Release: 20230414

Topics we cover

Basic aggregations
Aggregation stages
Compass aggregation builder
Aggregation expressions and categories
Join and group stages
Database internal stats
Expression variables
Aggregation optimization and memory usage

Aggregation Basics

Retrieval operations can filter:

- What Documents
- What Fields
- What Order

Aggregation allows us to compute new data

- Calculated fields
- Summarised and grouped values
- Reshape documents

Compared to SQL

MongoDB **find()**:

```
SELECT a,c,b
FROM database.table
WHERE d<100
ORDER BY d ASC
```

MongoDB **aggregate()**:

```
SELECT b+c as a,SUM(e) AS t
FROM D.T LEFT JOIN D.T2 ON y
WHERE T2.A=T.B
GROUP BY a
HAVING t > 100
```

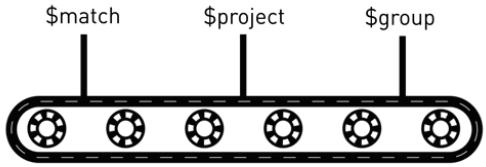
MongoDB's find is equivalent of SQL SELECT and WHERE statements
Aggregate stages such as $GROUP and $LOOKUP can be equivalent of SQL join and group
Find() and Aggregate are slowly converging in MongoDB so this distinction gets less and less with each release.

Aggregation is a pipeline

Each transformation is a single step known as a stage

Compared to one huge SQL style statement this is easier to:

- Understand
- Debug
- Rewrite and optimize



- Aggregation is a linear process with stages
- It makes it easier to understand and follow what queries are doing

Basic Aggregation Stages

`$match`	equivalent to `find(query)`
`$project`	equivalent to `find({},projection)`
`$sort`	equivalent to `find().sort(order)`
`$limit`	equivalent to `find().limit(num)`
`$skip`	equivalent to `find().skip(num)`
`$count`	equivalent to `find().count()`

When using these at the start of a pipeline, the query optimizer transforms them to a find()

The most common stages are $match, $project, $sort, $limit, $skip, $count and $group (which we will learn about later)

Comparing Aggregation syntax

Find the name of the host in Canada with the most "total listings":

Using **find()**:

```
db.listingsAndReviews.find(
    {"address.country":"Canada"},
    {"host.host_total_listings_count":1,"host.host_name":1}
).sort({"host.host_total_listings_count":-1}).limit(1)
```

Comparing Aggregation syntax (cont.)

Find the name of the host in Canada with the most "total listings":

Using **aggregate()**:

```
db.listingsAndReviews.aggregate([
    {$match:{"address.country":"Canada"}},
    {$sort:{"host.host_total_listings_count":-1 }},
    {$limit:1},
    {$project:{
    "host.host_total_listings_count":1,
    "host.host_name":1}}
])
```

Dollar Overloading

`{$match: {a: 5}}` - Dollar on left means a stage name - in this case a $match stage

`{$set: {b: "$a"}}` - Dollar on right of colon "$a" refers to the value of field a

`{$set: {area: {$multiply: [5,10]}}` - $multiply is an expression name left of colon

```
{$set: {priceswithtax: {$map: {input: "$prices",
                                    as: "p",
                                    in: {$multiply :["$$p",1.08]}}}}}
```

$$p Refers to the temporary loop variable "p" declared in $map

`{$set: {displayprice: {$literal: "$12"}}}` - Use $literal when you want either a string with a $ or to $project an explicit number

- Dollars are used in a number of ways in aggregation syntax, this can be confusing for a beginner
  - On the Left They refer to a stage or expression name
  - On the Right they refer to a field value
  - Double dollars refer to a temporary variable or constant
  - You can also use $literal if you need a dollar symbol as a variable.

How to write Aggregations

Think as a programmer - not as a DB shell

Variables help to keep track of brackets

```
//Do it THIS way for ease of testing and debugging

> no_celebs = {$match:{"user.followers_count"
:{$lt:200000}}}

> name_only = {$project:{"user.name":1, "
user.followers_count":1,_id:0}}

> most_popular = {$sort: {"user.followers_count":-1}}

> first_in_list = {$limit:1}

>
pipeline = [no_celebs,name_only,most_popular,first_in_lis
t]

> db.twitter.aggregate(pipeline)
```

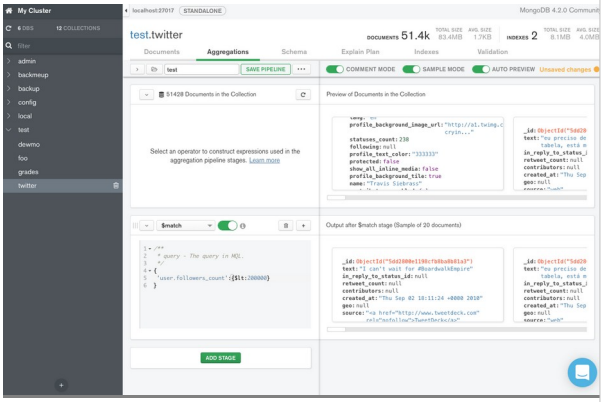
Write aggregations in variables and add these to your pipeline to make testing and debugging easier.

GUI Aggregation Builder

Compass is a MongoDB GUI query tool

Has an Aggregation Builder and Viewer

Helpful when learning

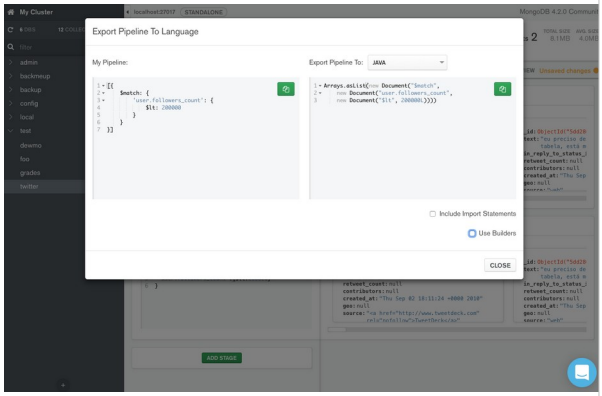


Compass is MongoDB's GUI tool, but Atlas also offers some aggregation functionality.

Compass - Code export

Compass generates code when exporting the aggregation pipeline

Multiple languages are supported



Compass/Atlas can generate code from aggregation pipelines for some programming languages.

Aggregations are programs

Initially, you write simple ones by hand but don't often write them ad-hoc (one-off)

Sometimes you write code to generate them

Very complex aggregations cannot be written by hand

Example: Train a neural network outside MongoDB to recognise fraud and compile it into an aggregation to use in real-time fraud detection

Aggregation is essentially a programming language

Aggregations are objects forming a metaprogram. They can be written by code as well as by hand.

Many people will only ever have simple - or perhaps slightly complex handwritten aggregations.

However really powerful aggregations can almost not be written by hand, you have to generate them from functions
that then call other functions to generate them. It's difficult to express this idea well but some of the most complex and
powerful aggregation can be >1MB in size - but are created from a combination of input data and machine learning and
recursive functions.

Aggregation stages from code

Write functions that generate aggregation stages

Allow them to be parameterised and call each other

This is a very simple example

```
> function recs_older_than(days) {
  days_in_millis = days*24*60*60*1000
  today= new Date()
  n_days_ago =  new Date(today - days_in_millis)
  return  { create_date: { "$lte" : n_days_ago}}
}

> pipe = [{$match : recs_older_than(180)}]

> db.people.aggregate(pipe)
```

Normally when you are writing aggregations you are doing it in code - not the shell, because aggregations are objects you can
easily create functions to output part of your aggregation to allow you to easily parameterise them.

This is an important technique in creating complex and powerful aggregations.

Aggregation Expressions

Aggregations have stages like `$match` , `$project`, and `$sort`

Stages often referred to expressions

Expressions can be simple like `"$name"` - the value of the field "name"

Or more complicated like this for RMS* of an array of values:

```
{
$sqrt:{$avg:{$map:{input:"$a",in:{$multiply:["$$this","$$this"]}}}}
}
```

Or 100s of KB long performing a complex calculation

*Root Mean Square is the Square root of the average of the squares of values and is often used in signal processing.

Some examples of arithmetic expressions

```
{ $subtract : [ "$cost", "$price" ] }
{ $add : [ "$price", "$shipping" ] }
{ $add : [ "$price", "$shipping", "$tax" ] }
{ $multiply : [ "$price", "$taxrate" ] }
{ $divide : [ "$quantity", "$price" ] }
{ $add : [
        "$price" , { $multiply : ["$price", "$taxrate" ] }
    ]
}
```

There are many type of expressions - if you think of a common function in a programming language then there is likely a matching mongodb expressions. Even simple things like basic maths are expressed like this, one advantage over normal inline operators like + and * is that you can
$add a list of things.

Expression arguments are always an array.
If there is only one argument you can give it as a scalar and MongoDB converts it to an Array of one element behind the scenes

Some examples of string expressions

```
{ $concat : [ "$firstname", "_", "$lastname" ] }

{ $ltrim :  "$emailaddress" }

{ $indexOfCP : [ "$emailaddress", "@" ] }

{ $split : [ "$telephone", "-" ] }
```

Another common thing you would expect in a language are string expressions.
You can concatenate strings together, remove leading space, search for strings in strings - typical developer things.

Expression Categories

Arithmetic Expression Operators
Array Expression Operators
Boolean Expression Operators
Comparison Expression Operators
Conditional Expression Operators
Date Expression Operators
Literal Expression Operator
Object Expression Operators
Set Expression Operators
String Expression Operators
Text Expression Operator
Trigonometry Expression Operators
Type Expression Operators
Accumulators ($group)

There are hundreds of different expressions - like built-in functions in a programming language that you can use to express any data transformation. These are the categories and links to them some are for specific data types, some, that we see later will let you iterate over arrays some even implement the idea of a mathematical set of unique values.

- Arithmetic Expression Operators:
  https://docs.mongodb.com/manual/meta/aggregation-quick-reference/#arithmetic-expression-operators
- Array Expression Operators:
  https://docs.mongodb.com/manual/meta/aggregation-quick-reference/#array-expression-operators
- Boolean Expression Operators:
  https://docs.mongodb.com/manual/meta/aggregation-quick-reference/#boolean-expression-operators
- Comparison Expression Operators:
  https://docs.mongodb.com/manual/meta/aggregation-quick-reference/#comparison-expression-operators
- Conditional Expression Operators:
  https://docs.mongodb.com/manual/meta/aggregation-quick-reference/#conditional-expression-operators
- Date Expression Operators:
  https://docs.mongodb.com/manual/meta/aggregation-quick-reference/#date-expression-operators
- Literal Expression Operator:
  https://docs.mongodb.com/manual/meta/aggregation-quick-reference/#literal-expresion-operator

Using $project

$project specifies the output document shape, fields are defined by expressions.

```
{
    $project: {
        name: "$fullname",
        average_speed: { $divide :
            ["$distance","$time"] }
    }
}
```

From MongoDB 4.4 - you can use aggregation style projections in find() as well as with aggregate() in a $project stage.
AddFields let's use add or modify a field without having to know all the other fields that are there. It's much less brittle.
A common anti-pattern is to use $project early in your pipeline to 'limit what fields are being processed' - you should not do this because MongoDB can and does work out what fields it needs to take from the database itself and doesn't pass anything into the pipeline that won't help compute the final output. It also limits several of MongoDB's optimization options if you do this.

- $addFields is an older name for $set
- Only use $project as a final stage to format output in production.
  - It useful to project just the fields you want early when developing a query.
  - Never use it early to 'optimize' the data in the pipeline, that's an anti-pattern

Using $set

To add in additional fields rather than specify the whole output use **$set**, not $project

It also lets you replace existing values

```
{
    $set : {
        average_speed: {
            $divide : ["$distance","$time"]
        }
    }
}
```

From MongoDB 4.4 - you can use aggregation style projections in find() as well as with aggregate() in a $project stage.
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Exercise - Max property price

Use the Shell or Compass aggregation builder to work with the **sample_airbnb** database and the **listingsAndReviews** collection and answer for these questions:

Use a $set stage and a $project stage too.

Scenario: The base price for the basic rental is `$price`; that price includes the number of guests provided in `$guests_included` field. But a property may take more guests in total (`$accommodates`). Those extra guests pay an `$extra_people` cost per person for every person more than the number of guests included.

1. How many extra guests can each property have? Add that as a new field with $set
2. How much it would cost with these extra guests? Use $project to show the basic price and the maximum price if fully occupied with $accommodates people

If you finish this easily you could test out using `$sort` and `$limit` to find out the most expensive property.
We could also use the same techniques to compute the cheapest place to stay per person.
Instead of $set we can also go for $addFields and it would provide us similar results.

The $group stage

Take the incoming document stream and reduce it to a smaller set of documents by combining (GROUP BY in SQL is the closest equivalent)

_id is what MongoDB uses as a unique field. Each unique value represents one 'group.'

```
{$group: {_id : <expression>,
          field1 : {<$accum>: <expression>},
          …}}
{$group : {_id: "$country",
           population :{$sum:"$city_population"}}}
```

$group with an _id of a constant (like null) to group everything into a total.
Grouping does not use an index - unless the index is used for covering.
If you want the highest (or lowest) value in each group you normally use the $max and $min accumulators
However, if you use $sort and then $first or $last instead and this is at the start of an aggregation MongoDB can optimise picking these values from the index
This is a common case to "Get the largest in each group" and so is worth knowing this optimization.

Note: Do not confuse this _id with the automatically generated _id in the collection while adding the record.

Common $group accumulators

`$addToSet`	array of unique expression values
`$avg`	average of numerical values
`$first/$last`	value from the first or last document for each group
`$max/$min`	highest or lowest expression value for each group
`$mergeObjects`	document combined by input documents for each group
`$push`	array of expression values for each group
`$stdDevSamp`	sample standard deviation of the input values
`$sum`	sum of numerical values

As well as being usable in $group - some of these can simply be applied to an array in a $project or $set.

Also, as of 4.4, there is the ability to write your own javascript accumulator expressions - DO NOT DO THIS - Javascript is much much slower than native.

$first and $last imply data is sorted.

https://docs.mongodb.com/manual/reference/operator/aggregation/group/#accumulators-group

Exercise - Properties by country

Use the Shell or Compass aggregation builder to work with the **sample_airbnb** database and the **listingsAndReviews** collection and answer for this question:

How many properties are there in each country? Order countries by number of properties descending, listing the country with the largest number first

Hint: Count things by adding an explicit value 1 to an accumulator using $sum

The $unwind stage

The opposite of $group

Applied to any array field

Converts one document to many

One per value in the array

Example: Having this initial document - `{ a: 1, b: [2,3,4] }`

Unwind on b (`{$unwind: "$b"}`) gives 3 documents in the pipeline:

`{a:1,b:2}`, `{a:1,b:3}`, and `{a:1,b:4}`

$unwind is opposite of group and allows you to expand arrays out to separate documents

Exercise - $unwind

Use the Shell or Compass aggregation builder to work with the **sample_airbnb** database and the **listingsAndReviews** collection and answer for the question:

What amenities are offered in the smallest number of countries?

"Join" Stages

$lookup

Run a pipeline and embed results

Like Left Outer Join or Nested Select

Needs Indexing and tuning

'From' collection cannot be sharded

Intended to lookup rapidly changing dimensions like stock prices

NOT an excuse for relational design

Two forms Query and Sub-pipeline

Returns an array of results

```
#Get Bobs stock records
db.stocks.aggregate([{$match: { customer: "bob"}},

#For each on $lookup the current value of that stock
{$lookup: {
  from: "currentprices",
  localfield: "symbol",
  foreignField : "tkr",
  as: "currentPrice" }},

#For each record multiply bob stocks by latest price
{$set:
   {holdings: {
      $multiply: ["$numheld",
                  {$arrayElemAt:["$currentPrice",
0]
}]}},

#Add them up by stock
{$group: {_id: "$symbol",
          value: {$sum : "$holdings"}
)

#Returns
{ _id: "MSFT", value: 20124 }
{ _id: "ORCL", value: 650 }
{ _id: "MDB", value: 987521 }
```

`$lookup` is like a Left outer Join, however, it is not a reason to use MongoDB like a relational database. There is always a cost when joining data so good document schema design is more important.
Sometimes you want to pull in data that changes very rapidly and you don't want to make huge edits all the time - in that case $lookup is good.

"Join" Stages

$graphLookup

Recursively lookup on same collection

A way to traverse trees or graphs

Rarely useful in practice as both limited in functionality and relatively slow

There are better schema design patterns for most use cases

```
db.landmarks.aggregate([
{ $match: { _id: "Brooklyn Bridge" }},
{ $graphLookup: {
        from: "places",
        startWith: "$location",
        connectFromField: "isIn",
        connectToField: "_id",
        as: "address"
      }}])


# Returns:

{
  _id: "Brooklyn Bridge",
  location: "Brooklyn",
  address : [
      { _id: "Brooklyn", isIn: "NYC"},
      { _id: "NYC", isIn: "New York" },
      { _id: "New York", isIn: "USA" }
  ]

}
```

More grouping

$bucket

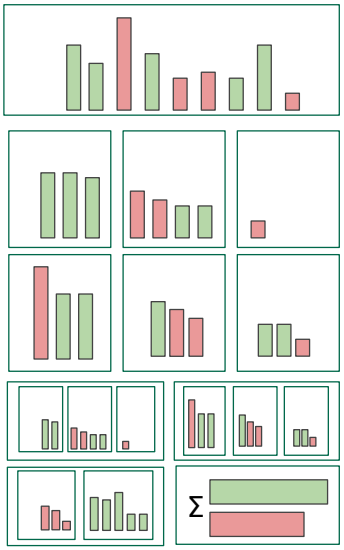
Group by defined Ranges of values

$bucketAuto

Group into N similar sized groups

$facet

Combine sub pipelines in one document



- $bucket is a more specialized form of $group
  - Group into ranges of values without additional expression to round them
  - For example group ages 0-10,10-20,20-30
- $bucketAuto
  - Determine boundaries of buckets automatically
  - Segment data set into same-sized groups
  - Lots of statistical options
- $facet
  - Run multiple sub aggregations and include in a single document
  - Efficient way to run multiple final stages
  - Limited by document size
  - Often used with $sortByCount to find largest group.

Grouping: $sortByCount

Shortcut for one of the most popular groupings to do

See what the most common values are of a field

```
[
      {
            $group: {
                  id: "$city" ,
                        count: {
                        $sum: 1
                        }
            }
      },
      {
            $sort: {
                        count: -1
            }
      }
]
```

```
{ $sortByCount:  "$city" }
```

Structural stages

`$set`	Add extra fields without $projecting all of them
`$out`	Write results to a new collection
`$merge`	Update an existing collection
`$replaceRoot`	Create a whole new shape of top-level document
`$sample`	Choose a random set of docs from the input

$set is really useful as we can change an existing field in the pipeline or add one without needing to know all the others - before we had this we had to use $project.
$out writes to a new collection, it can overwrite an existing one but not the one you are reading from. It writes to a temporary collection then renames, so is never see half written.
$merge lets you create a stream of insert/update/delete operations from a pipeline and apply them to a collection - similar to materialized views.
$replaceRoot is used when you want to take an object you have created and make it be the whole document rather than a field in it.
$sample uses an efficient method to grab random, non repeating documents. You can set the sample size,.

Database Internal Stats

Aggregation Pipeline provides internal database information and summaries it:

`$collStats`	Describe collection statistics
`$currentOp`	List ongoing database operations
`$indexStats`	Show what indexes have been used and how much since boot
`$listSessions`	Show what connected client sessions exist
`$planCacheStats`	Show what query shapes are cached and the query plans.

- $collStats shows us information about collection sizes and number of records.
- $currentOp is used to see what is happening on the database instance
- $indexStats shows size and usage of indexes
- $listSessions shows logged in users
- $planCacheStats shows how the query planner is working..

Expression Variables

Use a double dollar `$$`

Internal variables `$$NOW`, `$$CLUSTER_TIME`, `$$ROOT`, `$$REMOVE`

Used in `$let`, `$map`, `$reduce` expressions

`$map` and `$reduce` are list comprehension expressions

`$let` allows you to optimise by evaluating something only once

Expression variables use $$ syntax

Aggregation Optimization

The aggregation pipeline merges stages and reorder as needed

It works out the required early projection; do not $project to optimize

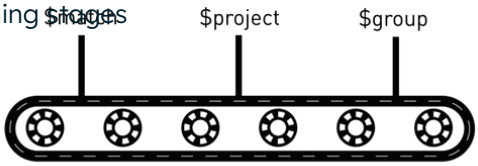
`$unwind -> $group(_id:"$_id")` is an anti-pattern, use projection accumulators

Stages can be Streaming or Blocking

`$sort (no index), $group, $bucket, $facet` block next step until complete

A blocking stage will block subsequent streaming stages

Run in parallel as much as possible



The MDB engine will attempt to optimize aggregations and reorder stages where possible.
Do not unwind an array to work on it, then regroup it - apply the operators to the array directly.

Aggregation and Memory Usage

Documents inside the pipeline can be up to 64MB in size

Final stage must be 16MB or less as they need to be BSON

Blocking stages can use up to 100MB of heap RAM

`$sort, $group, $bucket` and `$bucketAuto` can use disk with `allowDiskUse:true`

Aggregation uses Heap Memory - separate from the Database Cache.
Internally Aggregation does not use BSON and so internal temporary documents can be more then 16MB
Documents at the end of the pipeline must be 16MB or less though.
There is a 100MB limit for RAM usage in blocking stages like Group, Sort and GraphLookup
You can get round this by allowing Aggregation to use the Disk - passing the option
`allowDiskUse: true`

Aggregations on Sharded clusters

On Sharded clusters, operations run in parallel where possible

Combining operations run at different locations depending on what they are:

- mongos
- Random shard
- Primary shard

When aggregation operations run on multiple shards, the results are routed to the mongos to be merged, except in the following cases:

- If the pipeline includes the $out or $lookup stages, the merge runs on the primary shard.
- If the pipeline includes a sorting or grouping stage, and the allowDiskUse setting is enabled, the merge runs on a randomly-selected shard.

Aggregation capability

Aggregation is a powerful and flexible language
Examples written:

- Fractal generator
- Conway's Game of Life
- A Bitcoin Miner
- A financial stress tester for a Bank

Aggregation is also often faster than expected, but sometimes not as fast as find() in the simplest cases - Unless the optimizer just transforms to a find()

- The aggregation framework is a powerful tool.
- It has been used to write a Bitcoin Miner.

Exercise - Final practice

Aggregation is a large topic with many stages and expressions
This module introduces it but, like any other language, takes time and practice to master

Here is a final and more challenging exercise to begin that journey:
Using the Airbnb listings data:

- What are the 10 most common words in review comments that have 6 or more characters? A word is the same word regardless of case.
- How many unique reviews does each word appear in?

Reference:
https://docs.mongodb.com/manual/meta/aggregation-quick-reference/#aggregation-expressions

Quiz Time!

#1. What stage is a variation of the $bucket stage?

A	$match	B	$project	C	$group
D	$lookup	E	$facet		

Answer in the next slide.

#1. What stage is a variation of the $bucket stage?

A	$match	B	$project	C	$group
D	$lookup	E	$facet		

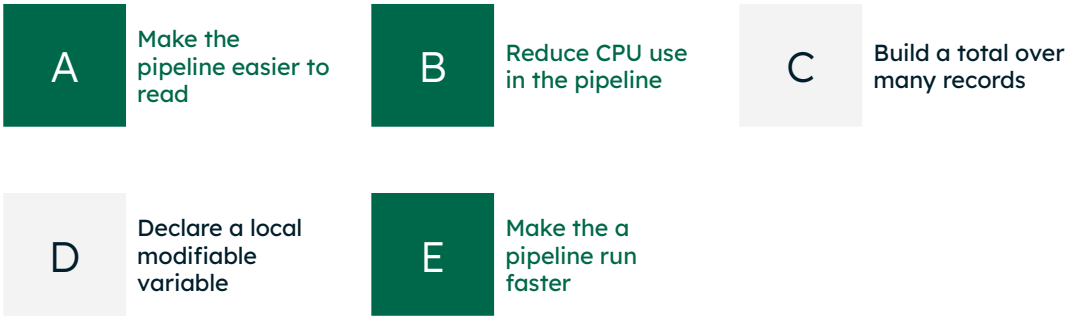
Answer: C

#2. Select three reasons to use $let in an aggregation pipeline?

A	Make the pipeline easier to read
B	Reduce CPU use in the pipeline
C	Build a total over many records
D	Declare a local modifiable variable
E	Make the a pipeline run faster

Answer in the next slide.

#2. Select three reasons to use $let in an aggregation pipeline?



Answer: A, B, E

#3. Which one of these aggregation stages should be used last in the pipeline?

A	$facet	B	$sort	C	$project
D	$addFields	E	$redact		

Answer in the next slide.

#3. Which one of these aggregation stages should be used last in the pipeline?

A	$facet	B	$sort	C	$project
D	$addFields	E	$redact		

Answer: C

#4. What stage is the opposite of $unwind in the aggregation pipeline?

A	$facet	B	$group	C	$bucket
D	$merge	E	$set		

Answer in the next slide.

#4. What stage is the opposite of $unwind in the aggregation pipeline?

A	$facet	B	$group	C	$bucket
D	$merge	E	$set		

Answer: B

#5. Select the expected outcome:

```
db.listingsAndReviews.aggregate([
{$match: {"room_type":/^Entire/}}, {$unwind:"$amenities"},
{$sortByCount: "$amenities"}, {$limit: 5}
])
```

A	The list of properties names with their amenities limited to a maximum of 5
B	The list of the top 5 entire properties names based the number of amenities
C	The list of the bottom 5 entire properties names based the number of amenities
D	The list of the top 5 most common amenities from the list of entire properties
E	The list of the top 5 most common amenities arrays based on entire properties

Answer in the next slide.

#5. Select the expected outcome:

```
db.listingsAndReviews.aggregate([
{$match: {"room_type":/^Entire/}}, {$unwind:"$amenities"},
{$sortByCount: "$amenities"}, {$limit: 5}
])
```

A	The list of properties names with their amenities limited to a maximum of 5
B	The list of the top 5 entire properties names based the number of amenities
C	The list of the bottom 5 entire properties names based the number of amenities
D	The list of the top 5 most common amenities from the list of entire properties
E	The list of the top 5 most common amenities arrays based on entire properties

Answer: D

Can someone guess whats the doc structure (fields) returned?
Try to run the command

Recap

Aggregation is a way to manipulate records inside the server before returning them

It is a full programming language in a mostly functional paradigm

It can filter, summarize and calculate almost anything

Exercise Answers

Exercise: Max property price

How much it would cost for these extra guests in each property? Calculate `"$extra_people"` cost and $project the basic price and the max price if fully populated

```
addextra = { $set: { numguestsextra : { $subtract:
["$accommodates","$guests_included"]}}}
db.listingsAndReviews.aggregate([addextra])
extraguestcost = { $multiply : ["$extra_people","$numguestsextra"]}
finaloutput = { $project: { price: 1 , maxprice: { $add:
[ "$price",extraguestcost]}}}
db.listingsAndReviews.aggregate([addextra,finaloutput])
```

Data quality is an issue, so you get some wacky answers.

Exercise: Properties by country

How many properties there are in each country, ordered by count, most first:

```
groupfield = "$address.country"
groupstage = { $group: { _id: groupfield, count:{$sum:1}}}
sortstage = {$sort:{count:-1}}
pipe = [groupstage,sortstage]
db.listingsAndReviews.aggregate(pipe)
```

OR

```
db.listingsAndReviews.aggregate([{$sortByCount:"$address.country"}])
```

Exercise Answer

Exercise: $unwind

What amenities are offered in the smallest number of countries?

```
unwindstage = { $unwind:"$amenities"}
groupcountry = {$group :{_id: "$amenities",countries: {$addToSet:"$address.country"}}}
unwind2 = { $unwind : "$countries" }
groupcount = {$group : { "_id" : "$_id", count : {$sum : 1}}}
sortstage = {$sort:{count:1}}
pipe=[unwindstage,groupcountry,unwind2,groupcount,sortstage]

db.listingsAndReviews.aggregate( pipe )
```

The second $unwind and $group is in one record so is better to be the expression

```
{$set: {count : {$size:"$countries"}}}
```

Exercise Answer

Exercise: Final practice

What are the 10 most common words in review comments that have 6 or more characters? A word is the same word regardless of case.

How many unique reviews does each appear in?

```
onereviewperdoc = { $unwind: "$reviews"}
splittext = {$project : { _id: 1 , words : { $split : [{$toLower:"$reviews.comments"},"  "]}}}
unique = { $project : { _id: 1, words : { $setUnion : ["$words",[]]}}}
flatten = { $unwind : "$words"}
filtershort = { $match : { words : /^[A-Za-z]{6}/}}
gbc = {$sortByCount:"$words"}
limit = { $limit:10}

db.listingsAndReviews.aggregate([
      onereviewperdoc,
      splittext,
      unique, flatten, filtershort, gbc, limit
])
```

Exercise Answer