Database Applications
Lecture 9: Data Models for MongoDB

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Topics

- Continue with queries on single document collections
- Writing queries with complex documents.
- A Data Model – **Will be discussed later**
  - Embedding
  - Referencing

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Demo time!

More queries on single document collections
Contd from week 8.

Let's do it on MongoDB Compass

Filter a document – with multiple conditions

- In SQL:

```
SELECT *
    FROM people
    WHERE status = 'A' AND
          age = 25;
```

AND is the default.

- In MongoDB Shell:

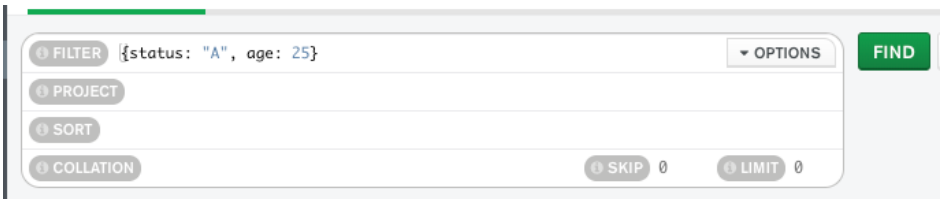
```
db.people.find(
    { status: "A",
      age: 25 }
)
```

Filter a document

- In SQL:

```
SELECT *
    FROM people
    WHERE status = 'A' AND
          age = 25;
```

- In MongoDB Compass:



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Filter a document – with OR conditions

- In SQL:

```
SELECT *
    FROM people
    WHERE status = 'A' OR
          age = 25;
```

OR is applied to an array of conditions. [ ] denotes an array.

- In MongoDB Shell:

```
db.people.find(
    { $or: [ { status: "A" } , { age: 25 } ] }
)
```

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Filter a document – with OR conditions

- In SQL:

```
SELECT *
    FROM people
    WHERE status = 'A' OR
          age = 25;
```

- In MongoDB Compass:

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Filter a document – with "Not Equal"

$ne means "not equal"

- In SQL:

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

- In MongoDB Shell:

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

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Filter a document – middle-aged people!

- In SQL:

```
SELECT *
    FROM people
    WHERE  age > 35 AND age <= 60;
```

- In MongoDB Shell:

```
db.people.find(
     { age: { $gt: 35, $lte: 60 }}
)
```

$gt: greater than
$gte: greater than or equal
$lt: less than
$lte: less than or equal

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Filter a document – Partial Matches

- In SQL:

```
SELECT *
    FROM people
    WHERE  name LIKE '%Sam%;
```

- In MongoDB Shell:

```
db.people.find(
     {name: /Sam/}
)
```

More complex regular expressions are possible. To be discussed later. E.g.
`{name: {$regex: /Sam/ } }`

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Filter a document – Using Composite Fields

- In SQL: Cannot be done!

```
SELECT *
    FROM people
    WHERE  address.suburb = 'Happyville';
```

- In MongoDB Shell:

```
db.people.find(
     {"address.suburb": "Happyville"}
)
```

Make sure to use double quotes.

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Filter a document – Using Array Values

- In SQL: Cannot be done!

```
SELECT *
    FROM people
    WHERE  sport = ['AFL', 'Cricket']
```

- In MongoDB Shell:

```
db.people.find(
    {sports:"AFL", "Cricket"}
)
```

Return documents that exactly contain this array.

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Aggregations -- count()

- In SQL:

```
SELECT COUNT(*)
    FROM people;
```

- In MongoDB Shell:

```
db.people.find().count()
```

Object-oriented. Two ways to do it:
`db.collection.find().count()`
`db.collection.count()`

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Sorting

- In SQL:

```
SELECT *
    FROM people
    ORDER BY name;
```

- In MongoDB Shell:

```
db.people.find().sort({name: 1})
```

```
db.people.find().sort({name: -1})
```

Descending order

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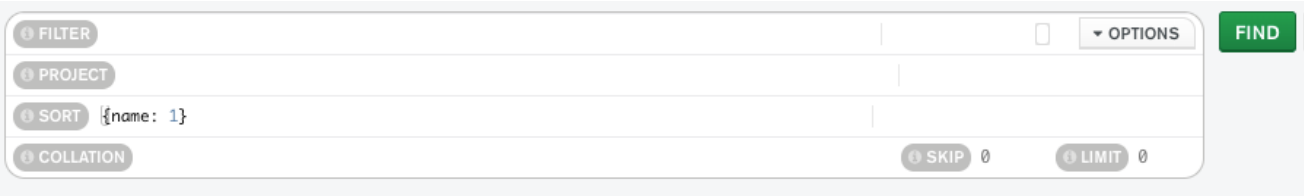
Sorting

- In SQL:

```
SELECT *
    FROM people
    ORDER BY name;
```

- In MongoDB Compass:



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Advanced Queries using Aggregation Pipelines!

- In mongoDB, we can run queries in stages.
- Result from first stage will be the input to the second stage, and so on.
- At each stage, we carry out some aggregation operations, hence the name "Aggregation Pipeline".

- In MongoDB Shell:

```
db.collection.aggregate(
     [ stage 1, stage 2, ...]
)
```

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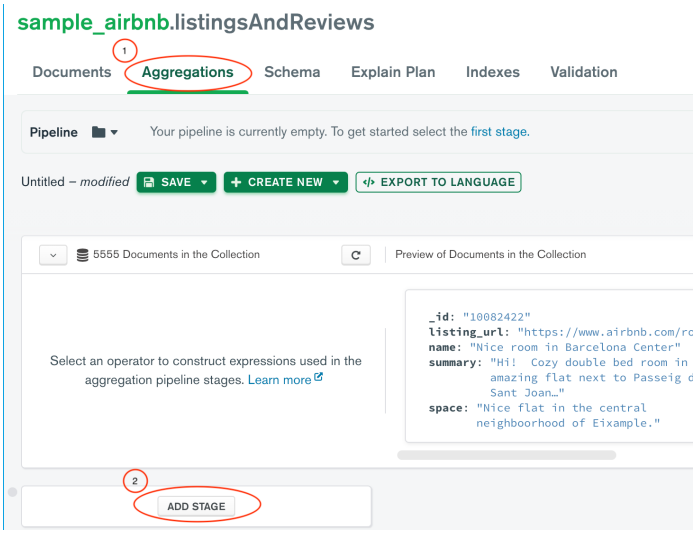
Advanced Queries using Aggregation Pipelines!

- In MongoDB Compass:



Counting Documents

- It is possible to use count() operator with a simple query, which will return the number of documents in a result set.
- However, we can do more with $count: in a pipeline.

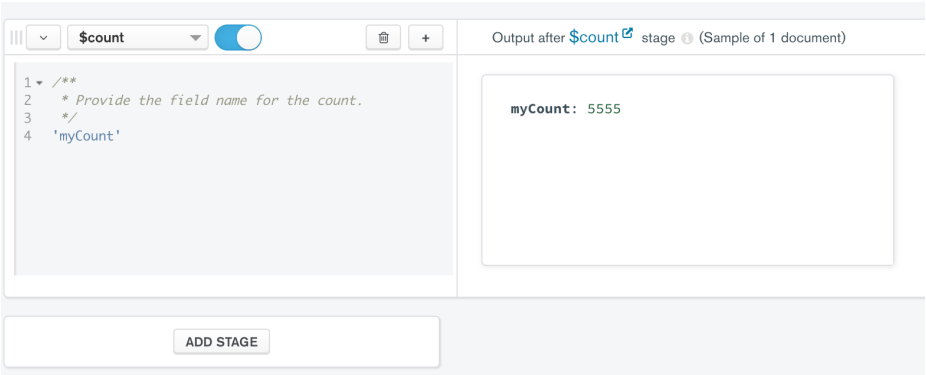
- In MongoDB Shell:

```
db.listingsAndReviews.aggregate(
                                {$count: "myCount"}
                                )
```

myCount is a new field that can be used in later stages in the pipeline.

Counting Documents

- In MongoDB Compass:



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Grouping Documents

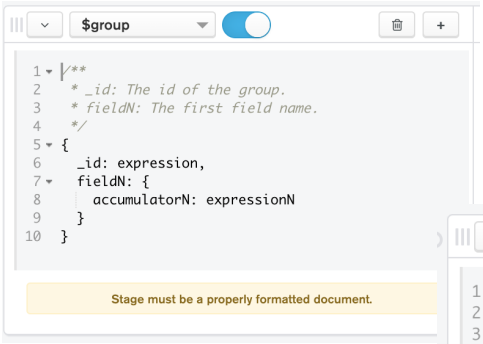
- Similar to GROUP BY clause in SQL, we can group documents based on a field (or more complex expression).
- E.g. Grouping documents on Room Type (field “room_type”)
- In MongoDB Shell:

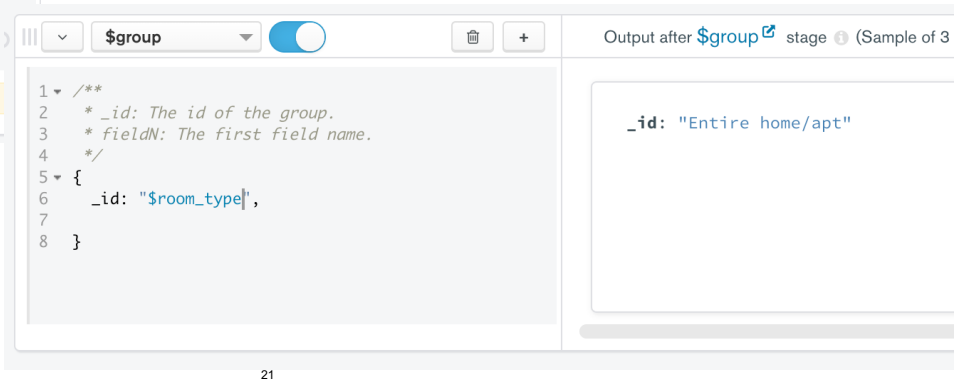
```
db.listingsAndReviews.aggregate(
                                { $group : { _id : "$room_type" } }
                                )
```

_id requires a field or expression which is used as “GROUP BY” clause.

Grouping Documents

- In MongoDB Compass:





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Grouped Aggregation

- As shown in the previous example, grouping will only show one document each showing the field used for grouping. – not much useful.
- Grouped aggregation uses both grouping and an aggregation, such as counting, together.
- E.g. Count no. of listings for each room type

- In MongoDB Shell:

```
db.listingsAndReviews.aggregate(
                                  { $group : { _id : "$room_type",
                                    "listingCount":{$count:{}} } }
                                )
```

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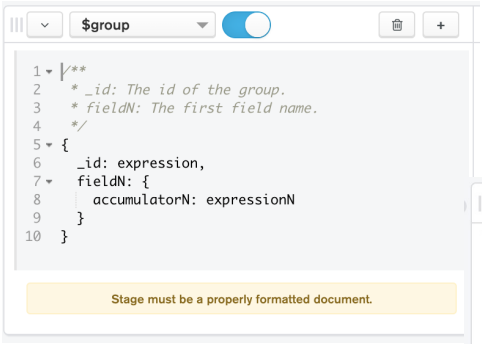
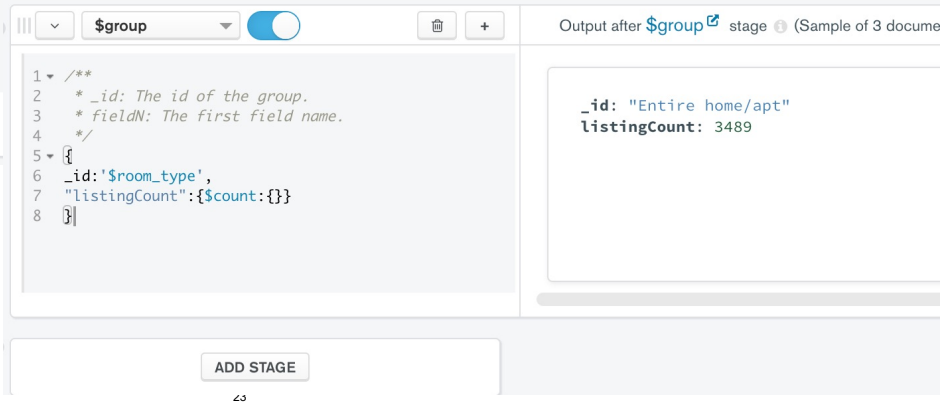
Grouped Aggregation

- In MongoDB Compass:





Filtering on Grouped Aggregation

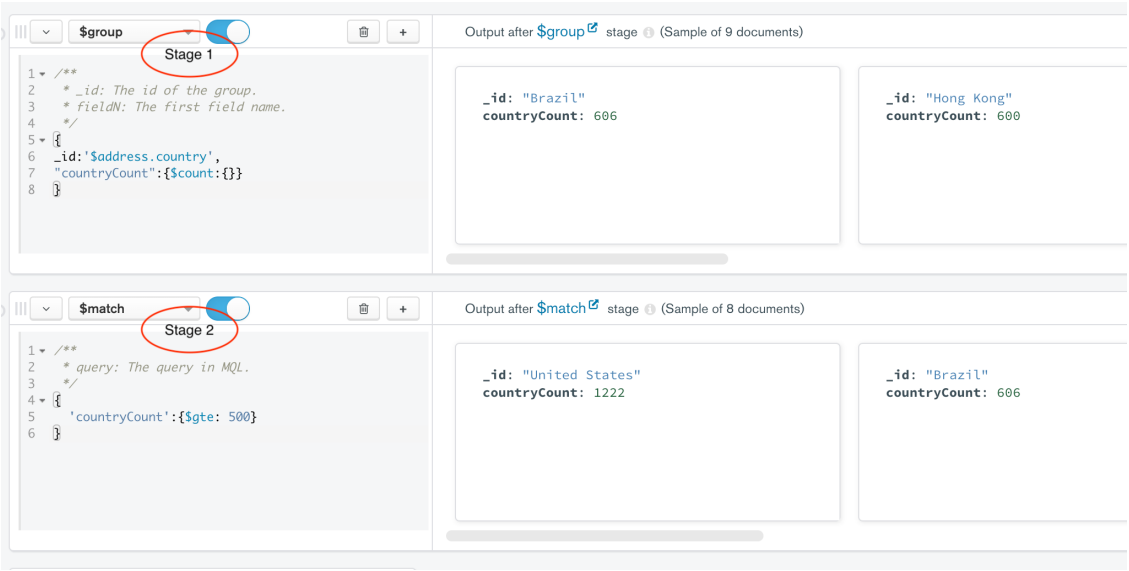
- Similar to HAVING clause in SQL, we can filter on the result of a group aggregation.
- E.g. Show the countries with more than 500 listings.
- First, group on country, then count, and finally filter on the count.

- In MongoDB Shell:

```
db.listingsAndReviews.aggregate( [ { $group :
                                      { _id : "$address.country",
                                       "countryCount":{$count:{}} }
                                      },
                                      { $match: { "countryCount":
                                                    { $gte: 500 } }
                                  }
                                  ] )
```

Grouped Aggregation

- In MongoDB Compass:



More complex groupings

- MongoDB (with pipelines) allows us to make complex groupings possible
- E.g. Count listings in $100 price brackets.
  - Stage 1: build a suitable expression to be used for grouping
  - Stage 2: Use the expression generated in Stage 1 for grouping

```
db.listingsAndReviews.aggregate( [ {
$project:
{
  "price":1,
  priceRange: { $round:{$divide: [ "$price", 100 ] }}
}},
{
$group:
{
_id:'$priceRange',
"RangeCount":{$count:{}}
}
}])
```

More complex groupings

$project

```
/**
 * specifications: The fields to
 *   include or exclude.
 */
{
  "price":1,
  priceRange: { $round:{$divide: [ "$price", 100 ] }
}
```

Output after $project stage (Sample of 10 documents)

```
_id: "10082422"
price: 50.00
priceRange: 0
```

```
_id: "1003530"
price: 135.00
priceRange: 1
```

$group

```
/**
 * _id: The id of the group.
 * fieldN: The first field name.
 */
{
_id:'$priceRange',
"RangeCount":{$count:{}}
}
```

Output after $group stage (Sample of 10 documents)

```
_id: 11
RangeCount: 24
```

```
_id: 10
RangeCount: 52
```

$sort

```
/**
 * Provide any number of field/order pairs.
 */
{
  _id: 1
}
```

Output after $sort stage (Sample of 10 documents)

```
_id: 0
RangeCount: 868
```

```
_id: 1
RangeCount: 2235
```

More complex groupings

- Amenities is an array. If you wish to group documents by the amenities offered, you will have to dis-integrate the array into individual values and then apply the $group on the result.
- Use $unwind: to disintegrate an array.

```
db.listingsAndReviews.aggregate( [ {$unwind: {
                                        path: "$amenities" }
                                   },
                                   {$group :
                                     { _id : "$amenities",
                                     "amenitiesCount":{$count:{}} }
                                   }
                                    ] )
```

More complex groupings

$unwind

```
/**
 * path: Path to the array field.
 * includeArrayIndex: Optional name for index.
 * preserveNullAndEmptyArrays: Optional
 *   toggle to unwind null and empty values.
 */
{
  path: "$amenities"
}
```

Output after $unwind stage (Sample of 10 documents)

```
_id: "10082422"
listing_url: "https://www.airbnb.com/rooms/1
name: "Nice room in Barcelona Center"
summary: "Hi!  Cozy double bed room in
          amazing flat next to Passeig de
          Sant Joan…"
space: "Nice flat in the central
        neighboorhood of Eixample."
```

```
_id: "10082422"
listing_url: "https://www.air
name: "Nice room in Barcelona
summary: "Hi!  Cozy double be
          amazing flat next to
          Sant Joan…"
space: "Nice flat in the cent
        neighboorhood of Eixam
```

$group

```
/**
 * _id: The id of the group.
 * fieldN: The first field name.
 */
{
_id:'$amenities',
"amenitiesCount":{$count:{}}
}
```

Output after $group stage (Sample of 10 documents)

```
_id: "Coffee maker"
amenitiesCount: 1450
```

```
_id: "Free parking on premise
amenitiesCount: 1489
```

$sort

```
/**
 * Provide any number of field/order pairs.
 */
{
  amenitiesCount: -1
}
```

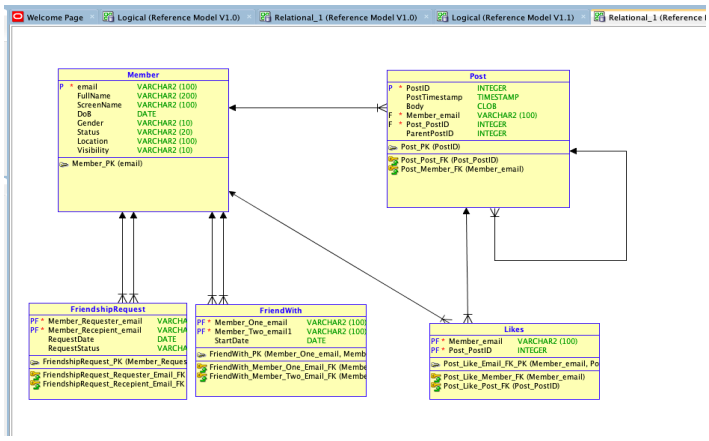
Output after $sort stage (Sample of 10 documents)

```
_id: "Wifi"
amenitiesCount: 5303
```

```
_id: "Essentials"
amenitiesCount: 5048
```

What is a data model?

- It is clear in the relational model.
- The database schema defines the underlying data model.



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What is a data model?

- In non-relational context, the data model is not explicit.
- Unlike in the relational model, it is not a requirement to define the data model up-front.
- MongoDB's collections, by default, does not require its documents to have the same schema.
  - However, in practice, the documents in a collection share a similar structure.

Recall AirBnB database. Not all documents have the same fields, but, many of them are common!

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Document Structure

- The data model, in a non-relational context, is based on the structure of the documents:
  - "Document" is considered as an atomic building block of the data model.
- When designing data models, always consider the application usage of the data (i.e. queries, updates, and processing of the data) as well as the inherent structure of the data itself.

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Document Structure

- Simple documents
  - Captures and stores facts about a single entity.
  - In MongoDB, such documents are collated and stored in one document collection.

We are familiar with such documents. We created, populated and queried such documents last week.

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Document Structure

- Simple documents

MyDB.Movies

Documents | Aggregations | Explain Plan | Indexes

FILTER

INSERT DOCUMENT | VIEW | LIST | TABLE

Movies

	_id ObjectId	mvNumb Int32	mvTitle String	yrMade Int32
1	5d8b77a782da1eb3add62925	1	"Annie Hall"	1977
2	5d8b784482da1eb3add62926	2	"Dr. Strangelove"	1964
3	5d8b78bb82da1eb3add62927	7	"Interiors"	1978

Document Structure

- Complex documents
  - Most of the time, our applications require storing information about many “inter-related” entities.
  - Consider information about movies and directors.
  - MongoDB data model handles such complex documents in two ways:
    - Embedding sub-documents
    - Referencing from one document to another.

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Document Structure -- Embedded

- MongoDB allows related data to be embedded within a single document.
- MongoDB allows us to embed sub-documents in a field or array within a document.
- These denormalized data models allow applications to retrieve and manipulate related data way faster than the relational model, as there aren’t any JOIN operations.

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An Example

```
{
  _id: <ObjectId1>,
  username: "123xyz",
  contact: {
              phone: "123-456-7890",
              email: "xyz@example.com"
            },
  access: {
             level: 5,
             group: "dev"
           }
}
```

Embedded sub-document

Embedded sub-document

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Another Example

```
_id: ObjectId("5d8b8a5882da1eb3add6292b")
username: "dba"
email: "dba@example.com"
address: Array
  0: Object
     streetNo: "1"
     streetName: "Happy Street"
     suburb: "Happyville"
     postCode: "3999"
     state: "VIC"
  1: Object
     streetNo: "2"
     streetName: "Jollymont Ave"
     suburb: "Tigerland"
     postCode: "3990"
     state: "VIC"
```

This particular document has two sub-documents embedded within the address field. Each sub-document has its own document structure.

Document Structure -- Embedded

- In general, use embedded data models when:
  - you have “contains” (or “has”) relationships between entities.
  - you have one-to-many relationships between entities. In these relationships the “many” or child documents always appear with or are viewed in the context of the “one” or parent documents. E.g. directors → movies

```
_id: ObjectId("5d8b793882da1eb3add62928")
dirNumb: 1
dirName: "Allen, Woody"
dirBorn: 1935
director_movies: Array
  0: Object
  1: Object
```

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Another Example

Will discuss about this example later!

```
_id: ObjectId("5d8b77a782da1eb3add62925")
mvNumb: 1
mvTitle: "Annie Hall"
movie_directors: Array
  0: Object

    dirNumb: 1
    dirName: "Allen, Woody"
    dirBorn: 1935
```

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Querying with Embedded Documents

- **Querying is easy with embedded sub-documents**.
- Each sub-document is treated as an object or an array.
- Use [ ] (square bracket) or . (dot) to refer them in filtering, projections, etc.

```
db.movies.find({"Director.dirName": "Allen, Woody"})
```

or

```
db.movies.find({"Star.starName": "Allen, Woody"})
```

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Drawbacks of Embedding

- Embedding a sub-document is like "de-normalising" a document.
- This can lead into redundancies, and that can result in undesirable anomalies (insertion, update, delete, etc).
- While you gain performance gains (by avoiding JOINs), embedding is not suited for some instances.
- An example is when documents are in a many-to-many relationships, or, in a one-to-many relationship where most of the queries are based on many side.

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Drawbacks of Embedding

```
_id: ObjectId("5d8b78bb82da1eb3add62927")
mvNumb: 7
mvTitle: "Interiors"
movie_directors: Array
  0: Object

    dirNumb: 1
    dirName: "Allen, Woody"
    dirBorn: 1935
```

```
_id: ObjectId("5d8b77a782da1eb3add62925")
mvNumb: 1
mvTitle: "Annie Hall"
movie_directors: Array
  0: Object

    dirNumb: 1
    dirName: "Allen, Woody"
    dirBorn: 1935
```

Redundant data

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Drawbacks of Embedding

```
_id: ObjectId("5d8b78bb82da1eb3add62927")
mvNumb: 7
mvTitle: "Interiors"
movie_directors: Array
  0: Object

    dirNumb: 1
    dirName: "Allen, Woody"
    dirBorn: 1935
```

```
_id: ObjectId("5d8b77a782da1eb3add62925")
mvNumb: 1
mvTitle: "Annie Hall"
movie_directors: Array
  0: Object

    dirNumb: 1
    dirName: "Allen, Woody"
    dirBorn: 1935
```

If the performance gains outweigh the troubles of managing the redundancy anomalies, MongoDB prefers this (denormalised) data model!

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Drawbacks of Embedding

```
_id: ObjectId("5d8b78bb82da1eb3add62927")
mvNumb: 7
mvTitle: "Interiors"
movie_directors: Array
  0: Object
    dirNumb: 1
    dirName: "Allen, Woody"
    dirBorn: 1935
```

```
_id: ObjectId("5d8b77a782da1eb3add62925")
mvNumb: 1
mvTitle: "Annie Hall"
movie_directors: Array
  0: Object
    dirNumb: 1
    dirName: "Allen, Woody"
    dirBorn: 1935
```

In IMDB application, many more queries are executed based on movies, compared to queries on directors. So, the above can still be the desirable data model.

Drawbacks of Embedding

```
_id: ObjectId("5d8b78bb82da1eb3add62927")
mvNumb: 7
mvTitle: "Interiors"
movie_directors: Array
  0: Object
    _id: ObjectId("5d8b793882da1eb3add62928")
    dirNumb: 1
    dirName: "Alle  ody"
    dirBorn: 1935
```

```
_id: ObjectId("5d8b77a782da1eb3add629
mvNumb: 1
mvTitle: "Annie Hall"
movie_directors: Array
  0: Object
    _id: ObjectId("5d8b793882da1eb3ac
    dirNumb: 1
    dirName: "Allen, Woody"
    dirBorn: 1935
```

If redundancy poses a bigger problem, consider “referencing”!

Document Structure -- Referencing

- This is a ”normalised” data model, where relationships between entities are established between documents using references.

user document

```
{
  _id: <ObjectId1>,
  username: "123xyz"
}
```

contact document

```
{
  _id: <ObjectId2>,
  user_id: <ObjectId1>,
  phone: "123-456-7890",
  email: "xyz@example.com"
}
```

access document

```
{
  _id: <ObjectId3>,
  user_id: <ObjectId1>,
  level: 5,
  group: "dev"
}
```

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Another Example

MyDB.Movies

Documents | Aggregations | Explain Plan

FILTER
PROJECT
SORT {yrMade: -1}
COLLATION

INSERT DOCUMENT VIEW LIST TABLE

```
_id: ObjectId("5d8b78bb82da1eb3add62927")
mvNumb: 7
mvTitle: "Interiors"
yrMade: 1978
mvType: "DRAMA"
dirNumb: 1
```

```
_id: ObjectId("5d8b77a782da1eb3add62925")
mvNumb: 1
mvTitle: "Annie Hall"
yrMade: 1977
mvType: "COMEDY"
crit: 4
MPAA: 5
noms: 5
awrd: 4
dirNumb: 1
```

MyDB.Directors

Documents | Aggregations | Explain Plan

FILTER

INSERT DOCUMENT VIEW LIST TABLE

```
_id: ObjectId("5d8b793882da1eb3add62928")
dirNumb: 1
dirName: "Allen, Woody"
dirBorn: 1935
```

```
_id: ObjectId("5d8b795e82da1eb3add62929")
dirNumb: 2
dirName: "Hitchcock, Alfred"
dirBorn: 1899
dirDied: 1980
```

```
_id: ObjectId("5d8b799882da1eb3add6292a")
dirNumb: 5
dirName: "Kubrick, Stanley"
dirBorn: 1928
```

Another Example

```
_id: ObjectId("5d8b78bb82da1eb3add62927")
mvNumb: 7
mvTitle: "Interiors"
movie_directors: Array
  0: Object
    _id: ObjectId("5d8b793882da1eb3add62928")
    dirNumb: 1
    dirName: "Alle  ody"
    dirBorn: 1935
```

```
_id: ObjectId("5d8b77a782da1eb3add629
mvNumb: 1
mvTitle: "Annie Hall"
movie_directors: Array
  0: Object
    _id: ObjectId("5d8b793882da1eb3ac
    dirNumb: 1
    dirName: "Allen, Woody"
    dirBorn: 1935
```

Information about Woody Allen are stored in a document with _id "5d8b79388..." and all his movies refers to this document. Woody's information stored once.

Document Structure -- Referencing

- In general, use normalised data models:
  - when embedding would result in duplication of data but would not provide sufficient read performance advantages to outweigh the implications of the duplication;
  - to represent more complex many-to-many relationships;
  - to model large hierarchical data sets.

How about "posts" in our Facebook-Lite application?

Querying with Referenced Documents

- **Querying is not straight-forward with referenced documents**.
- Early versions of MongoDB didn't even support referencing.
- Starting from MongoDB 3.2 (current version is 4.2), **$lookup()** function allows us to write queries to retrieve information from referenced documents.

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Querying with $lookup()

- Querying with $lookup() can be a part of "Aggregation Pipeline"
- Starts from one-side of the join, then state what document collection to be in the many-side and local and destination fields to match.

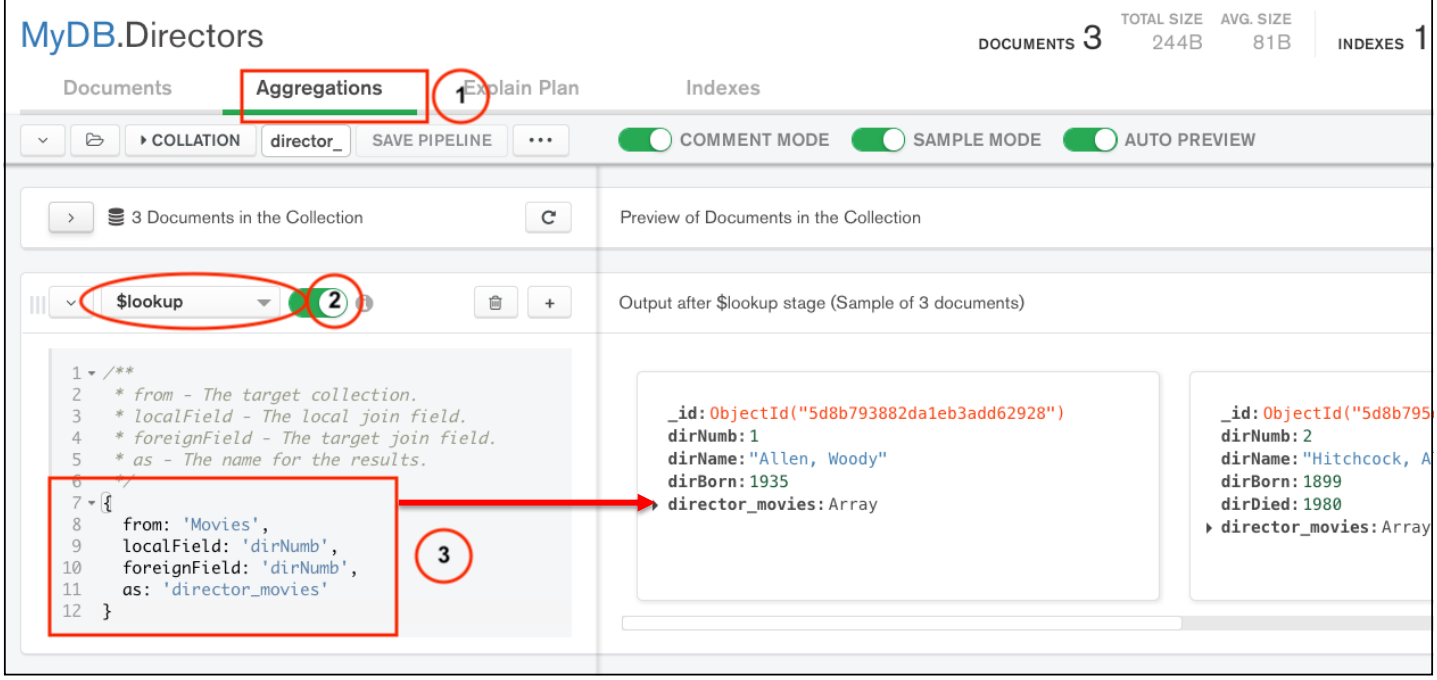
```
{
   $lookup:
     {
       from: <collection to join>,
       localField: <field from the input documents>,
       foreignField: <field from the documents of the "from" collection>,
       as: <output array field>
     }
}
```

Querying with $lookup() – An example

- Let's suppose directors have many movies.
- So, join starts from "Directors" collection, destination collection is "Movies".
- Common field is "dirNumb" (on both collections, but can have different fields)

```
{
   $lookup:
     {
       from: Movies,
       localField: dirNumb,
       foreignField: dirNumb,
       as: director_movies
     }
}
```


Querying with $lookup() – An example



Demo time!

Referencing

Let's do it on MongoDB Compass

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Querying with $lookup()

- For more details and complex operations, see:

  https://docs.mongodb.com/manual/reference/operator/aggregation/lookup

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Further Readings

- https://docs.mongodb.com/manual/reference/operator/aggregation/lookup/
- https://docs.mongodb.com/php-library/current/tutorial/
- https://docs.mongodb.com/ecosystem/drivers/php/

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Next Week

- We continue this MongoDB discussion in Week 10. We discuss on replication, etc.

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Menti-time!

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Code: to be supplied

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Questions?

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