MongoDB Robustness and Performance

CS 4417B

The University of Western Ontario

MongoDB Features and Design Decisions

- Similar concepts to Hadoop
  - Replication
  - Sharding

- Differences from "traditional" DBMS
  - Data consistency is "optional"
  - User control over how much consistency is required

- Very complex in terms of operations and configuration options; this is an overview

`mongod`

- `mongod` is the main daemon process for the MongoDB system. It handles data requests, manages data access, and performs background management operations.

- `mongod` can be a:
  - "regular" server
  - shard server
  - config server

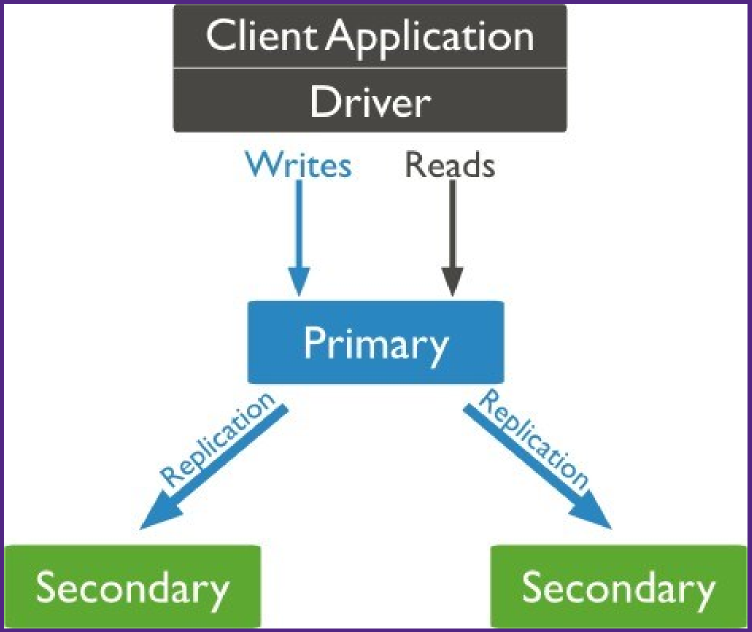
- The `mongosh` shell connects to a `mongod` process (for non-sharded deployments) or a `mongos` process (for sharded deployments)

Replica Sets

- A *replica set* is is a group of `mongod` processes that maintain the same data:
  - **Primary:** only one - receives all write operations
  - **Secondaries:** normally at least 2 - replicate operations from the primary to maintain an identical data set.
  - Minimum recommended config is 3 in a replica set. (Primary + 2 secondaries.)
- Primary maintains *oplog* – log of all operations on its data.
- Secondaries replicate this and apply to their own data so everything is synced.
- Secondaries can dynamically choose their own *sync from* source based on ping, availability.

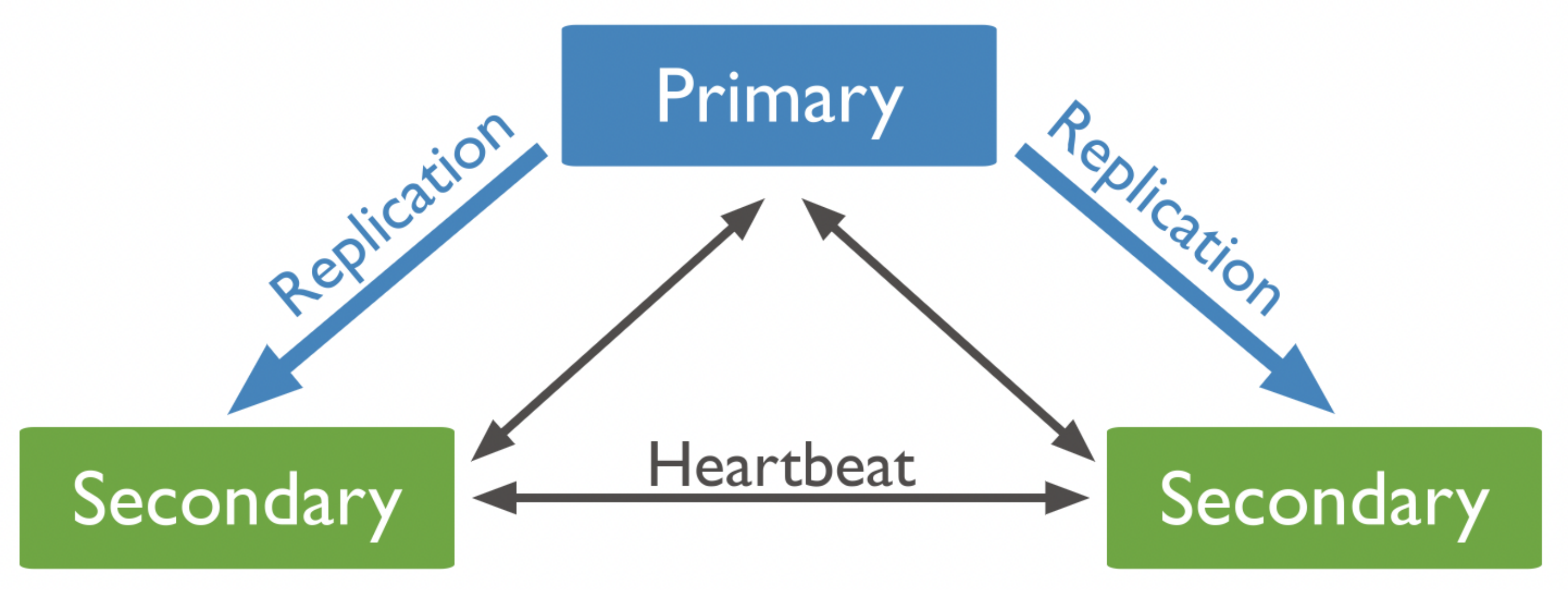
Replica Sets

- The required number of secondary replicas depends on the read volume
  - Can dynamically be added
  - You don’t have to stop operations



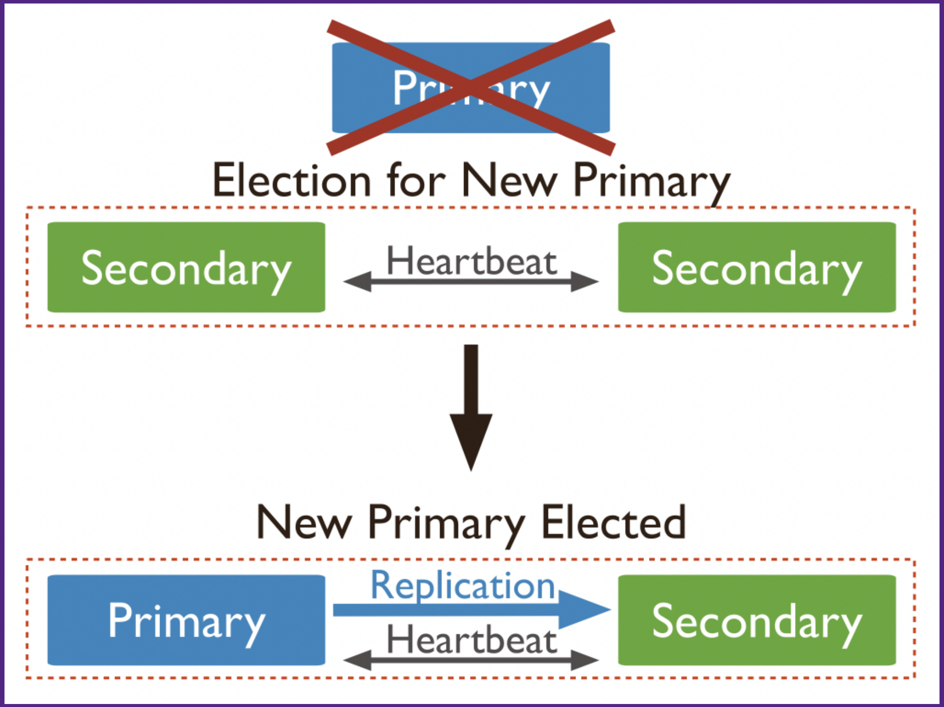
Replicas

- All replicas have a number, 0, 1, 2, ..., N
- Replicas know about each other
- heartbeats are exchanged



Automatic Failover

- When a secondary replica does not receive a response from the primary within the specified amount of time, it invokes the bully algorithm to "elect" a new primary



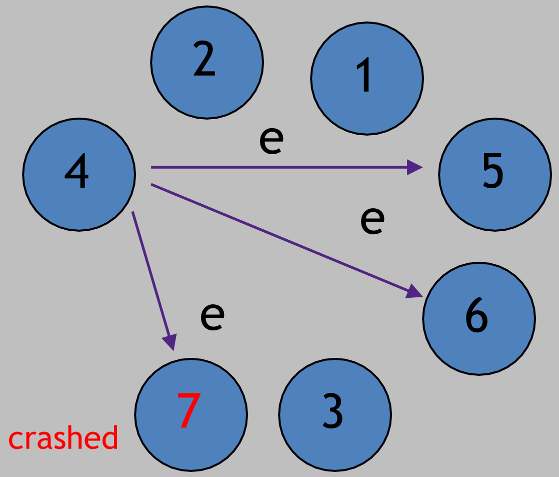
Bully Algorithm

- When a secondary replica, P, notices that the primary is no longer responding, it initiates an election.
  - P sends an ELECTION message to all secondary replicas with higher numbers.
  - If no one responds, P wins the election and becomes the primary.
  - If one of the higher-ups answers, it takes over. P's job is done.
- This algorithm is used in many distributed systems.

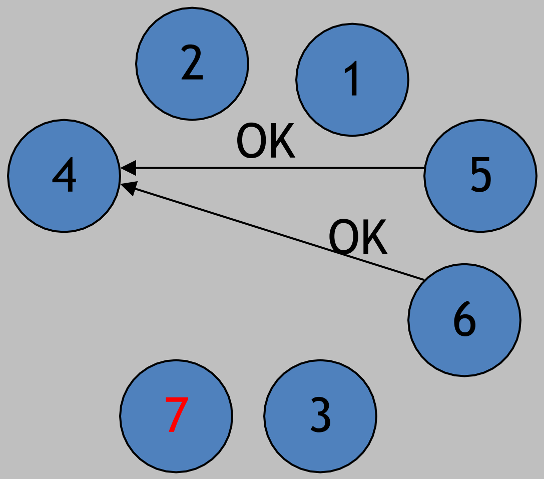
Bully Algorithm

- When a replica gets an ELECTION message from one of its lower-numbered colleagues:
  - Receiver sends an OK message back to the sender to indicate that it is alive and will take over.
  - Receiver holds an election, unless it is already holding one.
  - Eventually, all replicas give up but one, and that one is the new primary.
  - The new primary announces its victory by sending all processes a message telling them that starting immediately it is the new primary.

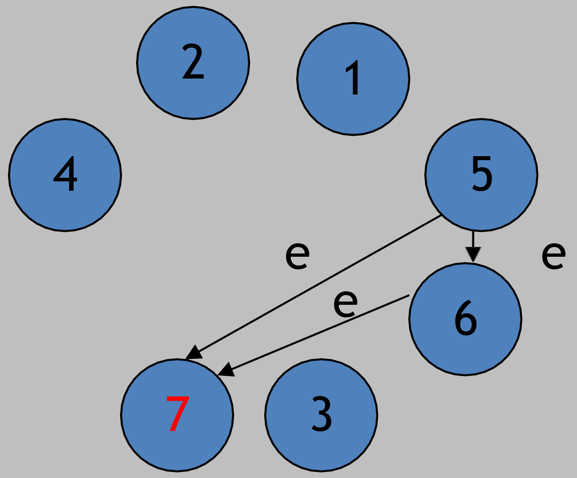
The Bully Algorithm (Example)



- The primary (or coordinator) which is 7 crashes
- Secondary replica 4 holds an election

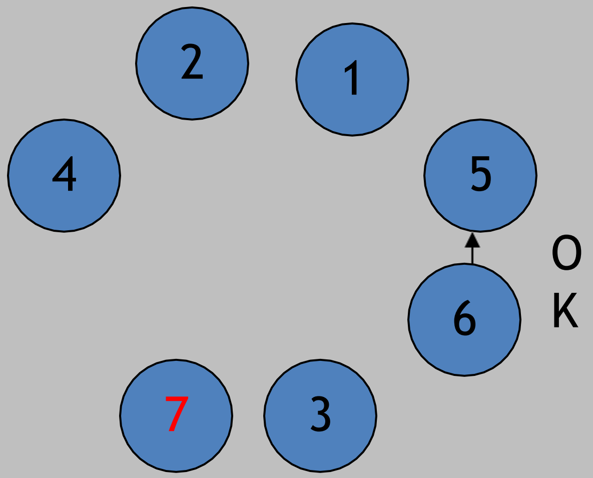


- 5 and 6 Respond
- Replica 4 stops participating

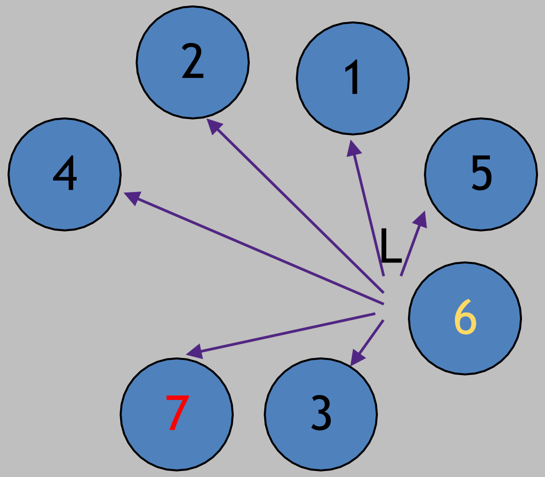


- 5 and 6 each hold an election

The Bully Algorithm



- 6 Responds
- Replica 5 stops participating

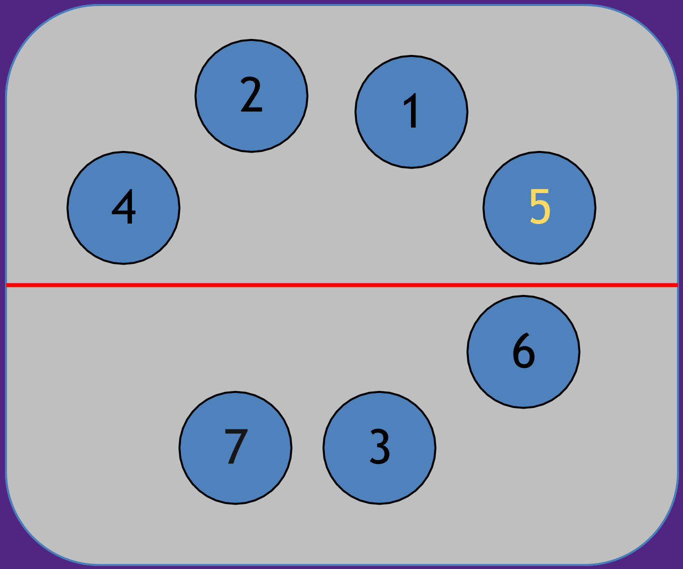


- 6 announces that it is the new primary (L)

Network Partition

- If the Primary cannot see a majority of the nodes in its replica set, it steps down and becomes a Secondary.

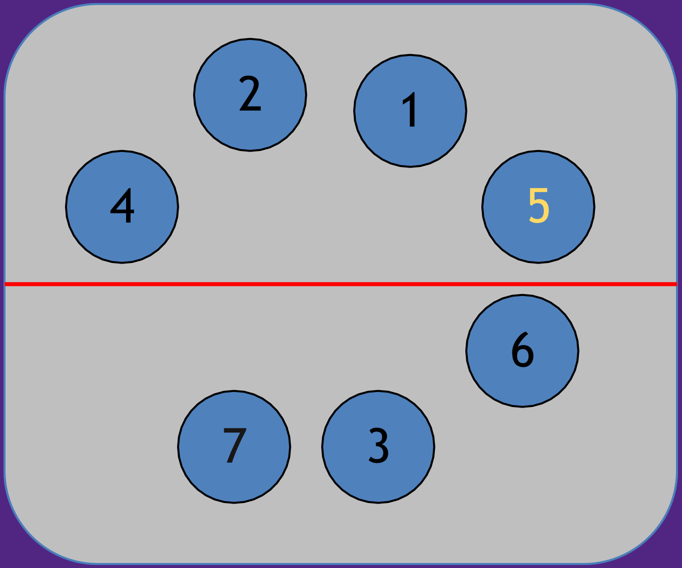
- Secondary nodes that can't see a majority won't start an election.



Network Partition

- Why?
  - A) Because 3 nodes are not enough to be a primary replica
  - B) Because of the network problem
  - C) Because “Write” ops. goes to two primary replicas
  - D) All above

- Why not two primaries?
- Why 3 is not enough?
- How do they make sure?



Recovery

- If a Primary that was previously down comes back:
  - It becomes a Secondary replica
  - Things might be inconsistent!

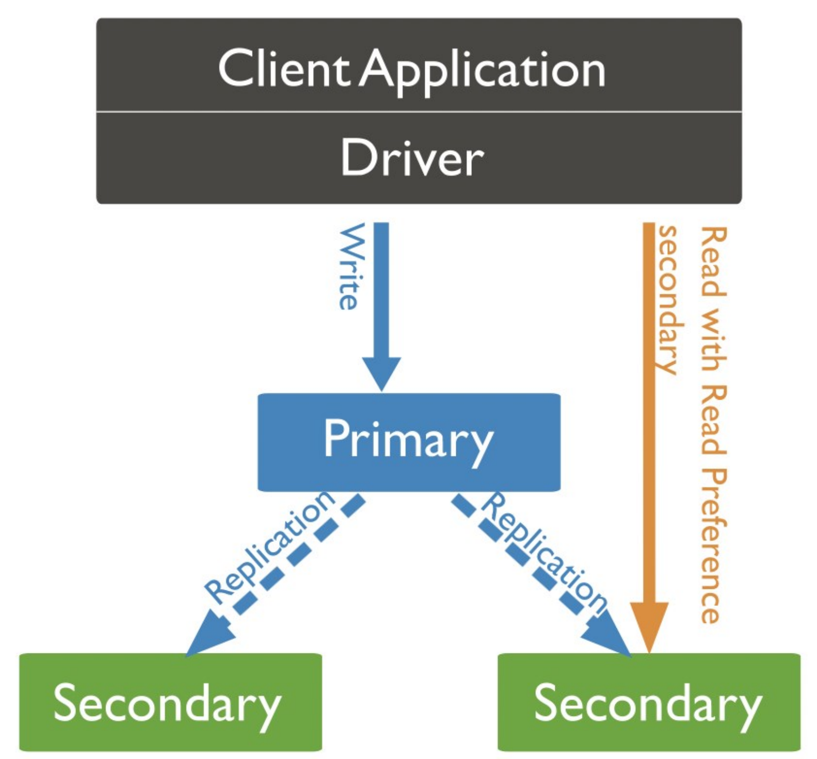
Rollbacks

- Suppose primary accepts a write, but crashes (or network fails) before replication.
- Primary is removed from the Replica Set
- Later on, it comes back as a Secondary
    - But it's inconsistent because of the write that never got replicated
- The node "rolls back" (undoes) the write operation.
- "Shouldn't happen often," says MongoDB docs.

Availability During Elections

- The replica set cannot process write operations until the election completes successfully.
- The replica set can continue to serve read queries if such queries are configured to run on secondaries while the primary is offline.

Read Preference



- primary
- primaryPreferred
- secondary
- secondaryPreferred
- nearest

Consistency of Data

- All read operations issued to the primary are consistent with the last write
  - Reads to a primary have strict consistency
    - Since it reflects the latest changes to the data

- Reads to a secondary have eventual consistency
    - Updates propagate gradually

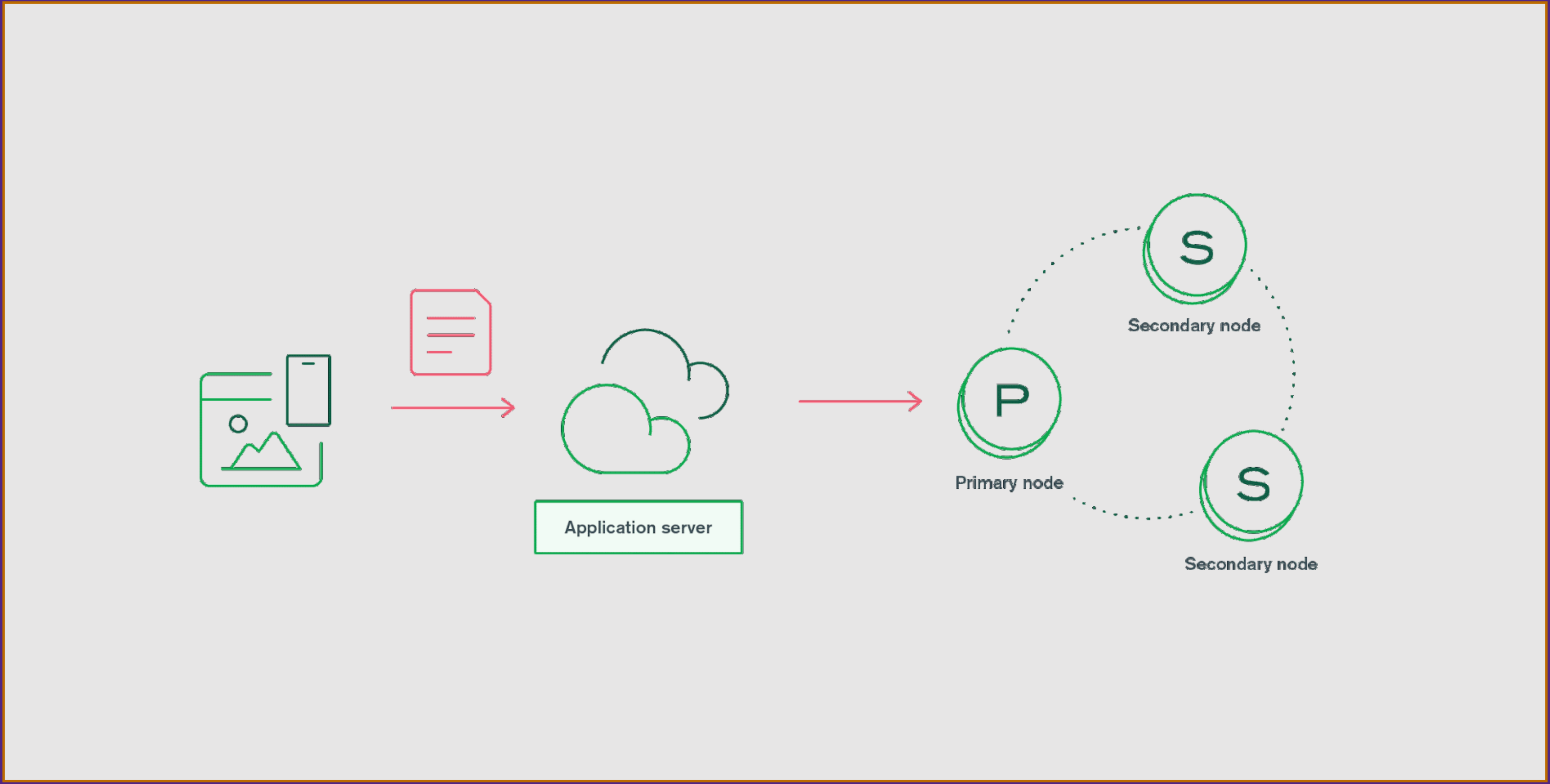
- It is possible that a client reads stale data

Write "Durability"

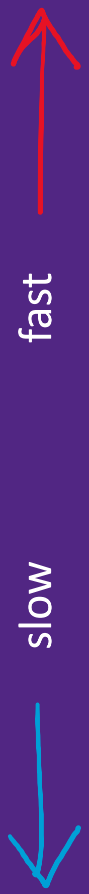
- Data "durability" is just how resistant a system is to data loss.

- "Write concern":
  - How many nodes in the MongoDB database cluster need to acknowledge the write before success is passed back to the application?
  - w:1 – "success" after writing to at least one node
  - w:majority – "success" after writing to majority of replicas
  - w:majority avoids rollbacks (if confirmed)

w:majority


Application server
P
Primary node
S
Secondary node
S
Secondary node

Read Concern



fast

slow

- "local"
  - No guarantees; might be rolled back
- "available"
  - No guarantees; might be rolled back, might return "orphaned documents"
- "majority"
  - Only returns majority-acknowledged writes
- "linearizable"
  - Returns *all* majority-acknowledged writes
- "snapshot"
  - Returns *all* majority-acknowledged writes at specified timestamp

https://www.mongodb.com/docs/manual/reference/read-concern/

Why didn’t we have these "Concerns" with Hadoop?

Hadoop has *one-copy-update* semantics

- Roughly, an HDFS file must behave like a regular POSIX file (Linux, etc.)
- Once a create/update/delete completes, **everybody sees the same thing.**
- A file doesn't become visible to anybody until it is completely written.
- This is ensured by the **NameNode**

The NameNode

- HDFS cluster has a single NameNode
  - A master server that manages the file system and regulates access to files by clients.
- A physical server is dedicated to NameNode
- The NameNode keeps track of which blocks make up each file and where they are stored

Sharding

REQUIRED WATCHING:

https://www.youtube.com/watch?v=8sk75-6W0ik

MongoDB

Demystifying Sharding in MongoDB

Albert T. Wong, Solutions Architect, MongoDB