# Designing Document Database Models

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# Document Databases

# Document Databases

- store key/value pairs, and the value is generally a JSON document

```
{
  '_id': <ObjectId>,
  'version': '2.7',
  'user_id': 'KWCH-G25',
  'api_id': 'KL1S-Z4L',
  'api_data': {...},
  'name': {'given': 'Carmelo', 'full': 'Carmelo Zappal\xe0', 'family': 'Zappal\xe0'},
  'gender': 'Male',
  'living': 'False',
  'facts': {'death': {'date': '16 March 1983', 'year': '1983', 'place': 'Burbank, Los Angeles, California, United States', 'day': '16', 'month': '3'}, 'birth': {'date': '6 October 1886', 'year': '1886', 'place': 'Linguaglossa, Catania, Sicily, Italy', 'day': '6', 'month': '10'}}
  ...
```

# Data Models

- embedded
  - store related information in a single document
  - useful for one-to-one relationships
  - useful for one-to-many relationships when the child documents always appear with the parent, e.g. comments on a blog
- normalized
  - store related information across separate documents
  - use references to create relationships
  - useful for one-to-many relationships when the children are accessed separately, e.g. want to list a particular user's comments on all blog entries
  - useful for many-to-many relationships
  - useful for very large hierarchical datasets, where the size of a document would exceed database limits

# PyMongo Example

```
from pymongo import MongoClient
client = MongoClient()

// get a database
db = client.blog

// get a collection
posts = db.posts

// create a post
import datetime
post = {"author": "Mike",
        "text": "My first blog post!",
        "tags": ["mongodb", "python", "pymongo"],
        "date": datetime.datetime.utcnow()}

// insert
posts.insert(post)

// get all posts
posts.find()

// get posts by Mike
posts.find({'author':'Mike'})
```

# Why Use a Document Database?

- scale
  - cloud computing provides cheap storage, ability to easily add more servers
  - but data must be spread across multiple servers, difficult to use SQL joins in across distributed set of tables
- unstructured data
  - social media, multimedia
  - SQL is best suited for structured data
- agile development
  - database scheme must rapidly evolve
  - easier to do when all items in a table don't need to maintain consistent structure

# Document Databases are Good At...

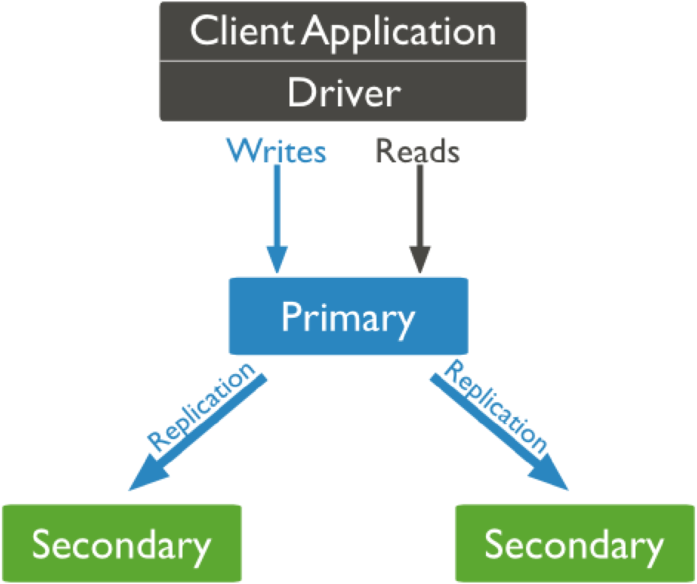
- independent documents
    - fast read performance
    - easy to distribute across servers
- easy application logic
    - object-oriented syntax translates directly into document storage
- unstructured data
    - documents can store whatever keys and values the app requires
    - migrations not needed in advance, can adapt on the fly

# Consistency

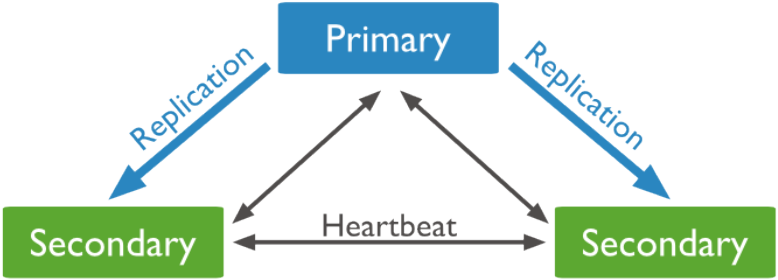
- CAP Theorem
  - a database can only have two of Consistency, Availability, and Partition tolerance
  - under Partition, a system cannot maintain both Availability and Consistency
- strongly consistent
  - favor consistency over availability
  - relational database
  - MongoDB
- eventually consistent
  - favor availability over consistency
  - Amazon Dynamo, CouchDB, Riak
- easier to provide even load distribution and multi-data center support in eventually consistent systems
- easier to write code for strongly consistent systems, applicable to a wider set of problems

# How Mongo Works

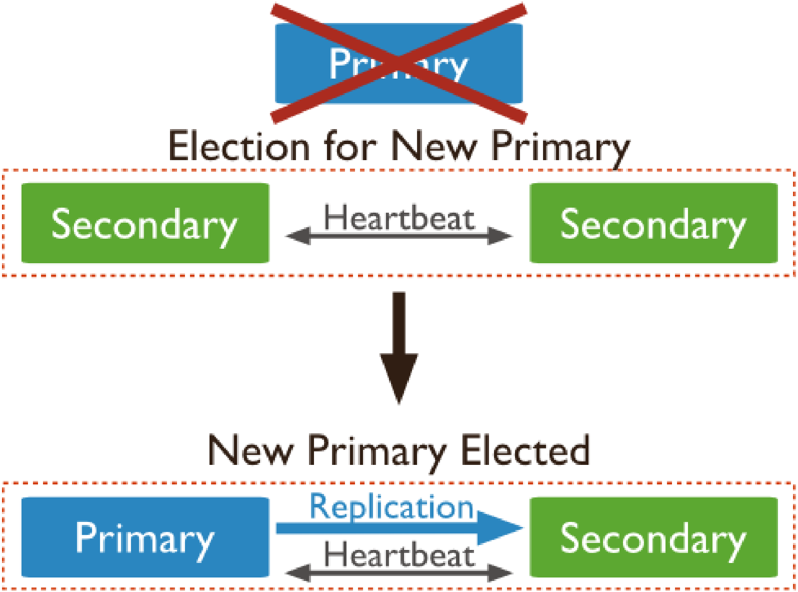
# Replication



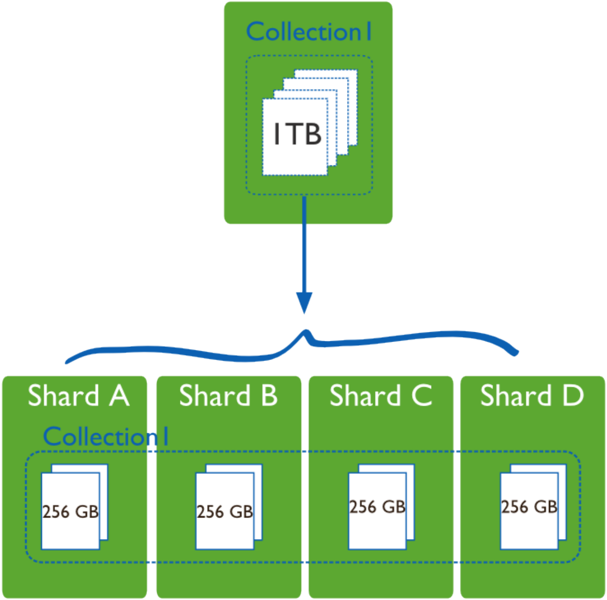
# Heartbeats


Primary
Replication
Replication
Heartbeat
Secondary
Secondary

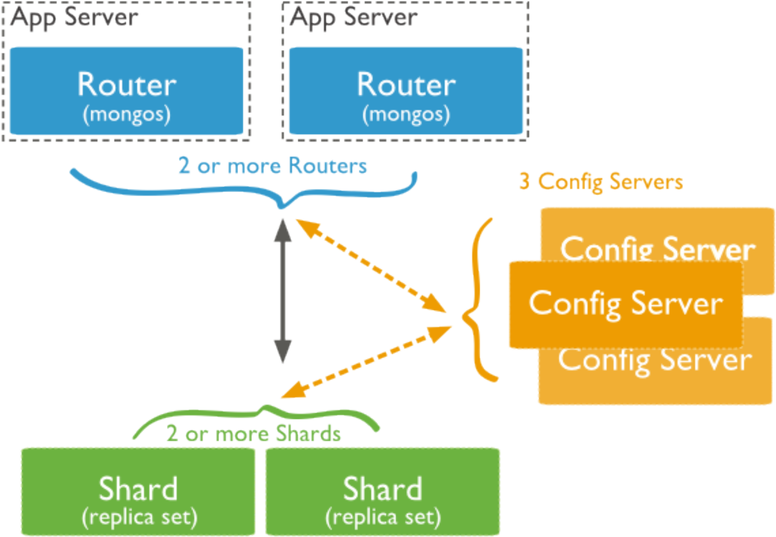
# Failover


Primary
Election for New Primary
Secondary
Heartbeat
Secondary
New Primary Elected
Primary
Replication
Heartbeat
Secondary

# Sharding


Collection I
I TB
Shard A
Shard B
Shard C
Shard D
Collection I
256 GB
256 GB
256 GB
256 GB

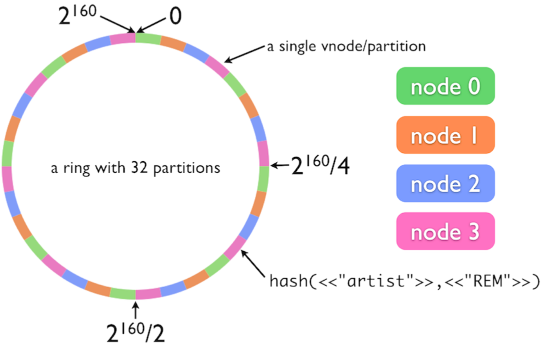
# Sharding Configuration



# How Riak Works

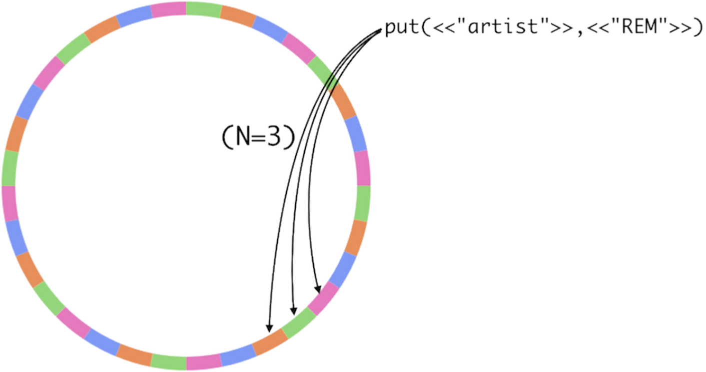
# Storage

- all nodes in a Riak cluster are equivalent; there is no master
- data is distributed across nodes using consistent hashing
  - stores key/value pairs in a bucket namespace (roughly a table)
  - hashes bucket/key combination into a 160-bit integer space
  - each node responsible for portions of the space
- 4-node cluster with 32 partitions:



# Replication

- writes specify a replication number $W$, specifying amount of replication
- stored in that number of consecutive locations
- nearby virtual locations map to physical locations that may be geographically distinct



# Eventual Consistency

- reads specify a level of consistency, $R$
  - specifies how many replicas must return results for a successful read
  - send a request to all nodes where data is stored, return when $r$ have responded
- $W + R > N$ ensures strict consistency
- $W + R <= N$ provides eventual consistency for better availability or lower latency
- a write may occur during a partition
  - reads will return different values in each partition
  - when the partition is healed, write ordering will eventually result in consistent data

# Example

# Example

- Sample FamilyTree App model
- uses PyMongo