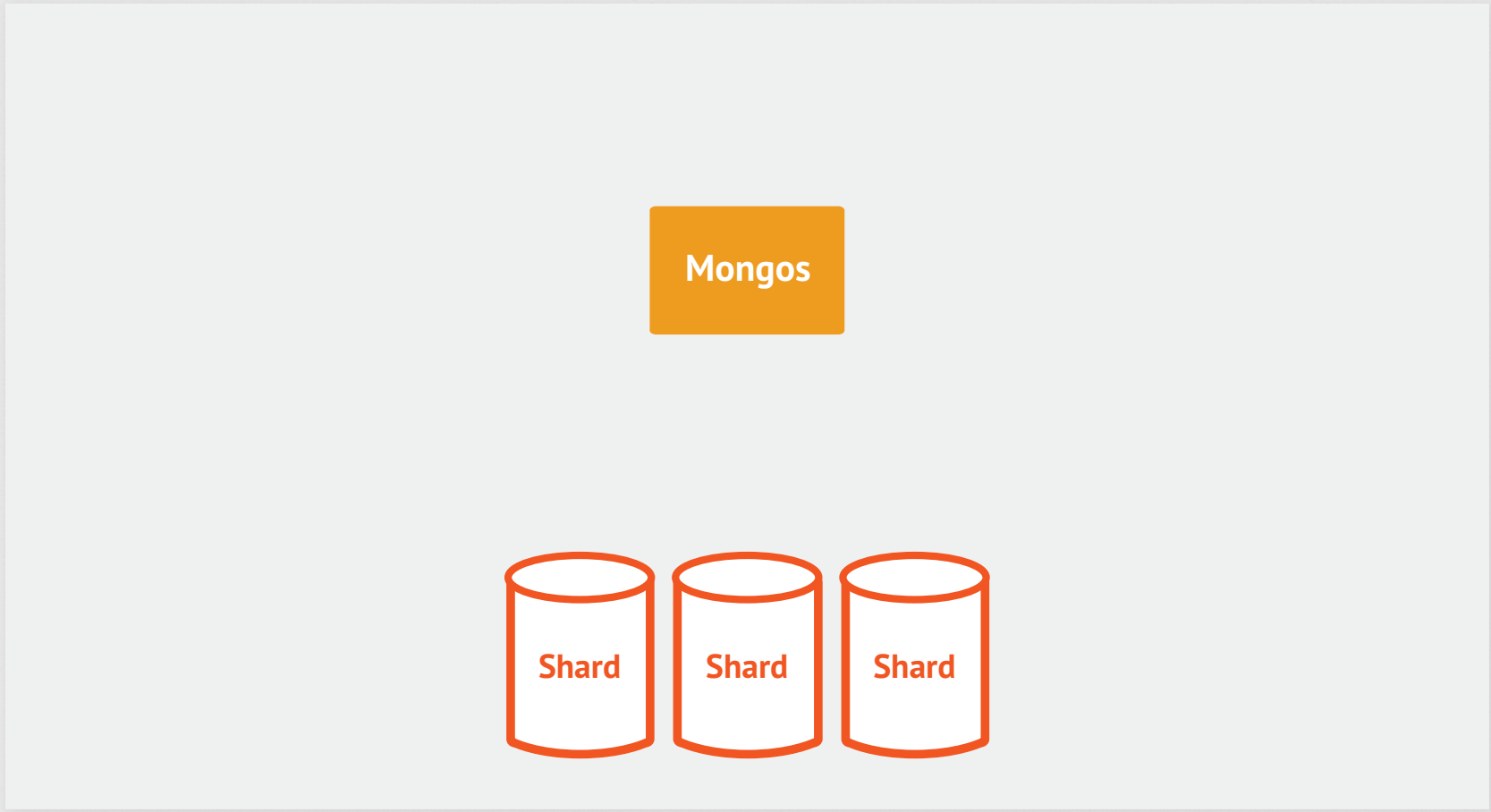
Request routed to appropriate shard



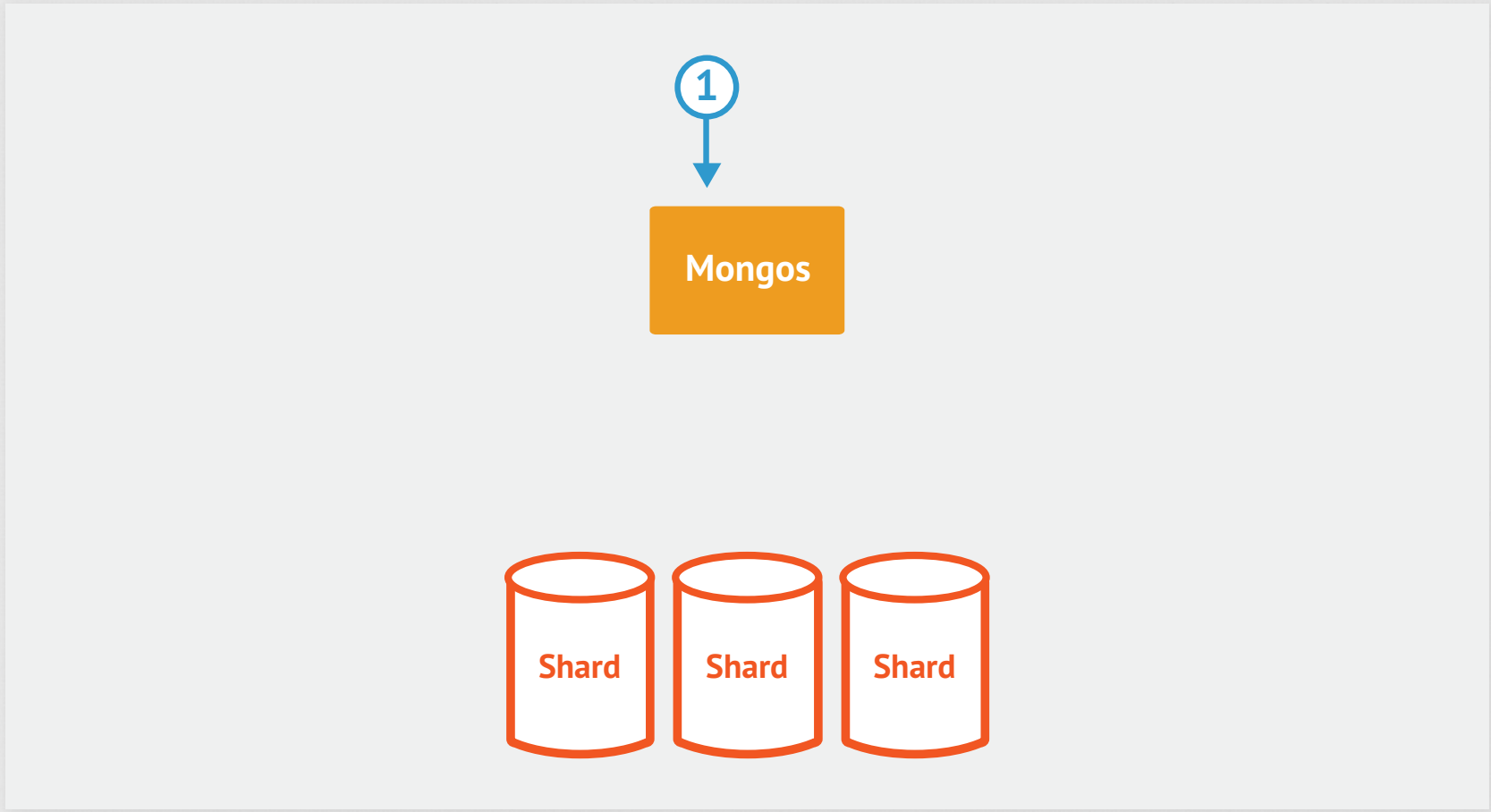
Shard returns results



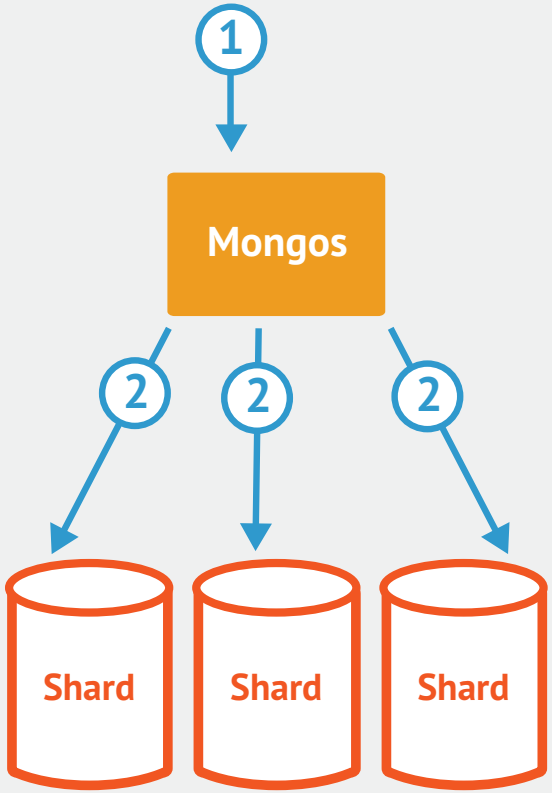
Mongos returns results to client



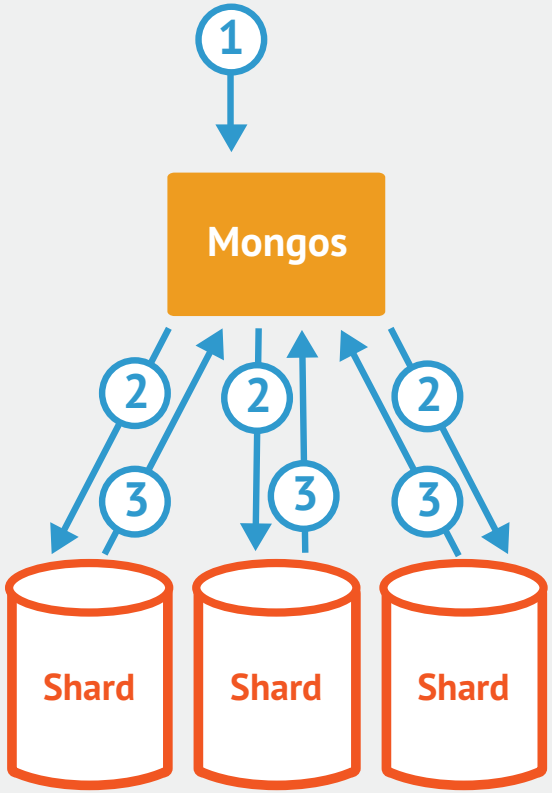
Cluster Request Routing: Non-Targeted Query



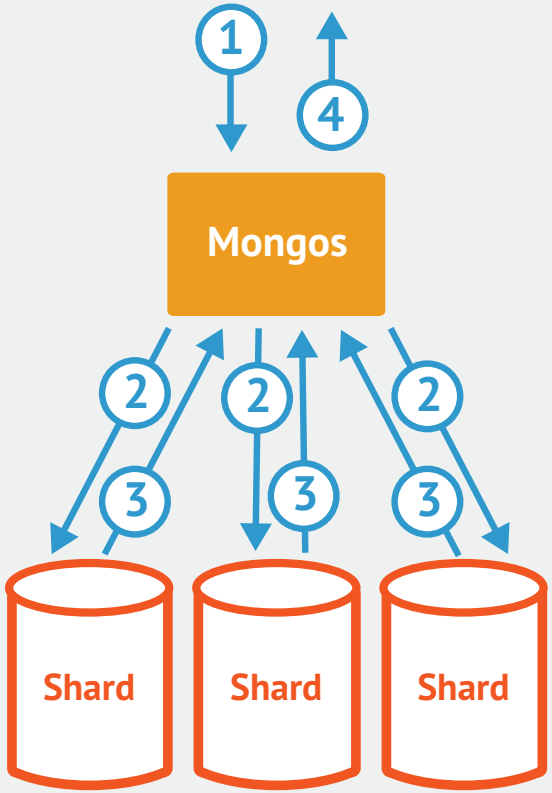
Non-Targeted Request Received



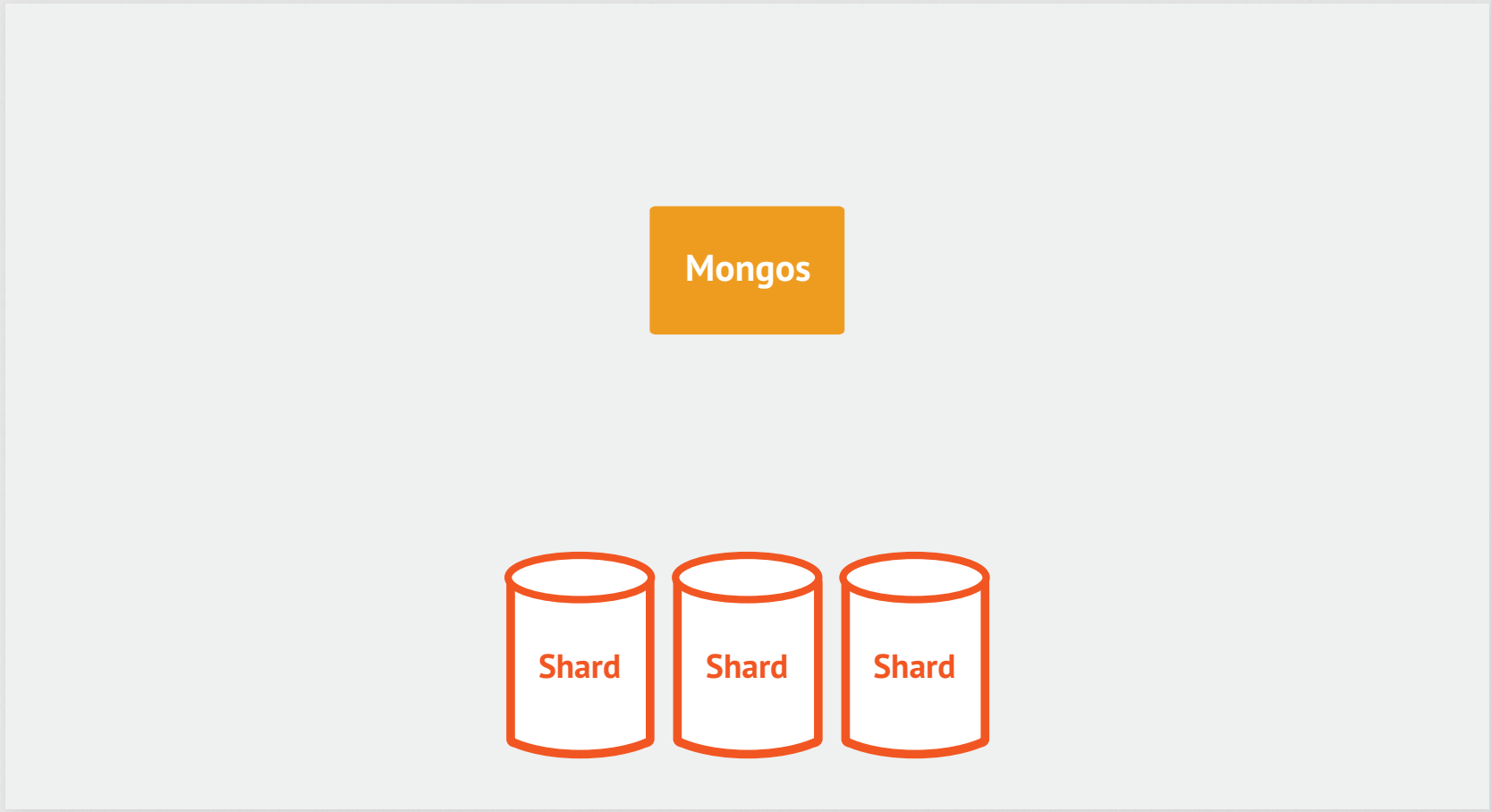
Request sent to all shards



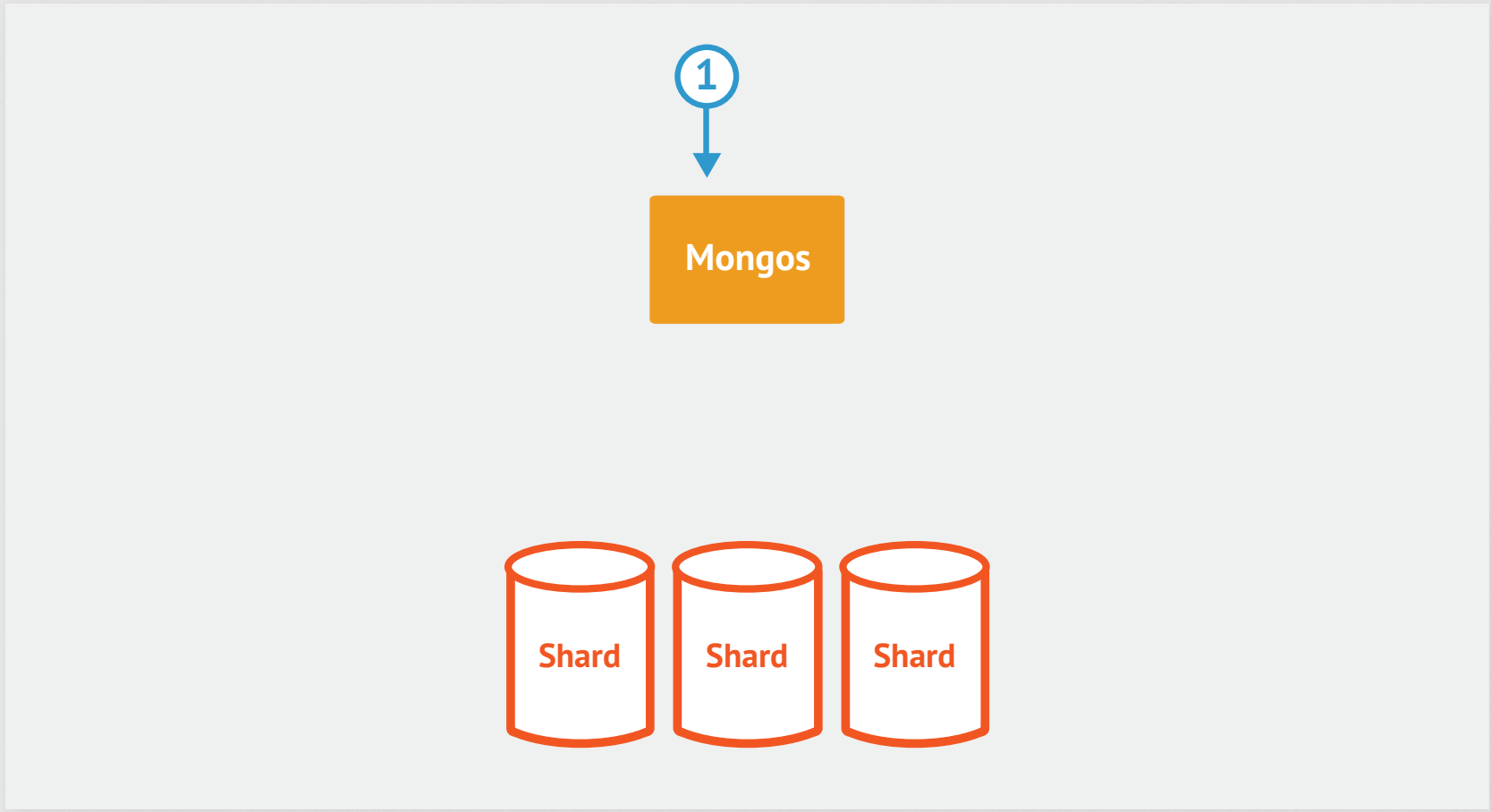
Shards return results to mongos



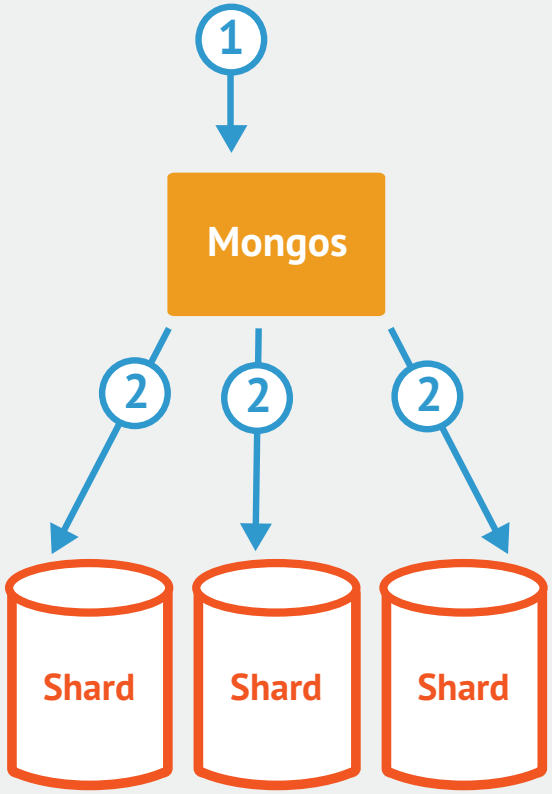
Mongos returns results to client



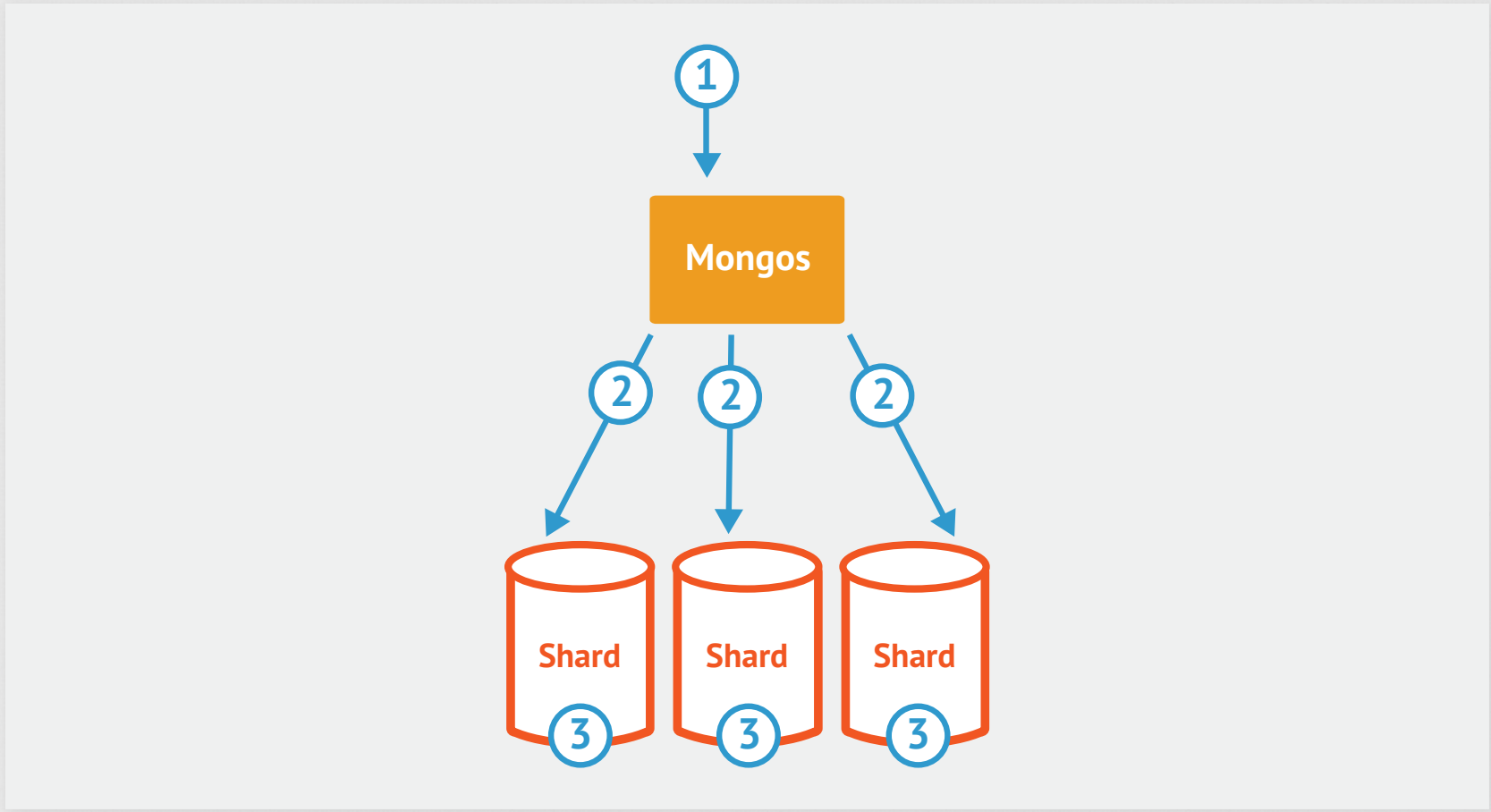
Cluster Request Routing: Non-Targeted Query with Sort



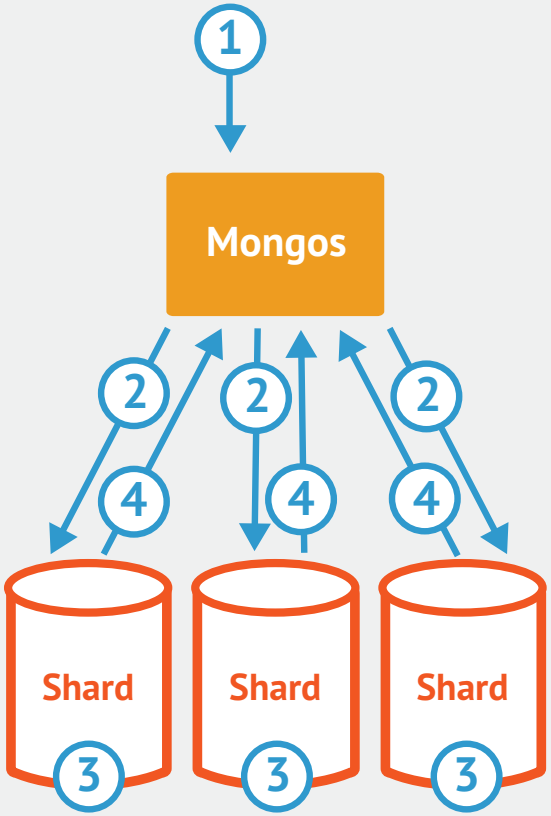
Non-Targeted request with sort received



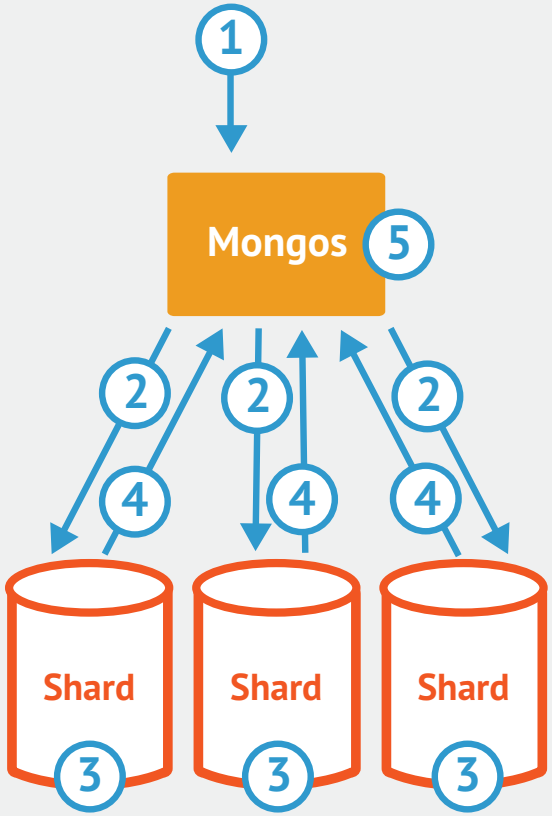
Request sent to all shards



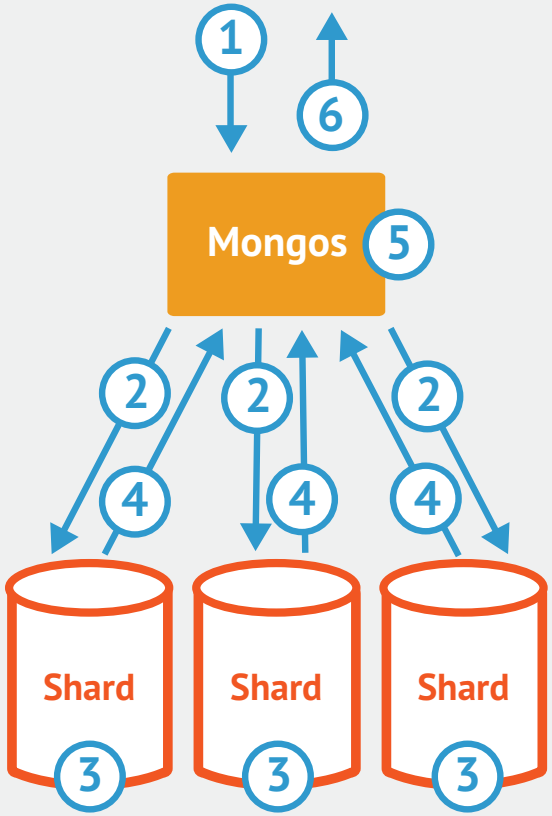
Query and sort performed locally



Shards return results to mongos



Mongos merges sorted results



Mongos returns results to client

Shard Key

Shard Key

- Shard key is **immutable**
- Shard key values are **immutable**
- Shard key must be indexed
- Shard key limited to 512 bytes in size
- Shard key used to route queries
- Only shard key can be unique across shards
  - `_id` field is only unique within individual shard

Shard Key Considerations

- Cardinality
- Write Distribution
- Query Isolation
- Reliability
- Index Locality

Conclusion

- Sharding Enables Scaling
- MongoDB's Auto-Sharding
  - Easy to Install
  - Consistent
- What's next?
  - Hash based sharding in 2.4

#CodeMash

Questions?

Sridhar Nanjundeswaran

Engineer, 10gen

@snanjund

10gen | the MongoDB company