Document Databases

UA.DETI.CBD
José Luis Oliveira / Carlos Costa

Outline

- Document databases
  - General introduction
  - Relational versus Document stores
- MongoDB
  - Data model
  - CRUD operations
    - Insert, Update, Remove
    - Find: projection, selection, modifiers
  - Index structures
- Java driver

Storage example: *Linkedin* in RDMS

http://www.linkedin.com/in/williamhgates

Bill Gates

Greater Seattle Area | Philanthropy

Summary

Co-chair of the Bill & Melinda Gates Foundation. Chairman, Microsoft Corporation. Voracious reader. Avid traveler. Active blogger.

Experience

Co-chair • Bill & Melinda Gates Foundation
2000 – Present

Co-founder, Chairman • Microsoft
1975 – Present

Education

Harvard University
1973 – 1975

Lakeside School, Seattle

Contact Info

Blog: thegatesnotes.com
Twitter: @BillGates

users table

user_id	first_name	last_name	summary
251	Bill	Gates	Co-chair of … blogger.

region_id	industry_id	photo_id
us:91	131	57817532

regions table

id	region_name
us:7	Greater Boston Area
us:91	Greater Seattle Area

industries table

id	industry_name
43	Financial Services
48	Construction
131	Philanthropy

positions table

id	user_id	job_title	organization
458	251	Co-chair	Bill & Melinda Gates F…
457	251	Co-founder, Chairman	Microsoft

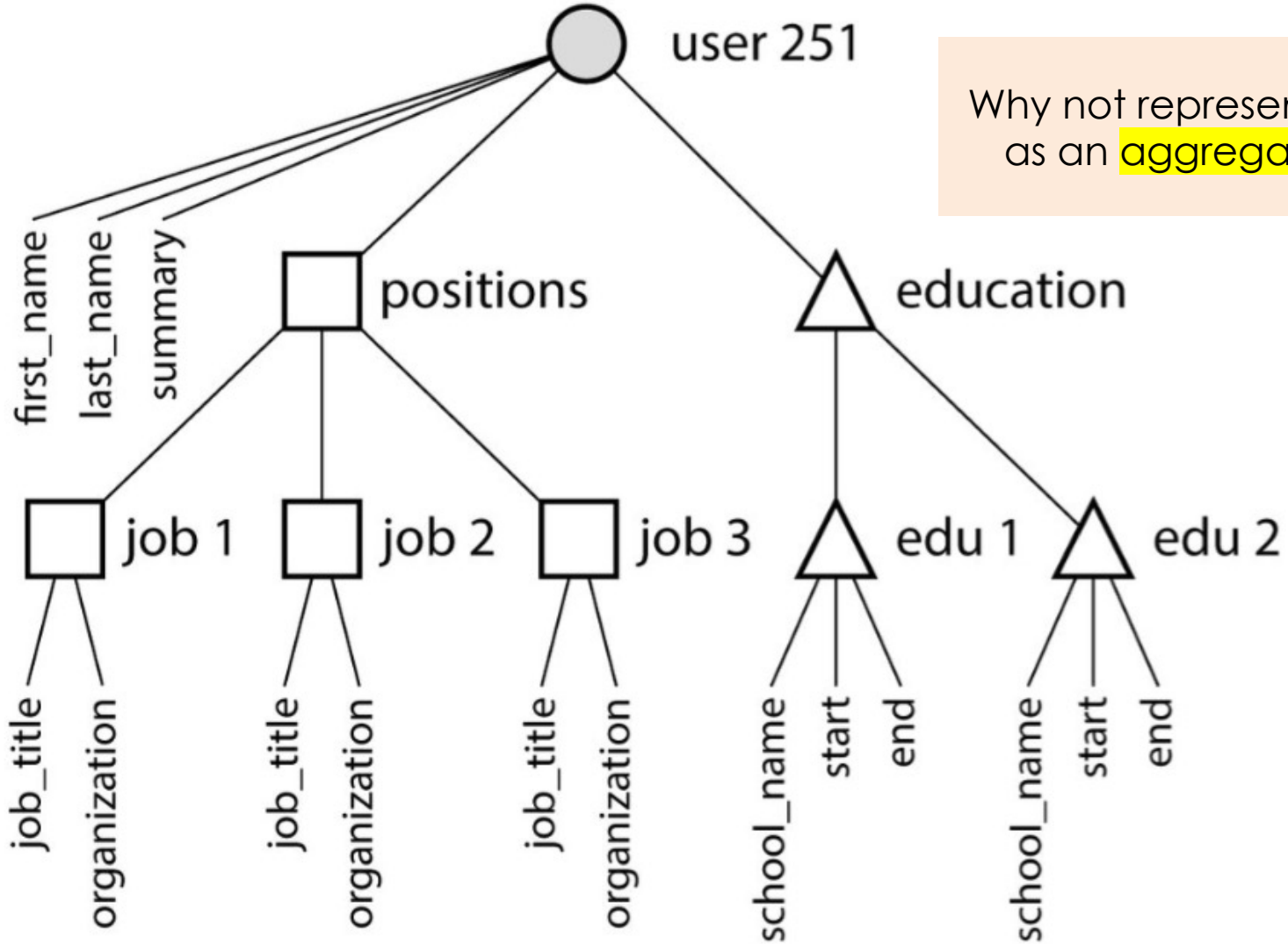
education table

id	user_id	school_name	start	end
807	251	Harvard University	1973	1975
806	251	Lakeside School, Seattle	NULL	NULL

contact_info table

id	user_id	type	url
155	251	blog	http://thegatesnotes.com
156	251	twitter	http://twitter.com/BillGates

One-to-Many relations



Why not represent this as an aggregate?

JSON representation


```
{
    "user_id": 251,
    "first_name": "Bill",
    "last_name": "Gates",
    "summary": "Co-chair of the Bill & Melinda Gates... Active blogger.",
    "region_id": "us:91",
    "photo_url": "/p/7/000/253/05b/308dd6e.jpg",
    "positions": [
        {"job_title": "Co-chair", "organization": "B&M Gates Foundation"},
        {"job_title": "Co-founder, Chairman", "organization": "Microsoft"}
    ],
    "education": [
        {"school_name": "Harvard University", "start": 1973, "end": 1975},
        {"school_name": "Lakeside School, Seattle", "start": null, "end": null}
    ]
}
```

Document vs. Relational databases

- The main arguments in favour of the document data model are:
  - simpler application code, schema flexibility, and better performance due to locality.

- May be used for data with a document-like structure,
  - i.e. a tree of one-to-many relationships, where typically the entire tree is loaded at once.
  - When splitting a document-like structure into multiple tables can lead to unnecessarily complicated application code.
    - Event logging, content management systems, blogs, web analytics, e-commerce applications, …

Documents for schema flexibility

- The *schemaless* approach is **advantageous if the data is heterogeneous**
  - i.e. the items in the collection don't all have the same structure.
- For example, because:
  - there are many different types of objects, and it is not practical to put each type of object in its own table, or
  - Data structure determined by external systems, over which we have no control, and which may change at any time.
- In situations like these, a schema may hurt more

Documents for schema flexibility

- A document is usually stored as a **single continuous string**, encoded as JSON, XML or a binary variant thereof (such as MongoDB's BSON).
  - If one needs to access the entire document, there is a performance advantage to this storage locality.
- The **locality advantage** only applies if you need large parts of the document at the same time.
  - The database typically needs to load the entire document, even if you access only a small portion of it, which can be wasteful on large documents.
  - On updates to a document, the entire document usually needs to be re-written.
- Recommended to keep documents small.

Document vs. Relational databases

- When not to use Document?
  - Set operations involving multiple documents
  - Design of document structure is constantly changing
    - i.e. when the required level of granularity would outbalance the advantages of aggregates
- If the application does use **many-to-many relationships**, the document model becomes less appealing (no joins).
  - We may denormalize the database, or joins can be emulated in application code by making multiple requests to the database.
  - But… the problems of managing denormalization and joins may be greater than the problem of object-relational mismatch.

Convergence of document and relational databases

- Most **relational** database systems also started supporting XML and JSON
  - i.e. functions to create/update documents, and the ability to index and query inside documents.
  - This allows applications to use data models similar to document databases.

- On the **document** database side..
  - Several solutions have also evolving to provide SQL-like experience in document databases (MongoDB Atlas, RethinkDB, Knomi, ObjectRocket, …)

Document Stores

- Data model
  - **Documents**
    - Self-describing
    - Hierarchical tree structures (JSON, XML, …) – Scalar values, maps, lists, sets, nested documents, …
    - Identified by a unique identifier (key, …)
  - **Collections** – a set of documents
- Query patterns (CRUD)
  - **C**reate, **U**pdate or **D**elete a document
  - **R**ead/retrieve documents according to complex query conditions
  - Extended key-value stores where the value part is examinable

Document Stores

- Document
  - MongoDB, Couchbase, CouchDB,
  - RethinkDB, RavenDB,
  - Google Cloud Firestore

- Multi-model
  - MarkLogic, OrientDB, ArangoDB
  - Amazon DynamoDB,
  - Microsoft Azure Cosmos DB,

  - *… many others*

DB-Engines Ranking of Document Stores

☐ include secondary database models

58 systems in ranking, October 2024

Rank Oct 2024	Rank Sep 2024	Rank Oct 2023	DBMS	Database Model	Score Oct 2024	Score Sep 2024	Score Oct 2023
1.	1.	1.	MongoDB	Document, Multi-model	405.21	-5.02	-26.21
2.	2.	↑ 3.	Databricks	Multi-model	85.60	+1.35	+9.78
3.	3.	↓ 2.	Amazon DynamoDB	Multi-model	71.85	+1.78	-9.07
4.	4.	4.	Microsoft Azure Cosmos DB	Multi-model	24.50	-0.47	-9.80
5.	5.	5.	Couchbase	Document, Multi-model	17.10	+0.36	-5.31
6.	6.	6.	Firebase Realtime Database	Document	13.59	-0.01	-3.89
7.	7.	7.	CouchDB	Document, Multi-model	7.53	+0.07	-5.91
8.	8.	↑ 9.	Realm	Document	7.05	-0.13	-1.16
9.	9.	↓ 8.	Google Cloud Firestore	Document	6.46	-0.17	-3.86
10.	10.	↑ 11.	Aerospike	Multi-model	5.57	+0.41	-0.86
11.	11.	↓ 10.	MarkLogic	Multi-model	4.38	+0.22	-3.82
12.	12.	12.	Google Cloud Datastore	Document	4.04	-0.09	-1.55
13.	13.	13.	Virtuoso	Multi-model	3.91	-0.08	-1.51
14.	14.	↑ 15.	ArangoDB	Multi-model	3.44	+0.13	-0.83
15.	15.	↑ 16.	Oracle NoSQL	Multi-model	3.27	+0.20	-0.67

https://db-engines.com/en/ranking/document+store

MongoDB Document Database

MongoDB

- JSON document database
  - https://www.mongodb.com/
- Features
  - Open source, high availability, eventual consistency, automatic sharding, master-slave replication, automatic failover, secondary indexes, …
- Developed by MongoDB, Inc.
- Implemented in C++, C, and JavaScript
- Operating systems: Windows, Linux, Mac OS X, …
- Initial release in 2009

Data Model

- Structure
  - Instance → databases → collections → documents

- **Database**
  - Set of Collections
- **Collection**
  - Set of Documents, usually of a similar structure
- **Document**
  - MongoDB document = one JSON object
  - Internally stored as BSON
  - Each document…
    - belongs to exactly one collection
    - has a unique identifier `_id`

```
{
  name: "martin",
  age: 22,
  interests: [ sports, CBD ]
}
```

Example

Collection redwine

```
{
  _id: "1",
  name: "Cartuxa",
  year: 2012
}
{
  _id: "2",
  name: "Evel",
  year: 2010
}
{
  _id: "3",
  name: ”EA",
  year: 2016
}
```

Query statement

Wines older than 2014 and later, sorted by these titles in descending order

```
db.redwine.find(
{ year: { $lt: 2014} },
{ _id: false, name: true } )
.sort({ name: -1 })
```

Query result

```
{ "name" : "Evel" }
{ "name" : "Cartuxa" }
```

Data Model – Primary Keys

- **_id** is reserved for a primary key
  - Unique within a collection
  - Immutable (cannot be changed once assigned)
  - Can be of any type other than an array
- Possible values
  - Natural identifier (e.g., a key)
    - Must be unique!
  - UUID (Universally unique identifier)
    - 16-byte number (ISO/IEC 11578:1996, RFC 4122)
  - **ObjectId**
    - Special 12-byte BSON type (default option)
    - Small, likely unique, fast to generate, ordered, based on a timestamp, machine id, process id, and a process-local counter

Data Model – Denormalized

- **Embedded documents**
  - Related data in a single structure with subdocuments
  - Suitable for one-to-one or one-to-many relationships
  - Brings ability to read / write related data in a single operation
    - i.e., better performance, less queries need to be issued

```
> db.redwine.insertOne( {
   winepack: "Dinner",
   bottles: [
      { name: "Cartuxa", year: 2012 },
      { name: "Evel", year: 2010 },
      { name: "EA", year: 2016 }
      ]
   })
```

Data Model – Normalized

References

- Directed links between documents, expressed via identifiers
  - Idea analogous to foreign keys in relational databases
  - Suitable for **many-to-many relationships**
  - Embedding in this case would result in data duplication
- References provide more flexibility than embedding
  - But follow up queries are needed

```
> db.redwine.insertOne( {
    winepack: "Dinner",
    bottles: [
        { "$id" : "1" },
        { "$id" : "3" }
        ]
    })
```

```
{ _id: "1",
   name: "Cartuxa",
   year: 2012 }
{ _id: "2",
   name: "Evel",
   year: 2010 }
{ _id: "3",
   name: ”EA",
   year: 2016 }
```

  - The $id field contains the value of the _id field in the referenced document.

Tools

- MongoDB Atlas – cloud server
  - https://www.mongodb.com/cloud/atlas
- Local installation
  - https://www.mongodb.com/try/download/community
  - Local server

```
$ mongod --dbpath <path to data directory>
```

- Mongo Shell (client)
  - https://www.mongodb.com/try/download/shell
  - interactive JavaScript interface to MongoDB.

```
$ mongosh
```

- Mongo CLI Database Tools
  - https://www.mongodb.com/try/download/database-tools
  - bsondump, dump, mongodump, mongoexport, mongofiles, mongoimport, mongooplog, mongoperf, mongoreplay, mongorestore, mongos, mongostat, mongotop

Query Language

- JavaScript commands
  - Each individual command is evaluated over exactly one collection
  - Queries return a cursor
    - Allows us to iterate over all the selected documents

- Query patterns
  - Basic CRUD operations
    - Accessing documents via identifiers or conditions on fields
  - Aggregations: MapReduce, pipelines, grouping

CRUD Operations

- Create
  - db.collection.**insertOne**()
  - db.collection.**insertMany**()
- Read
  - db.collection.**find**()
    - Finds documents based on filtering/projection/sorting conditions
- Update
  - db.collection.**updateOne**()
  - db.collection.**updateMany**()
- Delete
  - db.collection.**deleteOne**()
  - db.collection.**deleteMany**()

https://docs.mongodb.com/manual/crud/

Create – insert examples

```
> db.invoice.insertOne({ _id: 901, inv_no: "I001", inv_date: "20171010"
})
{ "acknowledged" : true, "insertedId" : 901 }

> db.orders.insertMany(
...     [
...       { _id: 15, ord_no: 2001, qty: 200, unit: "doz" },
...       { ord_no: 2005, qty: 320 },
...       { ord_no: 2008, qty: 250, rate:85 }
...     ]
... );
{
    "acknowledged" : true,
    "insertedIds" : [
        15,
        ObjectId("59b1a6d6935c2a0ca72c432a"),
        ObjectId("59b1a6d6935c2a0ca72c432b")
    ]
}
```

Read/query operation

```
> db.inventory.insertMany([
   { item: "journal", qty: 25, size: { h: 14, w: 21, uom: "cm" }, status: "A" },
   { item: "notebook", qty: 50, size: { h: 8.5, w: 11, uom: "in" }, status: "A" },
   { item: "paper", qty: 100, size: { h: 8.5, w: 11, uom: "in" }, status: "D" },
   { item: "planner", qty: 75, size: { h: 22.85, w: 30, uom: "cm" }, status: "D" },
   { item: "postcard", qty: 45, size: { h: 10, w: 15.25, uom: "cm" }, status: "A" }
]);

> db.inventory.find( {} )  // SELECT * FROM inventory
{ "_id" : ObjectId("59b1b730935c2a0ca72c432c"), "item" : "journal", "qty" : 25,
"size" : { "h" : 14, "w" : 21, "uom" : "cm" }, "status" : "A" }
{ "_id" : ObjectId("59b1b730935c2a0ca72c432d"), "item" : "notebook", "qty" : 50,
"size" : { "h" : 8.5, "w" : 11, "uom" : "in" }, "status" : "A" }
{ "_id" : ObjectId("59b1b730935c2a0ca72c432e"), "item" : "paper", "qty" : 100,
"size" : { "h" : 8.5, "w" : 11, "uom" : "in" }, "status" : "D" }
{ "_id" : ObjectId("59b1b730935c2a0ca72c432f"), "item" : "planner", "qty" : 75,
"size" : { "h" : 22.85, "w" : 30, "uom" : "cm" }, "status" : "D" }
{ "_id" : ObjectId("59b1b730935c2a0ca72c4330"), "item" : "postcard", "qty" : 45,
"size" : { "h" : 10, "w" : 15.25, "uom" : "cm" }, "status" : "A" }
```

Selection

```
> db.inventory.find( { status: "D" } )
                    // SELECT * FROM inventory WHERE status = "D"

> db.inventory.find( { status: { $in: [ "A", "D" ] } } )
                    // SELECT * FROM inventory WHERE status in ("A", "D")

> db.inventory.find( { status: "A", qty: { $lt: 30 } } )
                    // SELECT * FROM inventory WHERE status = "A" AND qty < 30

> db.inventory.find( { $or: [ { status: "A" }, { qty: { $lt: 30 } } ] } )
                    // SELECT * FROM inventory WHERE status = "A" OR qty < 30

> db.inventory.find( {
    status: "A",
    $or: [ { qty: { $lt: 30 } }, { item: /^p/ } ]
} )     // SELECT * FROM inventory WHERE status = "A" AND ( qty < 30 OR item LIKE "p%")
```

Selection operators

- Comparison
  - **`$eq, $ne`**
    - Tests the actual field value for equality / inequality
  - **`$lt, $lte, $gte, $gt`**
    - Less than / less than or equal / greater than or equal / greater
  - **`$in`**
    - Equal to at least one of the provided values
  - **`$nin`**
    - Negation of `$in`
- Logical
  - **`$and, $or`**
  - **`$nor`**
    - returns all documents that fail to match both clauses.
  - **`$not`**

Selection operators

- Element operators
  - **`$exists`**
    - tests whether a given field exists / not exists
  - **`$type`**
    - selects documents if a field is of the specified type.

- Evaluation operators
  - **`$regex`**
    - tests whether the field value matches a regular expression (PCRE)
  - **`$text`**
    - performs text search (text index must exists)

Selection operators

- Array query operators
  - `$all`
    - Matches arrays that contain all elements specified in the query.
  - `$elemMatch`
    - Selects documents if an element in the array field matches all the specified $elemMatch conditions.
  - `$size`
    - Selects documents if the array field is a specified size.

Projection

```
// SELECT _id, item, status FROM inventory
> db.inventory.find( { } , { item: 1, status: 1 } )
{ "_id" : ObjectId("59b1bd23ed835ca4380da8b2"), "item" : "journal", "status" : "A" }
{ "_id" : ObjectId("59b1bd23ed835ca4380da8b3"), "item" : "notebook", "status" : "A" }
{ "_id" : ObjectId("59b1bd23ed835ca4380da8b4"), "item" : "paper", "status" : "D" }
{ "_id" : ObjectId("59b1bd23ed835ca4380da8b5"), "item" : "planner", "status" : "D" }
{ "_id" : ObjectId("59b1bd23ed835ca4380da8b6"), "item" : "postcard", "status" : "A" }

// SELECT item, status FROM inventory
> db.inventory.find( { } , { _id: 0, item: 1, status: 1 } ) // true or 1 is included
{ "item" : "journal", "status" : "A" }
{ "item" : "notebook", "status" : "A" }
{ "item" : "paper", "status" : "D" }
{ "item" : "planner", "status" : "D" }
{ "item" : "postcard", "status" : "A" }

> db.inventory.find( {} , { _id: 0, qty: 0, size: 0 } ) // false or 0 is excluded
{ "item" : "journal", "status" : "A" }
{ "item" : "notebook", "status" : "A" }
{ "item" : "paper", "status" : "D" }
{ "item" : "planner", "status" : "D" }
{ "item" : "postcard", "status" : "A" }
```

Modifiers (sort, limit, skip)

```
// SELECT _id, item, status FROM inventory ORDER BY status ASC
> db.inventory.find( {} , { _id: 0, item: 1, status:1 }).sort({ status: 1 })
{ "item" : "journal", "status" : "A" }
{ "item" : "notebook", "status" : "A" }
{ "item" : "postcard", "status" : "A" }
{ "item" : "paper", "status" : "D" }
{ "item" : "planner", "status" : "D" }

> db.inventory.find( {} , { _id: 0, item: 1, status:1 }).sort({ status: -1 })
{ "item" : "paper", "status" : "D" }
{ "item" : "planner", "status" : "D" }
{ "item" : "journal", "status" : "A" }
{ "item" : "notebook", "status" : "A" }
{ "item" : "postcard", "status" : "A" }
> db.inventory.find( {} , { _id: 0, item: 1, status:1 }).limit(3)
{ "item" : "journal", "status" : "A" }
{ "item" : "notebook", "status" : "A" }
{ "item" : "paper", "status" : "D" }
> db.inventory.find( {} , { _id: 0, item: 1, status:1 }).skip(3)
{ "item" : "planner", "status" : "D" }
{ "item" : "postcard", "status" : "A" }
```

CRUD Operations – Update

- Syntax

```
db.collection.updateOne(filter, update, options)
db.collection.updateMany(filter, update, options)

db.collection.updateOne(
     <filter>,   // = selectors in find()
     <update>,   // modification to apply
     {            // optional …
          upsert: <boolean>,         // if no doc -> insert
          writeConcern: <document>, // ack of num of replicas
          collation: <document>     // language/type-specific rules
          ..
     }
)
```

- Update operators

  $set, $unset, $rename

https://docs.mongodb.com/manual/reference/delete-methods/

Update

```
> db.inventory.find({"item":"journal"}, {_id:0, size:0})
{ "item" : "journal", "qty" : 25, "status" : "A" }

> db.inventory.updateOne({"item":"journal"}, {$set: {"status":"B"}})
{ "acknowledged" : true, "matchedCount" : 1, "modifiedCount" : 1 }

> db.inventory.find({"item":"journal"}, {_id:0, size:0})
{ "item" : "journal", "qty" : 25, "status" : "B" }

> db.inventory.updateOne({"item":"computer"},
    {$set: {"status":"C", qty:30 } },
    {upsert:true})
{ "acknowledged" : true, "matchedCount" : 0, "modifiedCount" : 0,
"upsertedId" : ObjectId("59b2524f92403315277cbd8f") }

> db.inventory.find( {"item":"computer"} )
{ "_id" : ObjectId("59b2524f92403315277cbd8f"), "item" : "computer",
"status" : "C", "qty" : 30 }
```

Update

```
> db.inventory.updateMany({}, {$unset: { size:""}})
{ "acknowledged" : true, "matchedCount" : 5, "modifiedCount" : 5 }

> db.inventory.find()
{ "_id" : ObjectId("59b1b730935c2a0ca72c432c"), "item" : "journal", "qty" :
25, "status" : "A" }
{ "_id" : ObjectId("59b1b730935c2a0ca72c432d"), "item" : "notebook", "qty"
: 50, "status" : "A" }
{ "_id" : ObjectId("59b1b730935c2a0ca72c432e"), "item" : "paper", "qty" :
100, "status" : "D" }
{ "_id" : ObjectId("59b1b730935c2a0ca72c432f"), "item" : "planner", "qty" :
75, "status" : "D" }
{ "_id" : ObjectId("59b1b730935c2a0ca72c4330"), "item" : "postcard", "qty"
: 45, "status" : "A" }
```

CRUD Operations – Delete

- Syntax

```
db.collection.deleteOne(filter, options)
db.collection.deleteMany(filter, options)

db.collection.deleteOne(
    <filter>,   // = selectors in find()
    {           // optional …
        writeConcern: <document>, // ack of num of replicas
        collation: <document>     // language-specific rules
        ..
    }
)
```

https://docs.mongodb.com/manual/reference/delete-methods/

Delete

```
> db.inventory.find( {} , { _id: 0, qty: 0, size: 0 } )
{ "item" : "journal", "status" : "B" }
{ "item" : "notebook", "status" : "A" }
{ "item" : "paper", "status" : "D" }
{ "item" : "planner", "status" : "D" }
{ "item" : "postcard", "status" : "A" }
{ "item" : "computer", "status" : "C" }

> db.inventory.deleteOne({"item":"computer"})
{ "acknowledged" : true, "deletedCount" : 1 }

> db.inventory.find( {} , { _id: 0, qty: 0, size: 0 } )
{ "item" : "journal", "status" : "B" }
{ "item" : "notebook", "status" : "A" }
{ "item" : "paper", "status" : "D" }
{ "item" : "planner", "status" : "D" }
{ "item" : "postcard", "status" : "A" }
```

Indexes

- **Motivation**
  - Full collection scan must be performed when searching for the documents, unless an appropriate index exists
- **Primary** index
  - MongoDB creates a unique index on the *_id* field during the creation of a collection
- **Secondary** indexes
  - Created manually for a given key field / fields
  - To create an index, use *db.collection.createIndex()* or a similar method from your driver.

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

  - MongoDB indexes use a B-tree data structure.

Index Types

- **Single** Field
  - Ascending/descending indexes on a single field.
- **Compound** Index
  - Indexes on multiple fields
    - The order of fields listed in a compound index has significance
    - e.g. { userid: 1, score: -1 }, sort by userid ASC and then, by score DESC.
- **Multikey** Index
  - To index a field that holds an array value.
- **Text** Indexes
- **Hashed** Indexes
- **Geospatial** Index

Index Types

- **1, -1** – standard ascending / descending value indexes

```
db.<collection>.createIndex( { field: -1 } )
```

- **hashed** – hash values of a single field are indexed

```
db.<collection>.createIndex( { _id: "hashed" } )
```

- **text** – basic full-text index

```
db.<collection>.createIndex( { comments: "text" } )
```

- **2d** – points in planar geometry

```
db.<collection>.createIndex( { <location field> : "2d" , <additional field> : <value> } , { <index-specification options> } )
```

- **2dsphere** – points in spherical geometry

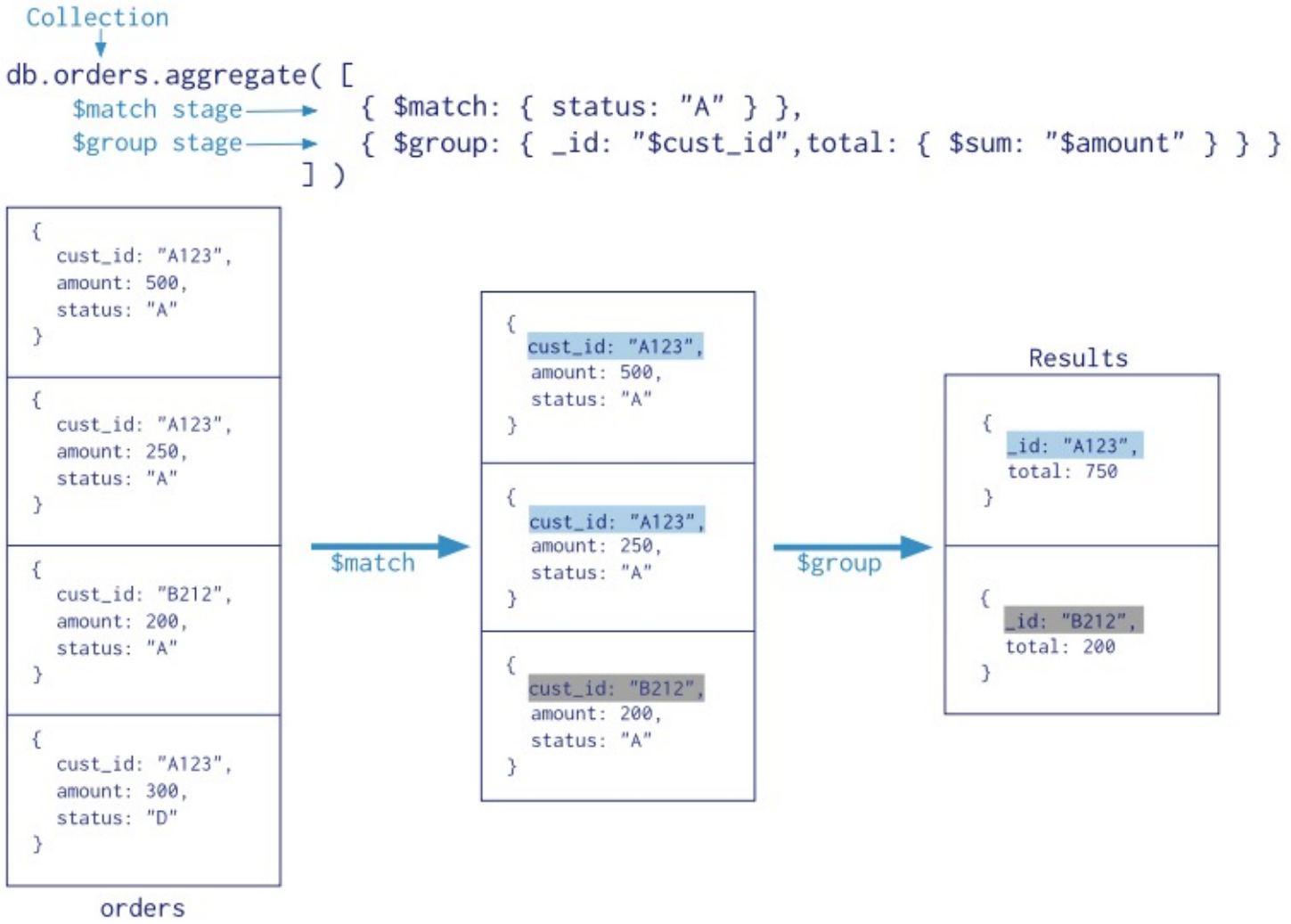
```
db.<collection>.createIndex( { <location field> : "2dsphere" } )
```

Indexes

```
// Full collection scan
> db.inventory.find( {qty: { "$gte" : 50 }}, {_id:0}).sort( {qty: -1})
{ "item" : "paper", "qty" : 100, "status" : "D" }
{ "item" : "planner", "qty" : 75, "status" : "D" }
{ "item" : "notebook", "qty" : 50, "status" : "A" }

> db.inventory.getIndexes()
[
   {"v": 2, "key": { "_id": 1 }, "name": "_id_", "ns": "test.inventory" }
]

> db.inventory.createIndex( { qty : 1 } )

> db.inventory.getIndexes()
[
   {"v": 2, "key": { "_id": 1 }, "name": "_id_", "ns": "test.inventory" }
   {"v": 2, "key": { "qty": 1 }, "name": "qty_1", "ns": "test.inventory" }
]
```

Aggregation pipeline

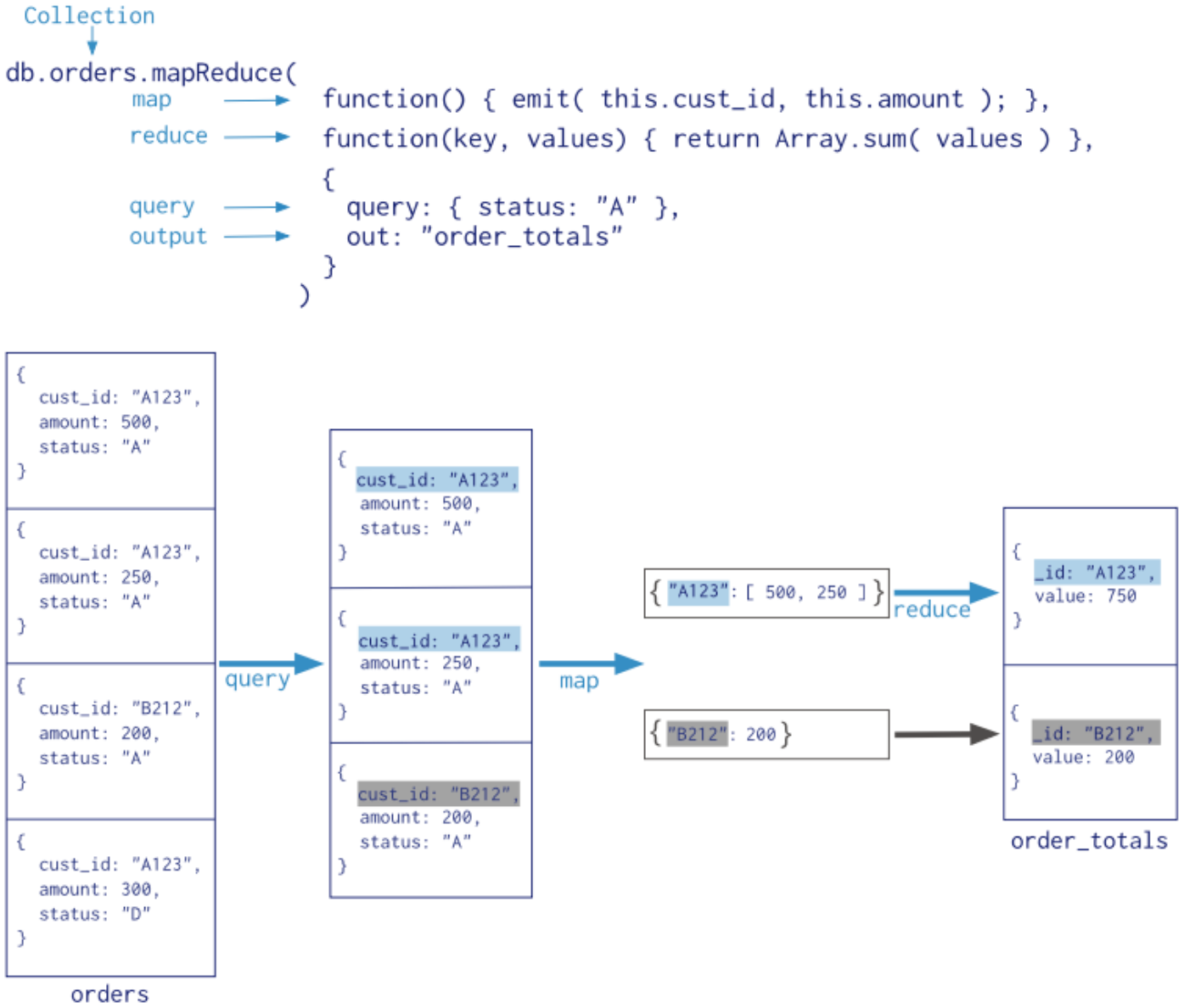
– Documents enter a multi-stage pipeline that transforms the documents into aggregated results



MapReduce

- Data processing paradigm for condensing large volumes of data into useful *aggregated* results.
- Both map and reduce functions are implemented as ordinary JavaScript functions
  - **Map** function: current document is accessible via this, emit(key, value) is used for emissions
  - **Reduce** function: key and array of values are provided as arguments, reduced value is published via return
- Beside others, **query**, **sort** or **limit** options are accepted
  - **out** option determines the output (e.g. a collection name)

MapReduce example



MongoDB Drivers

- The MongoDB Ecosystem contains documentation for the drivers, frameworks, tools, and platform services that work with MongoDB.
  - https://docs.mongodb.com/ecosystem/drivers/
- Drivers are available for many languages
  - C, C++, Java, Python, Ruby, …
- Java
  - http://mongodb.github.io/mongo-java-driver/
    - bson.jar
    - mongodb-driver-core.jar
    - mongodb-driver.jar

Java driver – example 1 (list)

```
public class Test {
    public static void main(String[] args) {
            // remove log in the console
        java.util.logging.Logger.getLogger("org.mongodb.driver").setLevel(
                Level.SEVERE);
        MongoClient mongo = new MongoClient("localhost", 27017);
            // os dados foram colocados manualmente no mongo
        MongoDatabase out = mongo.getDatabase("test");
        System.out.println("-- Colecções na BD " + "'"  + out.getName() + "'" );
        MongoIterable<String> x = out.listCollectionNames();
        for (String s : x)
            System.out.println(s);
        MongoCollection<Document> c = out.getCollection("inventory");
        System.out.println("-- Total de documentos em 'inventory': " +
c.count());
        FindIterable<Document> docs = c.find();
        for (Document doc : docs)
            System.out.println(doc.toJson());
        mongo.close();
    }
}
```

Java driver – example 1 output

```
--- Colecções na BD 'test'
invoice
inventory
collection
orders
--- Total de documentos em 'countries': 5
{ "_id" : { "$oid" : "59b1b730935c2a0ca72c432c" }, "item" : "journal",
"qty" : 25.0, "status" : "A" }
{ "_id" : { "$oid" : "59b1b730935c2a0ca72c432d" }, "item" : "notebook",
"qty" : 50.0, "status" : "A" }
{ "_id" : { "$oid" : "59b1b730935c2a0ca72c432e" }, "item" : "paper", "qty"
: 100.0, "status" : "D" }
{ "_id" : { "$oid" : "59b1b730935c2a0ca72c432f" }, "item" : "planner",
"qty" : 75.0, "status" : "D" }
{ "_id" : { "$oid" : "59b1b730935c2a0ca72c4330" }, "item" : "postcard",
"qty" : 45.0, "status" : "A" }
```

Java driver – example 2 (insert)

```
public class Test2 {
    public static void main(String[] args) {
            // remove log in the console
        java.util.logging.Logger.getLogger("org.mongodb.driver").setLevel(
                Level.SEVERE);
        MongoClient mongo = new MongoClient("localhost", 27017);
        MongoCollection<Document> coll =
            mongo.getDatabase("test").getCollection("inventory");

        Document doc = new Document("item", "database")
            .append("qty", 1)
            .append("status","M");
        coll.insertOne(doc);
        FindIterable<Document> docs = coll.find();
        for (Document d : docs)
            System.out.println(d.toJson());
        mongo.close();
    }
}
```

Java driver – example 2 output

```
{ "_id" : { "$oid" : "59b1b730935c2a0ca72c432c" }, "item" : "journal",
"qty" : 25.0, "status" : "A" }
{ "_id" : { "$oid" : "59b1b730935c2a0ca72c432d" }, "item" : "notebook",
"qty" : 50.0, "status" : "A" }
{ "_id" : { "$oid" : "59b1b730935c2a0ca72c432e" }, "item" : "paper", "qty"
: 100.0, "status" : "D" }
{ "_id" : { "$oid" : "59b1b730935c2a0ca72c432f" }, "item" : "planner",
"qty" : 75.0, "status" : "D" }
{ "_id" : { "$oid" : "59b1b730935c2a0ca72c4330" }, "item" : "postcard",
"qty" : 45.0, "status" : "A" }
{ "_id" : { "$oid" : "59b2a7e98cbca6f6497c7110" }, "item" : "database",
"qty" : 1, "status" : "M" }
```

Java driver – example 3 (multi-doc)

```
public class Test3 {
    public static void main(String[] args) {
        java.util.logging.Logger.getLogger("org.mongodb.driver").setLevel(
                Level.SEVERE);
        MongoClient mongo = new MongoClient("localhost", 27017);
        MongoCollection<Document> coll =
            mongo.getDatabase("test").getCollection("inventory");
        Document doc = new Document("item", "record")
            .append("size",
                new Document("h", 10).append("l", 20).append("w", 30))
            .append("qty", 1)
            .append("status","R");
        coll.insertOne(doc);
        FindIterable<Document> docs = coll.find(new Document("status", "R"));
        for (Document d : docs)
            System.out.println(d.toJson());
        mongo.close();
    }
}
```

```
{ "_id" : { "$oid" : "59b2a9eb8cbca6f6527068b2" }, "item" : "record",
"size" : { "h" : 10, "l" : 20, "w" : 30 }, "qty" : 1, "status" : "R" }
```

Summary

- Document Database
- MongoDB
  - JSON document database
  - Sharding with master-slave replication architecture
- Query functionality
  - CRUD operations
    - Insert, find, update, remove
  - Complex filtering conditions
  - Index structures
  - MapReduce
- Java driver

Resources

- Eric Redmond, Jim R. Wilson. ***Seven databases in seven weeks***, Pragmatic Bookshelf, 2012.
- Martin Kleppmann, ***Designing Data-Intensive Applications***, O'Reilly Media, Inc., 2017.
- Pramod J Sadalage and Martin Fowler, ***NoSQL Distilled*** Addison-Wesley, 2012.

- MongoDB Docs, https://docs.mongodb.com
- Java Driver, http://mongodb.github.io/mongo-java-driver/