CC5212-1

Procesamiento Masivo de Datos

Otoño 2020

Lecture 10

NoSQL: MongoDB

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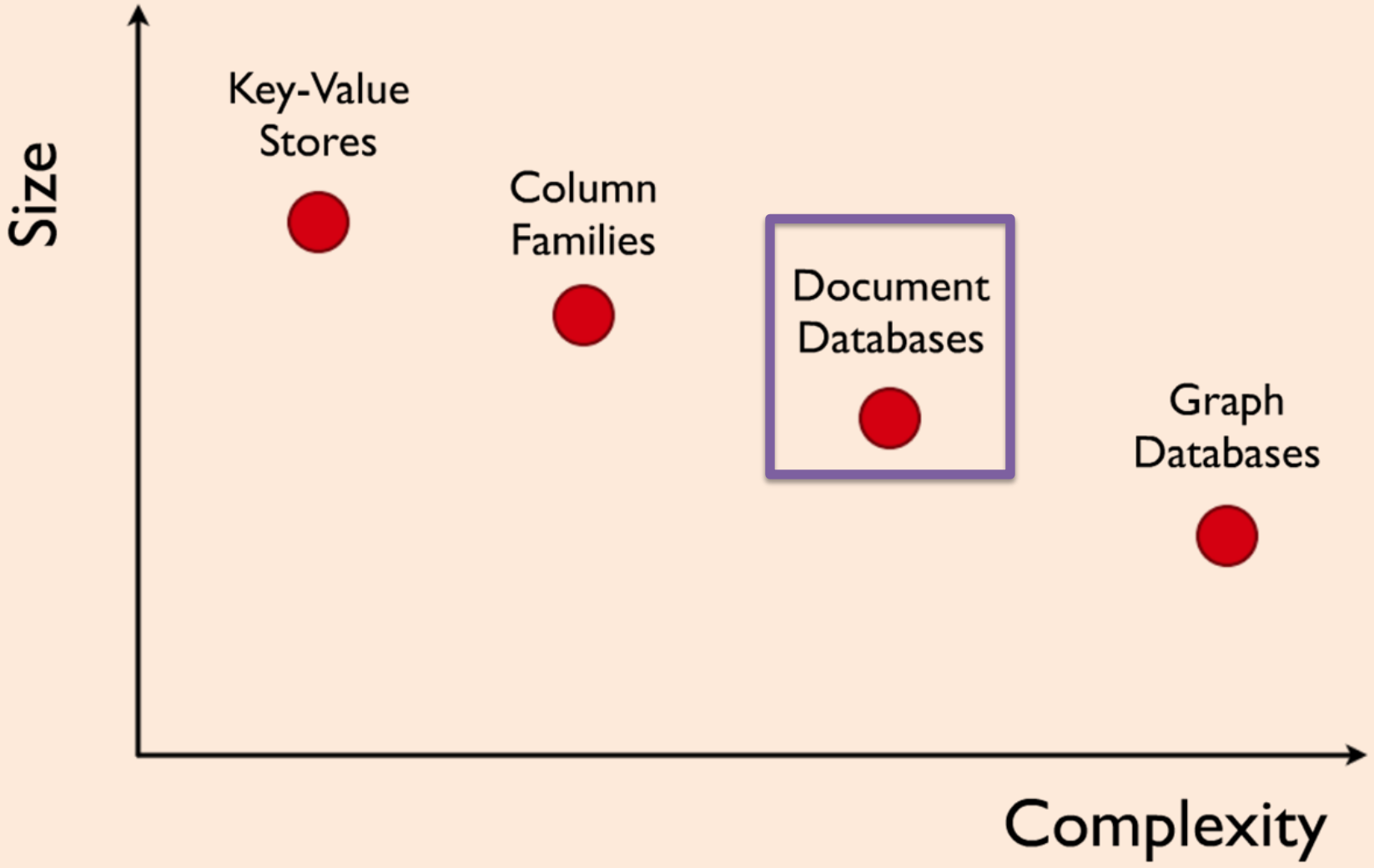
NoSQL


Size
Key-Value Stores
Column Families
Document Databases
Graph Databases
Complexity

Document Stores

Key–Value: a Distributed Map

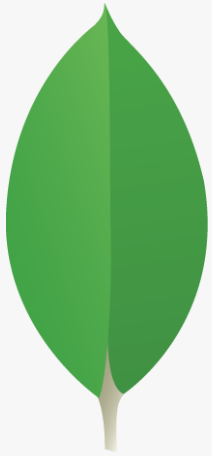
Countries	
Primary Key	**Value**
Afghanistan	capital:Kabul,continent:Asia,pop:31108077#2011
…	…

Tabular: Multi-dimensional Maps

Countries				
Primary Key	**capital**	**continent**	**pop-value**	**pop-year**
Afghanistan	Kabul	Asia	31108077	2011
…	…	…	…	…

Document: Value is a document

Countries	
Primary Key	**Value**
Afghanistan	{ cap: “Kabul”, con: “Asia”, pop: { val: 31108077, y: 2011 } }
…	…



mongoDB®

{JSON}

JavaScript Object Notation

358 systems in ranking, July 2020

Rank Jul 2020	Rank Jun 2020	Rank Jul 2019	DBMS	Database Model	Score Jul 2020	Score Jun 2020	Score Jul 2019
1.	1.	1.	Oracle	Relational, Multi-model	1340.26	-3.33	+19.00
2.	2.	2.	MySQL	Relational, Multi-model	1268.51	-9.38	+38.99
3.	3.	3.	Microsoft SQL Server	Relational, Multi-model	1059.72	-7.59	-31.11
4.	4.	4.	PostgreSQL	Relational, Multi-model	527.00	+4.02	+43.73
5.	5.	5.	MongoDB	Document, Multi-model	443.48	+6.40	+33.55
6.	6.	6.	IBM Db2	Relational, Multi-model	163.17	+1.36	-10.97
7.	7.	7.	Elasticsearch	Search engine, Multi-model	151.59	+1.90	+2.77
8.	8.	8.	Redis	Key-value, Multi-model	150.05	+4.40	+5.78
9.	9.	↑ 11.	SQLite	Relational	127.45	+2.64	+2.82
10.	10.	10.	Cassandra	Wide column	121.09	+2.08	-5.91
11.	11.	↓ 9.	Microsoft Access	Relational	116.54	-0.64	-20.77
12.	12.	↑ 13.	MariaDB	Relational, Multi-model	91.13	+1.34	+6.69
13.	13.	↓ 12.	Splunk	Search engine	88.27	+0.19	+2.78
14.	14.	14.	Hive	Relational	76.42	-2.23	-4.45
15.	15.	15.	Teradata	Relational, Multi-model	75.97	+2.69	-1.85
16.	16.	↑ 20.	Amazon DynamoDB	Multi-model	64.58	-0.29	+8.17
17.	17.	↑ 19.	SAP Adaptive Server	Relational	53.87	+0.78	-2.78
18.	↑ 23.	↑ 25.	Microsoft Azure SQL Database	Relational, Multi-model	52.63	+4.84	+23.97
19.	↓ 18.	↓ 16.	Solr	Search engine	51.64	+0.38	-8.00
20.	↓ 19.	↑ 21.	SAP HANA	Relational, Multi-model	51.34	+0.52	-4.21
21.	↓ 20.	↓ 17.	FileMaker	Relational	49.45	-0.71	-8.45
22.	22.	22.	Neo4j	Graph	48.92	+0.65	-0.05
23.	↓ 21.	↓ 18.	HBase	Wide column	48.66	-0.07	-8.88
24.	24.	24.	Microsoft Azure Cosmos DB	Multi-model	30.40	-0.40	+1.32
25.	↑ 26.	↑ 28.	Google BigQuery	Relational	29.65	+1.36	+5.73


mongoDB.

MongoDB:
Data model

JavaScript Object Notation: JSON


```
{
  "id": 179,
  "name": "The Wire",
  "type": "Scripted",
  "language": "English",
  "genres": [ "Drama", "Crime", "Thriller" ],
  "status": "Ended",
  "runtime": 60,
  "premiered": "2002-06-02",
  "schedule": {
    "time": "21:00",
    "days": [
      "Sunday"
    ]
  },
  "rating": {
    "average": 9.4
  }
}
```


Binary JSON: BSON

```
{
  "_id": ObjectId(99a88b77c66d),
  "name": "The Wire",
  "type": "Scripted",
  "language": "English",
  "genres": [ "Drama", "Crime", "Thriller" ],
  "status": "Ended",
  "runtime": 60,
  "premiered": ISODate("2002-06-02"),
  "schedule": {
    "time": "21:00",
    "days": [
      "Sunday"
    ]
  },
  "rating": {
    "average": 9.4
  }
}
```

MongoDB: Datatypes

String: `"sí"`

Array: `[]`

Object: `{}`

Boolean: `true`

Double: `43.2`

{JSON}
JavaScript Object Notation

etc.

ObjectID: `ObjectId(0A0A0A0A0A0A)`

Date: `ISODate("2003-14-15T09:26:53.589Z")`

BSON {01010100 11101011 10101110 01010101}

etc.

MongoDB: Map from keys to BSON values

TVSeries	
Key	**BSON Value**

99a88b77c66d	<pre>{
	  "_id": ObjectId(99a88b77c66d),
	  "name": "The Wire",
	  "type": "Scripted",
	  "language": "English",
	  "genres": ["Drama", "Crime", "Thriller"],
	  "status": "Ended",
	  "runtime": 60,
	  "premiered": ISODate("2002-06-02"),
	  "schedule": {
	  "time": "21:00",
	  "days": [
	  "Sunday"
	  ]
	  },
	  "rating": {
	  "average": 9.4
	  }
	}</pre>

…	…

MongoDB Collection: Similar Documents

TVSeries	
Key	**BSON Value**
99a88b77c66d	`{ "_id": ObjectId(99a88b77c66d), "name": "The Wire", "type": "Scripted", ... }`
11f22e33d44c	`{ "_id": ObjectId(11f22e33d44c), "name": "Rick and Morty", "type": "Animation", ... }`

MongoDB Database: Related Collections

TVSeries

Key	BSON Value
…	…

TVEpisodes

Key	BSON Value
…	…

TVNetworks

Key	BSON Value
…	…

database: TV

Load database `tvdb` (and create if not exists):

```
> use tvdb

switched to db tvdb
```

See all (non-empty) databases (`tvdb` is empty):

```
> show dbs

local     0.00001 GB
test      0.00231 GB
```

See current database:

```
> db

tvdb
```

Drop current database:

```
> db.dropDatabase()

{ "dropped" : "tvdb", "ok" : 1 }
```

Create collection `series`:

```
> db.createCollection("series")

{ "ok" : 1 }
```

See all collections in current database:

```
> show collections

series
```

Drop collection `series`:

```
> db.series.drop()

true
```

Clear all documents from collection `series`:

```
> db.series.remove( {} )

WriteResult({ "nRemoved" : 0 })
```

Create capped collection (keeps only most recent):

```
> db.createCollection("last100episodes",
   { capped: true, size: 12285600, max: 100 } )

{ "ok" : 1 }
```

MongoDB:
Inserting Data

Insert document: without _id

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "type": "Scripted",
    "runtime": 60,
    "genres": [
      "Science-Fiction",
      "Thriller"
    ]
  })

WriteResult({ "nInserted" : 1 })
```

Insert document: with _id

```
> db.series.insert(
  {
    _id: ObjectId("5951e0b265ad257d48f4a7d5"),
    "name": "Black Mirror",
    "type": "Scripted",
    "runtime": 60,
    "genres": [
      "Science-Fiction",
      "Thriller"
    ]
  })

WriteResult({ "nInserted" : 1 })
```

… fails if _id already exists

… use update or save to update existing document(s)

Use save and _id to overwrite:

```
> db.series.insert(
  {
    _id: ObjectId("5951e0b265ad257d48f4a7d5"),
    "name": "Black Mirror",
    "type": "Scripted",
    "runtime": 60
  })

WriteResult({ "nInserted" : 1 })
```

```
> db.series.save(
  {
    _id: ObjectId("5951e0b265ad257d48f4a7d5"),
    "name": "Black Mirror (Overwritten)"
  })

WriteResult({ "nMatched" : 1, "nUpserted" : 0, "nModified" : 1 })
```

... overwrites old document

MongoDB:

Queries with Selection

Query documents in a collection with `find`:

```
> db.series.insert(
  {
    _id: ObjectId("5951e0b265ad257d48f4a7d5"),
    "name": "Black Mirror",
    "type": "Scripted",
    "runtime": 60
  })
```

```
> db.series.find()

{ "_id" : ObjectId("5951e0b265ad257d48f4a7d5"), "name" : "Black Mirror",
"type" : "Scripted", "runtime" : 60 }
```

… use `findOne()` to return one document

Pretty print results with `pretty`:

```
> db.series.insert(
  {
    _id: ObjectId("5951e0b265ad257d48f4a7d5"),
    "name": "Black Mirror",
    "type": "Scripted",
    "runtime": 60
  })
```

```
> db.series.find().pretty()

{
    "_id" : ObjectId("5951e0b265ad257d48f4a7d5"),
    "name" : "Black Mirror",
    "type" : "Scripted",
    "runtime" : 60
}
```

Selection: find documents matching σ

```
> db.series.find(σ)
```

Selection σ: Equality

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "type": "Scripted",
    "runtime": 60
  })
```

Equality: `{ key: value }`

```
> db.series.find( { "type": "Scripted" } )

{ "name" : "Black Mirror", "type" : "Scripted", "runtime" : 60 }
```

Results would include `_id` but for brevity, we will omit this from examples where it is not important.

Selection σ: Nested key

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "rating": { "avg": 9.4 },
    "runtime": 60
  })
```

Key can access nested values:

```
> db.series.find( { "rating.avg": 9.4 } )

{ "name" : "Black Mirror", "rating": { "avg": 9.4 }, "runtime" : 60 }
```

Selection σ: Equality on null

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "rating": { "avg": null },
    "runtime": 60
  })
```

Equality on nested null value:

```
> db.series.find( { "rating.avg": null } )

{ "name" : "Black Mirror", "rating": { "avg": null }, "runtime" : 60 }
```

... matches when value is null or ...

Selection σ: Equality on null

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "rating": { "val": 9.4 },
    "runtime": 60
  })
```

Key can access nested values:

```
> db.series.find( { "rating.avg": null } )

{ "name" : "Black Mirror", "rating": { "val": 9.4 }, "runtime" : 60 }
```

... when field doesn't exist with key.

Selection σ: Equality on document

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "rating": { "avg": 9.4 },
    "runtime": 60
  })
```

Value can be an object/document:

```
> db.series.find( { "rating": { "avg": 9.4 } } )

{ "name" : "Black Mirror", "rating": { "avg": 9.4 }, "runtime" : 60 }
```

Selection σ: Equality on document

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "rating": { "avg": 9.4, "votes": 9001 },
    "runtime": 60
  })
```

Value can be an object/document:

```
> db.series.find( { "rating": { "votes":9001 } } )
```

… no results: needs to match full object.

Selection σ: Equality on document

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "rating": { "avg": 9.4, "votes": 9001 },
    "runtime": 60
  })
```

Value can be an object/document:

```
> db.series.find( { "rating": { "votes":9001, "avg":9.4 } } )
```

… no results: order of attributes matters.

Selection σ: Equality on exact array

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "genres": [ "Science-Fiction", "Thriller" ],
    "runtime": 60
  })
```

Equality can match an exact array:

```
> db.series.find( { "genres": [ "Science-Fiction",
                                "Thriller" ] } )

{ "name" : "Black Mirror", "genres": [ "Science-Fiction", "Thriller" ],
"runtime" : 60 }
```

Selection σ: Equality on exact array

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "genres": [ "Science-Fiction", "Thriller" ],
    "runtime": 60
  })
```

Equality can match an exact array

```
> db.series.find( { "genres": [ "Science-Fiction" ] } )
```

… no results: needs to match full array.

Selection σ: Equality on exact array

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "genres": [ "Science-Fiction", "Thriller" ],
    "runtime": 60
  })
```

Equality can match an exact array

```
> db.series.find( { "genres": [ "Thriller",
                                "Science-Fiction" ] } )
```

… no results: order of elements matters.

Selection σ: Equality matches inside array

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "genres": [ "Science-Fiction", "Thriller" ],
    "runtime": 60
  })
```

Equality matches a value in an array:

```
> db.series.find( { "genres": "Thriller" } )

{ "name" : "Black Mirror", "genres": [ "Science-Fiction", "Thriller" ],
"runtime" : 60 }
```

Selection σ: Equality matches both

```
> db.series.insert( { "name": "A" , "val": [ 5, 6 ] } )
> db.series.insert( { "name": "B", "val": 5 } )
```

Equality matches a value inside and outside an array:

```
> db.series.find( { "val": 5 } )

{ "name": "A" , "val": [ 5, 6 ] }
{ "name": "B" , "val": 5 }
```

cough

Selection σ: Inequalities

Less than:	`{ key: { $lt: value } }`
Greater than:	`{ key: { $gt: value } }`
Less than or equal:	`{ key: { $lte: value } }`
Greater than or equal:	`{ key: { $gte: value } }`
Not equals:	`{ key: { $ne: value } }`

Selection σ: Less Than

```
> db.series.insert(
  {
    _id: ObjectId("5951e0b265ad257d48f4a7d5"),
    "name": "Black Mirror",
    "genres": [ "Science-Fiction", "Thriller" ],
    "runtime": 60
  })
```

Less than: `{ key: { $lt: value } }`

```
> db.series.find({ "runtime": { $lt: 70 } })

{ "name" : "Black Mirror", "genres": [ "Science-Fiction", "Thriller" ],
"runtime" : 60 }
```

Selection σ: Match one of multiple values

Match any value: `{ key: { $in: [ v1, …, vn ] } }`

Match no value: `{ key: { $nin: [ v1, …, vn ] } }`

… also passes if key does not exist.

Selection σ: Match one of multiple values

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "genres": [ "Science-Fiction", "Thriller" ],
    "runtime": 60
  })
```

Match any value: `{ key: { $in: [ v1, …, vn ] } }`

```
> db.series.find({ "runtime": { $in: [30, 60] } })

{ "name" : "Black Mirror", "genres": [ "Science-Fiction", "Thriller" ],
"runtime" : 60 }
```

Selection σ: Match one of multiple values

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "genres": [ "Science-Fiction", "Thriller" ],
    "runtime": 60
  })
```

Match any value: `{ key: { $in: [ v1, …, vn ] } }`

```
> db.series.find({ "genres": { $in: ["Noir", "Thriller"] } })

{ "name" : "Black Mirror", "genres": [ "Science-Fiction", "Thriller" ],
"runtime" : 60 }
```

… if key references an array, any value of array should match any value of `$in`

Selection σ: Boolean connectives

And: `{ $and: [ σ , σ′ ] }`

Or: `{ $or: [ σ , σ′ ] }`

Not: `{ $not: [ σ ] }`

Nor: `{ $nor: [ σ , σ′ ] }`

… naturally, we can nest such conditions

Selection σ: And

```
> db.series.insert(
  {
    _id: ObjectId("5951e0b265ad257d48f4a7d5"),
    "name": "Black Mirror",
    "genres": [ "Science-Fiction", "Thriller" ],
    "runtime": 60
  })
```

And: { $and: [σ , σ′] }

```
> db.series.find({ $and: [
    { "runtime": { $in: [30, 60] } } ,
    { "name": { $ne: "Lost" } } ] }
)

{ "name" : "Black Mirror", "genres": [ "Science-Fiction", "Thriller" ],
"runtime" : 60 }
```

Selection σ: Attribute (not) exists

Exists: `{ key: { $exists : true } }`

Not Exists: `{ key: { $exists : false } }`

Selection σ: Attribute exists

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "genres": [ "Science-Fiction", "Thriller" ],
    "runtime": 60
  })
```

Exists: `{ key: { $exists : true } }`

```
> db.series.find({ "name": { $exists : true } })

{ "name" : "Black Mirror", "genres": [ "Science-Fiction", "Thriller" ],
"runtime" : 60 }
```

… checks that the field key exists
(even if value is NULL)

Selection σ: Attribute not exists

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "genres": [ "Science-Fiction", "Thriller" ],
    "runtime": 60
  })
```

Not exists: `{ key: { $exists : false } }`

```
> db.series.find({ "name": { $exists : false } })
```

… checks that the field key doesn't exist (empty results)

Selection σ: Arrays

All: `{ key: { $all : [v1, …, vn] } }`

Match one: `{ key: { $elemMatch : {σ1, …, σn } } }`

Size: `{ key: { $size : int } }`

Selection σ: Array contains (at least) all elements

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "genres": [ "Sci-Fi", "Thriller", "Comedy" ],
    "runtime": 60
  })
```

All: `{ key: { $all : [v1, …, vn] } }`

```
> db.series.find(
  { "genres": { $all : [ "Comedy", "Sci-Fi" ] } })

{ "name" : "Black Mirror", "genres": [ "Sci-Fi", "Thriller", "Comedy" ],
"runtime" : 60 }
```

… all values are in the array

Selection σ: Array element matches (with AND)

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "series": [ 1, 2, 3 ],
    "runtime": 60
  })
```

Match one: `{ key: { $elemMatch : {σ1, …, σn } } }`

```
> db.series.find(
  { "series": { $elemMatch : { $gt: 1, $lt: 3 } } })

{ "name" : "Black Mirror", "series": [ 1, 2, 3 ], "runtime" : 60 }
```

… one element matches all criteria (with AND)

Selection σ: Array with exact size

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "series": [ 1, 2, 3 ],
    "runtime": 60
  })
```

Size: `{ key: { $size : int } }`

```
> db.series.find( { "series": { $size : 3 } })

{ "name" : "Black Mirror", "series": [ 1, 2, 3 ], "runtime" : 60 }
```

… only possible for exact size of array (not ranges)

Selection σ: Type of value

Type: `{ key: { $type: typename } }`

"timestamp"

"decimal"

"string"

"double"

"binData"

"date"

"object"

"int"

"array"

"long"

"bool"

"undefined"

"objectId"

"null"

"regex"

"dbPointer"

"array"

"javascript"

"number"

…

Selection σ: Type of value

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "genres": [ "Science-Fiction", "Thriller" ],
    "runtime": 60
  })
```

Type: `{ key: { $type: typename } }`

```
> db.series.find({ "runtime": { $type : "number" } })

{ "name" : "Black Mirror", "genres": [ "Science-Fiction", "Thriller" ],
"runtime" : 60 }
```

Selection σ: Matching an array by type?

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "genres": [ "Science-Fiction", "Thriller" ],
    "runtime": 60
  })
```

Type: `{ key: { $type: typename } }`

```
> db.series.find({ "genres": { $type : "array" } })
```

… empty

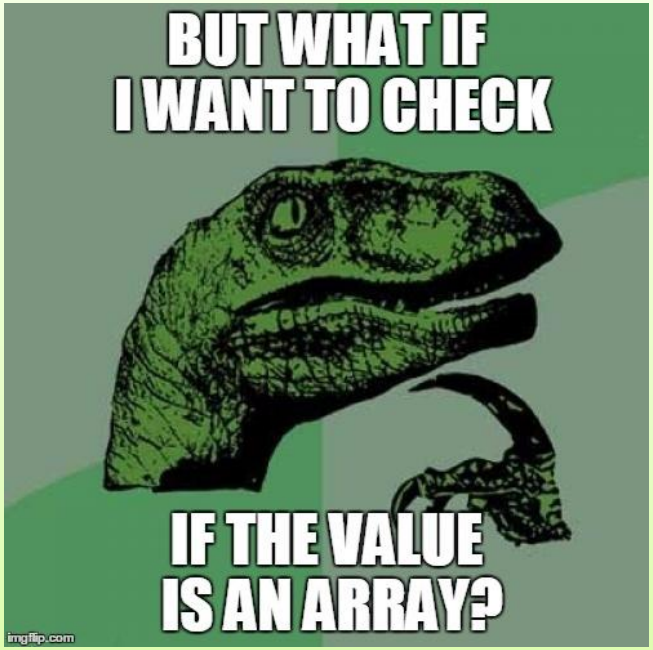
… passes if any value in the array has that type

Selection σ: Matching an array by type?

Arrays

When applied to arrays, `$type` matches any **inner** element that is of the specified BSON type. For example, when matching for `$type : 'array'`, the document will match if the field has a nested array. It will not return results where the field itself is an `array`.

https://docs.mongodb.com/manual/reference/operator/query/type/




```
> db.series.insert(
  {
    "name": "Black Mirror",
    "genres": [ "Science-Fiction", "Thriller" ],
    "runtime": 60
  })
```

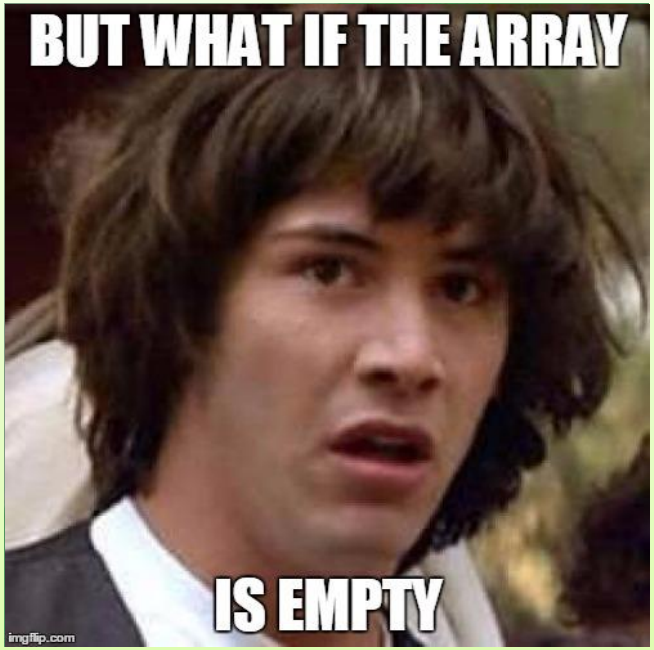
```
> db.series.find(
 { "genres": { $elemMatch: { $exists : true } } }
 )

{ "name" : "Black Mirror", "genres": [ "Science-Fiction", "Thriller"
], "runtime" : 60 }
```

Selection σ: Matching an array by type?

Arrays

When applied to arrays, `$type` matches any **inner** element that is of the specified BSON type. For example, when matching for `$type : 'array'`, the document will match if the field has a nested array. It will not return results where the field itself is an `array`.

https://docs.mongodb.com/manual/reference/operator/query/type/




```
> db.series.insert(
  {
    "name": "Black Mirror",
    "genres": [],
    "runtime": 60
  })
```

```
> db.series.find(
  { $or: [
   { "genres": { $elemMatch: { $exists: true } } },
   { "genres": [] }
  ] } )

{ "name" : "Black Mirror", "genres": [], "runtime" : 60 }
```

Selection σ: Other operators

Mod: `{ key: { $mod [ div, rem ] } }`

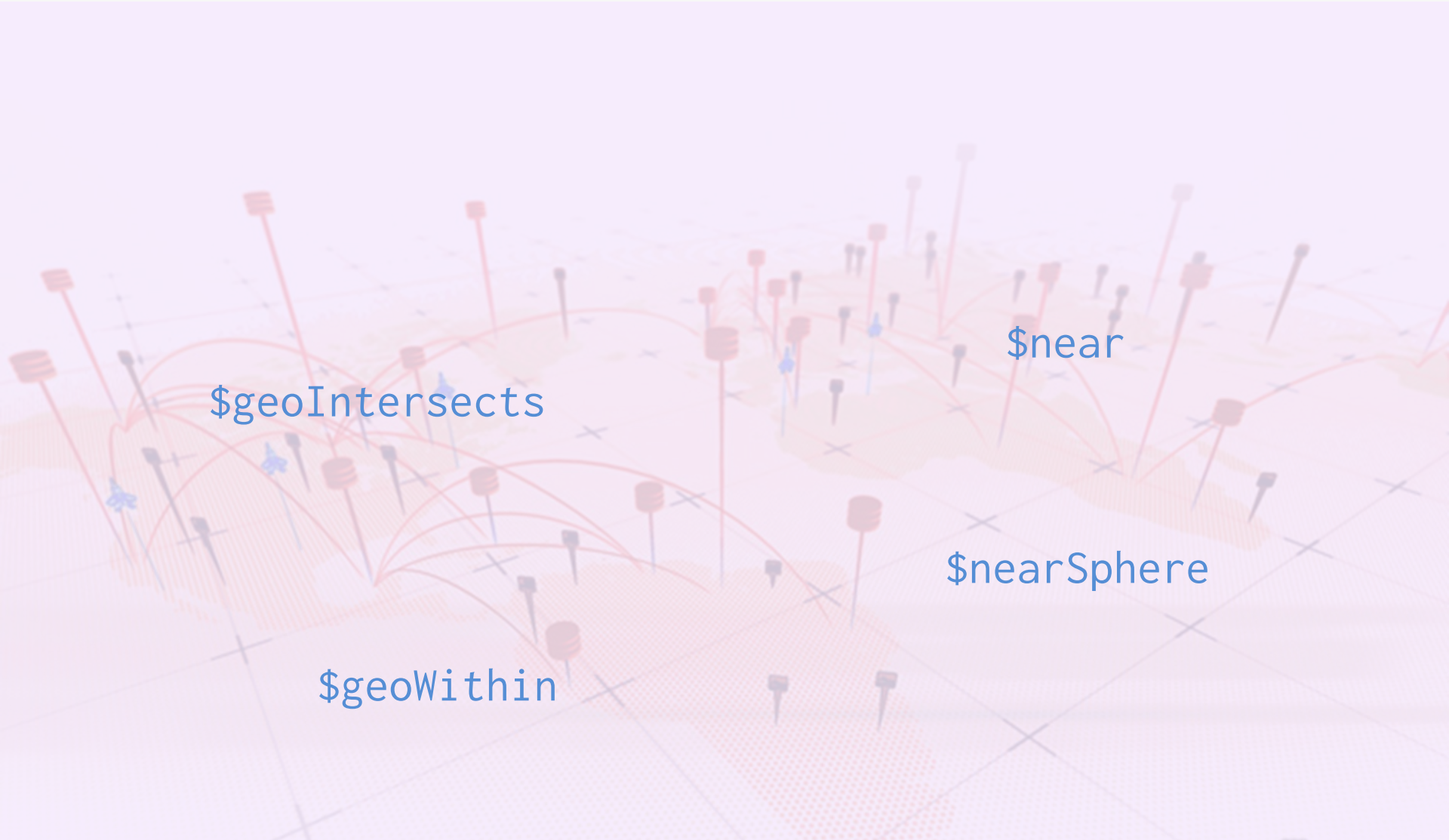
Regex: `{ key: { $regex: pattern } }`

Text search: `{ $text: { $search: terms } }`

Where (JS): `{ $where: javascript_code }`

… `where` is executed over all documents
(and should be avoided where possible)

Selection σ: Geographic features



https://docs.mongodb.com/manual/reference/operator/query-geospatial/

Selection σ: Bitwise features

$bitsAllClear

$bitsAllSet

$bitsAnyClear

$bitsAnySet

...

https://docs.mongodb.com/manual/reference/operator/query-bitwise/

MongoDB:

Projection of output values

Projection π: Choose output values

`key: 1`:	Output field(s) with `key`
`key: 0`:	Suppress field(s) with `key`
`array.$: 1`	Project first matching array element I
`$elemMatch`:	Project first matching array element II
`$slice`:	Output first or last `slice` array values

https://docs.mongodb.com/manual/reference/operator/projection/

Projection π: Output certain fields

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "series": [ 1, 2, 3 ],
    "runtime": 60
  })
```

Project only certain fields: `{ k1: 1, ..., kn: 1 }`

```
> db.series.find(
  { "runtime": { $gt: 30 } },
  { "name": 1 , "runtime": 1, "network": 1 })

{ "_id" : ObjectId("5951e0b265ad257d48f4a7d5"), "name" : "Black Mirror",
"runtime" : 60 }
```

... outputs what is available; by default also outputs `_id` field

Projection π: Output embedded fields

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "rating": { "avg": 9.4 , "votes": 9001 },
    "runtime": 60
  })
```

Project (embedded) fields: `{ k1: 1, ..., kn: 1 }`

```
> db.series.find(
  { "runtime": { $gt: 30 } },
  { "name": 1 , "rating.avg": 1 })

{ "_id" : ObjectId("5951e0b265ad257d48f4a7d5"), "name" : "Black Mirror",
"rating" : { "avg": 9.4 } }
```

... field is still nested in output

Projection π: Output embedded fields in array

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "reviews": [
       { "user": "jack" , "score": 9.1 },
       { "user": "jill" , "score": 8.3 }
    ],
    "runtime": 60
  })
```

Project (embedded) fields: `{ k1: 1, ..., kn: 1 }`

```
> db.series.find(
  { "runtime": { $gt: 30 } },
  { "name": 1 , "reviews.score": 1 })

{ "_id" : ObjectId("5951e0b265ad257d48f4a7d5"), "name" : "Black Mirror",
"reviews" : [ { "score": 9.1 } , { "score": 8.3 } ] }
```

... projects from within the array.

Projection π: Suppress certain fields

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "series": [ 1, 2, 3 ],
    "runtime": 60
  })
```

Return all but specified fields: `{ k1: 0, ..., kn: 0 }`

```
> db.series.find(
  { "runtime": { $gt: 30 } },
  { "series": 0 })

{ "_id" : ObjectId("5951e0b265ad257d48f4a7d5"), "name" : "Black Mirror",
"runtime" : 60 }
```

... cannot combine 0 and 1 except ...

Projection π: Suppress certain fields

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "series": [ 1, 2, 3 ],
    "runtime": 60
  })
```

Suppress ID: `{ _id: 0, k1: 1, ..., kn: 1 }`

```
> db.series.find(
  { "runtime": { $gt: 30 } },
  { "_id": 0, "name": 1 , "series": 1 })

{ "name" : "Black Mirror", "series" : [ 1, 2, 3 ] }
```

... `0` suppresses `_id` when other fields are output

Projection π: Output first matching element

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "series": [ 1, 2, 3 ],
    "runtime": 60
  })
```

Project first matching element: `array.$: 1`

```
> db.series.find(
  { "series": { $elemMatch: { $gt: 1 } } },
  { "series.$": 1 } )

{ _id: ..., "series": [ 2 ] }
```

Projection π: Output first matching element

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "series": [ 1, 2, 3 ],
    "runtime": 60
  })
```

Project first matching element: $elemMatch

```
> db.series.find(
  { "series": { $elemMatch: { $gt: 1 } } },
  { "series": { $elemMatch: { $lt: 3 } } } )

{ "_id": ..., "series": [ 1 ] }
```

… allows to separate selection and projection criteria.

Projection π: Output first matching element

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "series": [ 1, 2, 3 ],
    "runtime": 60
  })
```

Project first matching element: $elemMatch

```
> db.series.find(
  { "series": { $elemMatch: { $gt: 1 } } },
  { "series": { $elemMatch: { $gt: 3 } } } )

{ "_id": ... }
```

… drops array field entirely if no element is projected.

Projection π: Output first matching element

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "series": [ 1, 2, 3 ],
    "reviews": [
       { "user": "jack" , "score": 9.1 },
       { "user": "jill" , "score": 8.3 }
    ]
  })
```

Project first matching element: $elemMatch

```
> db.series.find(
  { "series": { $elemMatch: { $gt: 1 } } },
  { "reviews": { $elemMatch: { "score": { $gt: 8 } } } } )

{ "_id": ..., "reviews": [ { "user": "jack" , "score": 9.1 } ] }
```

... can match on array of documents.

Projection π: Output some matching elements

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "series": [ 1, 2, 3 ],
    "runtime": 60
  })
```

Return first n elements: `$slice: n` (where n > 0)

```
> db.series.find(
  { "series": { $elemMatch: { $gt: 1 } } },
  { "series": { $slice: 2 } } )

{ "_id": ..., "name": "Black Mirror", "series": [ 1, 2 ], "runtime": 60 }
```

Projection π: Output some matching elements

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "series": [ 1, 2, 3 ],
    "runtime": 60
  })
```

Return last n elements: `$slice: n` (where n < 0)

```
> db.series.find(
  { "series": { $elemMatch: { $gt: 1 } } },
  { "series": { $slice: -2 } } )

{ "_id": ..., "name": "Black Mirror", "series": [ 2, 3 ], "runtime": 60 }
```

Projection π: Output some matching elements

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "series": [ 1, 2, 3 ],
    "runtime": 60
  })
```

Skip n and return m: `$slice: [n,m]` (n, m > 0)

```
> db.series.find(
  { "series": { $elemMatch: { $gt: 1 } } },
  { "series": { $slice: [ 2, 1 ] } } )

{ "_id": ..., "name": "Black Mirror", "series": [ 3 ], "runtime": 60 }
```

Projection π: Output some matching elements

```
> db.series.insert(
  {
    "name": "Black Mirror",
    "series": [ 1, 2, 3 ],
    "runtime": 60
  })
```

From last n, return m: `$slice: [n,m]` (n < 0, m > 0)

```
> db.series.find(
  { "series": { $elemMatch: { $gt: 1 } } },
  { "series": { $slice: [ -2, 1 ] } } )

{ "_id": ..., "name": "Black Mirror", "series": [ 2 ], "runtime": 60 }
```

MongoDB:
Updates

Update **u**: Modify fields in documents

`$set`:	Set the value
`$unset`:	Remove the key and value
`$rename`:	Rename the field (change the key)
`$setOnInsert`:	Set value only if a new document is created
`$inc`:	Increment number by `inc`
`$mul`:	Multiply number by `mul`
`$min`:	Replace values less than `min` by `min`
`$max`:	Replace values greater than `max` by `max`
`$currentDate`:	Set to current date

https://docs.mongodb.com/manual/reference/operator/update-field/

Use update with query criteria and update criteria:

```
> db.series.insert(
  {
    _id: ObjectId("5951e0b265ad257d48f4a7d5"),
    "name": "Black Mirror",
    "type": "Scripted",
    "language": "English",
  })

WriteResult({ "nInserted" : 1 })

> db.series.update(
    { "type": "Scripted" },
    { $set: { "type": "Fiction" } },
    { "multi": true }
  )

WriteResult({ "nMatched" : 1, "nUpserted" : 0, "nModified" : 1 })

> db.series.find({ "name": "Black Mirror" })

{           "_id": ObjectId("5951e0b265ad257d48f4a7d5"),
            "name": "Black Mirror",
            "type": "Fiction",
            "language": "English"               }
```

Update **u**: Modify arrays in documents

`$addToSet`:	Adds value if not already present
`$pop`:	Deletes first or last value
`$push`:	Appends (an) item(s) to the array
`$pullAll`:	Removes values from a list
`$pull`:	Removes values that match a condition

(Sub-)operators used upon pushing/adding values:

`$`:	Select first element matching query condition
`$each`:	Add or push multiple values
`$slice`:	After pushing, keep first or last `slice` values
`$sort`:	Sort the array after pushing [1 for ASC; −1 for DESC]
`$position`:	Push values to a specific array index

https://docs.mongodb.com/manual/reference/operator/update-array/

Update u: Modify arrays in documents

```
> db.series.insert(
  {
    _id: ObjectId("5951e0b265ad257d48f4a7d5"),
    "name": "Black Mirror",
    "type": [ "Scripted", "Drama" ],
    "languages": [ "English", "Spanish" ],
  })

WriteResult({ "nInserted" : 1 })

> db.series.update(
    { "type": "Scripted" },
    { $pull: { "type": { $in: [ "Drama", "Sci-Fi" ] },
               "languages": "Spanish" } },
    { "multi": true } )

WriteResult({ "nMatched" : 1, "nUpserted" : 0, "nModified" : 1 })

> db.series.find({ "name": "Black Mirror" })

{       "_id" : ObjectId("5951e0b265ad257d48f4a7d5"),
        "name" : "Black Mirror",
        "type" : [ "Scripted" ],
        "languages" : [ "English" ] }
```

Update **u**: Modify arrays in documents

```
> db.series.insert(
  {
    _id: ObjectId("5951e0b265ad257d48f4a7d5"),
    "name": "Black Mirror",
    "ratings": [ 8, 11, 13, 9 ],
    "languages": [ "English", "Spanish" ],
  })

WriteResult({ "nInserted" : 1 })

> db.series.update(
    { "ratings": { $gt: 10 } },
    { $set: { "ratings.$": 10 } },
    { "multi": true } )

WriteResult({ "nMatched" : 1, "nUpserted" : 0, "nModified" : 1 })

> db.series.find({ "name": "Black Mirror" })

{       "_id" : ObjectId("5951e0b265ad257d48f4a7d5"),
        "name" : "Black Mirror",
        "ratings" : [ 8, 10, 13, 9 ],
        "languages" : [ "English", "Spanish" ]  }
```

Update **u**: Modify arrays in documents

```
> db.series.insert(
  {
    _id: ObjectId("5951e0b265ad257d48f4a7d5"),
    "name": "Black Mirror",
    "ratings": [ 8, 11, 13, 9 ],
    "languages": [ "English", "Spanish" ],
  })

WriteResult({ "nInserted" : 1 })

> db.series.update(
    { "ratings": { $gt: 10 } },
    { $push: { "ratings": { $each: [4, 9],
                            $sort: 1, $slice: 4 } } },
    { "multi": true } )

WriteResult({ "nMatched" : 1, "nUpserted" : 0, "nModified" : 1 })

> db.series.find({ "name": "Black Mirror" })

{       "_id" : ObjectId("5951e0b265ad257d48f4a7d5"),
        "name" : "Black Mirror",
        "ratings" : [ 4, 8, 9, 9 ],
        "languages" : [ "English", "Spanish" ] }
```

MongoDB:

Aggregation and Pipelines

Aggregation: without grouping

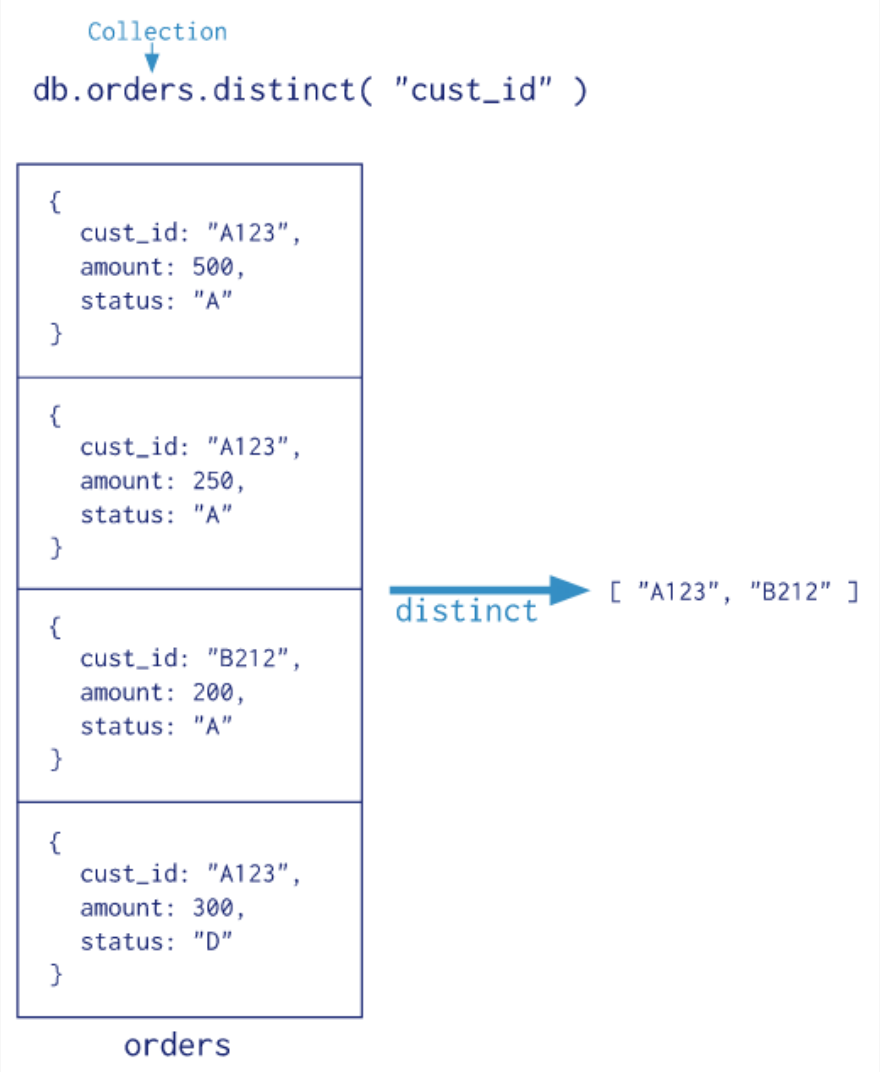
`db.coll.distinct(key)`: Array of unique values for that key

https://docs.mongodb.com/manual/reference/method/db.collection.distinct/

`db.coll.count()`: Count the documents

https://docs.mongodb.com/manual/reference/method/db.collection.count/

Aggregation: distinct



Pipelines: Transforming Collections

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

Pipeline ρ: Stage Operators

`$match`: Filter by selection criteria σ

`$project`: Perform a projection π

`$group`: Group documents by a key/value

[used with *`$sum`*, *`$avg`*, *`$first`*, *`$last`*, *`$max`*, *`$min`*, etc.]

`$lookup`: Perform left-outer-join with another collection

`$unwind`: Copy each document for each array value

`$collStats`: Get statistics about collection

`$count`: Count the documents in the collection

`$sort`: Sort documents by a given key (`ASC|DESC`)

`$limit`: Return (up to) n first documents

`$sample`: Return (up to) n sampled documents

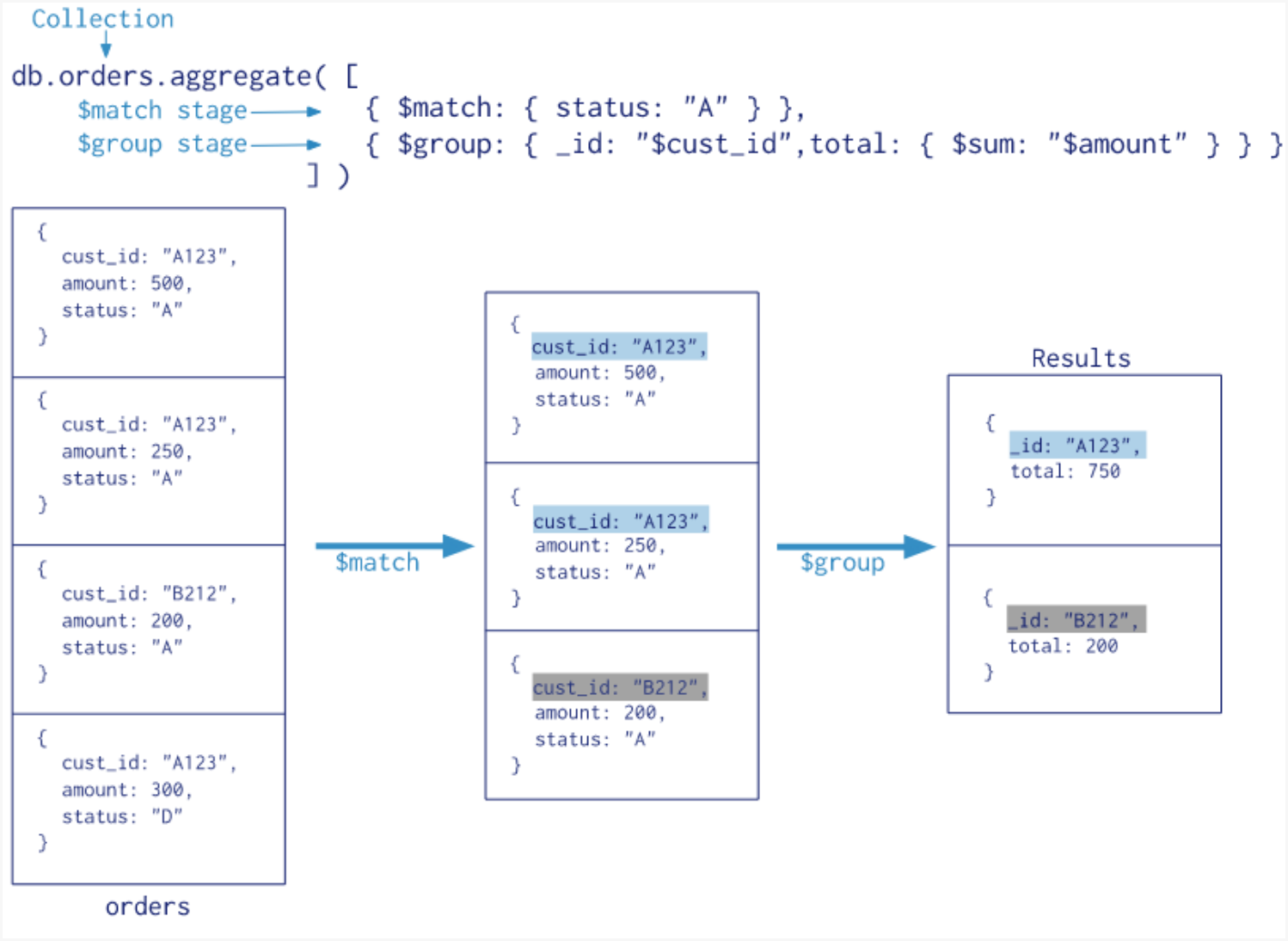
`$skip`: Skip n documents

`$out`: Save collection to MongoDB

(more besides)

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

Pipeline Aggregation: $match and $group



Pipeline Aggregation: $lookup

```
{
  "name": "The Wire",
  "country": "US"
}
{
  "name": "Black Mirror",
  "country": "UK"
}
```

```
{
  "nation": "US",
  "network": "HBO"
}
{
  "nation": "US",
  "network": "FOX"
}
```

```
> db.series.aggregate( [
  { $lookup: { from: "networks", localField: "country",
     foreignField: "nation", as: "possibleNetworks" }
  } ] )
```

```
{
  "name": "The Wire",
  "country": "US",
  "possibleNetworks": [
    { "nation": "US", "network": "HBO" } ,
    { "nation": "US", "network": "FOX" }
  ]
}
{
  "name": "Black Mirror",
  "country": "UK"
  "possibleNetworks": []
}
```

Pipeline Aggregation: $unwind

```
{
  "name": "The Wire",
  "genres": [ "Drama", "Crime", "Thriller" ]
}
```

```
> db.series.aggregate( [ { $unwind : "$genres" } ] )
```

```
{
  "name": "The Wire",
  "genres": "Drama"
}
{
  "name": "The Wire",
  "genres": "Crime"
}
{
  "name": "The Wire",
  "genres": "Thriller"
}
```

MongoDB:

Indexing

MongoDB Indexing

Per collection:

- `_id` Index
- Single-field Index (sorted)
- Compound Index (sorted)
- Multikey Index (for arrays)
- Geospatial Index
- Full-text Index
- Hash-based indexing (hashed)

MongoDB: Text Indexing Example

```
> db.series.insert(
  {
    _id: ObjectId("5951e0b265ad257d48f4a7d5"),
    "name": "Black Mirror",
    "summary": "A British sci-fi series with a dystopian setting",
    "languages": [ "English", "Spanish" ],
  })

WriteResult({ "nInserted" : 1 })

> db.series.createIndex( { summary: "text"})

> db.series.getIndexes()

[      {               "v" : 2,
                       "key" : { "_id" : 1 },
                       "name" : "_id_",
                       "ns" : "test.series"            },
       {               "v" : 2,
                       "key" : { "fts" : "text", "_ftsx" : 1 },
                       "name" : "summary_text",
                       "ns" : "test.series",
                       "weights" : { "summary" : 1 },
                       "default_language" : "english",
                       "language_override" : "language",
                       "textIndexVersion" : 3          }
]
```

MongoDB: Text Indexing Example

```
> db.series.insert(
  {
    _id: ObjectId("5951e0b265ad257d48f4a7d5"),
    "name": "Black Mirror",
    "summary": "A British sci-fi series with a dystopian setting",
    "languages": [ "English", "Spanish" ],
  })

WriteResult({ "nInserted" : 1 })

> db.series.createIndex( { summary: "text"})

> db.series.find(
     { $text: { $search: "dystopia sci-fi" } } )

{       "_id" : ObjectId("5951e0b265ad257d48f4a7d5"),
        "name" : "Black Mirror",
        "summary" : "A British sci-fi series with a dystopian setting",
        "languages" : [
                "English",
                "Spanish"
        ]               }
```

MongoDB:
Distribution

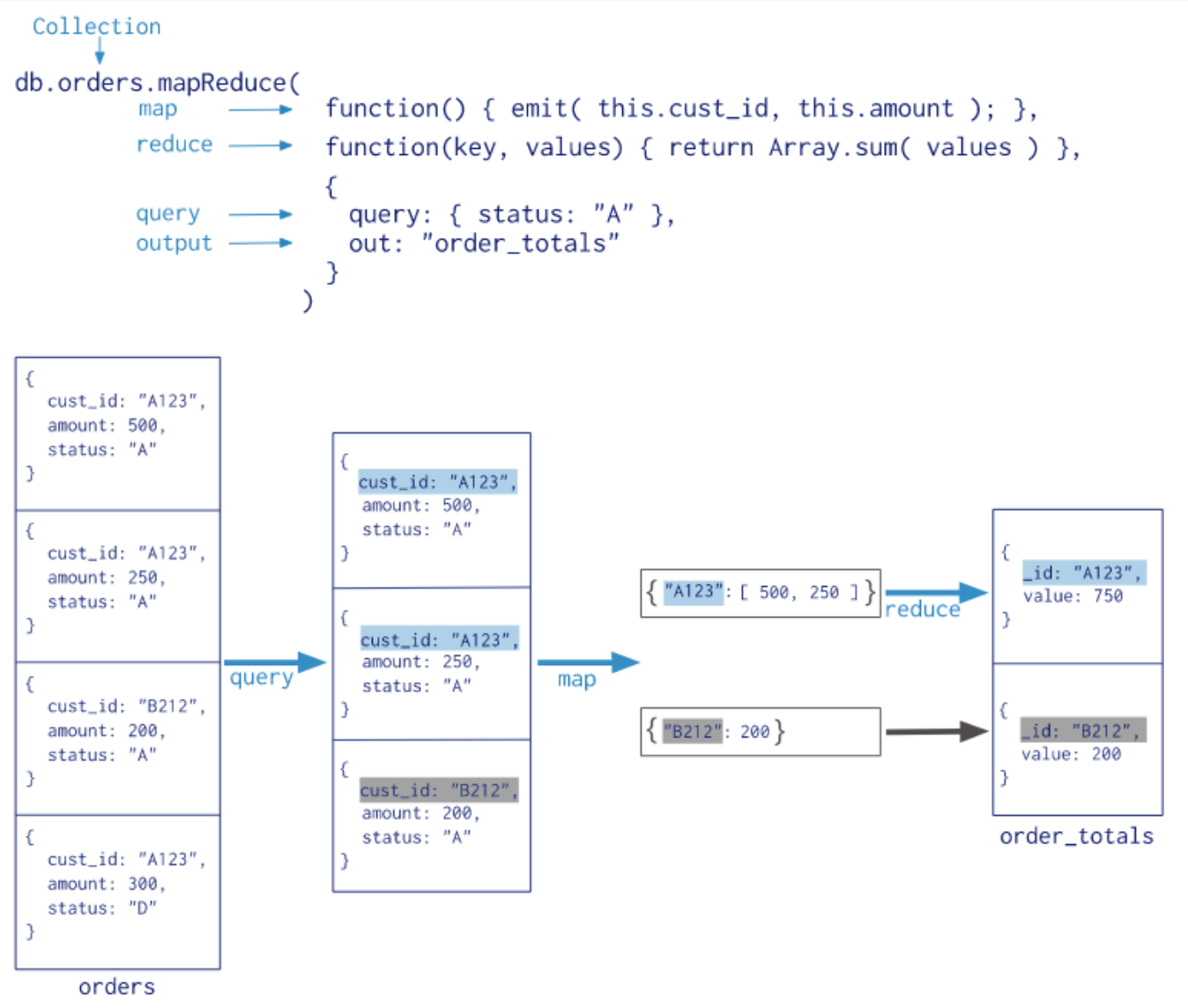
MongoDB: Distribution

- "Sharding":
  - Hash-based or Horizontal Ranged

    (Depends on indexes)

- Replication
  - Replica sets

mapreduce


Collection
db.orders.mapReduce(
map
function() { emit(this.cust_id, this.amount); },
reduce
function(key, values) { return Array.sum(values) },
{
query
query: { status: "A" },
output
out: "order_totals"
}
)
{ cust_id: "A123", amount: 500, status: "A" }
{ cust_id: "A123", amount: 250, status: "A" }
{ cust_id: "B212", amount: 200, status: "A" }
{ cust_id: "A123", amount: 300, status: "D" }
orders
query
{ cust_id: "A123", amount: 500, status: "A" }
{ cust_id: "A123", amount: 250, status: "A" }
{ cust_id: "B212", amount: 200, status: "A" }
map
{ "A123": [500, 250] }
{ "B212": 200 }
reduce
{ _id: "A123", value: 750 }
{ _id: "B212", value: 200 }
order_totals

MongoDB:

A WORD OF WARNING

joepie91's Ramblings RSS

Why you should never, ever, ever use MongoDB

19 Jul 2015

MongoDB is evil. It...

- ... loses data (sources: 1, 2)
- ... in fact, for a long time, ignored errors by default and assumed every single write succeeded no matter what (which on 32-bits systems led to losing all data silently after some 3GB, due to MongoDB limitations)
- ... is slow, *even* at its advertised usecases, and claims to the contrary are completely lacking evidence (sources: 3, 4)
- ... forces the poor habit of implicit schemas in nearly all usecases (sources: 4)
- ... has locking issues (sources: 4)
- ... has an atrociously poor response time to security issues - it took them **two years** to patch an insecure default configuration that would expose *all of your data* to anybody who asked, without authentication (sources: 5)
- ... is not ACID-compliant (sources: 6)
- ... is a nightmare to scale and maintain
- ... isn't even exclusive in its offering of JSON-based storage; PostgreSQL does it too, and other (better) document stores like CouchDB have been around for a long time (sources: 7, 8)

http://cryto.net/~joepie91/blog/2015/07/19/why-you-should-never-ever-ever-use-mongodb/

Ransomware groups have deleted over 10,000 MongoDB databases

Five groups of attackers are competing to delete as many publicly accessible MongoDB databases as possible

By Lucian Constantin

CSO Senior Writer, IDG News Service | JAN 6, 2017 10:02 AM PST

Gerd Altmann (CC0)

Groups of attackers have adopted a new tactic that involves deleting publicly exposed MongoDB databases and asking for money to restore them. In a matter of days, the number of affected databases has risen from hundreds to more than 10,000.

The issue of misconfigured MongoDB installations, allowing anyone on the internet to access sensitive data, is not new. Researchers have been finding such open databases for years, and the latest estimate puts their number at more than 99,000.

https://www.computerworld.com/article/3155260/ransomware-groups-have-deleted-over-10000-mongodb-databases.html

MongoDB "open-source" Server Side Public License rejected

Red Hat won't use MongoDB in Red Hat Enterprise Linux or Fedora thanks to MongoDB's new Server Side Public License.

By Steven J. Vaughan-Nichols for Linux and Open Source |
January 16, 2019 -- 19:33 GMT (11:33 PST) | Topic: Cloud

MongoDB is an open-source document NoSQL database with a problem. While very popular, cloud companies, such as Amazon Web Services (AWS), IBM Cloud, Scalegrid, and ObjectRocket has profited from it by offering it as a service while MongoDB Inc. hasn't been able to monetize it to the same degree. MongoDB's answer? Relicense the program under its new Server Side Public License (SSPL). Open-source powerhouse Red Hat's reaction? Drop MongoDB from Red Hat Enterprise Linux (RHEL) 8.

Red Hat's Technical and Community Outreach Program Manager Tom Callaway explained, in a note stating MongoDB is being removed from Fedora Linux, that "It is the belief of Fedora that the SSPL is intentionally crafted to be aggressively discriminatory towards a specific class of users." Debian Linux had already dropped MongoDB from its distribution.

AI, ML & DATA ENGINEERING

Jepsen Disputes MongoDB's Data Consistency Claims

MAY 22, 2020 • 4 MIN READ

by
Jonathan Allen

In an article titled MongoDB and Jepsen, MongoDB claimed that their database passed "the industry's toughest data safety, correctness, and consistency Tests". In response, Jepsen published an article stating that MongoDB 3.6.4 had in fact failed their tests; the newer MongoDB 4.2.6 has more problems including "retrocausal transactions" where a transaction reverses order so that a read can see the result of a future write.

Jepsen LLC's response begins with this reply to Maxime Beugnet on their official Twitter feed:

> "
>
> I have to admit raising an eyebrow when I saw that web page. In that report, MongoDB lost data and violated causal by default. Somehow that became "among the strongest data consistency, correctness, and safety guarantees of any database available today"!

https://www.infoq.com/news/2020/05/Jepsen-MongoDB-4-2-6/

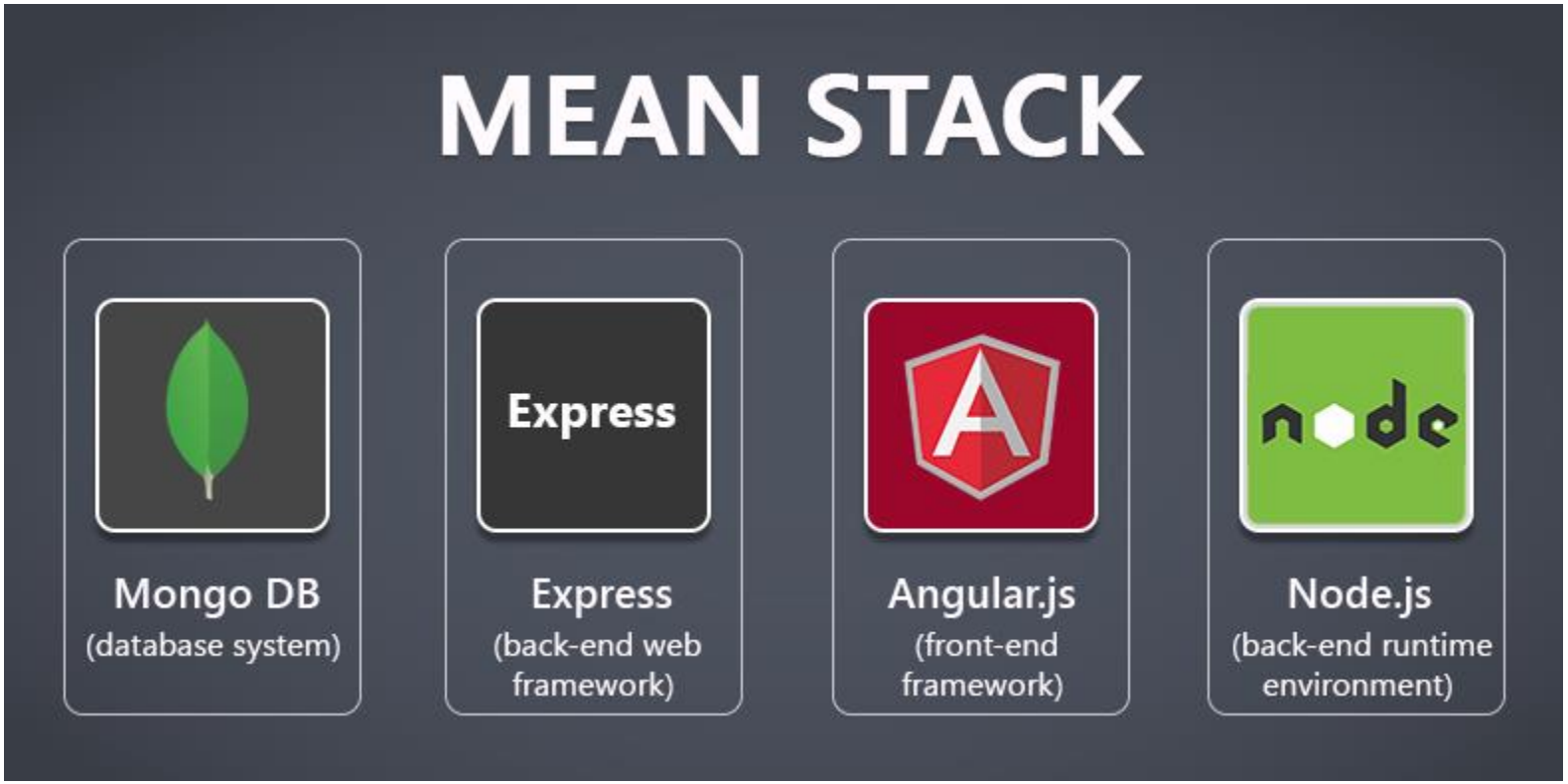
MongoDB:
Popularity

358 systems in ranking, July 2020

Rank Jul 2020	Rank Jun 2020	Rank Jul 2019	DBMS	Database Model	Score Jul 2020	Score Jun 2020	Score Jul 2019
1.	1.	1.	Oracle	Relational, Multi-model	1340.26	-3.33	+19.00
2.	2.	2.	MySQL	Relational, Multi-model	1268.51	-9.38	+38.99
3.	3.	3.	Microsoft SQL Server	Relational, Multi-model	1059.72	-7.59	-31.11
4.	4.	4.	PostgreSQL	Relational, Multi-model	527.00	+4.02	+43.73
5.	5.	5.	MongoDB	Document, Multi-model	443.48	+6.40	+33.55
6.	6.	6.	IBM Db2	Relational, Multi-model	163.17	+1.36	-10.97
7.	7.	7.	Elasticsearch	Search engine, Multi-model	151.59	+1.90	+2.77
8.	8.	8.	Redis	Key-value, Multi-model	150.05	+4.40	+5.78
9.	9.	↑ 11.	SQLite	Relational	127.45	+2.64	+2.82
10.	10.	10.	Cassandra	Wide column	121.09	+2.08	-5.91
11.	11.	↓ 9.	Microsoft Access	Relational	116.54	-0.64	-20.77
12.	12.	↑ 13.	MariaDB	Relational, Multi-model	91.13	+1.34	+6.69
13.	13.	↓ 12.	Splunk	Search engine	88.27	+0.19	+2.78
14.	14.	14.	Hive	Relational	76.42	-2.23	-4.45
15.	15.	15.	Teradata	Relational, Multi-model	75.97	+2.69	-1.85
16.	16.	↑ 20.	Amazon DynamoDB	Multi-model	64.58	-0.29	+8.17
17.	17.	↑ 19.	SAP Adaptive Server	Relational	53.87	+0.78	-2.78
18.	↑ 23.	↑ 25.	Microsoft Azure SQL Database	Relational, Multi-model	52.63	+4.84	+23.97
19.	↓ 18.	↓ 16.	Solr	Search engine	51.64	+0.38	-8.00
20.	↓ 19.	↑ 21.	SAP HANA	Relational, Multi-model	51.34	+0.52	-4.21
21.	↓ 20.	↓ 17.	FileMaker	Relational	49.45	-0.71	-8.45
22.	22.	22.	Neo4j	Graph	48.92	+0.65	-0.05
23.	↓ 21.	↓ 18.	HBase	Wide column	48.66	-0.07	-8.88
24.	24.	24.	Microsoft Azure Cosmos DB	Multi-model	30.40	-0.40	+1.32
25.	↑ 26.	↑ 28.	Google BigQuery	Relational	29.65	+1.36	+5.73

MEAN Stack

- MongoDB, Express.js, Angular(JS), Node.js



https://medium.com/@jeremyvsjeremy/what-is-the-mean-stack-9d11ae2cd384

Questions?