JSON stores (and MongoDB)

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Slides Courtesy (with some modifications): Ioana Manolescu

Motivation and outline

- **JSON** (JavaScript Object Notation) allows to describe nested, potentially heterogeneous data
  - Very flexible
  - Hugely adopted for sharing (Open) Data
  - Important to know how to work with JSON
- **MongoDB**: most widely used JSON store
  - Also considered flagship NoSQL system
  - Specific approach for *replication* (and consistency), *distribution*

Sample JSON document: Twitter

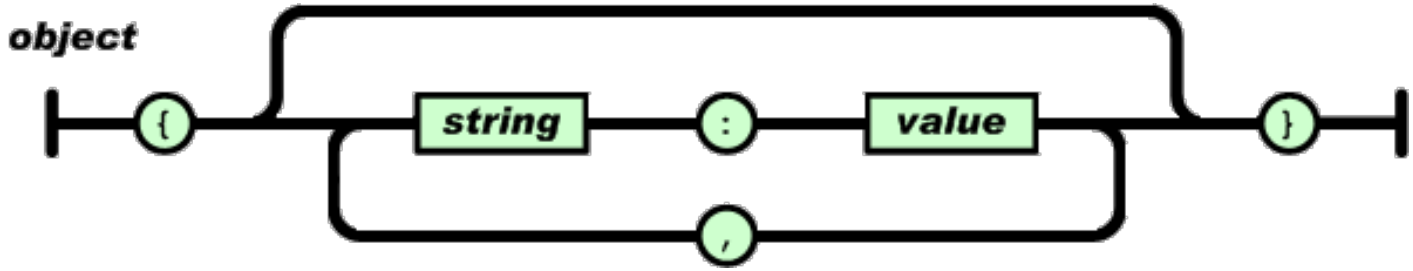

```
{ "results":[
     {"text":"@twitterapi  http://tinyurl.com/ctrefg",
     "to_user_id":396524,
     "to_user":"TwitterAPI",
     "from_user":"jkoum",
     "metadata":     {"result_type":"popular", "recent_retweets": 109 },
     "id":1478555574,
     "from_user_id":1833773,
     "iso_language_code":"nl",
     "source":"twitter< /a>",
     "profile_image_url":http://s3.amazonaws.com/twitter/a155_b_normal.jpg,
     "created_at":"Wed, 08 Apr 2009 19:22:10 +0000"},
     ... truncated ...],
    "refresh_url":"?since_id=1480307926&q=%40twitterapi",
    "results_per_page":15,
    "next_page":"?page=2&max_id=1480307926&q=%40twitterapi",
    "completed_in":0.031704,
    "page":1,
    "query":"%40twitterapi"}
}
```

More JSON from http://nosdeputes.fr

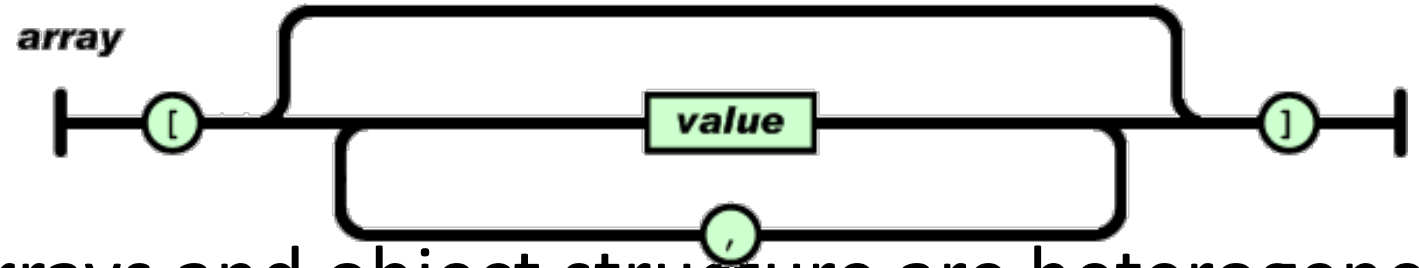
{"deputes": [
{"**depute**":{"id":**1**,"nom":"Cédric Roussel", "nom_de_famille":"Roussel", "prenom":"Cédric",
"sexe":"H", "date_naissance":"1972-10-10", "lieu_naissance":"Brest (Finistère)", "num_deptmt":"06",
"nom_circo":"Alpes-Maritimes", "num_circo"3, "mandat_debut":"2017-06-21", "groupe_sigle":"LREM",
"parti_ratt_financier":"La République en Marche",
"sites_web":[{"site":"https://twitter.com/CedricRoussel06"},
{"site":"http://cedricroussel.en-marche.fr"},
{"site":"https://fr-fr.facebook.com/CRoussel06/"},
{"site":"https://www.cedricroussel.fr"}
],
"emails":[{"email":"cedric.roussel@assemblee-nationale.fr"},{"email":"6circo03@en-marche.fr"}],
"adresses":[{"adresse":"Assemblée nationale, 126 Rue de l'Université, 75355 Paris 07 SP"}],
"collaborateurs":[{"collaborateur":"M. Yanis Lahmeri"},{"collaborateur":"Mme Justine
Birot"},{"collaborateur":"Mme Morgane Reclus"},{"collaborateur":"Mme Caroline Puiss\u00e9gur-
Ripet"},{"collaborateur":"M. Yassine Id-Nasser Medjani"}],
"autres_mandats":[],"anciens_autres_mandats":[],"anciens_mandats":[{"mandat":"21/06/2017//"}],
"profession":"Conseiller en gestion de patrimoine indépzndent","place_en_hemicycle":"309",
"url_an": http://www2.assemblee-nationale.fr/deputes/fiche/OMC_PA718902 ",
"id_an":"718902","slug":"cedric-roussel",
"url_nosdeputes":"https://www.nosdeputes.fr/cedric-roussel",
"url_nosdeputes_api":"https://www.nosdeputes.fr/cedric-
roussel/json","nb_mandats":1,"twitter":"CedricRoussel06"}},
{"**depute**":{"id":**2**,"nom":"Nadia Hai", ... } }
]
}

JSON document structure

- Object: collection of (name, value) pairs



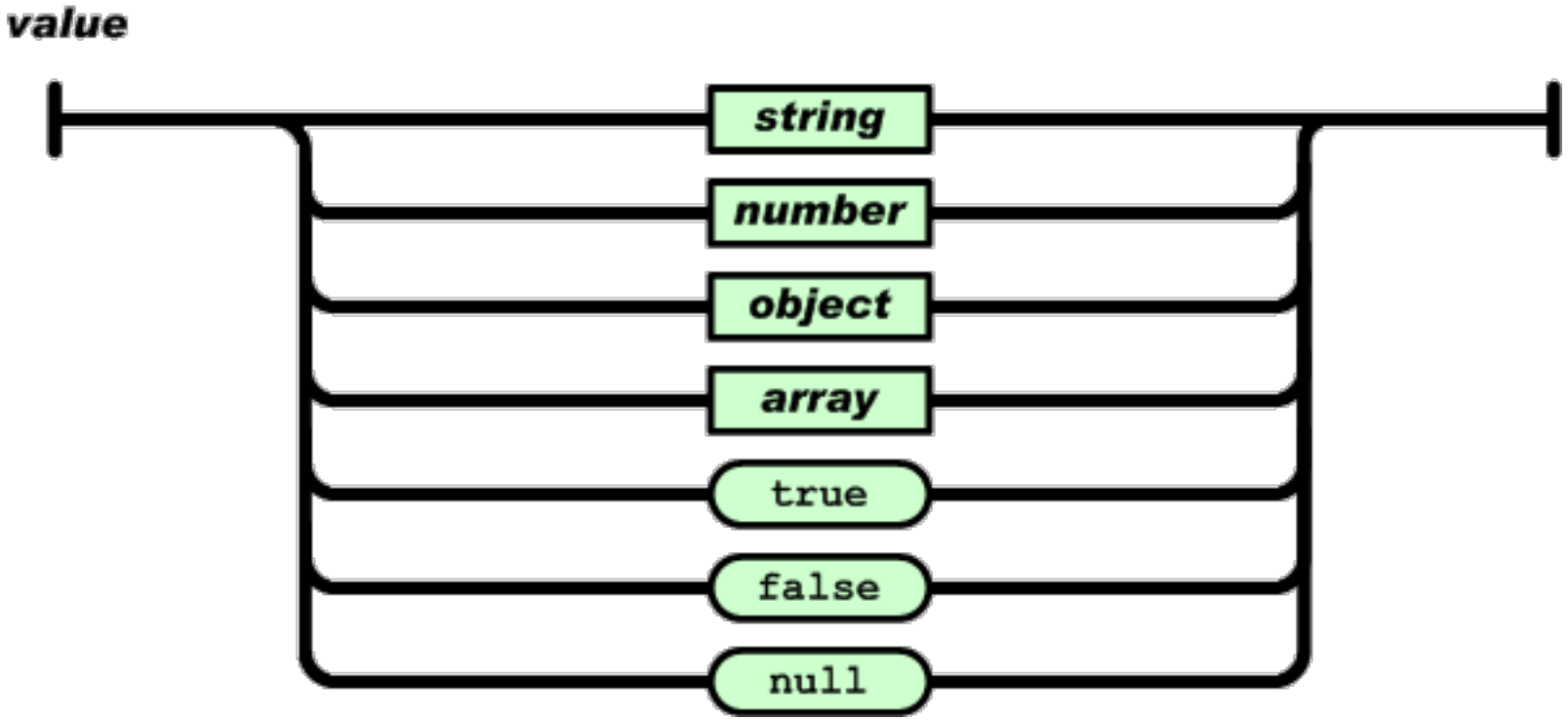
- Array: collection of values



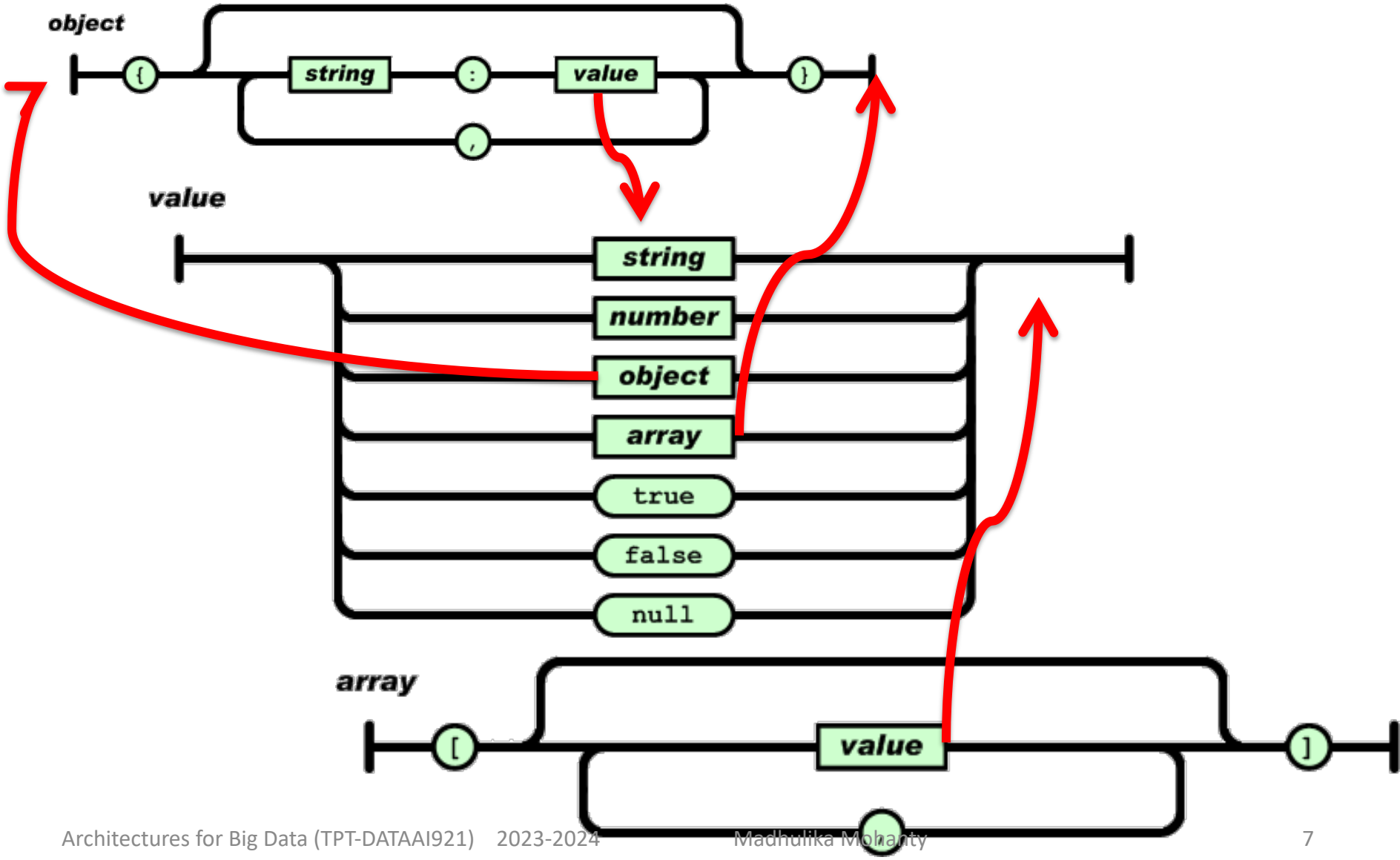
- Arrays and object structure are heterogeneous (no schema)

JSON document structure

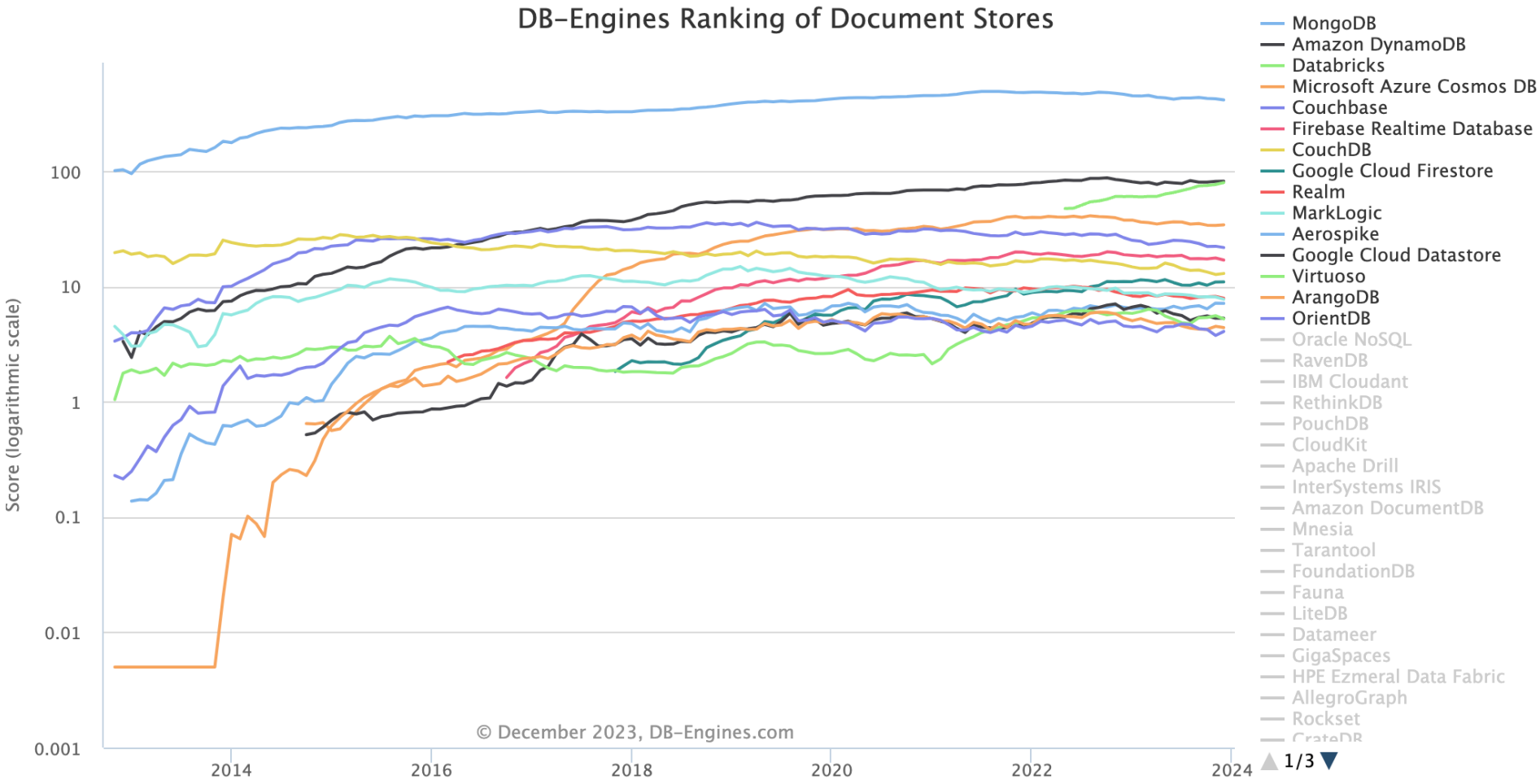
- Values (allow nesting):



JSON document structure



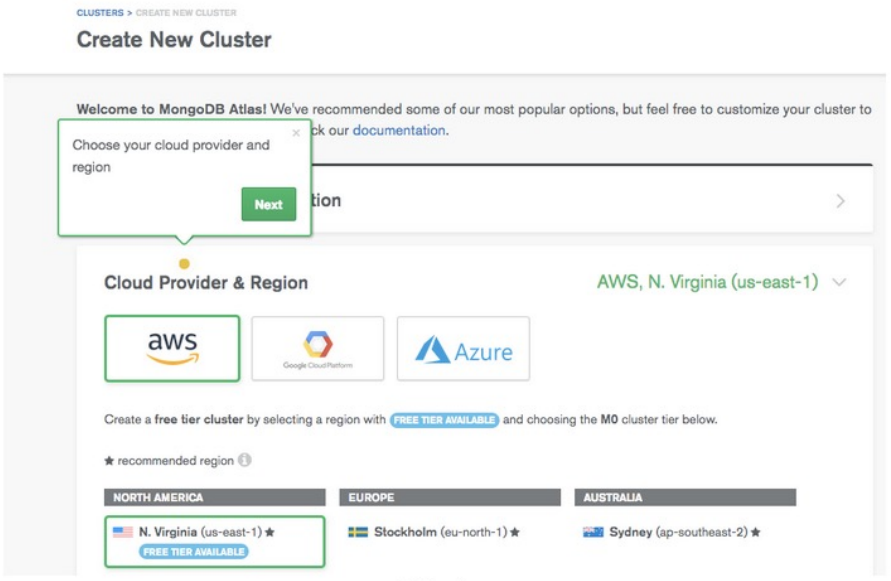
MongoDB: a JSON document store



Computed based on: popularity in search engine results, queries, job offers, social networks, questions on StackOverflow…

MongoDB tools

- MongoDB **server (mongod)**
  - Installed on top of an operating system (e.g., on a PC); assumes a file system and regular OS support
  - Accessed through (potentially concurrent) clients (mongo)
- MongoDB **Atlas** (or **cloud** edition)
  - Meant to deploy easily in the cloud (e.g. Amazon, Google, Azure...)
  - Assumes the respective cloud infrastructure services
- Other MongoDB tools:
  - Data lake
  - Charts to generate reporting images
  - Compass GUI to visualize the data
  - Spark connector



MongoDB server

The server data can be:

- Replicated
  - Several identical copies of the same data
- Partitioned (sharded)
  - Distributed across the machines of a cluster in order to take advantage of the storage and processing capacity

MongoDB storage organization

- **Documents** are stored in **collections** (which may have **indexes**)
- Collections are part of **databases**

```
> use myExample                  // Creates the database myExample
> db.towns.insertOne({           // Creates the collection towns
   name: "New York",             // and inserts a document into it
   population: 22200000,
   last_census: ISODate("2009-07-31"),
   famous_for: [ "statue of liberty", "food" ],
   mayor : {
      name : "Michael Bloomberg”,
      party : "I”
   }
})
```

Replica sets

Duplication (replication) to prevent against server failure and data loss

Example (three servers): mkdir ./mongo1 ./mongo2 ./mongo3

Create replication set:

```
mongod --replSet book --dbpath ./mongo1 --port 27011
mongod --replSet book --dbpath ./mongo2 --port 27012
mongod --replSet book --dbpath ./mongo3 --port 27013
```

Connect to each set:

```
mongosh localhost:27011
```

Then in one of the servers, initialize replication set:

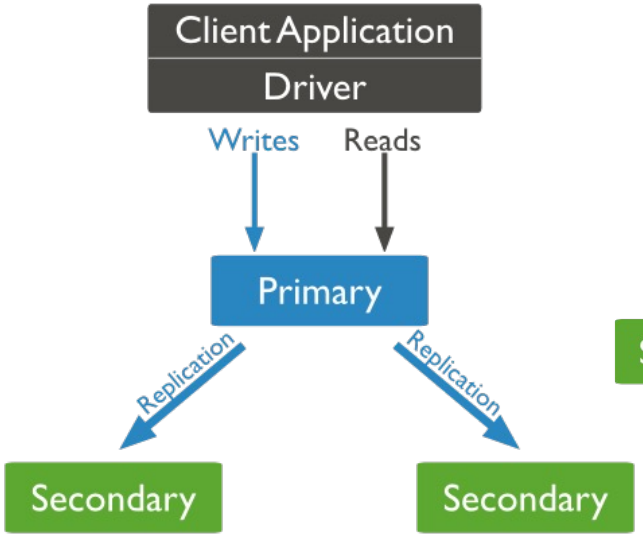
```
> rs.initiate({_id: 'book',
                members: [ {_id: 1, host: 'localhost:27011'},
                           {_id: 2, host: 'localhost:27012'},
                           {_id: 3, host: 'localhost:27013'} ] })
```

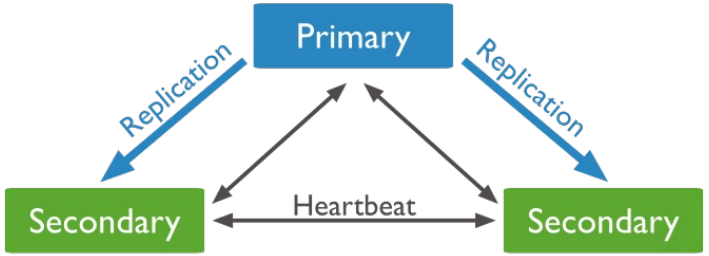
Then one server will output PRIMARY
while two will output SECONDARY

Replica sets in MongoDB

The servers held a vote to determine who is the master (primary); the two others are replicas ("secondary")

By default, applications *read/write through the primary*, who pushes updates to secondary servers



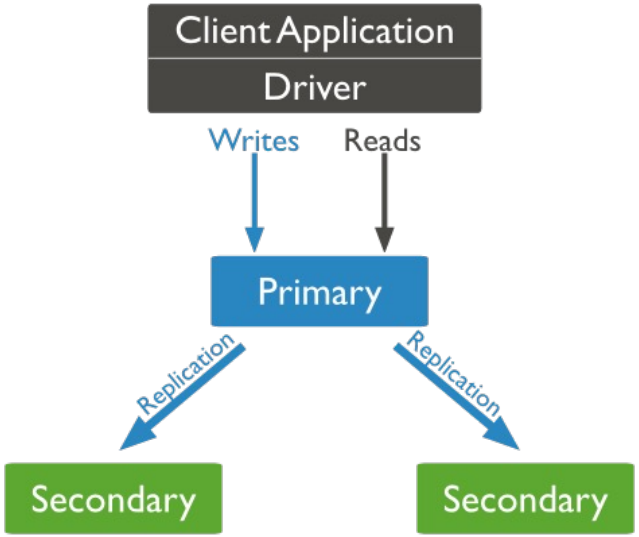


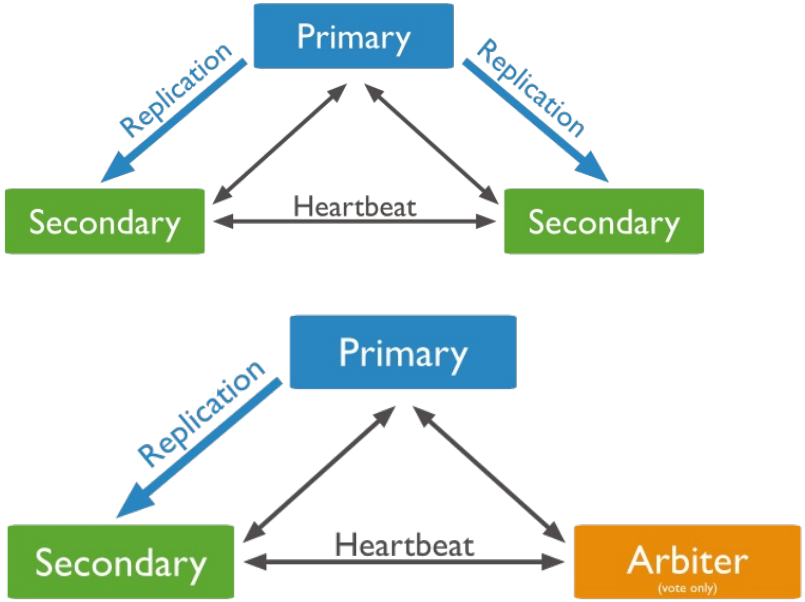
If the master is considered dead, there are new elections

- *Only succeed if more than half of the original replication set votes*
- Operations attempted on a demoted (dead) master are lost
- *A write is considered successful only if > half of the replicas "saw" it*

Replica sets

By default, write to the primary, which pushes updates to secondary servers





MongoDB recommends an *odd number of servers in a replica set*, to allow a majority in case of network failure. One arbiter may be added to the replica set

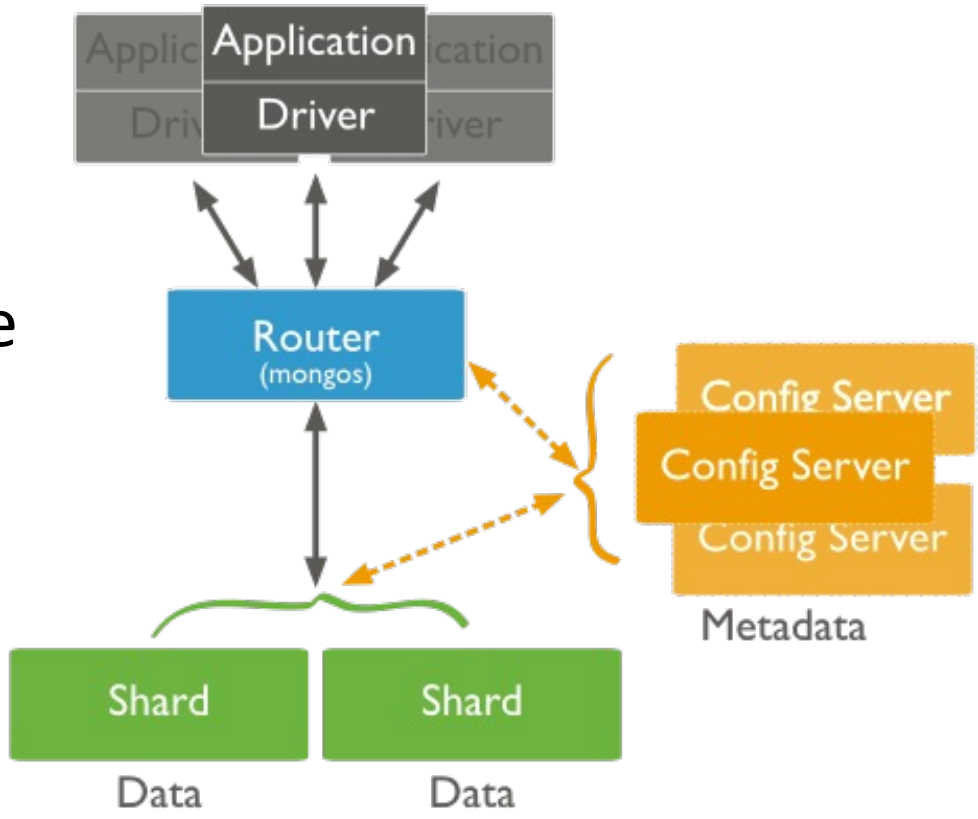
- Strong consistency on read
- Resistence to some partitioning

MongoDB sharding

Sharding = partitioning

1 shard = 1 fragment

- To distribute a very large collection across several servers



MongoDB sharding

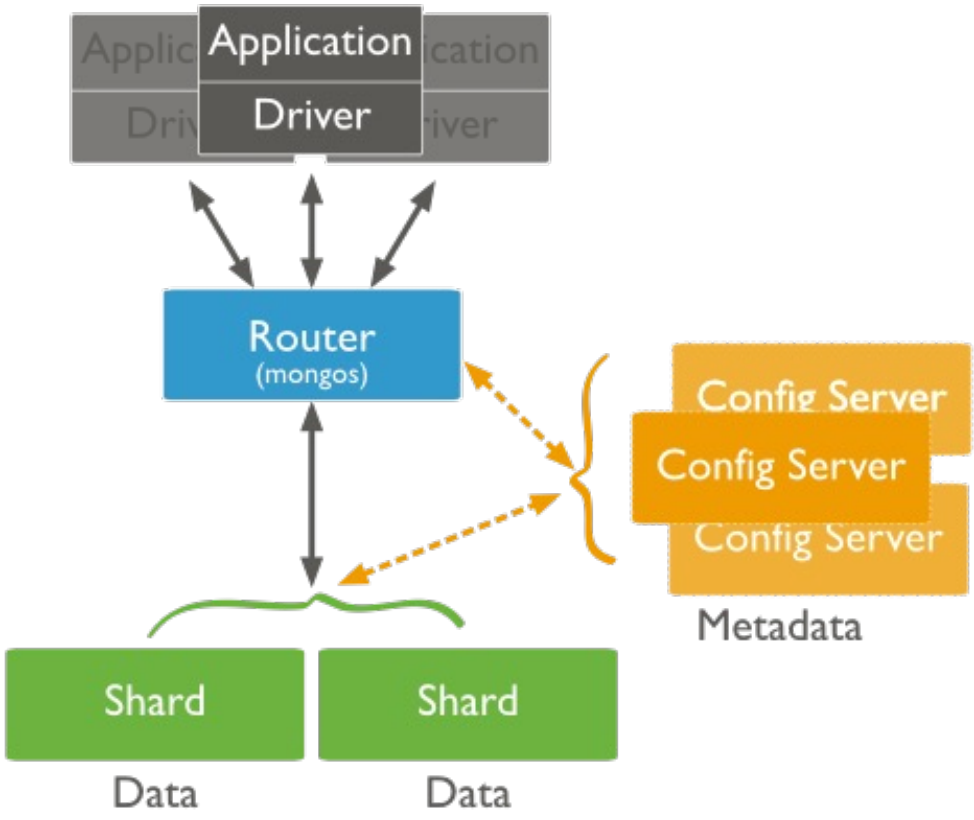
Sharding = partitioning

1 shard = 1 fragment

- To distribute a very large collection across several servers

Sharding is logically *on top of replication*

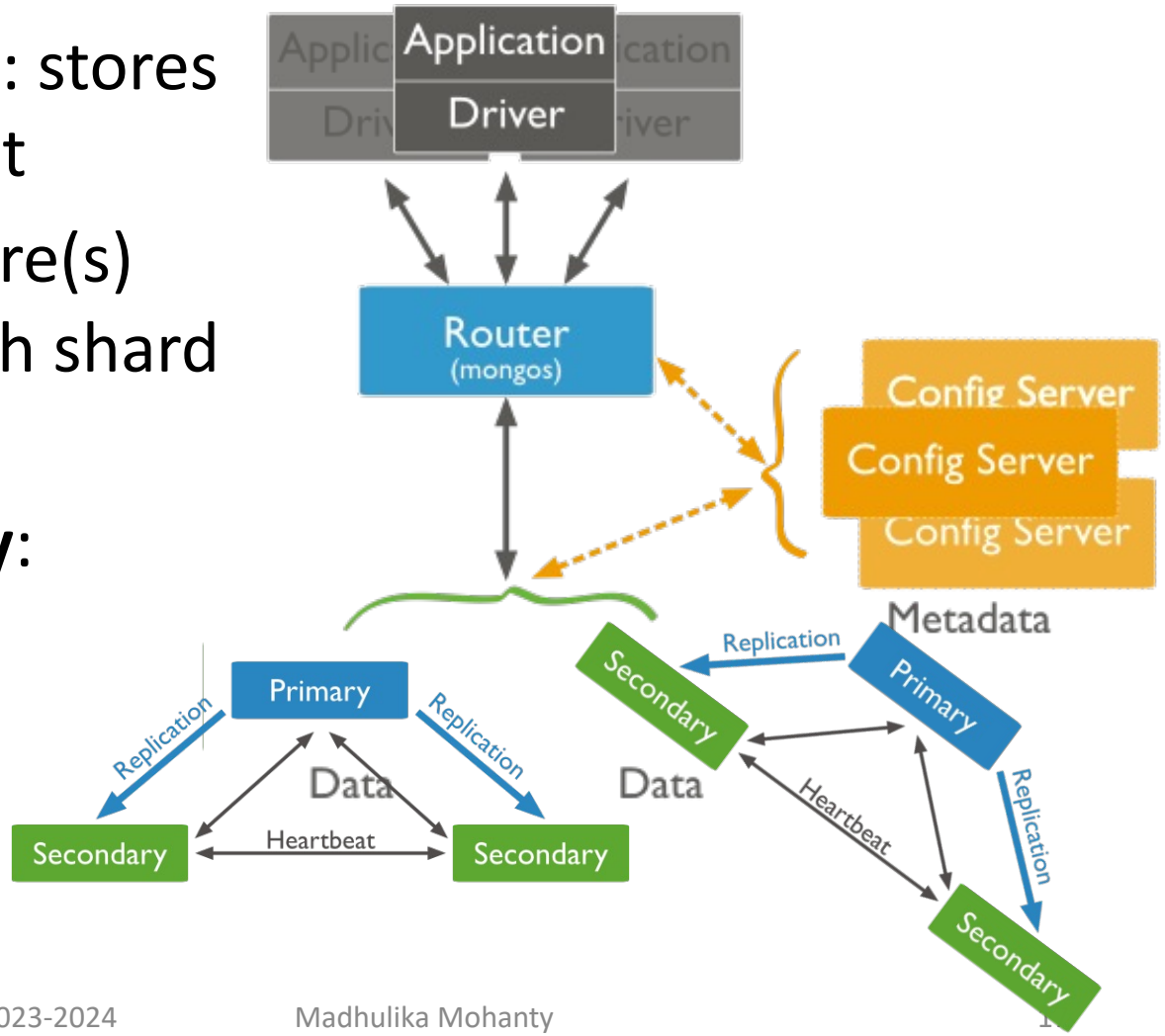
- Each shard server may participate to a replica set



MongoDB sharding

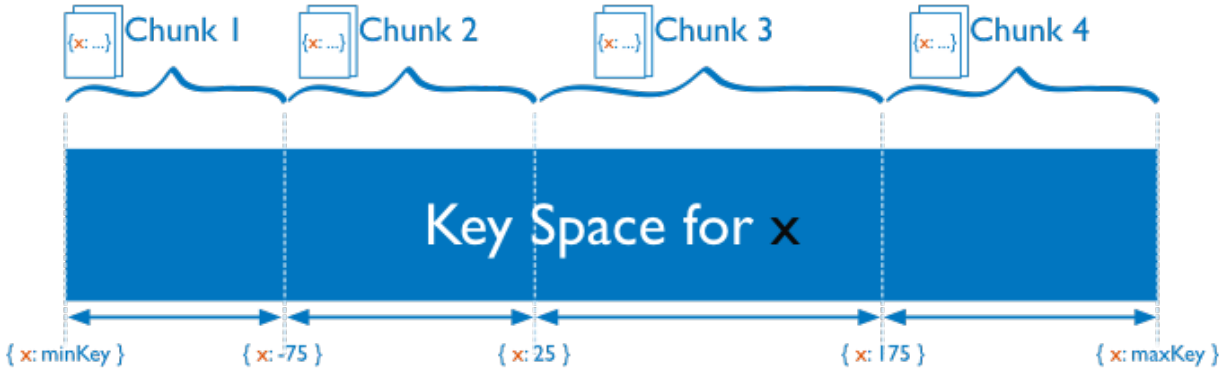
Roles:

- **Shard** (shard server): stores a collection fragment
- **Config server(s)**: store(s) information on which shard has what (~ catalog)
- **Single point of entry**: mongos



MongoDB sharding

- A data collection is partitioned into chunks based on the value of a shard key
- Each chunk covers a key range



- 1 shard = a set of chunks
- mongos routes writes to the appropriate chunk based on the shard key value
- Chunks are split when they grow beyond a fixed chunk size
- MongoDB migrates chunks across shards for load balancing

Conclusion: JSON stores

- **JSON**: extremely popular data interchange format
- **MongoDB**: (by far) most popular JSON data management system
- **MongoDB query language**:
  - Rich matching within one document (declarative)
  - Pipeline processing for more complex operations (non-declarative; see the documentation)
- MongoDB **replication:**
  - replica group, voting, quorum
- MongoDB **distribution**: sharding

- Other JSON stores:
  - Amazon DynamoDB (also serves as K-V store)
  - CouchDB

More document stores: http://db-engines.com/en/ranking_trend/document+store