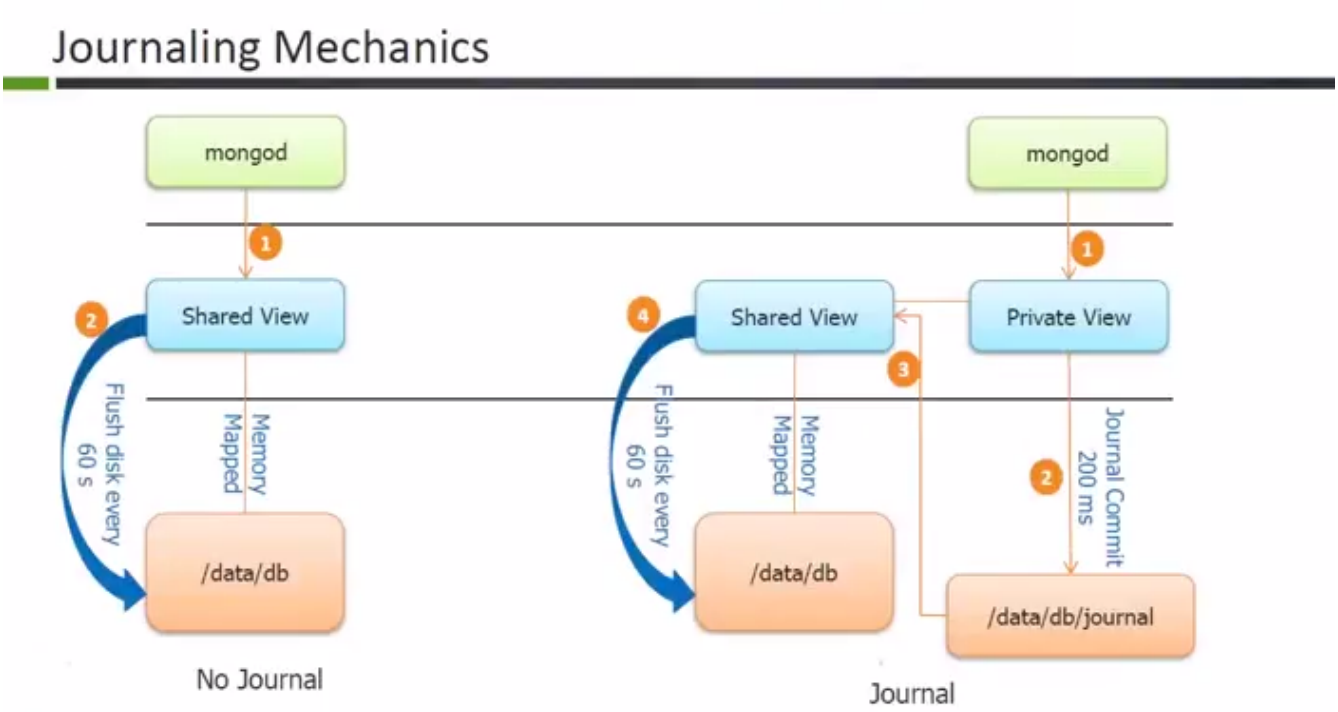
MongoDB Replication

1. **MongoDB write path**
2. Replication principles
3. Replica set Read and Write Semantics
4. Replica set in practice

MongoDB write path



- Journaling active by default
- low level log of an operation for crash recovery

MongoDB Journal vs Oplog

- **journal**
  - low level log of an operation for crash recovery (can be turned off)
- **oplog**
  - similar to RDBMS binlog
    - stores (idemopotent) high-level transactions that modify the database
    - kept on the master and used for replication

https://docs.mongodb.org/manual/core/read-isolation-consistency-recency/

Oplog stores high-level transactions that modify the database (queries are not stored for example), like insert this document, update that, etc. Oplog is kept on the master and slaves will periodically poll the master to get newly performed operations (since the last poll). Operations sometimes get transformed before being stored in the oplog so that they are idempotent (and can be safely applied many times).

Journal on the other hand can be switched on/off on any node (master or slave), and is a low-level log of an operation for the purpose of crash recovery and durability of a single mongo instance. You can read low-level op like 'write these bytes to this file at this position'.

MongoDB Replication

1. MongoDB write path
2. **Replication principles**
3. Replica set Read and Write Semantics
4. Replica set in practice

Replica set

- **Replica set** = a group of *mongod processes* that provide **redundancy** and **high availability**
- Writes: write to single node replicated to the others members of the replica set
- Read: read from a single member of the replica set

Disclaimer:

- we only consider replica sets **without sharding** (for now)
- we not include proposed MongoDB 3.2 replication modifications (readConcern…)

- usually associated with sharding but we must not confond the two.
- all that we'll discuss here applies
- sharding complexify more the architecture and we will treat it a part

Replica set members

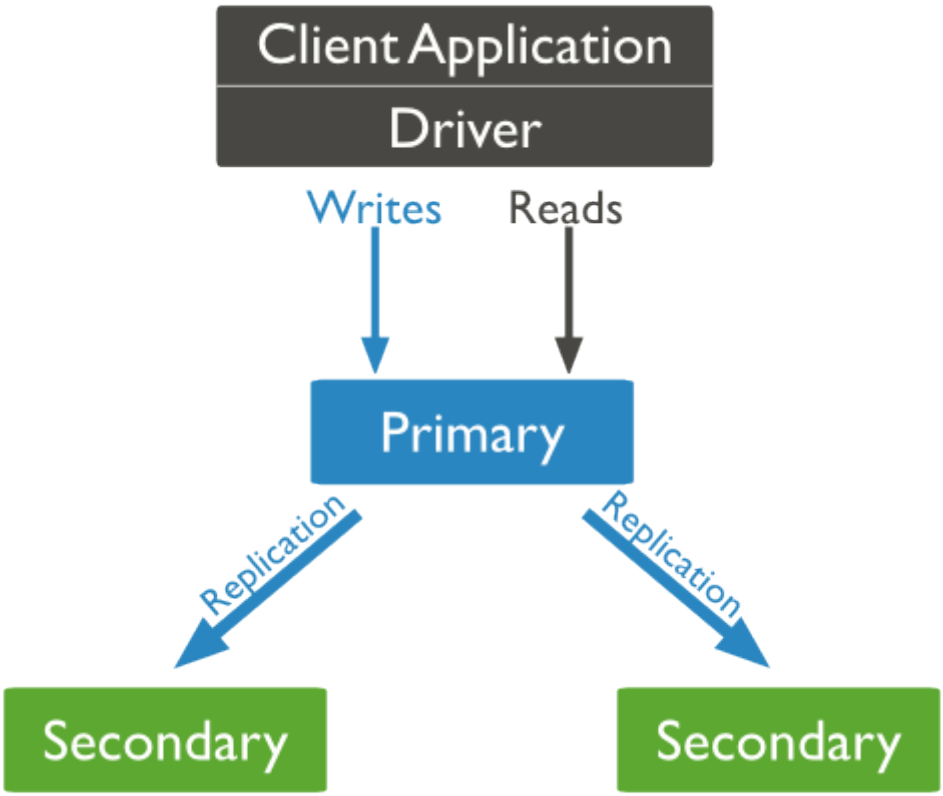
- **Primary**
  - acceptes all **writes** and reads
  - 1 primary per replica set
- **Secondaries** replicates data (and can serve **reads** ⇒ reads preferences)
  - Priority 0 ⇒ Hidden members ⇒ Delayed

- **Arbiters** (usually at most one) : break ties

- Mongo 3.0 max 50 members in a replica set, at most 7 voting (2.6 max 12 members)
- priority ⇒ nb of votes

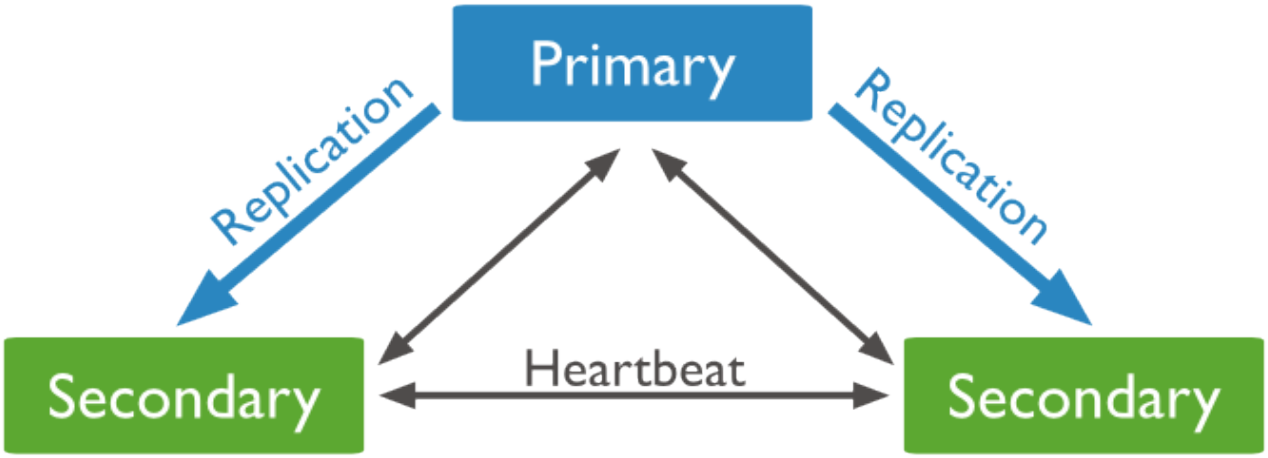
Primary and secondary members

- **Primary** acceptes all **writes** + reads + records them in oplog
- **Secondary** replicates primary oplogs (also accept reads)



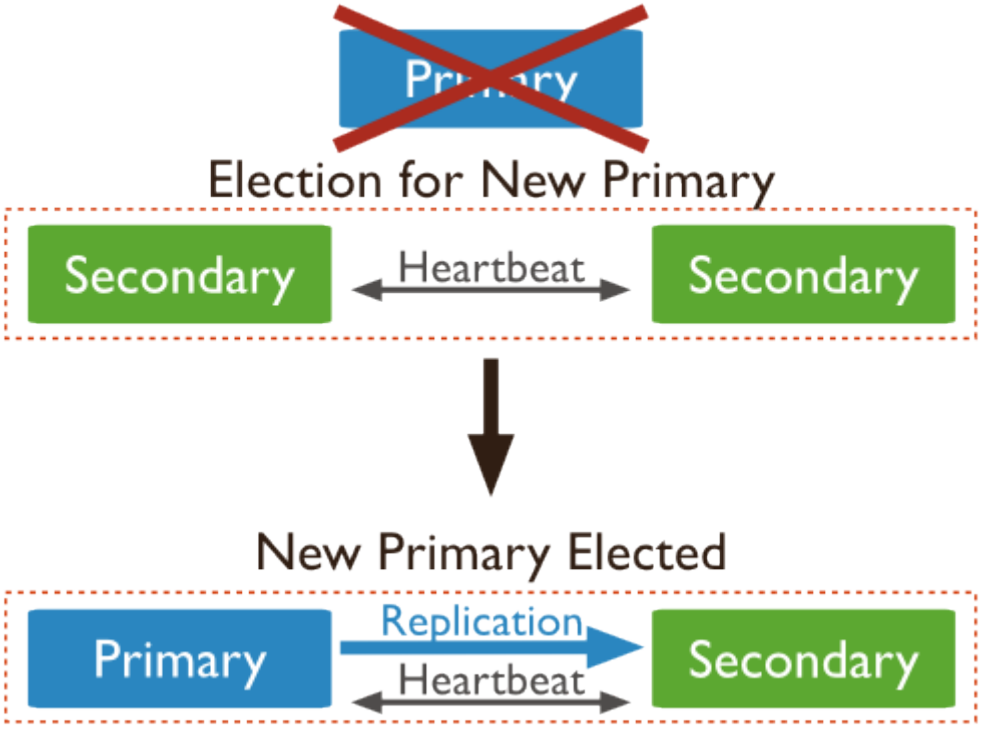
Replication data flow

- asynchronous **oplog** replication
- heartbeat for monitoring status



- very similar to binlog replication in RDBMS)

Automatic failover via new primary election

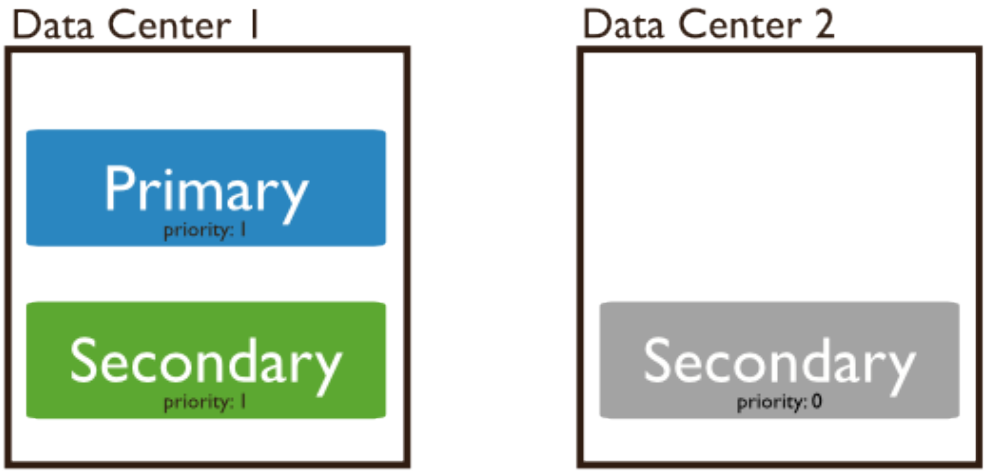


Strategy for election

- **member's priority**
- **latest optime in the oplog**
- uptime
- break the tie rules

Secondary members: Priority 0

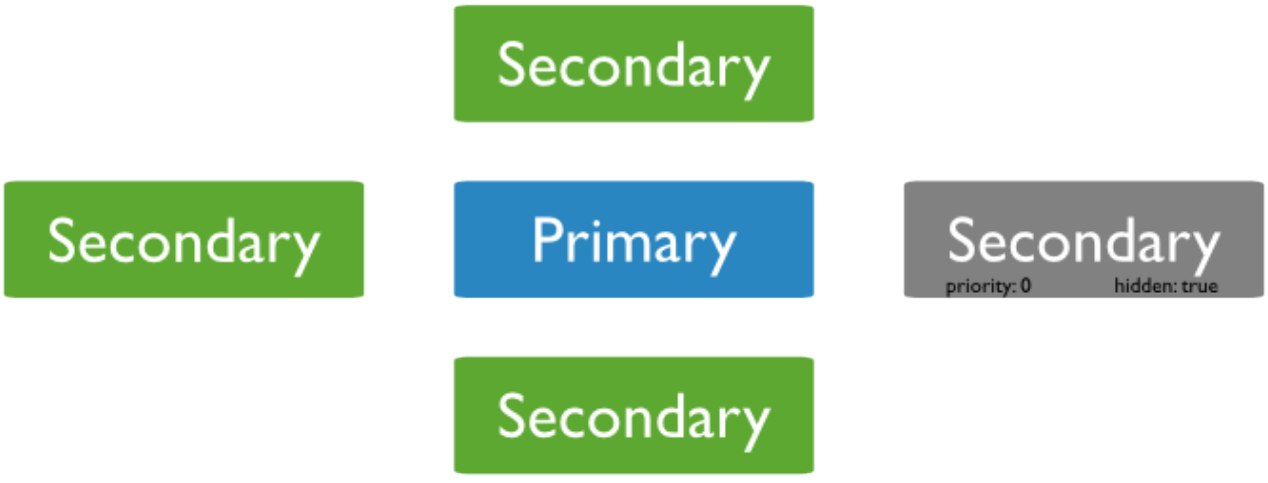
- cannot become primary
- cannot trigger elections
- can vote in elections
- copy of data + accepts reads



- Typical use cases:
  - data center separation: I want my primary to always be bound to a particular datacenter
  - standby member to replace a failed server
  - different hardware/workload profile

Secondary members: Hidden replica set member

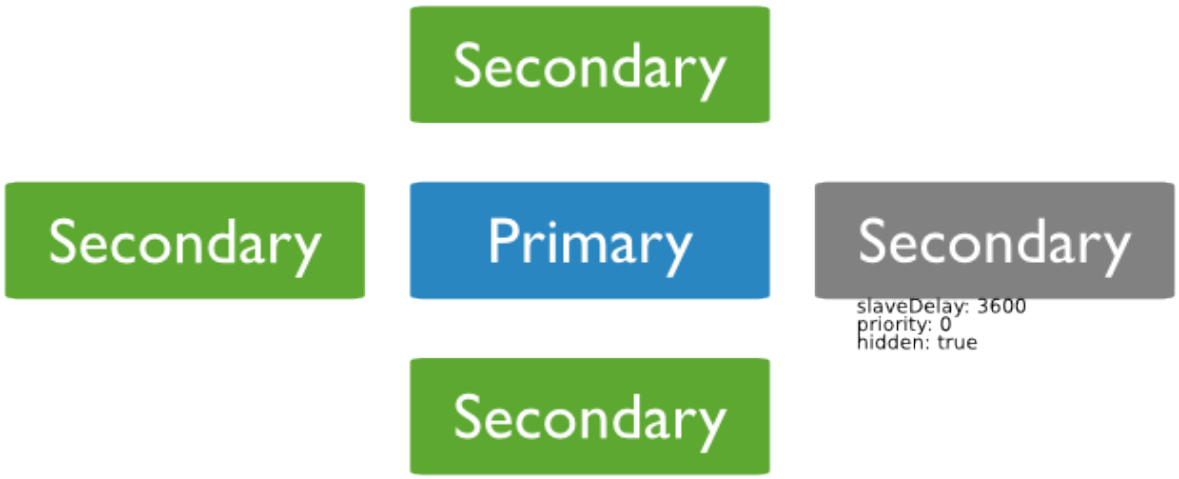
- Priority 0 members that don't accept reads



- Typical use cases:
  - dedicated task as reporting or replication

Secondary members: Delayed replica set members

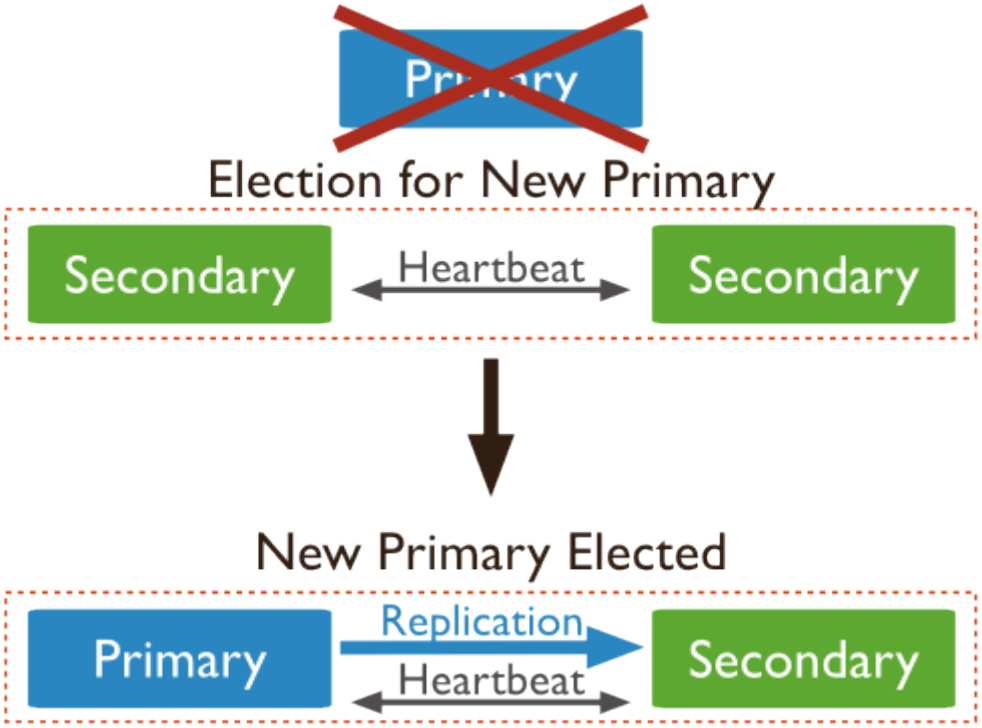
- reflect an delayed state of the set
  - **must be priority 0** ⇒ prevent them to become primary
  - **should be hidden** ⇒ prevent application to query stale data



- Typical use cases:
  - rolling backups or recovery from human error

Elections on odd number of nodes

- a replica cannot become primary with only 1 vote
- majority with even numbers of members ?



- use **Arbitrers** to break ties
  - does not hold data
  - cannot became a primary

Arbiters

Fault tolerance

- **No primary** ⇒ writes no longer possible, reads still accepted
- **Fault tolerance** : number of members that can become unavailable and still be able to elect a primary

Number of members	Majority required to elect a primary	Fault tolerance
3	2	1
4	3	1
5	3	2
6	4	2

```
https://docs.mongodb.org/manual/core/replica-set-architectures/
```

Rollbacks during replica set failover

- a rollback reverts write operations on a former primary when the member rejoins its replica set after a failover
  - the primary accepted a write that was not sucessfuly replicated to secondaries !

Cause of the problem ?

default write semantics { w:1 } ⇒ the primary acknowledge the write after the local write (local Journal!)

How to handle rollbacks

- manually apply/discard rollbacks (**rollback**/ folder)
- *avoid* rollbacks use **{ w:majority }**
  - READ UNCOMMITED SEMANTICS
    - ! Regardless of write concern, other clients can see the result of the write operations before the write operation is acknowledged to the issuing client.
    - ! Clients can read data which may be subsequently rolled back.

https://docs.mongodb.org/manual/core/replica-set-rollbacks/

https://docs.mongodb.org/manual/core/read-isolation-consistency-recency/

MongoDB Replication

1. MongoDB write path
2. Replication principles
3. **Replica set Read and Write Semantics**
   a. Write concerns
   b. Read preferences

4. Replica set in practice

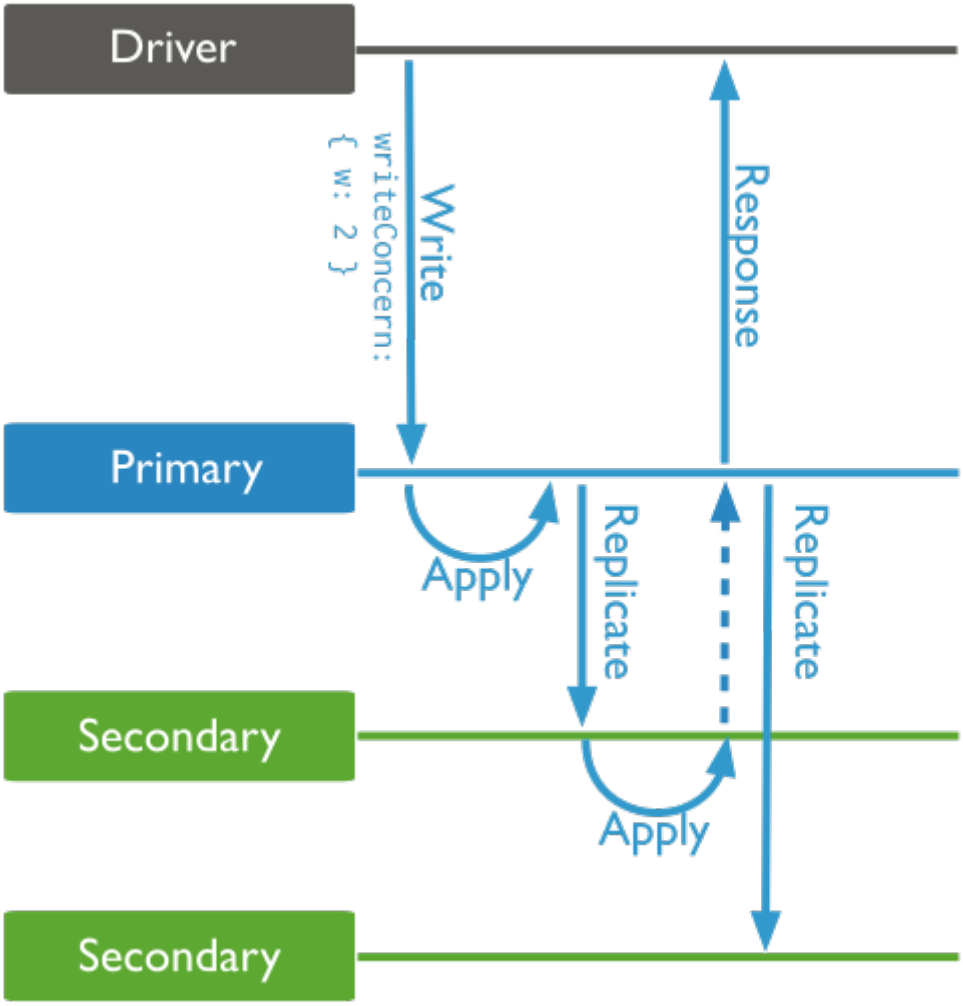
Replica set Read and Write Semantics

- parameters that change the default read/write semantics (**move** the *CAP cursor*)
  - **write concern**
    - is the guarantee an application requires from MongoDB to consider a write operation successful
  - **read preference**
    - applications specify read preference to control how drivers **direct read operations** to members of the replica set

Write semantics

- **w:1** (*default*)
  - the primary acknowledge the write after the local write
- other options:
  - **w:N**
    - ack the write after the ack of N members
  - **x:majority**
    - ack the write after the ack of the majority of the members
- optional parameter **wtimeout**
  - prevents write operations from blocking indefinitely if the write concern is unachievable

W:2 write semantics



Changing the write semantics

- at the query level

```
db.products.insert(
   { item: "envelopes", qty : 100, type: "Clasp" },
   { writeConcern: { w: 2, wtimeout: 5000 } }
)
```

- change the default write concern:

```
cfg = rs.conf()
cfg.settings = {}
cfg.settings.getLastErrorDefaults = { w: "majority", wtimeout: 5000 }
rs.reconfig(cfg)
```

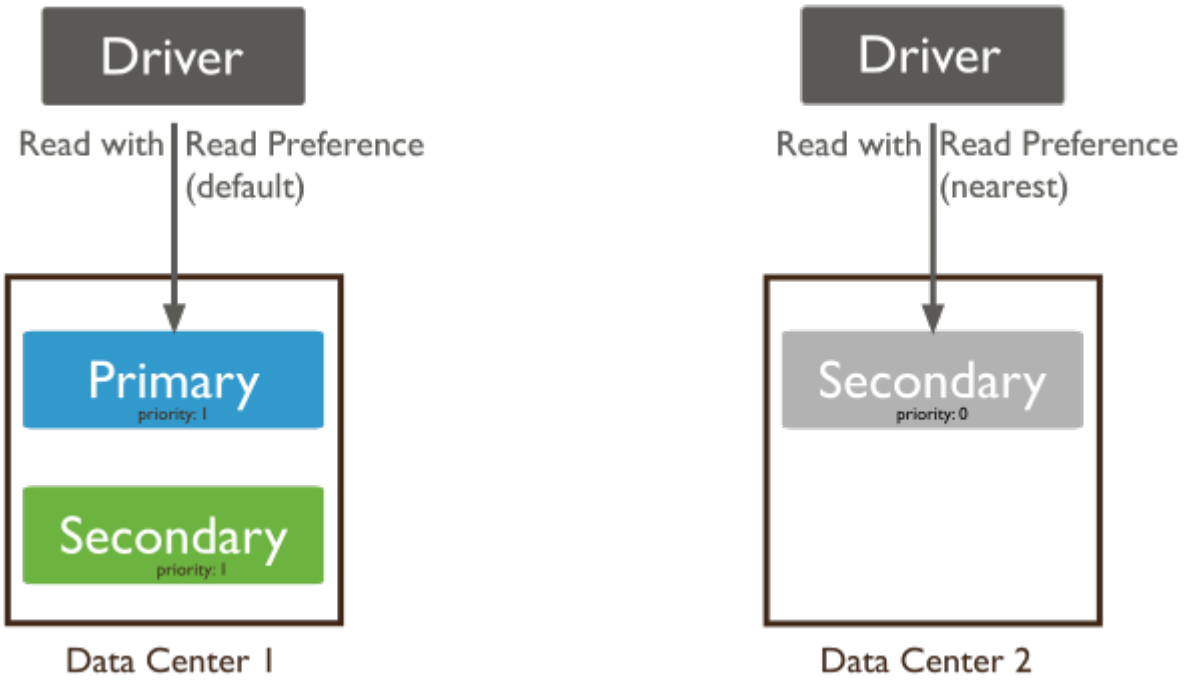
Read preference

- **primary**(*default*)

    - read from the current replica set primary.
- **primaryPreferred**
    - read from primary (or secondary iff no primary)
- **secondary**
    - read from secondary members
- **secondaryPreferred**
    - read from secondary(or primary iff no primary)
- **nearest**
    - read from the member with the least network latency

Async replication ⇒ stale data if read from replica

Read preferences example



Read preferences use cases

- **Maximize Consistency ⇒ primary** read preference
- **Maximize Availability ⇒ primaryPreferred** read preference
- **Minimize Latency ⇒ nearest** read preference

MongoDB Replication

1. MongoDB write path

2. Replication principles
3. Replica set Read and Write Semantics
4. **Replica set in practice**

MongoDB consistency in real world

> Read the documentation for the systems you depend on thoroughly–then verify their claims for yourself. You may discover surprising results!
>
> — Kyle Kingsbury(Aphyr)

https://aphyr.com/posts/322-jepsen-mongodb-stale-reads

Learn more:

- read the MongoDB documentation and the Jespen blog entry:
  - MongoDB Documentation
  - Jepsen MongoDB Stale reads on
- do the replica set tutorial in the MongoDB documentation:
  - https://docs.mongodb.org/manual/administration/replica-set-deployment/