CET4001B Big Data Technologies

School of Computer Engineering and Technology

CET4001B Big Data Technologies

Teaching Scheme
Credits: 03 + 01
Theory: 3 Hrs / Week
Practical: 2Hrs/Week

Course Objectives:

- Understand the various aspects and life cycle of Big Data
- Learn the concepts of NoSQL for Big Data
- Design an application for distributed systems on Big Data.
- To understand and analyse different storage technologies required for Big Data
- To explore the technological foundations of Big Data Analytics
- To understand the role of various visualization techniques and explore the various Big Data visualization tools.

Course Outcomes:

- Recognize the characteristics of Big Data
- Ability to demonstrate information retrieval of Big Data
- Analyse the HADOOP and Map Reduce technologies associated with big data
- Perform analytics to learn the usage of distributed processing framework
- To investigate the impact of different visualizations for real world applications

Unit-II: **NoSQL databases for Big Data**

- Types of databases
- structured versus unstructured data
- NoSQL movement and concept of NoSQL database
- comparative study of SQL and NoSQL
- Types and examples of NoSQL database
  - key value store, document store, columnar databases, graph databases.
- Characteristics of NoSQL
- NoSQL data modelling
- Advantages of NoSQL
- CAP theorem
- BASE properties
- Sharding
  - characteristics, advantages, types.
- NoSQL using MongoDB
  - - MongoDB shell, data types, CRUD operations, querying, aggregation framework operators, indexing.

Outline

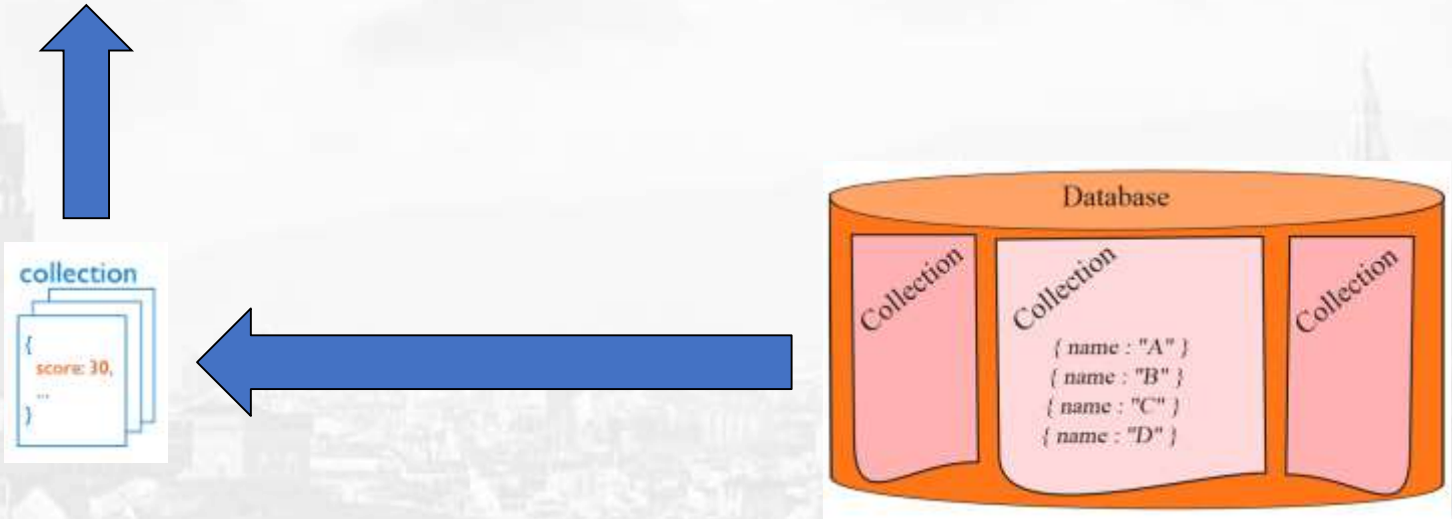
INDEXING

- Indexes support the efficient execution of queries in MongoDB.

Before Index

- **What does database normally do when we query?**
  - **MongoDB must scan every document.**
  - **Inefficient because process large volume of data**

db.users.find({ score: { “$lt” : 30} })



Definition of Index

Definition

- Indexes are special data structures that store a small portion of collection's data set in an easy to traverse form.

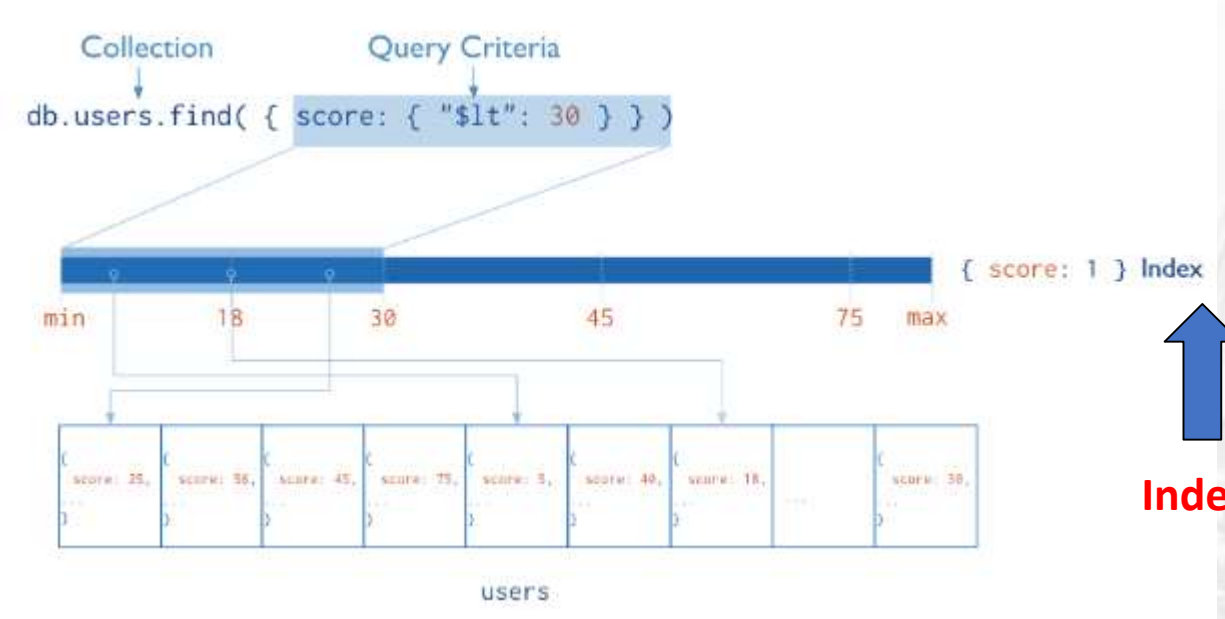


Diagram of a query that uses an index to select

Indexing Types

- ***Single Field Indexes***
  - A single field index only includes data from a single field of the documents in a collection.
- ***Compound Indexes***
  - A compound index includes more than one field of the documents in a collection.
- ***Multikey Indexes***
  - A multikey index is an index on an array field, adding an index key for each value in the array.
- ***Geospatial Indexes and Queries***
  - Geospatial indexes support location-based searches.
- ***Text Indexes***
  - Text indexes support search of string content in documents.
- ***Hashed Index***
  - Hashed indexes maintain entres with hashes of the values of the indexed field and are used with sharded clusters to support hashed shard keys.

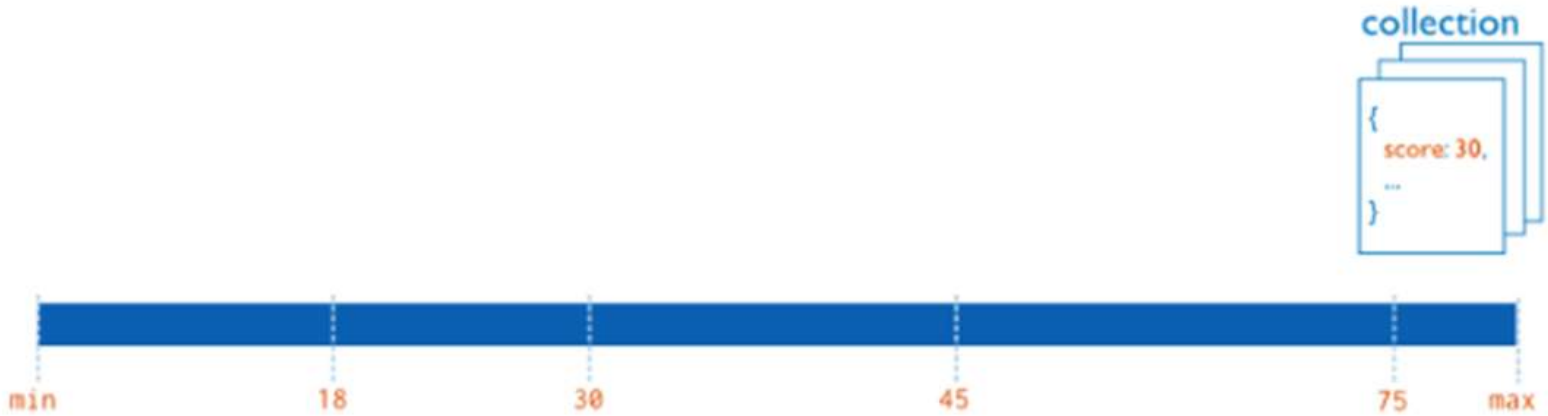


Diagram of an index on the score field (ascending).

Index Types in MongoDB

- Single Field
  - In addition to the MongoDB-defined _id index, MongoDB supports the creation of user-defined ascending/descending indexes on a single field of a document.

Index Types in MongoDB

Single Field

Consider the following Document Collection

```
{
"_id": ObjectId("570c04a4ad233577f97dc459"),
"score": 1034,
"location": { state: “MH", city: “Pune" }
}
db.records.createIndex( {score: 1 } )
```

Queries:

```
db.records.find( { score: 2 } )
db.records.find( { score: { $gt: 10 } } )
```

Index Types in MongoDB

Create Index on Embedded Field

```
db.records.createIndex( { "location.state": 1 } )
```

- Queries:
  - db.records.find({ "location.state": “MH" })
  - db.records.find({ "location.city": “Mumbai", "location.state": “MH" })
- Create Index on Embedded Document
  - Location filed is an embedded document here

```
db.records.createIndex( { location: 1 } )
```

- Queries:
  - db.records.find({ location: { city: “Pune", state: “MH" } })

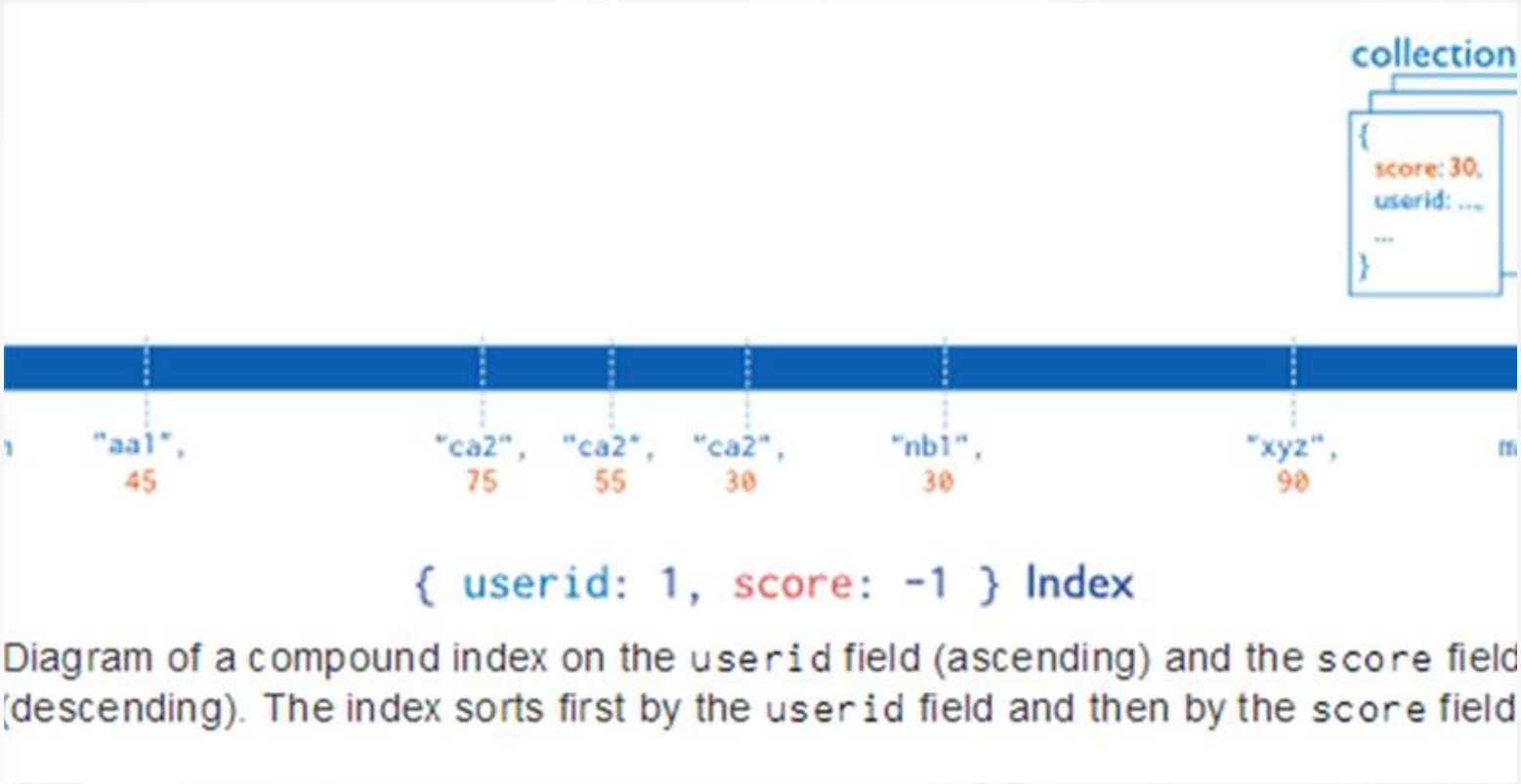


Diagram of a compound index on the `userid` field (ascending) and the `score` field (descending). The index sorts first by the `userid` field and then by the `score` field

Index Types in MongoDB

2. Compound Indexes
- MongoDB supports user-defined indexes on multiple fields, i.e. compound indexes
- The order of fields listed in a compound index has significance.
- *For instance, if a compound index consists of { userid: 1, score: -1 }, the index sorts first by userid and then, within each userid value, sorts by score.*

Index Types in MongoDB

- Compound Indexes

```
{
 "_id": ObjectId(...),
 "item": "Banana",
 "category": ["food", "produce", "grocery"],
 "location": "4th Street Store",
 "stock": 4,
 "type": "cases"
}
```

- Syntax:

```
db.collection.createIndex( { <field1>: <type>, <field2>: <type2>, ... } )
db.products.createIndex( { "item": 1, "stock": 1 } )
```

- Queries:

```
db.products.find( { item: “Apple" } )
db.products.find( { item: “Apple", stock: { $gt: 15 } } )
```

Index Types in MongoDB

2. Compound Indexes: Sort Order

Indexes store references to fields in either ascending (1) or descending (-1) sort order.

For single-field indexes, the sort order of keys doesn't matter because MongoDB can traverse the index in either direction.

However, for compound indexes, sort order can matter in determining whether the index can support a sort operation.

Index Types in MongoDB

- 2. Compound Indexes: Index Prefixes
  - Index prefixes are the beginning subsets of indexed fields.
  - For example, consider the following compound index:
  - db.collection.createIndex({ "item": 1, "location": 1, "stock": 1 })
  - The index has the following index prefixes:
  - { item: 1 }
  - { item: 1, location: 1 }

- MongoDB can use the index for queries on the following fields:
  - the *item* field,
  - the *item* field and the *location* field,
  - the *item* field and the *location* field and the *stock* field.

Index Types in MongoDB

3. Multikey Indexes

- MongoDB uses multikey indexes to index the content stored in arrays.
- If you index a field that holds an array value, MongoDB creates separate index entries for every element of the array.
- These multikey indexes allow queries to select documents that contain arrays by matching on element or elements of the arrays.
- MongoDB automatically determines whether to create a multikey index if the indexed field contains an array value;
- Do not need to explicitly specify the multikey type

Multikey Indexes

- To index a field that holds an array value, MongoDB creates an index key for each element in the array.
- These multikey indexes support efficient queries against array fields.
- Multikey indexes can be constructed over arrays that hold both scalar values (e.g. strings, numbers) and nested documents.

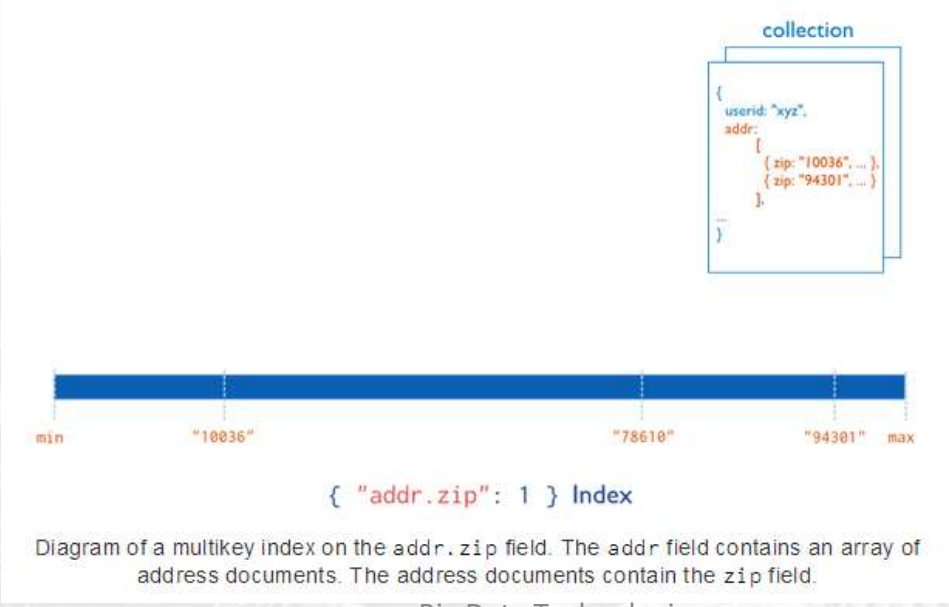


Diagram of a multikey index on the `addr.zip` field. The `addr` field contains an array of address documents. The address documents contain the `zip` field.

Index Types in MongoDB

Multikey Indexes

Syntax:

db.coll.createIndex({ <field>: < 1 or -1 > })

- db.survey.createIndex({ ratings: 1 })

Queries:

- db.survey.find({ ratings : { $elemMatch: { $gte: 3, $lte: 6 } } })

Index Properties

- *Index Properties* The properties you can specify when building indexes.
  - *TTL Indexes* The TTL index is used for TTL collections, which expire data after a period of time
  - *Unique Indexes* A unique index causes MongoDB to reject all documents that contain a duplicate value for the indexed field.
  - *Sparse Indexes* A sparse index does not index documents that do not have the indexed field.

Index Operations in MongoDB

Creation index

- db.users.ensureIndex({ score: 1 })

Show existing indexes

- db.users.getIndexes()

Drop index

- db.users.dropIndex({score: 1})

Explain—Explain

- db.users.find().explain()
- Returns a document that describes the process and indexes

Hint

- db.users.find().hint({score: 1})
- Overide MongoDB's default index selection

Index Creation

Using CreateIndex

db.CollectionName.createIndex({ KeyName: 1 or -1})

Using ensureIndex

db.CollectionName.ensureIndex({KeyName: 1 or -1})

1 for Ascending Sorting

-1 for Descending Sorting

Index Creation

Using CreateIndex

Single: db.stud.createIndex({ zipcode: 1})

Compound: db.stud.createIndex({ dob: 1, zipcode: -1 })

Unique: db.stud.createIndex({ rollno: 1 }, { unique: true })

Sparse: db.stud.createIndex({ age: 1 }, { sparse: true })

Using ensureIndex

Single: db.stud.ensureIndex({“name":1})

Compound: db.stud.ensureIndex ({“address":1,“name":-1})

Index Display

db.collection.getIndexes()

- Returns an array that holds a list of documents that identify and describe the existing indexes on the collection.

db.collection.getIndexStats()

Displays a human-readable summary of aggregated statistics about an index's B-tree data structure.

db.<collection>.getIndexStats({ index : "<index name>" })

Index Drop

Syntax

- db.collection.dropIndex()
- db.collection.dropIndex(*index*)

Example

- db.stud.dropIndex()
- db.stud.dropIndex({ “name" : 1 })

Drop Index Types in MongoDB

_id Index

- You can not drop default index

To drop all non-_id indexes , specify "*" for the index

- db.runCommand({ dropIndexes: "collection", index: "*" })

To drop a single index, specifying the name of the index you want to drop.

- db.runCommand({ dropIndexes: "collection", index: "age" })

Helper Methods

- db.collection.dropIndex("age_1")
- db.collection.dropIndexes()

To drop Multiple Indexes

- db.runCommand({ dropIndexes: "collection", index: ["age_1", "age_1_status_1"] })

Indexing and Querying

create an ascending index on the field ***name*** for a collection records:

```
db.records.createIndex( { name: 1 } )
```

This index can support an ascending sort on ***name*** :
db.records.find().sort({ name: 1 })

The index can also support descending sort

```
db.records.find().sort( { a: -1 } )
```

Indexing and Querying

- db.stud.findOne({rno:2}), using index {rno:1}
- db.stud.find ({rno:5}), using index {rno:1}
- db.stud.find({rno:{$in:[2,3]}}), using index {rno:1}
- db.stud.find({age:{$gt:15}}), using index {age:1}
- db.stud.find({age :{$gt:2,$lt:5}}), using index {age :1}
- db.stud.distinct({branch: “Computer”}) using index {branch:1}
- db.stud.count({age:19}) using index {age:1}

Indexing and Querying

db.stud.find({}, {name:1,age:1}), using index {name:1,age:1}

db.stud.find().sort({name:1,age:1}), using index {name:1,age:1}

db.stud.remove({name: “Jiya”}) using index {name:1}

db.stud.update({age:20}, {age:19}) using index {age:1}

Indexing with Unique

db.collectionname.ensureIndex({x:1}, {unique:true})

- Don't allow {_id:10,x:2} and {_id:11,x:2}
- Don't allow {_id:12} and {_id:13} (both match {x:null})

What if duplicates exist before index is created?

- Normally index creation fails and the index is removed
- db.ensureIndex({x:1}, {unique:true,dropDups:true})

Demo of indexes in MongoDB

- **Import Data**
- **Create Index**
  - Single Field Index
  - Compound Field Indexes
  - Multikey Indexes
- **Show Existing Index**
- **Hint**
  - Single Field Index
  - Compound Field Indexes
  - Multikey Indexes
- **Explain**
- **Compare with data without indexes**

```
> db.zips.find().limit(20)
{ "city" : "ACMAR", "loc" : [ -86.51557, 33.584132 ], "pop" : 6055, "state" : "AL", "_id" : "35004" }
{ "city" : "ADAMSVILLE", "loc" : [ -86.959727, 33.588437 ], "pop" : 10616, "state" : "AL", "_id" : "35005" }
{ "city" : "ADGER", "loc" : [ -87.167455, 33.434277 ], "pop" : 3205, "state" : "AL", "_id" : "35006" }
{ "city" : "KEYSTONE", "loc" : [ -86.812861, 33.236868 ], "pop" : 14218, "state" : "AL", "_id" : "35007" }
{ "city" : "NEW SITE", "loc" : [ -85.951086, 32.941445 ], "pop" : 19942, "state" : "AL", "_id" : "35010" }
{ "city" : "ALPINE", "loc" : [ -86.208934, 33.331165 ], "pop" : 3062, "state" : "AL", "_id" : "35014" }
{ "city" : "ARAB", "loc" : [ -86.489638, 34.328339 ], "pop" : 13650, "state" : "AL", "_id" : "35016" }
{ "city" : "BAILEYTON", "loc" : [ -86.621299, 34.268298 ], "pop" : 1781, "state" : "AL", "_id" : "35019" }
{ "city" : "BESSEMER", "loc" : [ -86.947547, 33.409002 ], "pop" : 40549, "state" : "AL", "_id" : "35020" }
{ "city" : "HUEYTOWN", "loc" : [ -86.999607, 33.414625 ], "pop" : 39677, "state" : "AL", "_id" : "35023" }
{ "city" : "BLOUNTSVILLE", "loc" : [ -86.568628, 34.092937 ], "pop" : 9058, "state" : "AL", "_id" : "35031" }
{ "city" : "BREMEN", "loc" : [ -87.004281, 33.973664 ], "pop" : 3448, "state" : "AL", "_id" : "35033" }
{ "city" : "BRENT", "loc" : [ -87.211387, 32.93567 ], "pop" : 3791, "state" : "AL", "_id" : "35034" }
{ "city" : "BRIERFIELD", "loc" : [ -86.951672, 33.042747 ], "pop" : 1282, "state" : "AL", "_id" : "35035" }
{ "city" : "CALERA", "loc" : [ -86.755987, 33.1098 ], "pop" : 4675, "state" : "AL", "_id" : "35040" }
{ "city" : "CENTREVILLE", "loc" : [ -87.11924, 32.950324 ], "pop" : 4962, "state" : "AL", "_id" : "35042" }
{ "city" : "CHELSEA", "loc" : [ -86.614132, 33.371582 ], "pop" : 4781, "state" : "AL", "_id" : "35043" }
{ "city" : "COOSA PINES", "loc" : [ -86.337622, 33.266928 ], "pop" : 7985, "state" : "AL", "_id" : "35044" }
{ "city" : "CLANTON", "loc" : [ -86.642472, 32.835532 ], "pop" : 13990, "state" : "AL", "_id" : "35045" }
{ "city" : "CLEVELAND", "loc" : [ -86.559355, 33.992106 ], "pop" : 2369, "state" : "AL", "_id" : "35049" }
> db.zips.find().count()
29467
```

Demo of indexes in MongoDB

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```
db.zips.ensureIndex({pop: -1})
db.zips.ensureIndex({state: 1, city: 1})
db.zips.ensureIndex({loc: -1})
```

Demo of indexes in MongoDB

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```
> db.zips.getIndexes()
[
        {
                "v" : 1,
                "key" : {
                        "_id" : 1
                },
                "ns" : "blog.zips",
                "name" : "_id_"
        },
        {
                "v" : 1,
                "key" : {
                        "pop" : 1
                },
                "ns" : "blog.zips",
                "name" : "pop_1"
        },
        {
                "v" : 1,
                "key" : {
                        "state" : 1,
                        "city" : 1
                },
                "ns" : "blog.zips",
                "name" : "state_1_city_1"
        },
        {
                "v" : 1,
                "key" : {
                        "loc" : 1
                },
                "ns" : "blog.zips",
                "name" : "loc_1"
        }
]
```

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```
> db.zips.find().limit(20).hint({pop: -1})
{ "city" : "CHICAGO", "loc" : [ -87.7157, 41.849015 ], "pop" : 112047, "state" : "IL", "_id" : "60623" }
{ "city" : "BROOKLYN", "loc" : [ -73.956985, 40.646694 ], "pop" : 111396, "state" : "NY", "_id" : "11226" }
{ "city" : "NEW YORK", "loc" : [ -73.958805, 40.768476 ], "pop" : 106564, "state" : "NY", "_id" : "10021" }
{ "city" : "NEW YORK", "loc" : [ -73.968312, 40.797466 ], "pop" : 100027, "state" : "NY", "_id" : "10025" }
{ "city" : "BELL GARDENS", "loc" : [ -118.17205, 33.969177 ], "pop" : 99568, "state" : "CA", "_id" : "90201" }
{ "city" : "CHICAGO", "loc" : [ -87.556012, 41.725743 ], "pop" : 98612, "state" : "IL", "_id" : "60617" }
{ "city" : "LOS ANGELES", "loc" : [ -118.258189, 34.007856 ], "pop" : 96074, "state" : "CA", "_id" : "90011" }
{ "city" : "CHICAGO", "loc" : [ -87.704322, 41.920903 ], "pop" : 95971, "state" : "IL", "_id" : "60647" }
{ "city" : "CHICAGO", "loc" : [ -87.624277, 41.693443 ], "pop" : 94317, "state" : "IL", "_id" : "60628" }
{ "city" : "NORWALK", "loc" : [ -118.081767, 33.90564 ], "pop" : 94188, "state" : "CA", "_id" : "90650" }
{ "city" : "CHICAGO", "loc" : [ -87.654251, 41.741119 ], "pop" : 92005, "state" : "IL", "_id" : "60620" }
{ "city" : "CHICAGO", "loc" : [ -87.706936, 41.778149 ], "pop" : 91814, "state" : "IL", "_id" : "60629" }
{ "city" : "CHICAGO", "loc" : [ -87.653279, 41.809721 ], "pop" : 89762, "state" : "IL", "_id" : "60609" }
{ "city" : "CHICAGO", "loc" : [ -87.704214, 41.946401 ], "pop" : 88377, "state" : "IL", "_id" : "60618" }
{ "city" : "JACKSON HEIGHTS", "loc" : [ -73.878551, 40.740388 ], "pop" : 88241, "state" : "NY", "_id" : "11373" }
{ "city" : "ARLETA", "loc" : [ -118.420692, 34.258081 ], "pop" : 88114, "state" : "CA", "_id" : "91331" }
{ "city" : "BROOKLYN", "loc" : [ -73.914483, 40.662474 ], "pop" : 87079, "state" : "NY", "_id" : "11212" }
{ "city" : "SOUTH GATE", "loc" : [ -118.201349, 33.94617 ], "pop" : 87026, "state" : "CA", "_id" : "90280" }
{ "city" : "RIDGEWOOD", "loc" : [ -73.896122, 40.703613 ], "pop" : 85732, "state" : "NY", "_id" : "11385" }
{ "city" : "BRONX", "loc" : [ -73.871242, 40.873671 ], "pop" : 85710, "state" : "NY", "_id" : "10467" }
```

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```
> db.zips.find().limit(20).hint({state: 1, city: 1})
{ "city" : "98791", "loc" : [  -176.310048,  51.938901 ], "pop" : 5345, "state" : "AK", "_id" : "98791" }
{ "city" : "AKHIOK", "loc" : [  -152.500169,  57.781967 ], "pop" : 13309, "state" : "AK", "_id" : "99615" }
{ "city" : "AKIACHAK", "loc" : [  -161.39233,  60.891854 ], "pop" : 481, "state" : "AK", "_id" : "99551" }
{ "city" : "AKIAK", "loc" : [  -161.199325,  60.890632 ], "pop" : 285, "state" : "AK", "_id" : "99552" }
{ "city" : "AKUTAN", "loc" : [  -165.785368,  54.143012 ], "pop" : 589, "state" : "AK", "_id" : "99553" }
{ "city" : "ALAKANUK", "loc" : [  -164.60228,  62.746967 ], "pop" : 1186, "state" : "AK", "_id" : "99554" }
{ "city" : "ALEKNAGIK", "loc" : [  -158.619882,  59.269688 ], "pop" : 185, "state" : "AK", "_id" : "99555" }
{ "city" : "ALLAKAKET", "loc" : [  -152.712155,  66.543197 ], "pop" : 170, "state" : "AK", "_id" : "99720" }
{ "city" : "AMBLER", "loc" : [  -156.455652,  67.46951 ], "pop" : 8, "state" : "AK", "_id" : "99786" }
{ "city" : "ANAKTUVUK PASS", "loc" : [  -151.679005,  68.11878 ], "pop" : 260, "state" : "AK", "_id" : "99721" }
{ "city" : "ANCHORAGE", "loc" : [  -149.876077,  61.211571 ], "pop" : 14436, "state" : "AK", "_id" : "99501" }
{ "city" : "ANCHORAGE", "loc" : [  -150.093943,  61.096163 ], "pop" : 15891, "state" : "AK", "_id" : "99502" }
{ "city" : "ANCHORAGE", "loc" : [  -149.893844,  61.189953 ], "pop" : 12534, "state" : "AK", "_id" : "99503" }
{ "city" : "ANCHORAGE", "loc" : [  -149.74467,  61.203696 ], "pop" : 32383, "state" : "AK", "_id" : "99504" }
{ "city" : "ANCHORAGE", "loc" : [  -149.828912,  61.153543 ], "pop" : 20128, "state" : "AK", "_id" : "99507" }
{ "city" : "ANCHORAGE", "loc" : [  -149.810085,  61.205959 ], "pop" : 29857, "state" : "AK", "_id" : "99508" }
{ "city" : "ANCHORAGE", "loc" : [  -149.897401,  61.119381 ], "pop" : 17094, "state" : "AK", "_id" : "99515" }
{ "city" : "ANCHORAGE", "loc" : [  -149.779998,  61.10541 ], "pop" : 18356, "state" : "AK", "_id" : "99516" }
{ "city" : "ANCHORAGE", "loc" : [  -149.936111,  61.190136 ], "pop" : 15192, "state" : "AK", "_id" : "99517" }
{ "city" : "ANCHORAGE", "loc" : [  -149.886571,  61.154862 ], "pop" : 8116, "state" : "AK", "_id" : "99518" }
```

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```
> db.zips.find().limit(20).hint({loc: -1})
{ "city" : "BARROW", "loc" : [ -156.817409, 71.234637 ], "pop" : 3696, "state" : "AK", "_id" : "99723" }
{ "city" : "WAINWRIGHT", "loc" : [ -160.012532, 70.620064 ], "pop" : 492, "state" : "AK", "_id" : "99782" }
{ "city" : "NUIQSUT", "loc" : [ -150.997119, 70.192737 ], "pop" : 354, "state" : "AK", "_id" : "99789" }
{ "city" : "PRUDHOE BAY", "loc" : [ -148.559636, 70.070057 ], "pop" : 153, "state" : "AK", "_id" : "99734" }
{ "city" : "KAKTOVIK", "loc" : [ -143.631329, 70.042889 ], "pop" : 245, "state" : "AK", "_id" : "99747" }
{ "city" : "POINT LAY", "loc" : [ -162.906148, 69.705626 ], "pop" : 139, "state" : "AK", "_id" : "99759" }
{ "city" : "POINT HOPE", "loc" : [ -166.72618, 68.312058 ], "pop" : 640, "state" : "AK", "_id" : "99766" }
{ "city" : "ANAKTUVUK PASS", "loc" : [ -151.679005, 68.11878 ], "pop" : 260, "state" : "AK", "_id" : "99721" }
{ "city" : "ARCTIC VILLAGE", "loc" : [ -145.423115, 68.077395 ], "pop" : 107, "state" : "AK", "_id" : "99722" }
{ "city" : "KIVALINA", "loc" : [ -163.733617, 67.665859 ], "pop" : 689, "state" : "AK", "_id" : "99750" }
{ "city" : "AMBLER", "loc" : [ -156.455652, 67.46951 ], "pop" : 8, "state" : "AK", "_id" : "99786" }
{ "city" : "KIANA", "loc" : [ -158.152204, 67.18026 ], "pop" : 349, "state" : "AK", "_id" : "99749" }
{ "city" : "BETTLES FIELD", "loc" : [ -151.062414, 67.100495 ], "pop" : 156, "state" : "AK", "_id" : "99726" }
{ "city" : "VENETIE", "loc" : [ -146.413723, 67.010446 ], "pop" : 184, "state" : "AK", "_id" : "99781" }
{ "city" : "NOATAK", "loc" : [ -160.509453, 66.97553 ], "pop" : 395, "state" : "AK", "_id" : "99761" }
{ "city" : "SHUNGNAK", "loc" : [ -157.613496, 66.958141 ], "pop" : 0, "state" : "AK", "_id" : "99773" }
{ "city" : "KOBUK", "loc" : [ -157.066864, 66.912253 ], "pop" : 306, "state" : "AK", "_id" : "99751" }
{ "city" : "KOTZEBUE", "loc" : [ -162.126493, 66.846459 ], "pop" : 3347, "state" : "AK", "_id" : "99752" }
{ "city" : "NOORVIK", "loc" : [ -161.044132, 66.836353 ], "pop" : 534, "state" : "AK", "_id" : "99763" }
{ "city" : "CHALKYITSIK", "loc" : [ -143.638121, 66.719 ], "pop" : 99, "state" : "AK", "_id" : "99788" }
```

Demo of indexes in MongoDB

- **Import Data**
- **Create Index**
  - Single Field Index
  - Compound Field Indexes
  - Multikey Indexes
- **Show Existing Index**
- **Hint**
  - Single Field Index
  - Compound Field Indexes
  - Multikey Indexes
- **Explain**
- **Compare with data without indexes**

```
> db.zips.find({city: 'NASHVILLE', state: 'TN'}).explain()
{
        "cursor" : "BasicCursor",
        "isMultiKey" : false,
        "n" : 19,
        "nscannedObjects" : 29467,
        "nscanned" : 29467,
        "nscannedObjectsAllPlans" : 29467,
        "nscannedAllPlans" : 29467,
        "scanAndOrder" : false,
        "indexOnly" : false,
        "nYields" : 0,
        "nChunkSkips" : 0,
        "millis" : 33,
        "indexBounds" : {

        },
        "server" : "g:27017"
}
```

Demo of indexes in MongoDB

- Import Data
- Create Index
  - Single Field Index
  - Compound Field Indexes
  - Multikey Indexes
- Show Existing Index
- Hint
  - Single Field Index
  - Compound Field Indexes
  - Multikey Indexes
- Explain
- Compare with data without indexes

```
> db.zips.dropIndexes()
{
        "nIndexesWas" : 4,
        "msg" : "non-_id indexes dropped for collection",
        "ok" : 1
}
> db.zips.find({city: 'NASHVILLE', state: 'TN'}).explain()
{
        "cursor" : "BasicCursor",
        "isMultiKey" : false,
        "n" : 19,
        "nscannedObjects" : 29467,
        "nscanned" : 29467,
        "nscannedObjectsAllPlans" : 29467,
        "nscannedAllPlans" : 29467,
        "scanAndOrder" : false,
        "indexOnly" : false,
        "nYields" : 0,
        "nChunkSkips" : 0,
        "millis" : 33,
        "indexBounds" : {

        },
        "server" : "g:27017"
}
```

Without Index

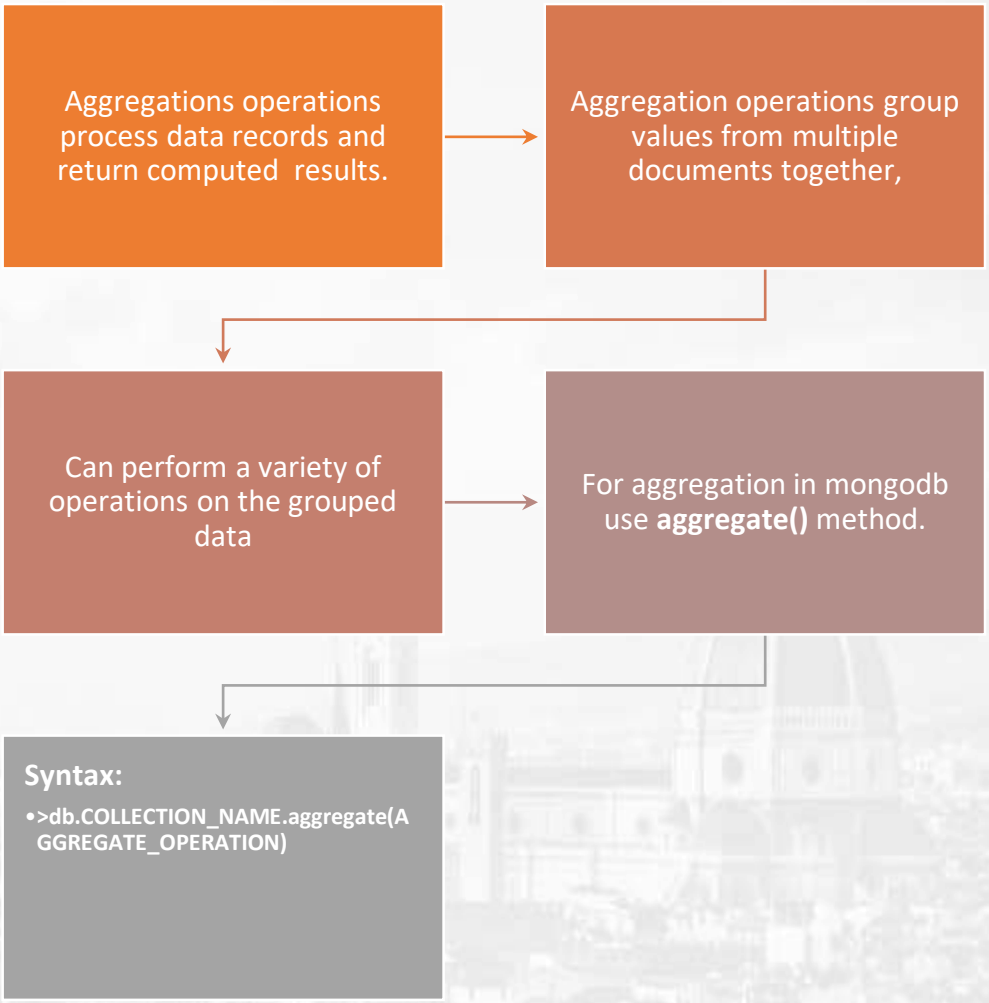
With Index

```
> db.zips.find({city: 'NASHVILLE', state: 'TN'}).explain()
{
        "cursor" : "BtreeCursor state_1_city_1",
        "isMultiKey" : false,
        "n" : 19,
        "nscannedObjects" : 19,
        "nscanned" : 19,
        "nscannedObjectsAllPlans" : 19,
        "nscannedAllPlans" : 19,
        "scanAndOrder" : false,
        "indexOnly" : false,
        "nYields" : 0,
        "nChunkSkips" : 0,
        "millis" : 0,
        "indexBounds" : {
                "state" : [
                        [
                                "TN",
                                "TN"
                        ]
                ],
                "city" : [
                        [
                                "NASHVILLE",
                                "NASHVILLE"
                        ]
                ]
        },
        "server" : "g:27017"
}
```

Indexing Aggregation

- Outline

Aggregation



Aggregation

MongoDB's aggregation framework is modeled on the concept of data processing pipelines.

Documents enter a multi-stage pipeline that transforms the documents into an aggregated result.

Other pipeline operations provide tools for grouping and sorting documents by specific field or fields.

- In addition, pipeline stages can use operators for tasks such as calculating the average or concatenating a string.

aggregate() method

Expression	Description
$sum	Sums up the defined value from all documents in the collection.
$avg	Calculates the average of all given values from all documents in the collection.
$min	Gets the minimum of the corresponding values from all documents in the collection.
$max	Gets the maximum of the corresponding values from all documents in the collection.
$first	Gets the first document from the source documents according to the grouping.
$last	Gets the last document from the source documents according to the grouping.

Pipeline Concept

- There is a set of possible stages and each of those is taken as a set of documents as an input and produces a resulting set of documents

Aggregation Framework in MongoDB

Three classes of aggregation commands

- Aggregation Pipeline,
- Map – Reduce,
- Single Purpose Aggregation

All three commands process documents from a single collection

Aggregation Pipeline uses native MongoDB operations and is the preferred aggregation method

Map – Reduce:

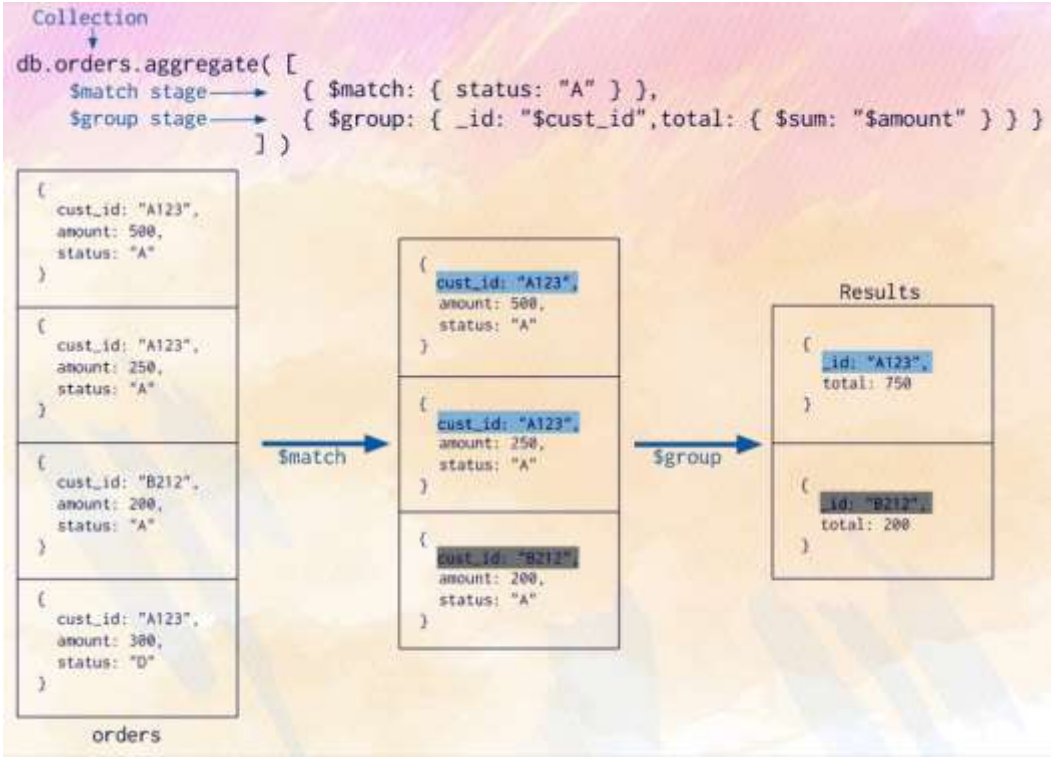
- Has two phases: a map phase that processes each input document and emits objects, and a reduce phase that combines the output of the map operation
- It is based on custom JavaScript functions and aimed for very large collection

Single Purpose Aggregation

- These operations aggregate all the documents from a single collection in MongoDB.
- Even though they provide simple access to common aggregation operations they lack the flexibility and capability of map-reduce and aggregation pipeline.

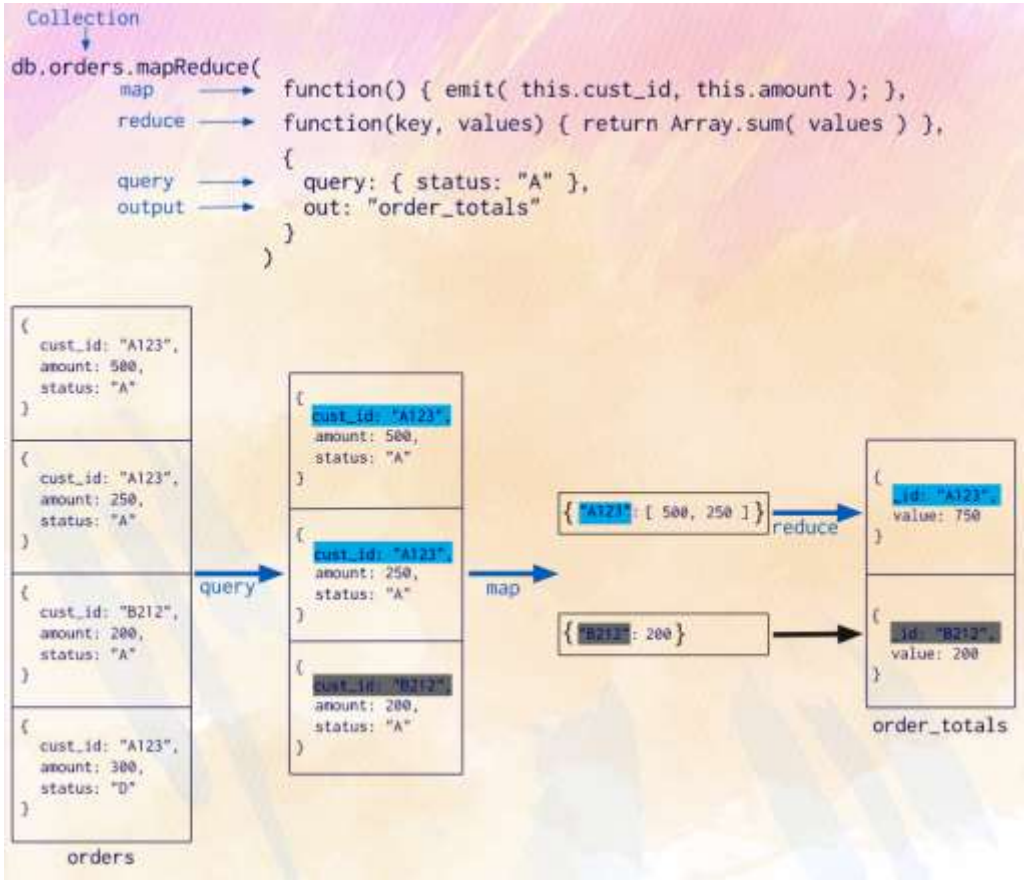
Aggregation Framework in MongoDB

- Aggregation Pipeline uses native MongoDB operations and is the preferred aggregation method



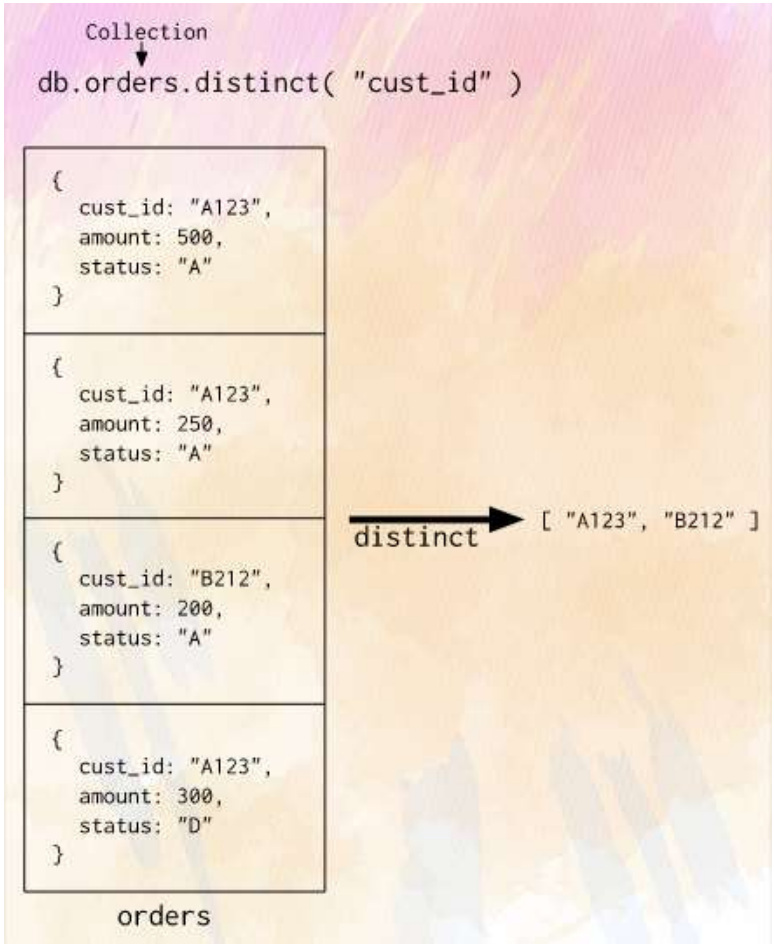
Aggregation Framework in MongoDB

Map-Reduce uses JavaScript to perform its operations including the finalize operation

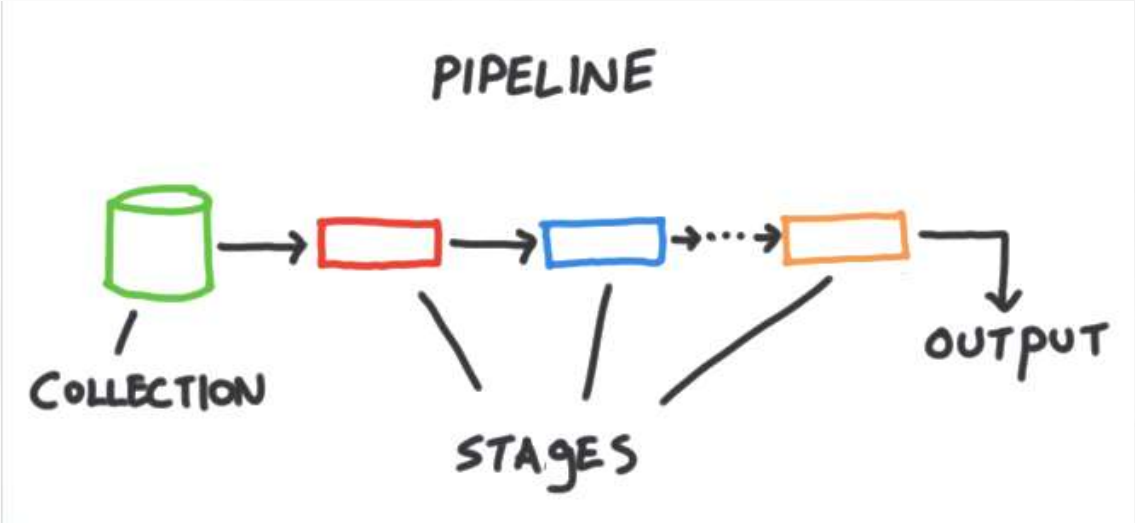


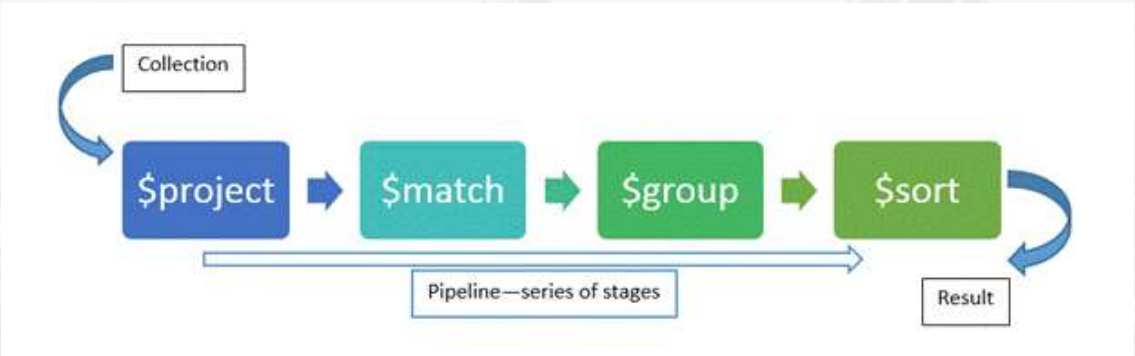
Aggregation Framework in MongoDB

These operations aggregate all the documents from a single collection in MongoDB.



Aggregation Pipeline





Aggregation pipeline

- Aggregation pipeline consists of *stages*
- Each stage transforms the documents as they pass through the pipeline:
  - Some stages transform old into new documents,
  - Others filter out documents,
  - The same stage can appear multiple times in a pipeline
- For the aggregation pipeline, MongoDB provides the
  - **db.collection.aggregate()** method in the mongo shell
  - Pipeline stages appear in an array
  - Documents pass through the stages in sequence
  - **db.collection.aggregate([{<stage> },...])**

Pipeline Expressions

- Some pipeline stages take pipeline expressions as their operands
- Pipeline expressions specify the transformation to apply to the input documents
- Expressions have a *document* structure and can contain other *expressions*
- Pipeline expressions can only operate on the current document in the pipeline and cannot refer to data from other documents:
  - Expression operations provide in-memory transformation of documents
  - Expression operators take an array of arguments and have the following form:
  - {<operator>: [<argument1>, ...] }
  - If an operator accepts a single argument
  - {<operator>: <argument>}

Aggregation Framework Operators

- $group
- $project
- $match
- $limit
- $skip
- $sort
- $unwind

Possible stages in aggregation

$project – Used to select some specific fields from a collection.

$match – This is a filtering operation and thus this can reduce the amount of documents that are given as input to the next stage.

$group – This does the actual aggregation as discussed above.

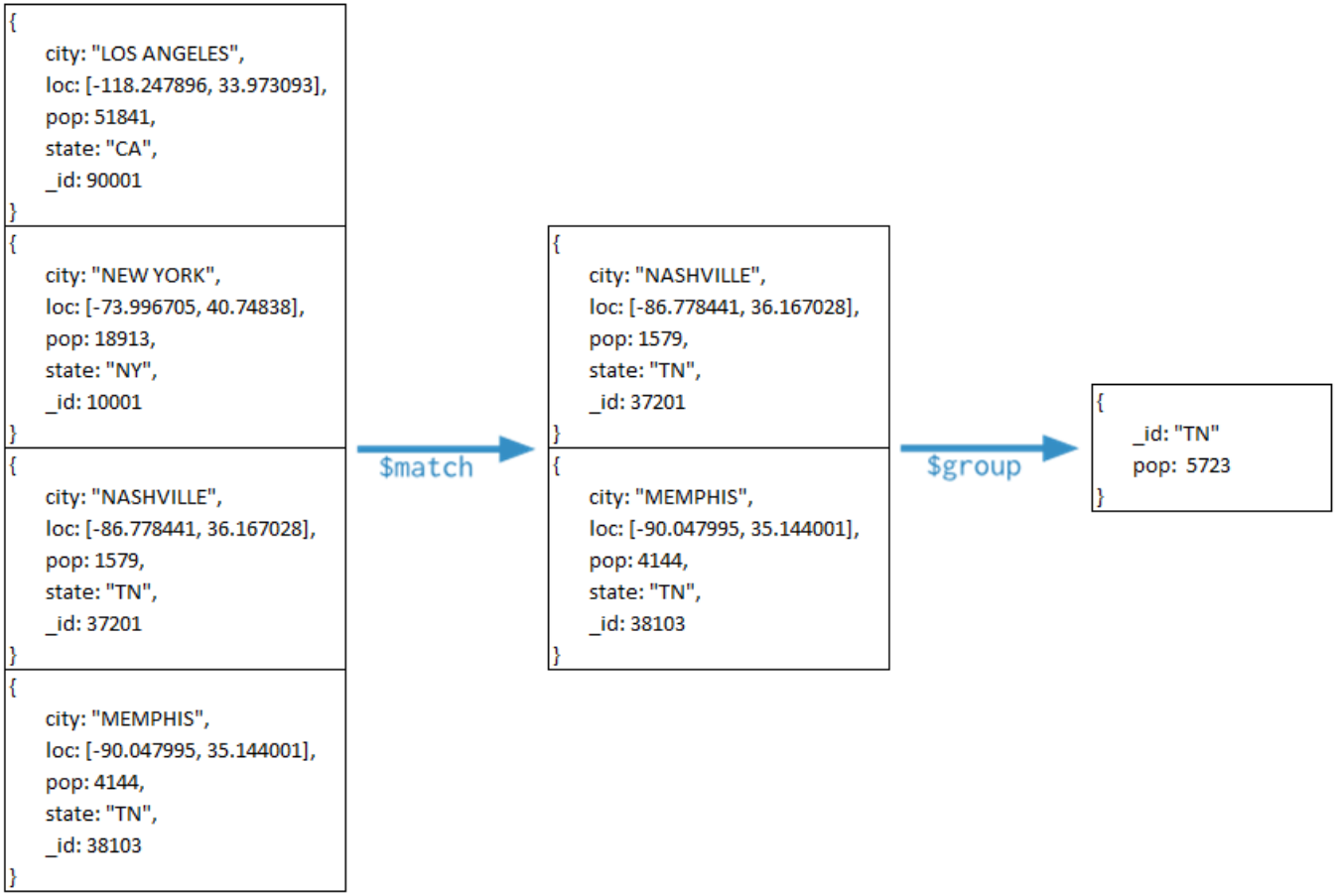
$sort – Sorts the documents.

$skip – With this, it is possible to skip forward in the list of documents for a given amount of documents.

$limit – This limits the amount of documents to look at, by the given number starting from the current positions.

$unwind – This is used to unwind document that are using arrays. When using an array, the data is kind of pre-joined and this operation will be undone with this to have individual documents again. Thus with this stage we will increase the amount of documents for the next stage.

```
db.zips.aggregate(
                    { $match: { state: "TN" } },
                    { $group: {_id: "TN", pop: { $sum: "$pop" } } }
                  );
```



Collection creation to run practical

- db.student.insert({Rollno:1,name:' Navin ',subject:'DMSA',marks:78});
- db.student.insert({Rollno:2,name:' anusha',subject:'OSD',marks:75});
- db.student.insert({Rollno:3,name:'ravi',subject:'TOC',marks:69});
- db.student.insert({Rollno:4,name:' veena',subject:'TOC',marks:70});
- db.student.insert({Rollno:5,name: ‘Pravini',subject: ‘OSD',marks:80});
- db.student.insert({Rollno:6,name: ‘Reena',subject: ‘DMSA',marks:50});
- db.student.insert({Rollno:7,name: ‘Geeta',subject: ‘CN',marks:90});
- db.student.insert({Rollno:8,name: ‘Akash',subject: ‘CN',marks:85});

MIN()

```
db.student.aggregate
([{$group : {_id :
"$subject",marks : {$min :
"$marks"}}}]);
```

SQL Equivalent Query

```
Select subject, min(marks)
from student  group by subject
```

MAX()

```
db.student.aggregate  ([{$group : {_id : "$subject", marks : {$max : "$marks"}}}]);
```

SQL Equivalent Query

```
Select subject, max(marks) from student group by subject
```

AVG()

```
db.student.aggregate  ([{$group : {_id : "$subject",marks : {$avg : "$marks"}}}]);
```

SQL Equivalent Query

```
Select subject, avg(marks) from student  group by subject
```

FIRST()

- db.student.aggregate([{$group : {_id : "$subject",marks : {$first : "$marks"}}}]);

LAST()

- db.student.aggregate ([{$group : {_id : "$subject",marks : {$last : "$marks"}}}]);

SUM()-Example 1

```
db.student.aggregate  ([{$group : {_id : "$subject",marks : {$sum :"$marks"}}}]);
```

SQL Equivalent Query

```
Select subject, sum(marks) from student  group by subject
```

SUM(): Example 2

```
db.student.aggregate  ([{$group : {_id : "$subject",Count: {$sum : 1}}}]);
```

SQL Equivalent Query

```
Select subject, count(*) from student  group by subject
```

$match

- db.student.aggregate([{ $match: {subject:"OSD"}}])
- db.student.aggregate([{$match:{subject:"OSD" }},{$group:{_id:null,count:{$sum:1}}}]);

SUM()- Example 3

```
db.student.aggregate([{ $match: {subject:"OSD"}},{$group:{_id:null,count:{$sum:1}}}]);
```

SQL Equivalent Query

```
Select subject, count(*) from student  group by subject having subject="OSD"
```

Limit() & Skip()

```
db.student.aggregate([{
$match:
{subject:"OSD"}},{$limit:1}]);
```

```
db.student.aggregate([{
$match:
{subject:"OSD"}},{$skip:1}]);
```

Sort()

```
db.student.aggregate([{ $match: {subject:"OSD"}},{$sort:{marks:-1}}]);
```

```
db.student.aggregate([{ $match: {subject:"OSD"}},{$sort:{marks:1}}]);
```

Unwind()

If following document is their in collection(Array)

- db.student.insert({rollno:9,name:"Anavi",marks:[80,30,50]});

Using Unwind the above document will be unwinded into 3 different document

- db.student.aggregate([{$unwind:"$marks"}])

Exercise 01

Return States with Populations above 10 Million

{ "_id": "10280", "city": "NEW YORK", "state": "NY", "pop": 5574, "loc": [-74.016323, 40.710537] }

Solution

- db.zipcodes.aggregate({ $group : { _id : "$state", totalPop : { $sum : "$pop" } } }, { $match : {totalPop : { $gte : 10*1000*1000 } } })

Exercise 02

Return Average City Population by State

{ "_id": "10280", "city": "NEW YORK", "state": "NY", "pop": 5574, "loc": [-74.016323, 40.710537] }

Solution

```
db.zipcodes.aggregate( [
{ $group : { _id : { state : "$state", city : "$city" },
 pop : { $sum : "$pop" } } },
{ $group : { _id : "$_id.state", avgCityPop :
 { $avg : "$pop" } } } ] )
```

Exercise 03

Return Usernames Ordered by Join Month

{ _id : "jane", joined : ISODate("2011-03-02"), likes : ["golf", "racquetball"] }

{ _id : "joe", joined : ISODate("2012-07-02"), likes : ["tennis", "golf", "swimming"] }

Solution

- db.users.aggregate([{ $project : { month_joined : { $month : "$joined" } } } ,

{ $group : { _id : {month_joined:"$month_joined"} , number : { $sum : 1 } } },

{ $sort : { "_id.month_joined" : 1 } }])

Exercise 04

Return the Five Most Common “Likes”

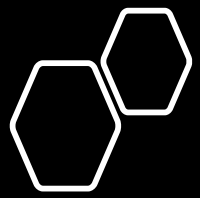
```
{ _id : "jane", joined : ISODate("2011-03-02"), likes : ["golf", "racquetball"] }
{ _id : "joe", joined : ISODate("2012-07-02"), likes : ["tennis", "golf", "swimming"] }
```

Solution

- db.users.aggregate([{ $unwind : "$likes" },

{ $group : { _id : "$likes" , number : { $sum : 1 } } },

{ $sort : { number : -1 } }, { $limit : 5 }])



$unwind

{ _id : "jane", joined : ISODate("2011-03-02"), likes : ["golf", "racquetball"] }

The $unwind operator would create the following documents:

{ _id : "jane", joined : ISODate("2011-03-02"), likes : "golf" }

{ _id : "jane", joined : ISODate("2011-03-02"), likes : "racquetball" }

Refernces

- https://www.tutorialspoint.com/mongodb/mongodb_aggrega_tion.htm
- http://pradipshewale.blogspot.in/2015/09/aggregation-and-_indexing-with-suitable.html
- https://www.infoq.com/articles/implementing-aggregation-_functions-in-mongodb
- http://docs.mongodb.org/manual/reference/operator/aggreg_ation/