NoSQL databases

Introduction to MongoDB

DBMG

MongoDB: Introduction

- The leader in the NoSQL Document-based databases
- Full of features, beyond NoSQL
  - High performance
  - High availability
  - Native scalability
  - High flexibility
  - Open source

Terminology – Approximate mapping

Relational database	MongoDB
Table	Collection
Record	Document
Column	Field

MongoDB: Document Data Design

High-level, business-ready representation of the data

- Records are stored into Documents
  - field-value pairs
  - similar to JSON objects
  - may be nested

MongoDB: Document Data Design

- High-level, business-ready representation of the data
- Flexible and rich syntax, adapting to most use cases
- Mapping into developer-language objects
  - year, month, day, timestamp,
  - lists, sub-documents, etc.
- Rich query language
  - Documents can be created, read, updated and deleted.
  - The **SQL language** is **not supported**
  - APIs available for many programming languages
    - JavaScript, PHP, Python, Java, C#, ..

MongoDB

Querying data using operators

MongoDB: query language

Most of the operations available in SQL language can be expressend in MongoDB language

MySQL clause	MongoDB operator
SELECT	find()

SELECT * FROM people	db.people.**find()**

MongoDB: Read data from documents

- Select documents
  - `db.<collection name>.find( {<conditions>}, {<fields of interest>} );`
- E.g.,

```
db.people.find();
```

  - Returns all documents contained in the people collection

MongoDB: Read data from documents

- Select documents
  - `db.<collection name>.find( {<conditions>}, {<fields of interest>} );`
- Select the documents satisfying the specified conditions and specifically only the fields specified in fields of interest
  - `<conditions>` are optional
    - conditions take a document with the form:
      `{field1 : <value>, field2 : <value> ... }`
    - Conditions may specify a value or a regular expression

MongoDB: Read data from documents

Select documents

- `db.<collection name>.find( {<conditions>}, {<fields of interest>} );`

Select the documents satisfying the specified conditions and specifically only the fields specified in fields of interest

- `<fields of interest>` are optional
  - projections take a document with the form:
    `{field1 : <value>, field2 : <value> ... }`
  - 1/true to include the field, 0/false to exclude the field

MongoDB: Read data from documents

E.g.,

```
db.people.find().pretty();
```

- No conditions and no fields of interest
  - Returns all documents contained in the people collection
  - `pretty()` displays the results in an easy-to-read format

```
db.people.find({age:55})
```

- One condition on the value of age
  - Returns all documents having *age* equal to 55

MongoDB: Read data from documents

```
db.people.find({ }, { user_id: 1, status: 1 })
```

No conditions, but returns a specific set of fields of interest

- Returns only **user_id** and **status** of all documents contained in the people collection
- Default of fields is false, except for _id

```
db.people.find({ status: "A",  age: 55})
```

`status = "A"` and `age = 55`

- Returns all documents having **status = "A"** and **age = 55**

MongoDB: find() operator

MySQL clause	MongoDB operator
SELECT	find()

```
SELECT id,
       user_id,
       status
FROM people
```

```
db.people.find(
    { },
    { user_id: 1,
      status: 1
    }
)
```

MongoDB: find() operator

MySQL clause	MongoDB operator
SELECT	find()

```
SELECT id,
       user_id,
       status
FROM people
```

```
db.people.find(
    { },
    { user_id: 1,
      status: 1
    }
)
```

Where Condition

Select fields

MongoDB: find() operator

MySQL clause	MongoDB operator
SELECT	find()
WHERE	find({<WHERE CONDITIONS>})

SELECT * FROM people WHERE status = "A"	db.people.find(**{ status: "A" }**)

Where Condition

MongoDB: find() operator

MySQL clause	MongoDB operator
SELECT	find()
WHERE	find({<WHERE CONDITIONS>})

```
SELECT user_id, status
FROM people
WHERE status = "A"
```

```
db.people.find(
    { status: "A" },
    { user_id: 1,
      status: 1,
      _id: 0
    }
)
```

Where Condition

Selection fields

By default, the `_id` field is shown.
To remove it from visualization use: `_id: 0`

MongoDB: find() operator

MySQL clause	MongoDB operator
SELECT	find()
WHERE	find({<WHERE CONDITIONS>})

```
db.people.find(
    {"address.city":"Rome" }
)
```

```
{ _id: "A",
  address: {
        street: "Via Torino",
        number: "123/B",
        city: "Rome",
        code: "00184"
    }
}
```

nested document

MongoDB: Read data from documents

```
db.people.find({ age: { $gt: 25, $lte: 50 } })
```

Age greater than 25 and less than or equal to 50

- Returns all documents having **age > 25 and age <= 50**

```
db.people.find({$or:[{status: "A"},{age: 55}]})
```

Status = "A" or age = 55

- Returns all documents having **status="A" or age=55**

```
db.people.find({ status: {$in:["A", "B"]}})
```

Status = "A" or status = B

- Returns all documents where the **status** field value is **either "A" or "B"**

MongoDB: Read data from documents

- Select a single document
  - `db.<collection name>.findOne( {<conditions>}, {<fields of interest>} );`
- Select one document that satisfies the specified query criteria.
  - If multiple documents satisfy the query, it returns the first one according to the natural order which reflects the order of documents on the disk.

MongoDB: comparison operators

In SQL language, comparison operators are essential to express conditions on data.

In Mongo query language they are available with a different syntax.

MySQL	MongoDB	Description
>	$gt	greater than
>=	$gte	greater equal then
<	$lt	less than
<=	$lte	less equal then
=	$eq	equal to
!=	$neq	not equal to

MongoDB: Comparison query operators

Name	Description
`$eq or :`	Matches values that are equal to a specified value
`$gt`	Matches values that are greater than a specified value
`$gte`	Matches values that are greater than or equal to a specified value
`$in`	Matches any of the values specified in an array
`$lt`	Matches values that are less than a specified value
`$lte`	Matches values that are less than or equal to a specified value
`$ne`	Matches all values that are not equal to a specified value
`$nin`	Matches none of the values specified in an array

MongoDB: comparison operators (>)

MySQL	MongoDB	Description
>	$gt	greater than

```
SELECT *
FROM people
WHERE age > 25
```

```
db.people.find(
    { age: { $gt: 25 } }
)
```

MongoDB: comparison operators (>=)

MySQL	MongoDB	Description
>	$gt	greater than
>=	**$gte**	**greater equal then**

```
SELECT *
FROM people
WHERE age >= 25
```

```
db.people.find(
    { age: { $gte: 25 } }
)
```

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MongoDB: comparison operators (<)

MySQL	MongoDB	Description
>	$gt	greater than
>=	$gte	greater equal then
<	**$lt**	**less than**

```
SELECT *
FROM people
WHERE age < 25
```

```
db.people.find(
    { age: { $lt: 25 } }
)
```

MongoDB: comparison operators (<=)

MySQL	MongoDB	Description
>	$gt	greater than
>=	$gte	greater equal then
<	$lt	less than
<=	**$lte**	**less equal then**

```
SELECT *
FROM people
WHERE age <= 25
```

```
db.people.find(
    { age: { $lte: 25 } }
)
```

MongoDB: comparison operators (=)

MySQL	MongoDB	Description
>	$gt	greater than
>=	$gte	greater equal then
<	$lt	less than
<=	$lte	less equal then
=	**$eq**	**equal to** The $eq expression is equivalent to { field: <value> }.

```
SELECT *
FROM people
WHERE age = 25
```

```
db.people.find(
    { age: { $eq: 25 } }
)
```

MongoDB: comparison operators (!=)

MySQL	MongoDB	Description
>	$gt	greater than
>=	$gte	greater equal then
<	$lt	less than
<=	$lte	less equal then
=	$eq	equal to
!=	**$neq**	**Not equal to**

```
SELECT *
FROM people
WHERE age != 25
```

```
db.people.find(
    { age: { $neq: 25 } }
)
```

MongoDB: conditional operators

To specify multiple conditions, **conditional operators** are used

MongoDB offers the same functionalities of MySQL with a different syntax.

MySQL	MongoDB	Description
AND	,	Both verified
OR	$or	At least one verified

MongoDB: conditional operators (AND)

MySQL	MongoDB	Description
AND	**,**	**Both verified**

```
SELECT *
FROM people
WHERE status = "A"
AND age = 50
```

```
db.people.find(
    { status: "A",
      age: 50 }
)
```

MongoDB: conditional operators (OR)

MySQL	MongoDB	Description
AND	,	Both verified
OR	**$or**	**At least one verified**

```
SELECT *
FROM people
WHERE status = "A"
OR age = 50
```

```
db.people.find(
{ $or:
   [ { status: "A" } ,
     { age: 50 }
   ]
}
)
```

MongoDB: Cursor

- `db.collection.find()` gives back a cursor. It can be used to iterate over the result or as input for next operations.

  E.g.,

  - `cursor.sort()`
  - `cursor.count()`
  - `cursor.forEach() //shell method`
  - `cursor.limit()`
  - `cursor.max()`
  - `cursor.min()`
  - `cursor.pretty()`

MongoDB: Cursor

Cursor examples:

```
db.people.find({ status: "A"}).count()
```

- Select documents with status="A" and count them.

```
db.people.find({ status: "A"}).forEach(
   function(myDoc) { print( "user: "+myDoc.name );
   })
```

- `forEach` applies a JavaScript function to apply to each document from the cursor.
  - Select documents with status="A" and print the document name.

MongoDB: sorting data

- Sort is a cursor method

  Sort documents
  - `sort( {<list of field:value pairs>} );`
  - field specifies which filed is used to sort the returned documents
  - value = -1 descending order
  - Value = 1 ascending order

  Multiple field: value pairs can be specified
  - Documents are sort based on the first field
  - In case of ties, the second specified field is considered

MongoDB: sorting data

E.g.,

```
db.people.find({ status: "A"}).sort({age:1})
```

- Select documents with status="A" and sort them in ascending order based on the age value
  - Returns all documents having status="A". The result is sorted in ascending age order

MongoDB: sorting data

Sorting data with respect to a given field in MongoDB: sort() operator

MySQL clause	MongoDB operator
ORDER BY	sort()

```
SELECT *
FROM people
WHERE status = "A"
ORDER BY user_id ASC
```

```
db.people.find(
  { status: "A" }
).sort( { user_id: 1 } )
```

MongoDB: sorting data

Sorting data with respect to a given field in MongoDB: sort() operator

MySQL clause	MongoDB operator
ORDER BY	sort()

SELECT * FROM people WHERE status = "A" **ORDER BY user_id ASC**	db.people.find({ status: "A" }).**sort({ user_id: 1 })**
SELECT * FROM people WHERE status = "A" **ORDER BY user_id DESC**	db.people.find({ status: "A" }).**sort({ user_id: -1 })**

MongoDB: counting

MySQL clause	MongoDB operator
COUNT	count()or find().count()

SELECT COUNT(*) FROM people	db.people.count() or db.people.find().count()

MongoDB: counting

MySQL clause	MongoDB operator
COUNT	count()or find().count()

Similar to the find() operator, count() can embed conditional statements.

```
SELECT COUNT(*)
FROM people
WHERE age > 30
```

```
db.people.count(
{ age: { $gt: 30 } }
)
```

MongoDB

Introduction to data aggregation

Aggregation in MongoDB

- Aggregation operations process data records and return computed results.
- Documents enter a multi-stage pipeline that transforms the documents into an aggregated result.

MongoDB: Aggregation Framework

SQL	MongoDB
WHERE	$match
GROUP BY	$group
HAVING	$match
SELECT	$project
ORDER BY	$sort
//LIMIT	$limit
SUM	$sum
COUNT	$sum

MongoDB: Aggregation

Aggregate functions can be applied to collections to group documents

```
db.collection.aggregate({<set of stages>})
```

- Common stages: `$match, $group ..`
- The aggregate function allows applying aggregating functions (e.g. sum, average, ..)
- It can be combined with an initial definition of groups based on the grouping fields

MongoDB: Aggregation

```
db.people.aggregate( [
   { $group: { _id: null,
               mytotal: { $sum: "$age" },
               mycount: { $sum: 1 }
             }
   }
] )
```

Considers all documents of people and

- sum the values of their age
- sum a set of ones (one for each document)

The returned value is associated with a field called “mytotal” and a field “mycount”

MongoDB: Aggregation

```
db.people.aggregate( [
    { $group: { _id: null,
                myaverage: { $avg: "$age" },
                mytotal: { $sum: "$age" }
              }
    }
] )
```

- Considers all documents of people and computes
  - sum of age
  - average of age

MongoDB: Aggregation

```
db.people.aggregate( [
    { $match: {status: "A"} },
    { $group: { _id: null,
                count: { $sum: 1 }
              }
    }
] )
```

Where conditions

- Counts the number of documents in people with status equal to “A”

MongoDB: Aggregation

```
db.people.aggregate( [
    { $group: { _id: "$status",
                count: { $sum: 1 } }
    }
] )
```

- Creates one group of documents for each value of status and counts the number of documents per group
  - Returns one value for each group containing the value of the grouping field and an integer representing the number of documents

MongoDB: Aggregation

```
db.people.aggregate( [
    { $group: { _id: "$status",
                count: { $sum: 1 }
              }
    },
    { $match: { count: { $gte: 3 } } }
] )
```

Creates one group of documents for each value of status and counts the number of documents per group. Returns only the groups with at least 3 documents

MongoDB: Aggregation

```
db.people.aggregate( [
    { $group: { _id: "$status",
                count: { $sum: 1 }
              }
    },
    { $match: { count: { $gte: 3 } } }
] )
```

Having condition

Creates one group of documents for each value of status and counts the number of documents per group. Returns only the groups with at least 3 documents

MongoDB: Aggregation Framework

SQL	MongoDB
WHERE	$match
GROUP BY	$group
HAVING	$match
SELECT	$project
ORDER BY	$sort
LIMIT	$limit
SUM	$sum
COUNT	$sum

Aggregation in MongoDB: Group By

MySQL clause	MongoDB operator
GROUP BY	aggregate($group)

```
SELECT status,
       AVG(age) AS total
FROM people
GROUP BY status
```

```
db.orders.aggregate( [
   {
     $group: {
        _id: "$status",
        total: { $avg: "$age" }
     }
   }
] )
```

Aggregation in MongoDB: Group By

MySQL clause	MongoDB operator
GROUP BY	aggregate($group)

```
SELECT status,
       SUM(age) AS total
FROM people
GROUP BY status
```

```
db.orders.aggregate( [
   {
     $group: {
        _id: "$status",
        total: { $sum: "$age" }
     }
   }
] )
```

Group field

Aggregation in MongoDB: Group By

MySQL clause	MongoDB operator
GROUP BY	aggregate($group)

```
SELECT status,
       SUM(age) AS total
FROM people
GROUP BY status
```

```
db.orders.aggregate( [
   {
     $group: {
        _id: "$status",
        total: { $sum: "$age" }
     }
   }
] )
```

Group field

Aggregation function

Aggregation in MongoDB: Group By

MySQL clause	MongoDB operator
HAVING	aggregate($group, $match)

```
SELECT status,
       SUM(age) AS total
FROM people
GROUP BY status
HAVING total > 1000
```

```
db.orders.aggregate( [
   {
     $group: {
        _id: "$status",
        total: { $sum: "$age" }
     }
   },
  { $match: { total: { $gt: 1000 } } }
] )
```

Aggregation in MongoDB: Group By

MySQL clause	MongoDB operator
HAVING	aggregate($group, $match)

```
SELECT status,
       SUM(age) AS total
FROM people
GROUP BY status
HAVING total > 1000
```

```
db.orders.aggregate( [
    {
      $group: {
         _id: "$status",
         total: { $sum: "$age" }
      }
    },
   { $match: { total: { $gt: 1000 } } }
] )
```

Group stage: Specify the aggregation field and the aggregation function

Aggregation in MongoDB: Group By

MySQL clause	MongoDB operator
HAVING	aggregate($group, $match)

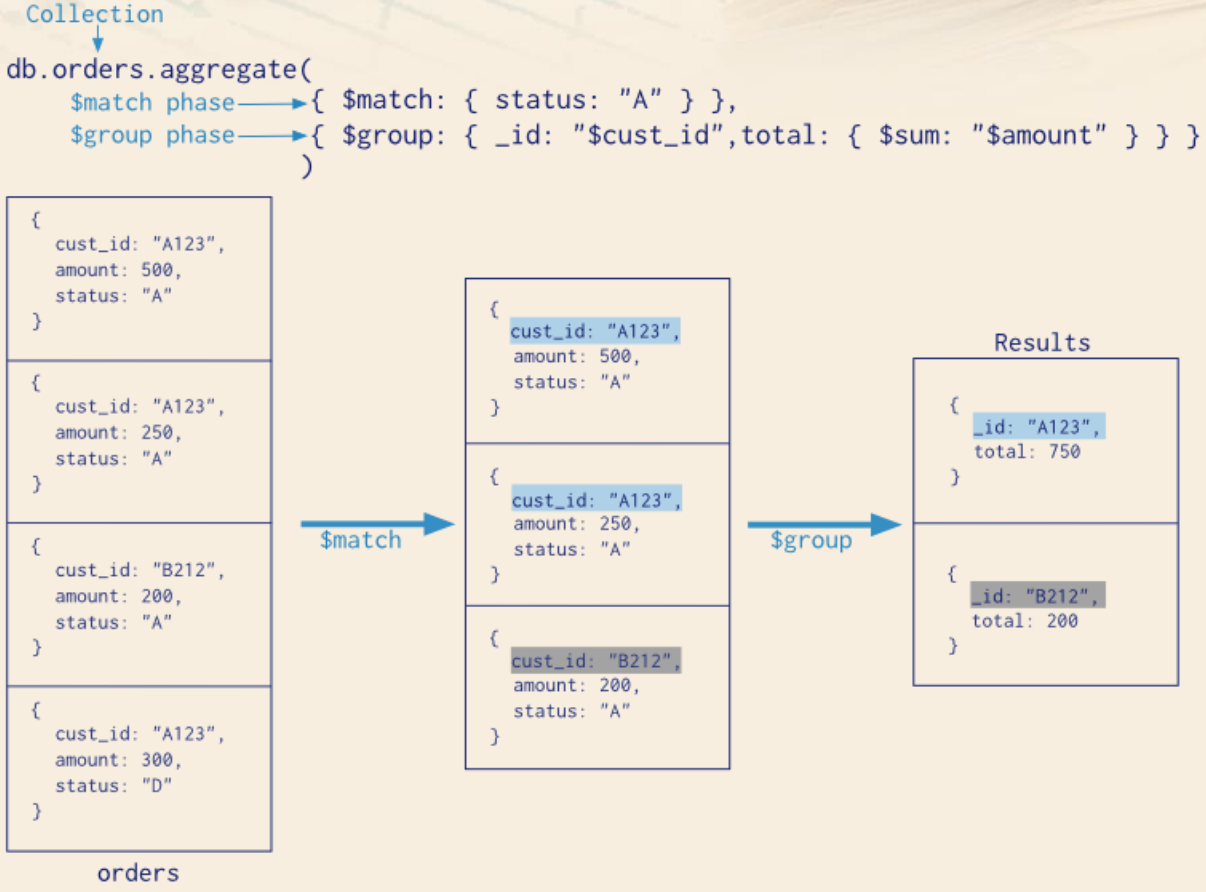
```
SELECT status,
       SUM(age) AS total
FROM people
GROUP BY status
HAVING total > 1000
```

```
db.orders.aggregate( [
    {
      $group: {
         _id: "$status",
         total: { $sum: "$age" }
      }
    },
   { $match: { total: { $gt: 1000
] )
```

Group stage: Specify the aggregation field and the aggregation function

Match Stage: specify the condition as in HAVING

Aggregation in MongoDB



MongoDB Compass

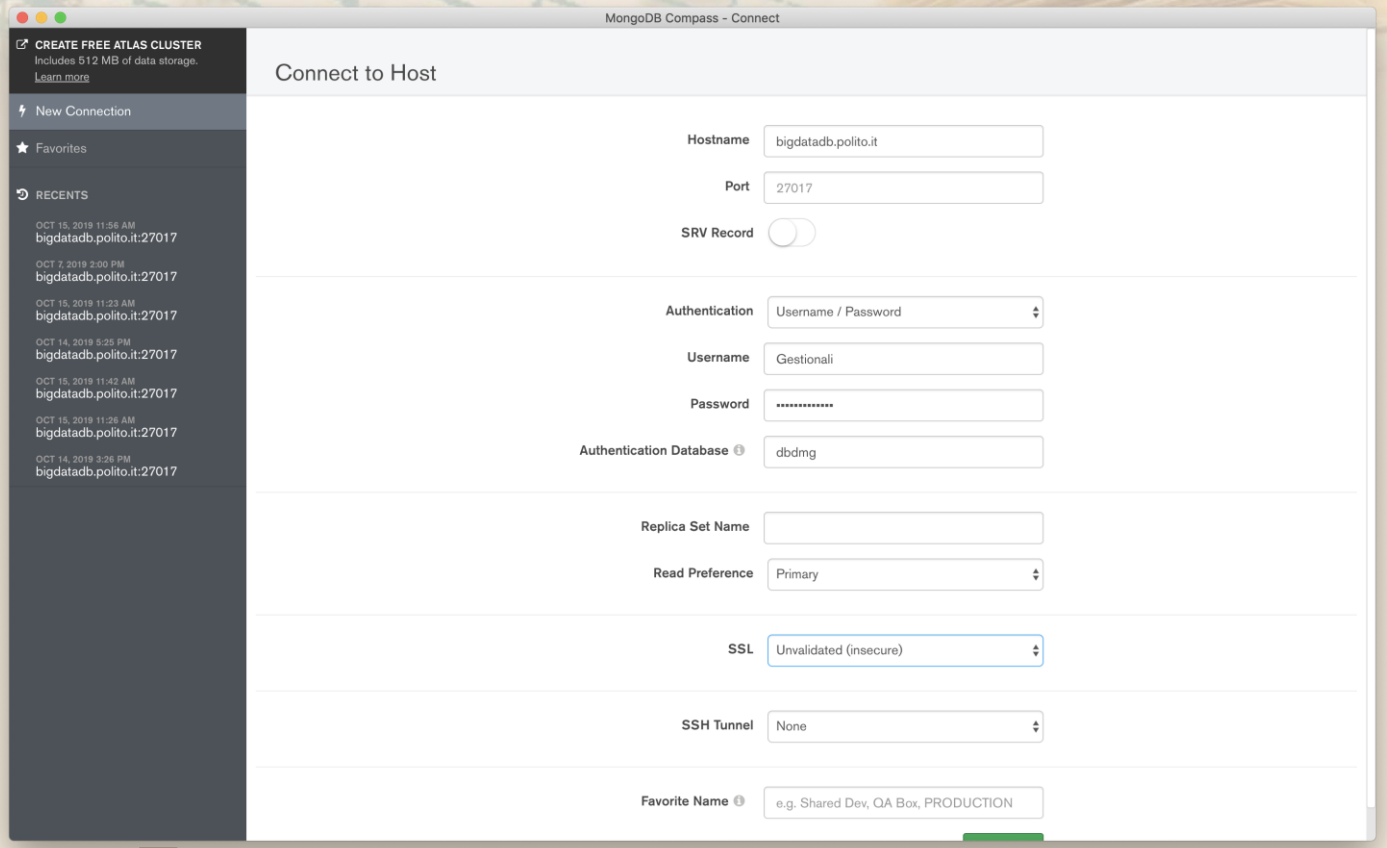
GUI for Mongo DB

DBMG

MongoDB Compass

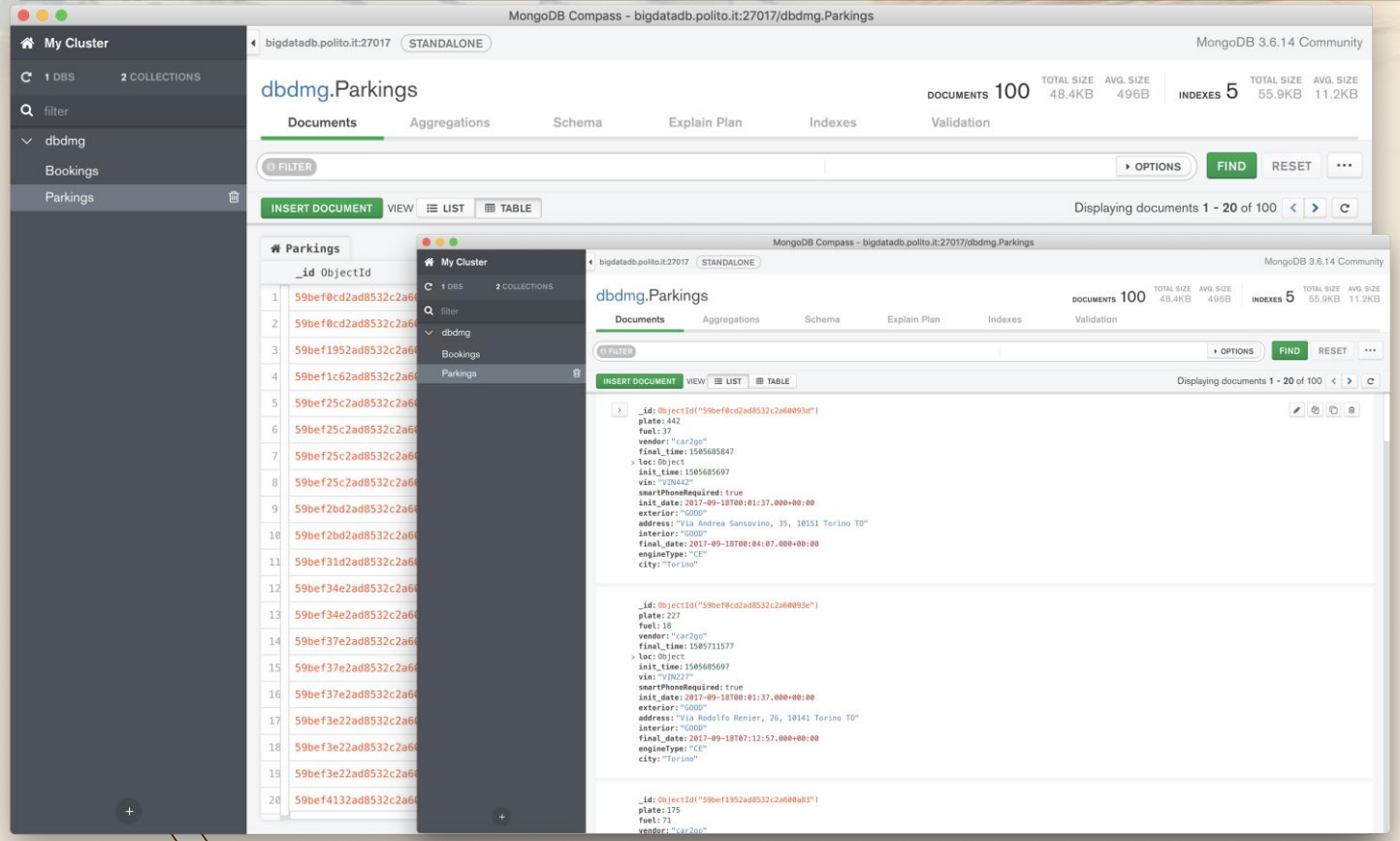
- Visually explore data.
- Available on Linux, Mac, or Windows.
- MongoDB Compass analyzes documents and displays rich structures within collections.
- Visualize, understand, and work with your geospatial data.

MongoDB Compass



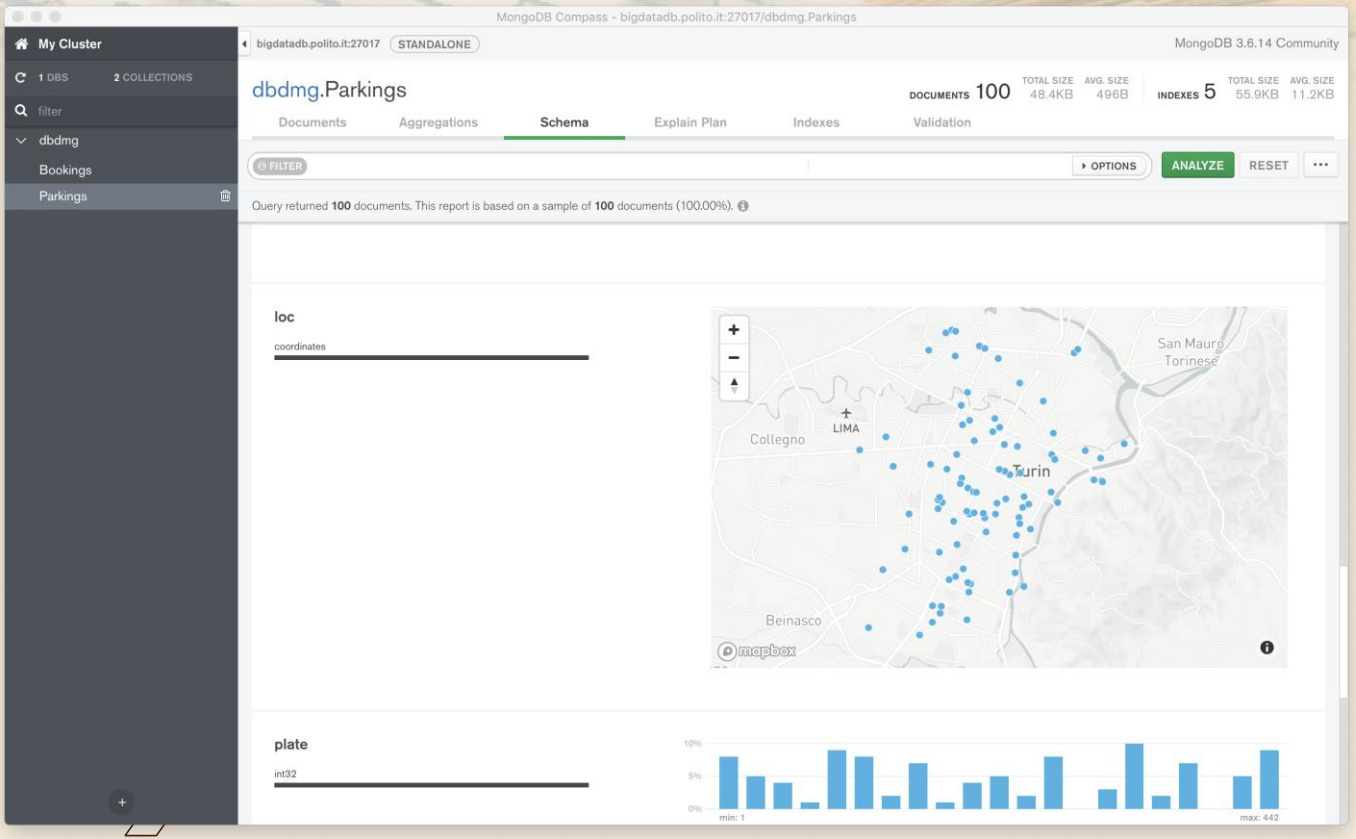
Connect to local or remote instances of MongoDB.

MongoDB Compass



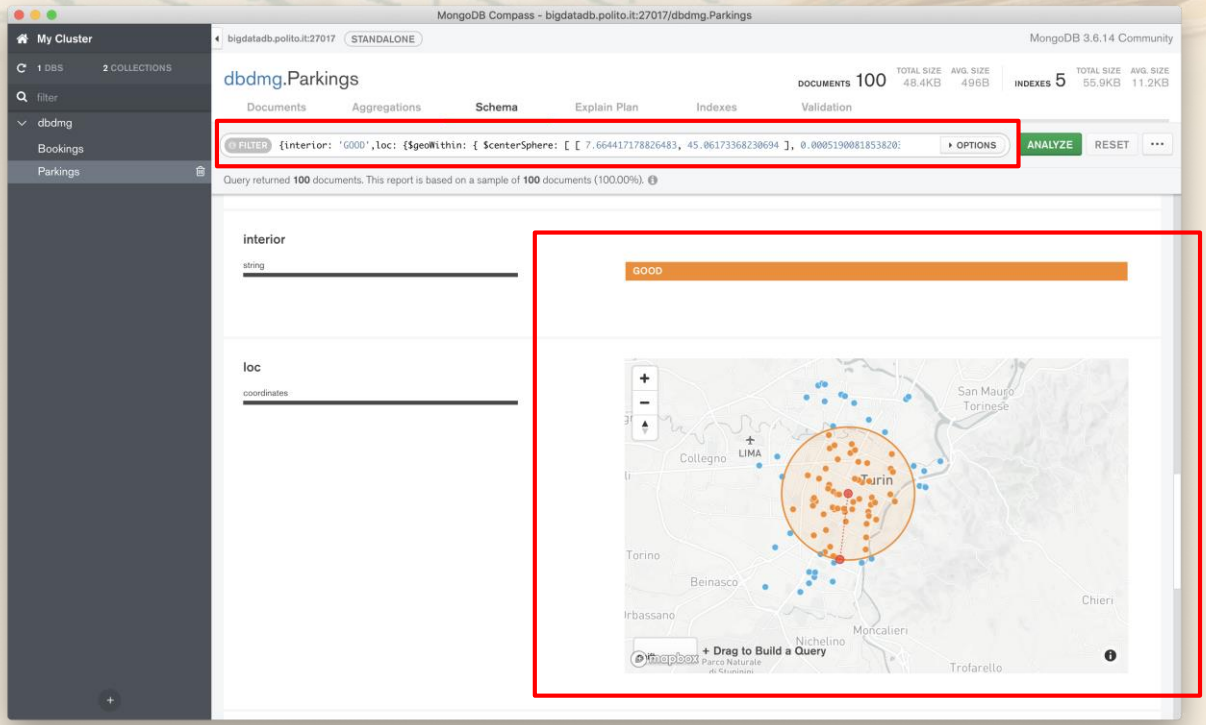
Get an overview of the data in list or table format.

MongoDB Compass



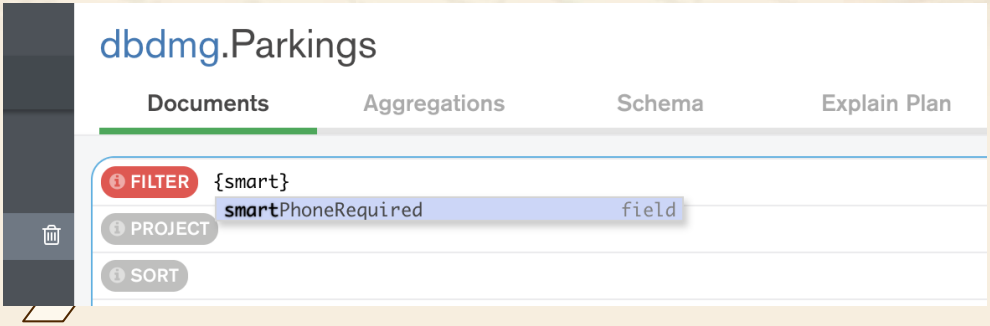
- Analyze the documents and their fields.
  Native support for geospatial coordinates.

MongoDB Compass

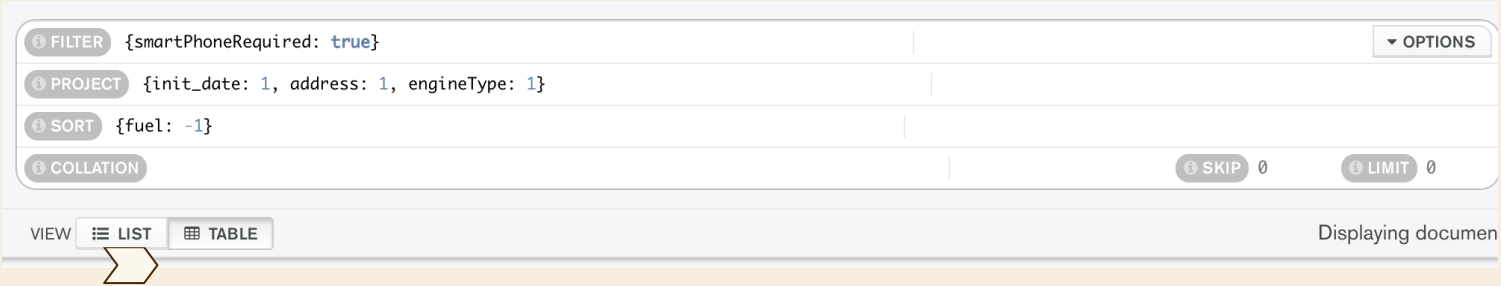


Visually build the query conditioning on analyzed fields.

MongoDB Compass

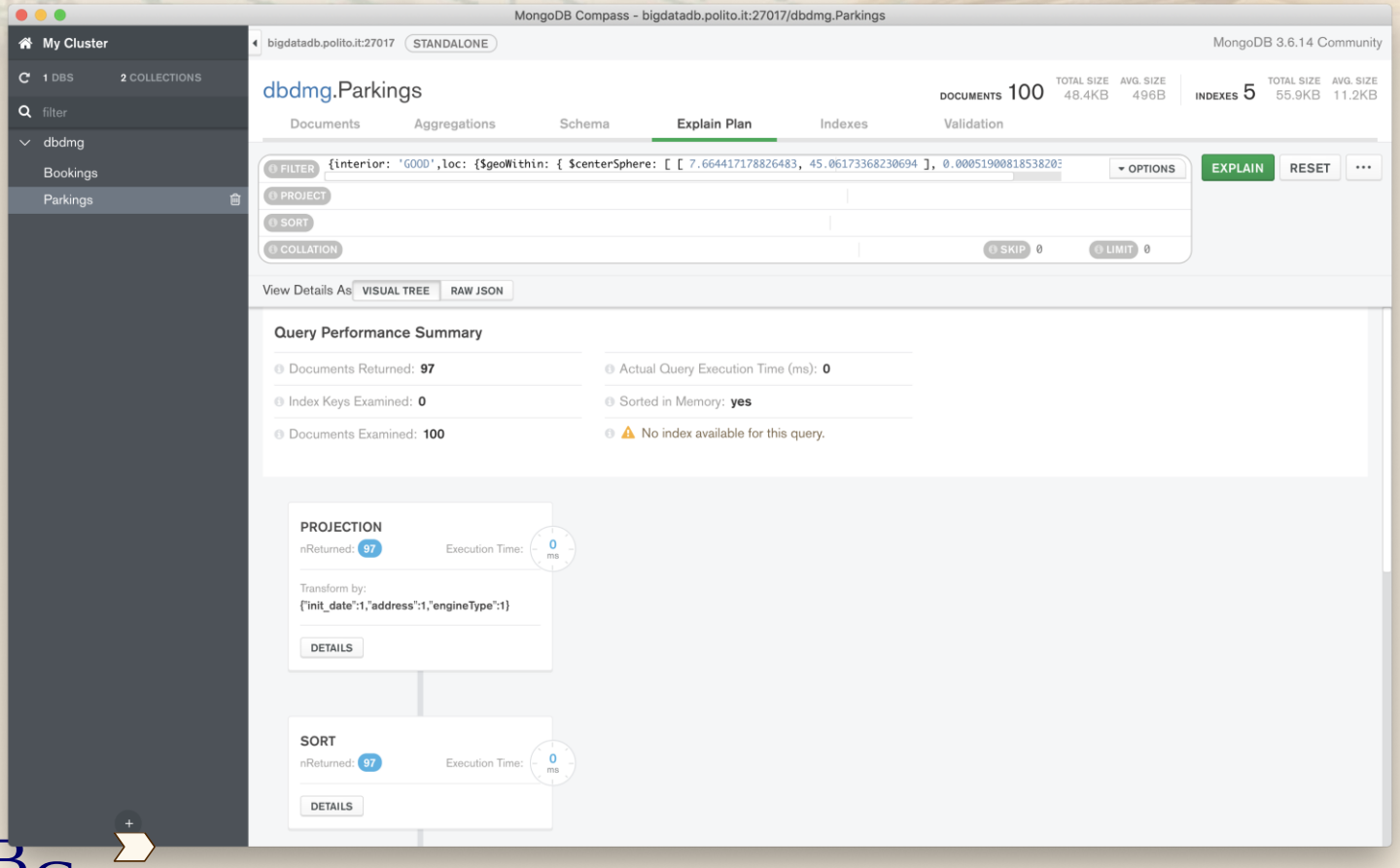


Autocomplete enabled by default.



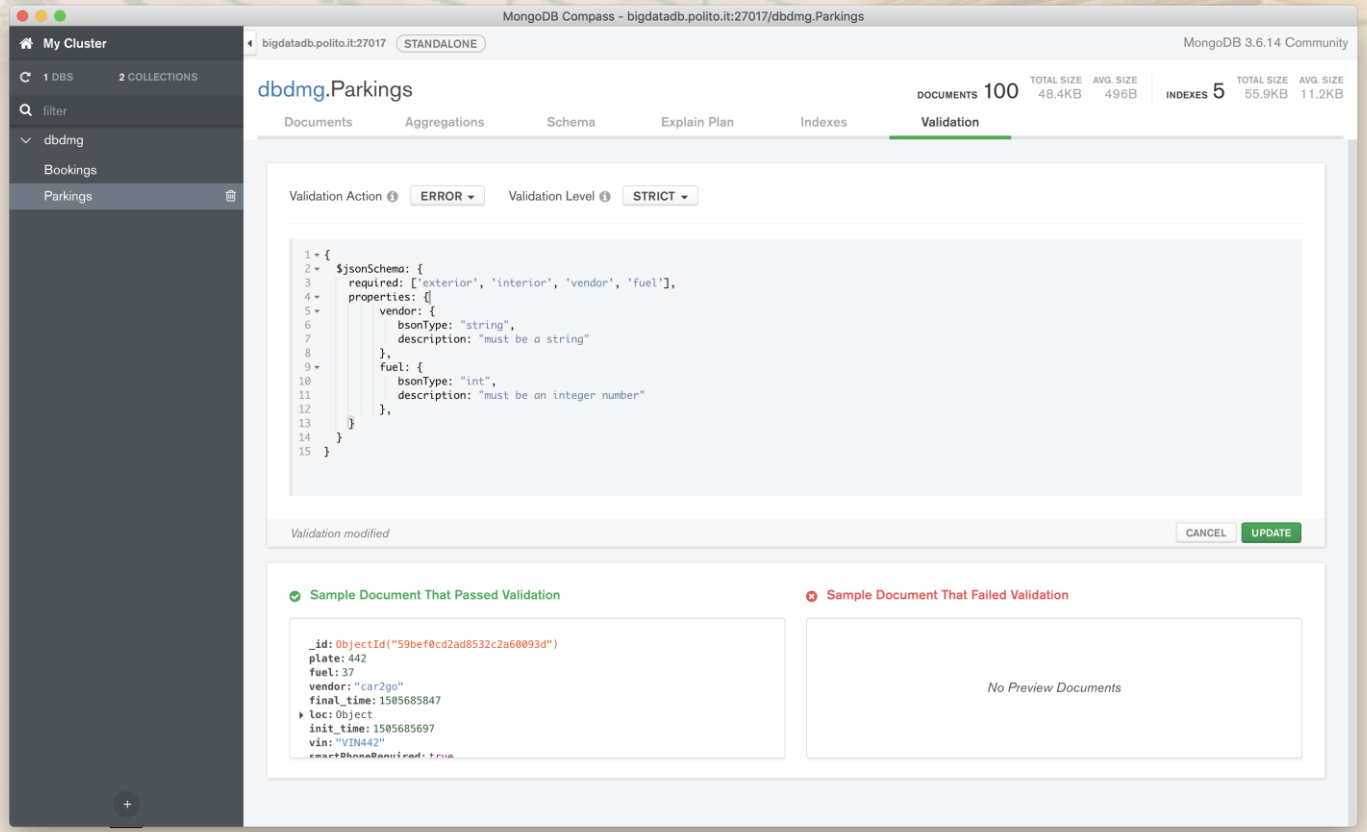
Construct the query step by step.

MongoDB Compass



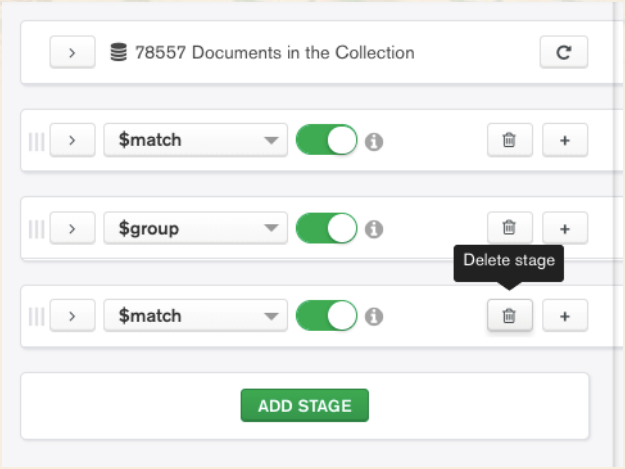
Analyze query performance and get hints to speed it up.

MongoDB Compass

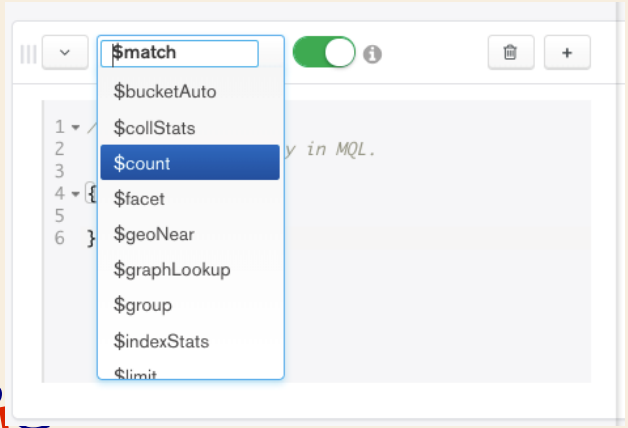


- Specify contraints to validate data
- Find unconsistent documents.

MongoDB Compass: Aggregation

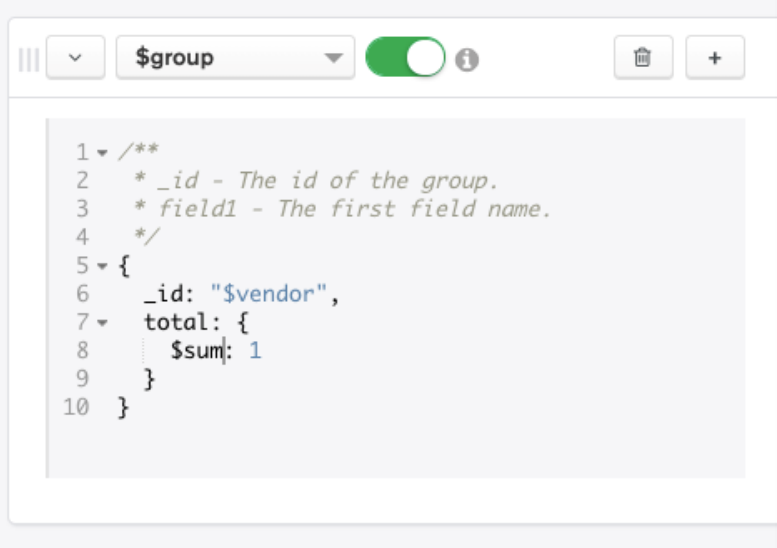


- Build a pipeline consisting of multiple aggregation stages.

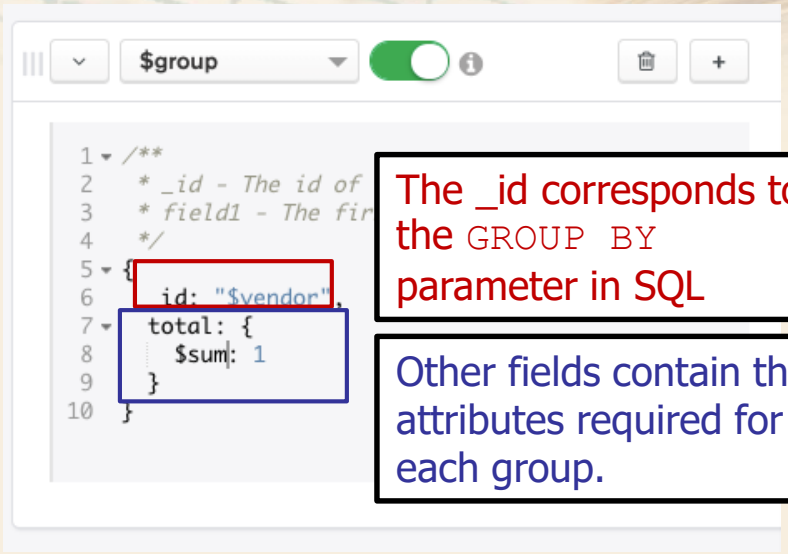


- Define the filter and aggregation attributes for each operator.

MongoDB Compass: Aggregation stages

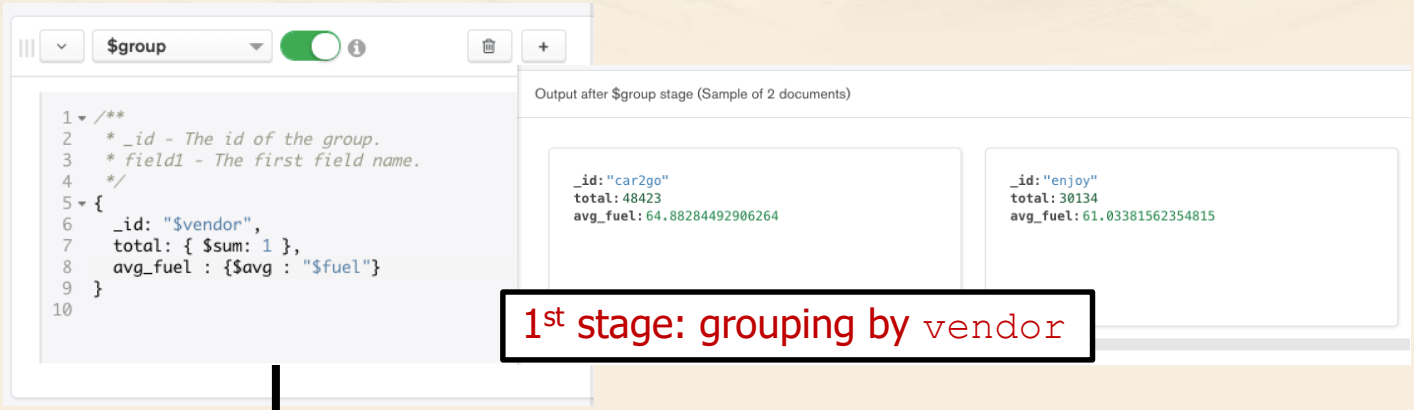


MongoDB Compass: Aggregation stages



One group for each "vendor".

MongoDB Compass: Pipelines



MongoDB

Indexing

MongoDB: Indexes

- Indexes are data structures that store a small portion of the collection's data set in a form easy to traverse.
- They store ordered values of a specific field, or set of fields, in order to efficiently support equality matches, range-based queries and sorting operations.

MongoDB: Indexes

MongoDB provides different data-type indexes

- Single field indexes
- Compound field indexes
- Multikey indexes
- Geospatial indexes
- Text indexes
- Hashed indexes

MongoDB: Create new indexes

Creating an index

```
db.collection.createIndex(<index keys>, <options>)
```

- Before v. 3.0 use `db.collection.ensureIndex()`

Options include: `name`, `unique` (whether to accept or not insertion of documents with duplicate index keys), `background`, `dropDups`, ..

MongoDB: Indexes

Single field indexes

- Support user-defined ascending/descending indexes on a single field of a document

E.g.,

- `db.orders.createIndex( {orderDate: 1} )`

Compound field indexes

- Support user-defined indexes on a set of fields

E.g.,

- `db.orders.createIndex( {orderDate: 1, zipcode: -1} )`

MongoDB: Indexes

- MongoDB supports efficient queries of geospatial data

Geospatial data are stored as:

- GeoJSON objects: embedded document { <type>, <coordinate> }
  - E.g., location: `{type: "Point", coordinates: [-73.856, 40.848]}`
- Legacy coordinate pairs: array or embedded document
  - `point: [-73.856, 40.848]`

MongoDB: Indexes

Geospatial indexes

- Two type of geospatial indexes are provided: `2d` and `2dsphere`

A `2dsphere` index supports queries that calculate geometries on an earth-like sphere

Use a `2d` index for data stored as points on a two-dimensional plane.

E.g.,

- `db.places.createIndex( {location: "2dsphere"} )`

Geospatial query operators

- $geoIntersects, $geoWithin, $near, $nearSphere

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`$near` syntax:

```
{
   <location field>: {
     $near: {
       $geometry: {
          type: "Point" ,
          coordinates: [ <longitude> , <latitude> ]
       },
       $maxDistance: <distance in meters>,
       $minDistance: <distance in meters>
     }
   }
}
```

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E.g.,

- `db.places.createIndex( {location: "2dsphere"} )`

Geospatial query operators

- $geoIntersects, $geoWithin, $near, $nearSphere

Geopatial aggregation stage

- $near

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E.g.,

```
db.places.find({location:
  {$near:
      {$geometry: {
          type: "Point",
          coordinates: [ -73.96, 40.78 ] },
        $maxDistance: 5000}
  }})
```

- Find all the places within 5000 meters from the specified GeoJSON point, sorted in order from nearest to furthest

MongoDB: Indexes

- Text indexes
  - Support efficient searching for string content in a collection
  - Text indexes store only *root words* (no language-specific *stop words* or *stem*)

E.g.,

```
db.reviews.createIndex( {comment: "text"} )
```

  - Wildcard ($**) allows MongoDB to index every field that contains string data
  - E.g.,

```
db.reviews.createIndex( {"$**": "text"} )
```