

B4M36DS2, BE4M36DS2: **Database Systems 2**

<http://www.ksi.mff.cuni.cz/~svoboda/courses/191-B4M36DS2/>

Practical Class 9

MongoDB

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Data Model

Database system structure

Instance → **databases** → **collections** → **documents**

- Database
- Collection
 - Collection of documents, usually of a similar structure
- Document
 - MongoDB **document** = **one JSON object**
 - I.e. even a complex JSON object with other recursively nested objects, arrays or values
 - **Unique immutable identifier** `_id`
 - **Field name restrictions:** `_id`, `$`, `.`

CRUD Operations

Overview

- `db.collection.insert()`
 - Inserts a new document into a collection
- `db.collection.update()`
 - Modifies an existing document / documents or inserts a new one
- `db.collection.remove()`
 - Deletes an existing document / documents
- `db.collection.find()`
 - Finds documents based on filtering conditions
 - Projection and / or sorting may be applied too

Mongo Shell

Connect to our NoSQL server

- SSH / PuTTY and SFTP / WinSCP
- **nosql.ms.mff.cuni.cz:42222**

Start mongo shell

- `mongo`

Try several basic commands

- `help`
 - Displays a brief description of database commands
- `exit`
`quit()`
 - Closes the current client connection

Databases

Switch to your database

- use `login`
`db = db.getSiblingDB('login')`
 - Use your login name as a name for your database

List all the existing databases

- `show databases`
`show dbs`
`db.adminCommand('listDatabases')`
 - Your database will be created later on implicitly

Collections

Create a new collection for actors

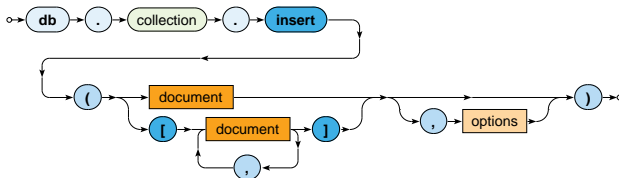
- `db.createCollection("actors")`
 - Suitable when creating collections with specific options since collections can also be created implicitly

List all collections in your database

- `show collections`
`db.getCollectionNames()`

Insert Operation

Inserts a new document / documents into a given collection



- Parameters
 - Document:** one or more documents to be inserted
 - Options**

Insert Operation

Insert a few new documents into the collection of actors

```
db.actors.insert({ _id: "trojan", name: "Ivan Trojan" })
```

```
db.actors.insert({ _id: 2, name: "Jiri Machacek" })
```

```
db.actors.insert({ _id: ObjectId(), name: "Jitka Schneiderova" })
```

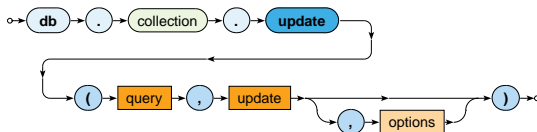
```
db.actors.insert({ name: "Zdenek Sverak" })
```

Retrieve all documents from the collection of actors

```
db.actors.find()
```


Update Operation

Modifies / replaces an existing document / documents



- Parameters
 - Query:** description of documents to be updated
 - Update:** modification actions to be applied
 - Options**

Update operators

- \$set, \$unset, \$rename, \$inc, \$mul, \$currentDate, \$push, \$addToSet, \$pop, \$pull, ...

Update Operation

Update the document of actor *Ivan Trojan*

```
db.actors.update(  
  { _id: "trojan" },  
  { name: "Ivan Trojan", year: 1964 }  
)
```

```
db.actors.update(  
  { name: "Ivan Trojan", year: { $lt: 2000 } },  
  { name: "Ivan Trojan", year: 1964 }  
)
```

- At most one document is updated
- Its content is replaced with a new value

Check the current content of the document

```
db.actors.find({ _id: "trojan" })
```

Update Operation

Use update method to **insert a new actor**

- Inserts a new document when upsert behavior was enabled and no document could be updated

```
db.actors.update(  
  { _id: "geislerova" },  
  { name: "Anna Geislerova" },  
  { upsert: true }  
)
```

Update Operation

Try to modify the document identifier of an existing document

- Your request will be rejected since **document identifiers are immutable**

```
db.actors.update(  
  { _id: "trojan" },  
  { _id: 1, name: "Ivan Trojan", year: 1964 }  
)
```

Update Operation

Update the document of actor *Ivan Trojan*

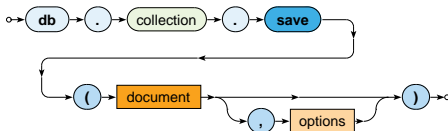
```
db.actors.update(  
  { _id: "trojan" },  
  {  
    $set: { year: 1964, age: 52 },  
    $inc: { rating: 1 },  
    $push: { movies: { $each: [ "samotari", "medvidek" ] } }  
  }  
)
```

Update multiple documents at once

```
db.actors.update(  
  { year: { $lt: 2000 } },  
  { $set: { rating: 3 } },  
  { multi: true }  
)
```

Save Operation

Replaces an existing / inserts a new document



- Parameters
 - Document:** document to be modified / inserted
 - Options**

Save Operation

Use save method to **insert new actors**

- Document identifier must not be specified in the query or must not yet exist in the collection

```
db.actors.save({ name: "Tatiana Vilhelмова" })
```

```
db.actors.save({ _id: 6, name: "Sasa Rasilov" })
```

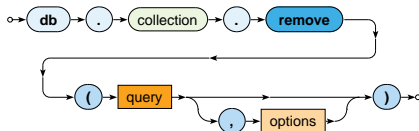
Use save method to **update actor *Ivan Trojan***

- Document identifier must be specified in the query and must exist in the collection

```
db.actors.save({ _id: "trojan", name: "Ivan Trojan", year: 1964 })
```

Remove Operation

Removes a document / documents from a given collection



- Parameters
 - Query:** description of documents to be removed
 - Options**

Remove Operation

Remove selected documents from the collection of actors

```
db.actors.remove({ _id: "geislerova" })
```

```
db.actors.remove(  
  { year: { $lt: 2000 } },  
  { justOne: true }  
)
```

Remove all the documents from the collection of actors

```
db.actors.remove({ })
```

Sample Data

Insert the following actors into your emptied collection

```
{ _id: "trojan",  
  name: "Ivan Trojan", year: 1964,  
  movies: [ "samotari", "medvidek" ] }
```

```
{ _id: "machacek",  
  name: "Jiri Machacek", year: 1966,  
  movies: [ "medvidek", "vratnelahve", "samotari" ] }
```

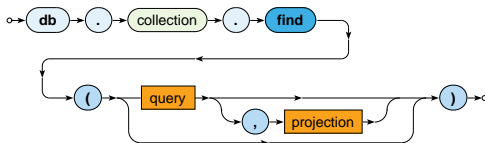
```
{ _id: "schneiderova",  
  name: "Jitka Schneiderova", year: 1973,  
  movies: [ "samotari" ] }
```

```
{ _id: "sverak",  
  name: "Zdenek Sverak", year: 1936,  
  movies: [ "vratnelahve" ] }
```

```
{ _id: "geislerova",  
  name: "Anna Geislerova", year: 1976 }
```

Find Operation

Selects documents from a given collection



- Parameters
 - Query:** description of documents to be selected
 - Projection:** fields to be included / excluded in the result

Querying

Execute and explain the meaning of **the following queries**

```
db.actors.find()
```

```
db.actors.find({ })
```

```
db.actors.find({ _id: "trojan" })
```

```
db.actors.find({ name: "Ivan Trojan", year: 1964 })
```

```
db.actors.find({ year: { $gte: 1960, $lte: 1980 } })
```

```
db.actors.find({ movies: { $exists: true } })
```

```
db.actors.find({ movies: "medvidek" })
```

```
db.actors.find({ movies: { $in: [ "medvidek", "pelisky" ] } })
```

```
db.actors.find({ movies: { $all: [ "medvidek", "pelisky" ] } })
```

Querying

Execute and explain the meaning of the following queries

```
db.actors.find({ $or: [ { year: 1964 }, { rating: { $gte: 3 } } ] })
```

```
db.actors.find({ rating: { $not: { $gte: 3 } } })
```

```
db.actors.find({ }, { name: 1, year: 1 })
```

```
db.actors.find({ }, { movies: 0, _id: 0 })
```

```
db.actors.find({ }, { name: 1, movies: { $slice: 2 }, _id: 0 })
```

```
db.actors.find().sort({ year: 1, name: -1 })
```

```
db.actors.find().sort({ name: 1 }).skip(1).limit(2)
```

```
db.actors.find().sort({ name: 1 }).limit(2).skip(1)
```

Index Structures

Motivation

- Full **collection scan** must be conducted when searching for documents **unless an appropriate index exists**

Primary index

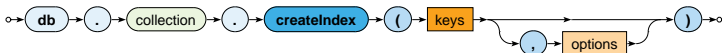
- Unique index on values of the **_id field**
- Created automatically

Secondary indexes

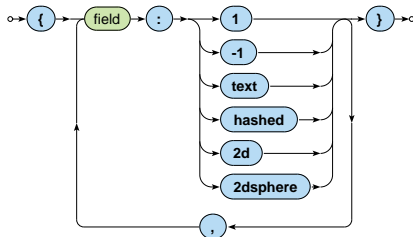
- Created manually for values of a given key field / fields
- Always within just a single collection

Index Structures

Secondary index creation



Definition of keys (fields) to be involved



Index Structures

Index types

- `1`, `-1` – standard ascending / descending value indexes
 - Both scalar values and embedded documents can be indexed
- `hashed` – hash values of a single field are indexed
- `text` – basic full-text index
- `2d` – points in planar geometry
- `2dsphere` – points in spherical geometry

Index Structures

Index forms

- One key / multiple keys (**composed index**)
- Ordinary fields / array fields (**multi-key index**)

Index properties

- **Unique** – duplicate values are rejected (cannot be inserted)
- **Partial** – only certain documents are indexed
- **Sparse** – documents without a given field are ignored
- **TTL** – documents are removed when a timeout elapses

Just some type / form / property combinations can be used!

Index Structures

Execute the following query and study its **execution plan**

```
db.actors.find({ movies: "medvidek" })
```

```
db.actors.find({ movies: "medvidek" }).explain()
```

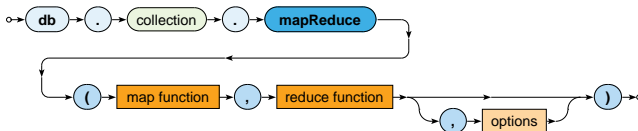
Create a multikey index for movies of actors

```
db.actors.createIndex({ movies: 1 })
```

Examine the execution plan once again

MapReduce

Executes a **MapReduce** job on a selected collection



- Parameters
 - **Map**: JavaScript implementation of the Map function
 - **Reduce**: JavaScript implementation of the Reduce function
 - **Options**

MapReduce

Map function

- Current document is accessible via `this`
- `emit(key, value)` is used for emissions

Reduce function

- Intermediate key and values are provided as arguments
- Reduced value is published via `return`

Options

- `query`: only matching documents are considered
- `sort`: they are processed in a specific order
- `limit`: at most a given number of them is processed
- `out`: output is stored into a given collection

MapReduce: Example

Count the number of movies filmed in each year, starting in *2005*

```
db.movies.mapReduce(  
  function() {  
    emit(this.year, 1);  
  },  
  function(key, values) {  
    return Array.sum(values);  
  },  
  {  
    query: { year: { $gte: 2005 } },  
    sort: { year: 1 },  
    out: "statistics"  
  }  
)
```

MapReduce

Implement and execute the following MapReduce jobs

- **Find a list of actors (their names sorted alphabetically) for each year (they were born)**
 - Only consider actors born in year 2000 or before
 - `values.sort()`
 - Use `out: { inline: 1 }` option
- **Calculate the overall number of actors for each movie**
 - `this.movies.forEach(function(m) { ... })`
 - `Array.sum(values)`
 - Use `out: { inline: 1 }` option once again

References

Documentation

- <https://docs.mongodb.com/v3.2/>