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MongoDB

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Presentation based on
•**slides "Document Databases"** by *David Novak, FI, Masaryk University, Brno*
http://disa.fi.muni.cz/david-novak/teaching/nosql-databases-2017/
•**Slides "MongoDB"** by Pietro Colombo, University of Insubria

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What Is It?

- A document-oriented database
  - documents encapsulate and encode data in some standard formats
- NoSQL database
  - non-adherence to the widely used relational database systems
  - highly optimized for retrieve and append operations
- It uses BSON format
- It is schema-less
  - No more configuring database columns with types
  - Documents are self-describing
  - Documents are analogous to structures in programming languages that associate keys with values
  - The values of a field can be any of the BSON data types, including other documents, arrays, and arrays of documents
- No transactions
- No joins

```
{
  name: "sue",                          <-- field: value
  age: 26,                              <-- field: value
  status: "A",                          <-- field: value
  groups: [ "news", "sports" ]          <-- field: value
}
```

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Why Document Databases

- XML and JSON are popular for data exchange
  - Recently mainly JSON
- Data stored in document DB can be used directly

- Databases often store objects from memory
  - Using RDBMS, we must do Object Relational Mapping (ORM)
    - ORM is relatively demanding
  - JSON is much closer to structure of memory objects
    - It was originally for JavaScript objects
    - Object Document Mapping (ODM) is faster

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JSON and BSON

JSON

- Text-based open standard for data interchange
  Serializing and transmitting structured data
- JSON = JavaScript Object Notation
  Derived from JavaScript scripting language
  Uses conventions of the C-family of languages
- Filename: *.json
- Language independent

(see www.json.org)

BSON

It is binary-encoded serialization of JSON documents

JSON representation of record describing a person

```
{
  "firstName": "John",
  "lastName": "Smith",
  "isAlive": true,
  "age": 27,
  "address": {
    "streetAddress": "21 2nd Street",
    "city": "New York",
    "state": "NY",
    "postalCode": "10021-3100"
  },
  "phoneNumbers": [
    {
      "type": "home",
      "number": "212 555-1234"
    },
    {
      "type": "office",
      "number": "646 555-4567"
    },
    {
      "type": "mobile",
      "number": "123 456-7890"
    }
  ],
  "children": [],
  "spouse": null
}
```

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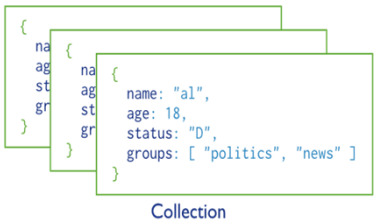
Terminology

mongoDB

RDBMS	MongoDB
database instance	MongoDB instance
schema	database
table	collection
row	document
rowid	_id

- each JSON document:
  - belongs to a collection
  - has a field _id
    - unique within the collection
- each collection:
  - belongs to a "database"



Collection

http://www.mongodb.org/

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Document

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- A document is a set of keys (also called field names) with associated values (no duplicate keys!!)
- Represented as JSON objects: *{"greeting" : "Hello, world!"}*
- Serialized as a BSON object
- Documents contain multiple key/value pairs: *{"greeting" : "Hello, world!", "foo" : 3}*
- Restrictions on keys:
  - ❑ The key cannot start with the $ character
    - Reserved for operators
  - ❑ The key cannot contain the . character
    - Reserved for accessing sub-fields
- Every document must have field _id
  - ❑ Used as a primary key
  - ❑ Unique within the collection
  - ❑ Immutable
  - ❑ Any type other than an array
  - ❑ Can be generated automatically
- The value of a field can be any of the BSON data types, including other documents, arrays, and arrays of documents

NOTE: the double quotes around the key can be omitted

Data Types

- *null:* can be used to represent both a null value and a nonexistent field:

  *{"x" : **null**}*
- *Boolean:* fields can be set to *true* and *false*:

  *{"x" : **true**}*
- *number:*

  If not specified the shell uses 64-bit floating point numbers

  {"x" : 3.14} or {"x" : 3}

  4-byte or 8-byte signed integers require the classes *NumberInt* or *NumberLong*

  {"x" : NumberInt("3")} or *{"x" : NumberLong("3")}*
- *string:* any sequence of UTF-8 characters

  {"x" : "foobar"}

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Data Types

- *date:* stored as milliseconds :

  *{"x" : **new** Date()}*
- *regular expression:* using JavaScript's regular expression syntax:

  {"x" : /foobar/i}
- *Array:* lists of values can be represented as arrays:

  {"x" : ["a", "b", "c"]}
- *embedded document:* Documents can contain entire documents embedded as values in a field

  {"x" : {"foo" : "bar"}}

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Data Types

- *binary data:* strings of arbitrary bytes
- *code:* queries and documents can include arbitrary JavaScript code: {"x" : *function*() { /* ... */ }}
- *object id:* 12-byte ID for documents.
  {"x" : ObjectId()} this method creates and returns an ObjectID
- An example: **507f1f77bcf86cd799439011**
- MongoDB documents must have an *"_id"* key.
- *"_id"* can be of any type, but it defaults to an *ObjectId*.
- In a collection, every document must have a unique value for *"_id"*

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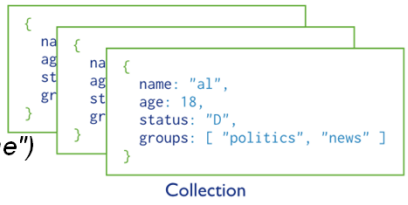
Collections

- A *collection* is a group of related documents
- Collections can be thought of as the analog to a tables in relational databases
- Collections have *dynamic schemas:*
  The documents within a single collection can have different structures
  {"greeting" : "Hello, world!"}
  {"foo" : 5}
- Collections are created using
  - the method *db.createCollection("name")*
    db.createCollection("myCollection")
  - implicitly by using it; if a collection that does not exist is referenced in a command, the system automatically creates it
    db.myCollection2.insert({{"name" : "Max"})



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Databases

- MongoDB groups collections into *databases*
- A single instance of MongoDB can host several databases
- Each database groups together zero or more collections
- A database has its own permissions, users and roles and each database is stored in separate files on disk
- A good rule is storing all data for a single application in the same database
- Reserved database names:
  - *admin:* the "root" database, in terms of authentication. If a user is added to the *admin* database, the user automatically inherits permissions for all databases.
  - *Config:* used for storing information of sharded setup

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Database Schema

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- Documents have flexible schema
  - Collections do not enforce specific data structure
- Key decision of data modeling:
  - References vs. embedded documents
  - In other words: Where to draw lines between aggregates
    - Structure of data
    - Relationships between data
- Embedded Documents
  - Related data in a single document structure
    - Documents can have subdocuments (in a field or array)

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

Embedded sub-document

Embedded sub-document

Embedded Docs

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- Denormalized schema
- Main advantage:
  Manipulate related data in a single operation
- Use this schema when:
  - One-to-one relationships: one doc "contains" the other
  - One-to-many: if children docs have one parent document
- Disadvantages:
  - Documents may grow significantly during the time
  - Impacts both read/write performance
    - Document must be relocated on disk if its size exceeds allocated space
    - May lead to data fragmentation on the disk

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References

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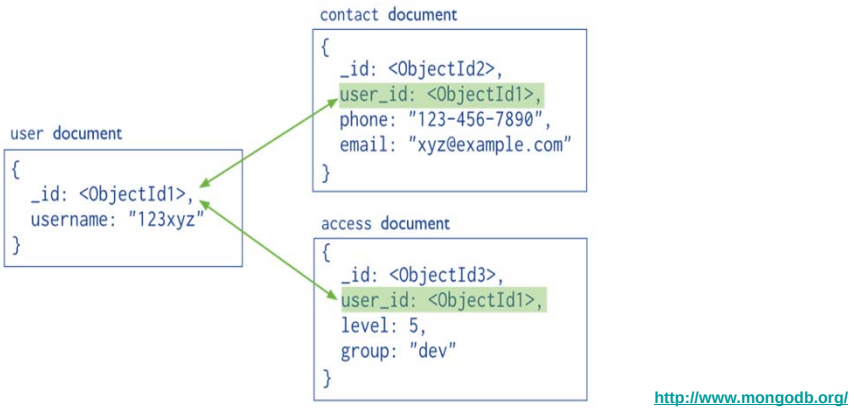
- Links/references from one document to another
- Normalization of the schema



http://www.mongodb.org/

References

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- More flexibility than embedding
- Use references:
  - When embedding would result in duplication of data
    - and only insignificant boost of read performance
  - To represent more complex many-to-many relationships
  - To model large hierarchical data sets
- Disadvantages:
  - Can require more roundtrips to the server
    - Documents are accessed one by one

Write Operations

- Write operations create or modify data in the MongoDB instance
  - target a single *collection*
  - atomic on the level of a single *document*
- There are three types of write operations: *insert, update and remove*.
- Write operations cannot affect more than one document atomically
- Update and remove operations allow one to specify selection criteria for identifying the documents to update or remove.
  - Selection criteria are the same as read operations

```
db.users.insert (          <-- collection
   {
     name: "sue",          <-- field: value
     age: 26,              <-- field: value
     status: "A"           <-- field: value
   }                       } document
)
```

Equivalent to

```
INSERT INTO users                <-- table
            ( name, age, status ) <-- columns
VALUES      ( "sue", 26, "A" )    <-- values/row
```

Insert

- Consider the document

{"title" : "My Blog Post",
"content" : "Here's my blog post.",
"date" : new Date()}

- We assign it to variable post

>post={"title" : "My Blog Post",
"content" : "Here's my blog post.",
"date" : new Date()}

- We use *insert* to store *post* into collection *blog*

>db.blog.insert(post)

- Before storing the document an "_id" key is added to the document (if one does not already exist)

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Insert

- If a new document *d* is added without the *_id* field, MongoDB
  - adds an *_id* field
  - initializes the field with a unique ObjectId
- The value of the _id field must be unique within the collection
- Any attempt to create a document with a duplicate *_id* value results into a duplicate key exception

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Read

- The post has been saved to the database. We can see it by calling *find* on the collection *blog*:

```
> db.blog.find()
{
"_id" : ObjectId("5037ee4a1084eb3ffeef7228"),
"title" : "My Blog Post",
"content" : "Here's my blog post.",
"date" : ISODate("2012-08-24T21:12:09.982Z")
}
```

- The method find is the method to be used for querying the database
- Definition: db.collection.find(**query**, **projection**)
- When used without input (or with input an empty set {}), it returns the entire collection

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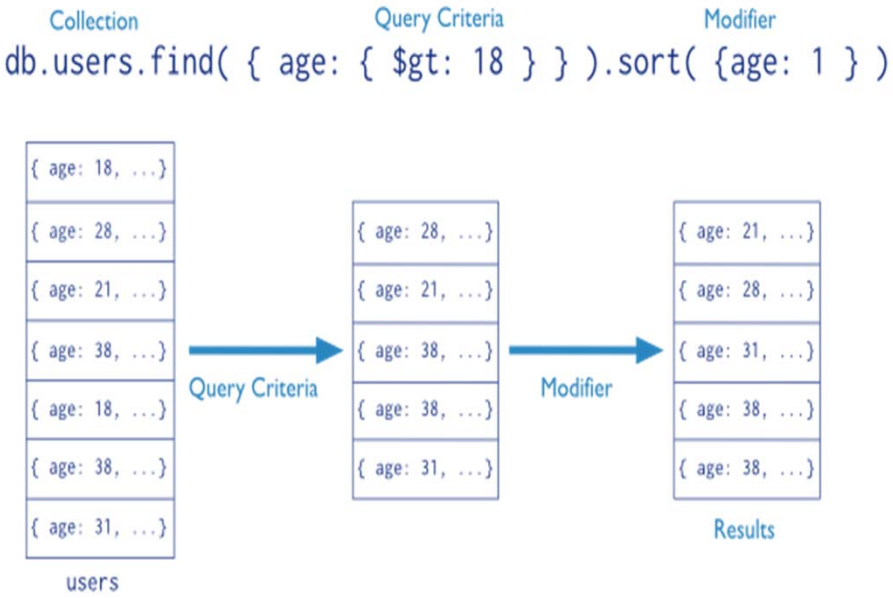
Query with Predicates



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Projection

- The second argument passed to *find* specifies the keys to be projected/pruned out from the selected documents
- In order to be projected/pruned out a key the corresponding document key parameter must be set to 1/0

> db.users.find({}, {"username" : 1, "email" : 1})

{"_id" : ObjectId("4ba0f0dfd22aa494fd523620"),
"username" : "joe",
"email" : "joe@example.com"}

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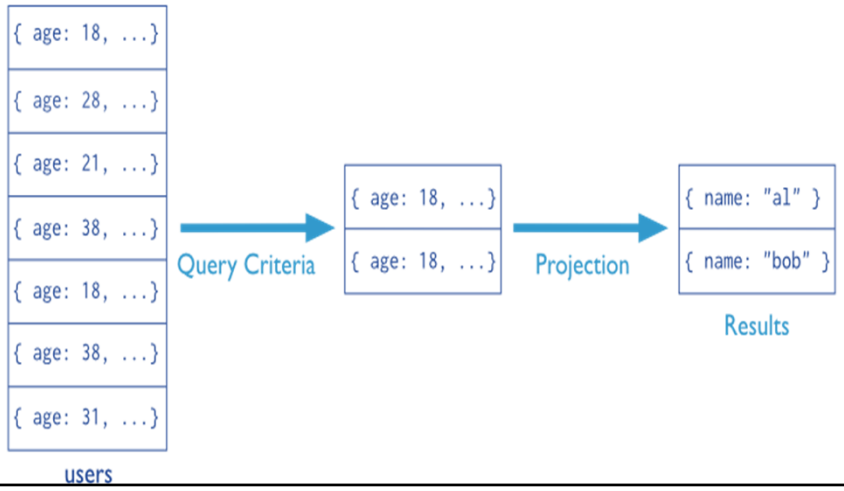
Query with Predicates and Projection

Collection Query Criteria Projection

```
db.users.find( { age: 18 }, { name: 1, _id: 0 } )
```



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Projection

- By default, the *_id* field is included in the results.
  - To suppress the *_id* field from the result set, specify *_id: 0* in the projection document
- Exclude One Field From a Result Set

➢ *db.records.find({ "user_id": { $lt: 42 } }, { "history": 0 })*

- Return Two fields and the _id Field

➢ *db.records.find({ "user_id": { $lt: 42 } }, { "name": 1, "email": 1 })*

- Return Two Fields and Exclude _id

> db.records.find({ "user_id": { $lt: 42} }, { "_id": 0, "name": 1 , "email": 1 })

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Selection criteria

- Selection of documents with specific keys
- Querying for a simple type is as easy as specifying the value that you are looking for.
  e.g., find all documents where the value for "age" is 27
  > db.users.find({"age" : 27})
- Multiple conditions are specified by adding more key/value pairs to the query document, which gets interpreted as "*condition1* AND *condition2* AND … AND *conditionN*."

  e.g, find all users who are 27-year-olds with the username "joe,"
  > db.users.find({"username" : "joe", "age" : 27})

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Example

```
db.users.find(                          ← collection
   { age: { $gt: 18 } },                ← query criteria
   { name: 1, address: 1 }              ← projection
).limit(5)                              ← cursor modifier
```

Equivalent to the SQL query

```
SELECT _id, name, address  ← projection
FROM   users               ← table
WHERE  age > 18            ← select criteria
LIMIT  5                   ← cursor modifier
```

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Query Conditions

- Query Conditions: make use of *comparison* operators *"$lt", "$lte", "$gt",* and *"$gte"* corresponding to <,<=, >, and >=, respectively
- The operators can be combined to look for a range of values.
  e.g, find users with an age between 18 and 30
  > db.users.find({"age" : {"$gte" : 18, "$lte" : 30}})
- Conditions are implicitly conjuncted: *age>=18 and age<=30*
- The operator "$ne“ is used to query for documents where a key’s value is not equal to a certain value
  e.g., find all users who do not have the username *“joe”*
  > db.users.find({"username" : {"$ne" : "joe"}})

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Query Conditions

- Operator "$in" is used to specify multiple match values for a single key
- E.g., suppose we were running a raffle and the winning ticket numbers were 725, 542, and 390. To find these documents:

  >db.raffle.find({"ticket_no" : {"$in" : [725, 542, 390]}})

- If "$in" is given an array with a single value, it behaves the same as directly matching

  >*db.raffle.find(*{ticket_no : {$in : [725]}})

  matches the same documents as

  >*db.raffle.find(*{ticket_no : 725})

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Query Conditions

- The operator "$nin" returns documents that don't match any of the criteria in the array.

  e.g., return all of the people who didn't win anything in the raffle

  > db.raffle.find({"ticket_no" : {"$nin" : [725, 542, 390]}})
- Different from *$in,* the operator *"$or"* takes an array of possible criteria possibly referring to multiple keys
- e.g. find documents where "ticket_no" is 725 or "winner" is true

  > db.raffle.find({"$or" : [{"ticket_no" : 725}, {"winner" : ***true****}]})*

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Query Conditions

- "$or" can contain other conditions

  e.g., match any of the three "ticket_no" values or the "winner" key

  *> db.raffle.find({"$or" : [{"ticket_no" : {"$in" : [725, 542,390]}},{"winner" : **true**}]})*

- The operators “$and“ and "$nor“ follow similar criteria

```
db.inventory.find(
{ $and : [
        { $or : [ { price : 0.99 }, { price : 1.99 } ] },
        { $or : [ { sale : true }, { qty : { $lt : 20 } } ] }
        ]
} )
```

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Query Conditions

- "$not" can be applied on top of other operators.

As an example, let’s consider the modulus operator, "$mod“ which queries for keys whose values, when divided by the first value given, have a remainder of the second value

e.g. find users with "id_num“s of 1, 6, 11 and so on.

> db.users.find({"id_num" : {"$mod" : [5, 1]}})

To return users with "id_num"s of 2, 3, 4, 5, 7, 8, 9, 10, 12, we can use "$not":

> db.users.find({"id_num" : {"$not" : {"$mod" : [5, 1]}}})

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Queries for Null or Missing Values

- *null* does match itself

- Suppose to have a collection with the following documents:

➢ *db.c.find()*
{ "_id" : ObjectId("4ba0f0dfd22aa494fd523621"), "y" : null }
{ "_id" : ObjectId("4ba0f0dfd22aa494fd523622"), "y" : 1 }
{ "_id" : ObjectId("4ba0f148d22aa494fd523623"), "y" : 2 }

- To find documents whose "y" key is null

> db.c.find({"y":null})
{ "_id" : ObjectId("4ba0f0dfd22aa494fd523621"), "y":null }

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Queries for Null or Missing Values

- Different query operators treat null values differently
- Example:

```
db.inventory.insertMany([ { _id: 1, item: null }, { _id: 2 } ])
/* insertMany creates and insert multiple documents */
```

- db.inventory.find({ item: null })
  - this query retrieves all documents that: (i) contain the key “item” and key has a null value; OR (ii) do not contain the key “item”
  - Both documents 1 and 2 are retrieved
- db.inventory.find({ item : { $type: 10 } })
  - This query finds only the documents that: contain the key “item”; AND (ii) the value of key is null (e.g., the value is of BSON type Null (type number 10)
  - Only document 1 is retrieved
- db.inventory.find({ item : { $exists: false } })
  - This query finds all documents that do not contain the key “item”
  - Only document 2 is retrieved
  - $exists: true would retrieve all documents that contain the key “item” (and thus only document 1 would be retrieved)

Regular Expressions

- Useful for flexible string matching
- E.g. find users with the name Joe or joe, we use a regular expression to do case insensitive matching:
  > db.users.find({"name" : /joe/i})
- In order to match also joey, we can specify a regular expression as
  > db.users.find({"name" : /joey?/i})
- MongoDB uses the Perl Compatible Regular Expression (PCRE); any regular expression syntax allowed by PCRE is allowed

Queries on Arrays

- Designed to behave the way querying for scalars does.
  E.g, if the array is a list of fruits, like this:
  > db.food.insert({"fruit" : ["apple", "banana", "peach"]})
  the query
  >db.food.find({"fruit" : "banana"})
  matches the document
- The document is selected if at least one cell of the array is set to the selected value
- $all is used to match arrays by more than one element
  E.g., suppose we created a collection with three elements:
  > db.food.insert({"_id" : 1, "fruit" : ["apple", "banana", "peach"]})
  > db.food.insert({"_id" : 2, "fruit" : ["apple", "kumquat", "orange"]})
  > db.food.insert({"_id" : 3, "fruit" : ["cherry", "banana", "apple"]})
  In order to find all documents with both "apple" and "banana" :
  > db.food.find({fruit : {$all : ["apple", "banana"]}})
  {"_id" : 1, "fruit" : ["apple", "banana", "peach"]}
  {"_id" : 3, "fruit" : ["cherry", "banana", "apple"]}

  Order does not matter

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Queries on Arrays

Exact match also works but it requires no missing or superfluous values in the array

> *db.food.find({"fruit" : ["apple", "banana", "peach"]})*

matches

> *db.food.find({"fruit" : ["apple", "banana"]})*

does not match

- Arrays can be queried by index

> *db.food.find({"fruit.2" : "peach"})*

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Queries on Embedded Documents

- Two strategies:

  Case 1: querying for the whole embedded document

  Case 2: querying for its individual key/value pairs

- Example:

```
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" }
]);
```

- To specify an equality condition on a field that is an embedded document, one must use the query filter document {<field>: <value>} where <value> is the embedded document to match
- Example of Case 1:

```
db.inventory.find( { size: { h: 14, w: 21, uom: "cm" } } )
/* this query retrieves all documents that have the specified size */
```

Which is the result?

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Queries on Embedded Documents

- Case 1: Equality matches on the whole embedded document require an *exact* match of the specified <value> document, including the field order.
- For example, the following query does not match any documents in the inventory collection:
  - db.inventory.find({ size: { w: 21, h: 14, uom: "cm" } })
- Case 2: To specify a query condition on fields of embedded documents, the dot notation must be used
- Example:

```
db.inventory.find( { "size.uom": "in" } )
```


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Queries on References

- MongoDB does not automatically resolve references into documents
- Two options:
  1. Perform additional queries to manually resolve the references
     - Simple, but requires multiple queries
  2. Use $lookup to perform a join
     - Performs the operation in one query, but can be complicated

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Queries on References

- To perform additional queries, save the results of a query as a variable
  - find().toArray() – stores the result of a find() as an array which can be compared to
  - findOne() – stores the result of a find() operation that returns a single document as an array
- In the previous example, with “name” implemented as a reference instead of a subdocument:
  - joeNameID = db.names.find({“first”: “Joe”, “last”: “Schmoe”})
    db.people.find({“name” : joeNameID})

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Queries on References

- Instead of manually resolving references, the $lookup operation can be used to join documents
- 4 fields in $lookup:
  - from: the collection in the *same* database to perform the join with – cannot be a sharded collection
  - localField: the field in the local collection to match with
  - foreginField: the field in the foreign collection to match with
  - as: the name of the new array field to add to the input documents
- $lookup can be used in conjunction with the *aggregate pipeline* in order to perform additional operations

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Update

- Three update methods:
  - `db.collection.updateOne(<filter>, <update>, <options>)`
  - `db.collection.updateMany(<filter>, <update>, <options>)`
  - `db.collection.replaceOne(<filter>, <update>, <options>)`
- The method accepts:
  - Selection criteria to determine which documents to update
  - Update criteria, namely how the selected document need to be modified
  - Update options, including upsert that creates a new document if no existing document matches the filter
  - For the updateOne method, if multiple documents are selected by the filter, only one will be modified
  - The replaceOne method replaces a single document within the collection using the replacement document
- Operations performed by an update are atomic within a single document.

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Update

```
db.users.update(                    ← collection
   { age: { $gt: 18 } },            ← update criteria
   { $set: { status: "A" } },       ← update action
   { multi: true }                  ← update option
)
```

Equivalent to

```
UPDATE users          ← table
SET    status = 'A'   ← update action
WHERE  age > 18       ← update criteria
```

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Update

- By default, the *db.collection.update()* method updates a single document.
- However, when the *multi* option is specified, it modifies all documents in a collection that match a query.
- The db.collection.update() method either updates specific fields in the existing document or replaces the document
  1. If the <update> document contains update operator modifiers, such as those using the $set modifier, then:
     - The update() method updates only the corresponding fields in the document
     - To update an embedded document or an array as a whole, specify the replacement value for the field.
  2. If the <update> document contains only field:value expressions, then:
     - The update() method replaces the matching document with the <update> document.
     - The update() method does not replace the _id value.

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Update

- For example, suppose we are making major changes to the following user document:

  {"_id" : ObjectId("4b2b9f67a1f631733d917a7a"),
  "name" : "joe","friends" : 32,"enemies" : 2}

- We want to move the "friends" and "enemies" fields to a "relationships" subdocument. We can change the structure of the document in the shell and then replace the database's version with an update:

```
> var joe = db.users.findOne({"name" : "joe"});
> joe.relationships = {"friends" : joe.friends, "enemies" : joe.enemies};
{
        "friends" : 32,
        "enemies" : 2
}> joe.username = joe.name;
> delete joe.friends;
> delete joe.enemies;
> delete joe.name;
> db.users.replaceOne({"name" : "joe"}, joe);
```

Structure of document after the update

```
{
    "_id" : ObjectId("4b2b9f67a1f631733d917a7a"),
    "username" : "joe",
    "relationships" : {
        "friends" : 32,
        "enemies" : 2
    }
}
```

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Update field operators

Name	Description
$inc	Increments the value of the field by the specified amount.
$mul	Multiplies the value of the field by the specified amount.
$rename	Renames a field.
$setOnInsert	Sets the value of a field if an update results in an insert of a document. Has no effect on update operations that modify existing documents.
$set	Sets the value of a field in a document.
$unset	Removes the specified field from a document.
$min	Only updates the field if the specified value is less than the existing field value.
$max	Only updates the field if the specified value is greater than the existing field value.
$currentDate	Sets the value of a field to current date, either as a Date or a Timestamp.

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Update with Upsert

- If the update() method includes *upsert: true*
  - And no document matches the selection criteria, a new document is created.
  - And at least one document matches the criteria, the matching documents are modified
- *upsert: true* specifies that, if no matching documents are found for the update, an insert need to be executed.

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Delete

- db.collection.delete() permanently delete documents from the collection
- The db.collection.delete() method accepts a query criteria to determine which documents to remove
- Called with no parameters, it removes all documents from a collection

E.g.

> db.blog.delete({title : "My Blog Post"})

- As with the updates, the remove method has two forms:
  - db.collection.deleteMany
  - Db.collection.deleteOne

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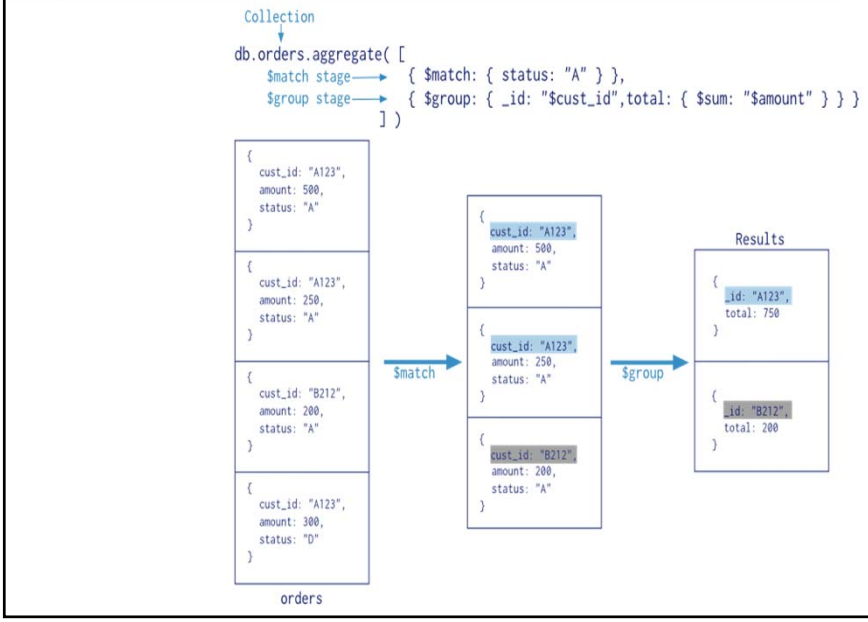
Aggregation Pipeline

- A framework for data aggregation based on data processing pipelines.
  - Documents enter a multi-stage pipeline that transforms them
- Pipeline stages do not need to produce one output document for every input document. Stages can:
  - generate new documents
  - filter out documents
- MongoDB provides the db.collection.aggregate() method in the mongo shell
  - Pipeline stages appear in an array. Documents pass through the stages in sequence. Stages can appear multiple times in a pipeline.

    >db.collection.aggregate([{ <stage> }, ...])



Main Aggregation Stage Operators

Select the documents to pass unmodified into the next pipeline stage.

$match — For each input document, outputs either one document (a match) or zero documents (no match).

Reshapes each document in the stream

$project — E.g., add new fields or remove existing fields.
For each input document, outputs one document.

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Main Aggregation Stage Operators

$unwind	*Deconstructs an array field from the input documents to output a document for each element.* Each output document replaces the array with an element value. For each input document, outputs *n* documents where *n* is the number of array elements (n=0 for an empty array).
$group	*Groups input documents by a specified identifier expression and applies the accumulator expression(s), if specified, to each group.* Consumes all input documents and outputs one document per each distinct group. The output documents only contain the identifier field and, if specified, accumulated fields.

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Main Aggregation Stage Operators

$sort	*Reorders the document stream by a specified sort key*. The documents remain unmodified. For each input document, outputs one document.
$limit	*Passes the first n documents unmodified to the pipeline where n is the specified limit*. For each input document, outputs either one document (for the first *n* documents) or zero documents (after the first *n* documents)
$skip	*Skips the first n documents where n is the specified skip number and passes the remaining documents unmodified to the pipeline*. For each input document, outputs either zero documents (for the first *n* documents) or one document (if after the first *n* documents).

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$match

- Filters the documents to pass only the documents that match the specified condition(s) to the next pipeline stage.

Syntax: *{ $match: { <query> } }*

E.g., suppose to have the collection

```
{ "_id" : ObjectId("512bc95fe835e68f199c8686"),
        "author" : "dave", "score" : 80, "views" : 100 }
{ "_id" : ObjectId("55f5a192d4bede9ac365b257"),
        "author" : "ahn", "score" : 60, "views" : 1000 }

>db.articles.aggregate(
   [ { $match : { author : "dave" } } ]
);
```


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$project

Reshapes each document in the stream

Syntax: *{ $project: { <specifications> } }*

<field>: <1 or true>	Specifies the inclusion of a field. if field does not exist no inclusion is performed
_id: <0 or false>	Specifies the suppression of the _id field. only achievable with _id
<field>: <expression>	Adds a new field or reset the value of an existing field.

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$project

```
{
  "_id" : 1,
  title: "abc123",
  isbn: "0001122223334",
  author: { last: "zzz", first:
          "aaa" },
  copies: 5
}
```

```
>db.books.aggregate(
 [{$project: {
        title: 1,
        _id: 0,
        isbn: {
          prefix: { $substr: [ "$isbn", 0, 3 ] },
          group: { $substr: [ "$isbn", 3, 2 ] },
          publisher: { $substr: [ "$isbn", 5, 4 ] },
          title: { $substr: [ "$isbn", 9, 3 ] },
          checkDigit: { $substr: [ "$isbn", 12, 1] }
        },
        lastName: "$author.last",
        copiesSold: "$copies"
 }}])
```

We can see this aggregation pipeline as the creation of a temporary view of a given document.
Unlike views in the relational DBMS, here a view may change the structure of the returned document.

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$unwind

- Deconstructs an array field from the input documents to output a document for each element.

- Prototype form: *{ $unwind: <field path> }*

E.g., collection inventory includes the document
{ "_id" : 1, "item" : "ABC1", sizes: ["S", "M", "L"] }

```
> db.inventory.aggregate( [ { $unwind : "$sizes" } ] )
{ "_id" : 1, "item" : "ABC1", "sizes" : "S" }
{ "_id" : 1, "item" : "ABC1", "sizes" : "M" }
{ "_id" : 1, "item" : "ABC1", "sizes" : "L" }
```

$group

- Groups documents by some specified expression and outputs to the next stage a document for each distinct grouping.
- Prototype:
  { $group:
  { _id: <expression>, <field1>:
  { <accumulator1> : <expression1> }, ... } }
  - The _id field specifies the mandatory grouping key
  - the <accumulator> specifies the aggregation operation

>{"$group" : {"_id" : "$author", "count" : {"$sum" : 1}}}

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Main Accumulator Operators

$sum	Returns a sum for each group. Ignores non-numeric values.
$avg	Returns an average for each group. Ignores non-numeric values.
$first/$last	Returns a value from the first/last document for each group. Order is only defined if the documents are in a defined order.
$min/$max	Returns the lowest/highest expression value for each group.
$push	Returns an array of expression values for each group.
$addToSet	Returns an array of unique expressions values for each group. Order of the array elements is undefined.

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$group Example

{ "_id" : 1, "item" : "abc", "price" : 10, "quantity" : 2, "date" : ISODate("2014-03-01T08:00:00Z") }
{ "_id" : 2, "item" : "jkl", "price" : 20, "quantity" : 1, "date" : ISODate("2014-03-01T09:00:00Z") }

Calculate total price and average quantity by date

```
>db.sales.aggregate( [{$group : {
        _id : { month: { $month: "$date" },
                day: {    $dayOfMonth: "$date" },
                year: { $year: "$date" } },
        totalPrice: { $sum: { $multiply: [ "$price", "$quantity" ] } },
        averageQuantity: { $avg: "$quantity" }}}])
```

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MongoDB Shell

- A JavaScript shell that allows interaction with a MongoDB instance from the command line
- Useful for:
  - Performing administrative functions
  - Inspecting a running instance
  - Executing queries
- To start the shell, run the *mongo* executable:

```
$ mongo
MongoDB shell version: 3.0
connecting to: test
>
```

- The shell is a full-featured JavaScript interpreter, capable of running arbitrary JavaScript
- On startup, the shell connects to the *test* database on a MongoDB server and assigns this database connection to the global variable *db*
- *db* is the primary access point to your MongoDB server through the shell
- CRUD operations: create, read, update, and delete to manipulate and view data in the shell

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Other Document DBMS

Apache CouchDB relax

OrientDB

RAVENDB

terrastore

PostgreSQL

amazon DynamoDB

MS Azure DocumentDB

Ranked list: http://db-engines.com/en/ranking/document+store