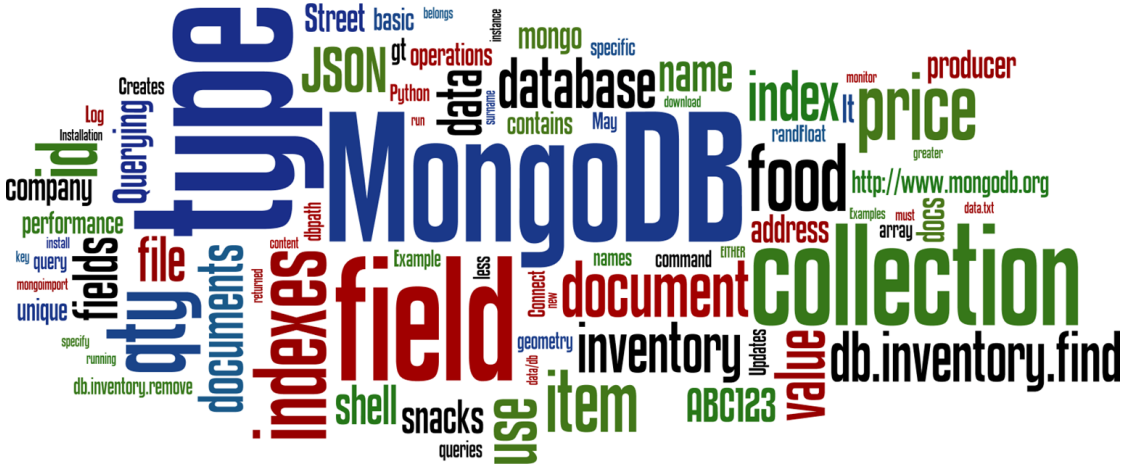


Document Databases: Practice

Seminar 3 of *NoSQL Databases* (PA195)

David Novak & Vlastislav Dohnal
Faculty of Informatics, Masaryk University, Brno

Agenda: MongoDB

- MongoDB: Review
- Operations
  - Using `mongo` shell
    - insert/update/querying
    - JSON Schema
    - adding indexes
- Basic Administration
  - Log monitoring, performance
  - Other tools: `mongoimport`, `mongodump`, etc.
- Language Connectors
  - Python: `pymongo`, `mongoengine`

MongoDB

- Initial release: 2009
  - Written in C++
  - Open-source
  - Cross-platform

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

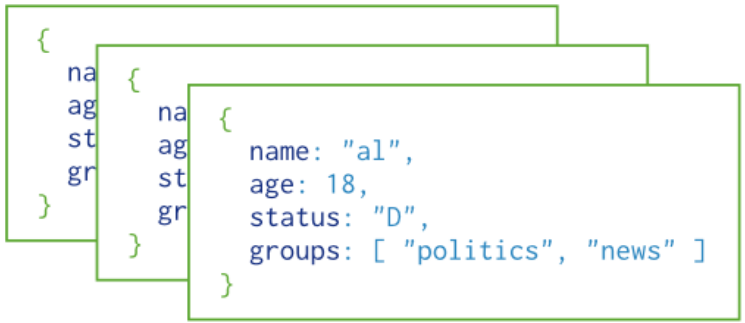
- JSON documents
  - Use JSON for API communication

- Internally: BSON
  - Binary representation of JSON
  - For storage and inter-server communication

http://www.mongodb.org/

MongoDB: Terminology

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



Collection

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

http://www.mongodb.org/

MongoDB Installation

Accessible from outside the FI net

1. Create your VM via http://stratus.fi.muni.cz
   - template: PA195 CentOS 7 (id 648)
   - `systemctl start mongod`

stratus

You may have it ready from Seminar 2, just start the VM.

2. or Install MongoDB on your machine
   - download: http://www.mongodb.org/downloads
   - install: http://docs.mongodb.org/manual/installation/
3. or Install on nymfe (very easy):
   - Download and unpack to `/var/tmp/<login>/`

     https://docs.mongodb.org/manual/tutorial/install-mongodb-on-linux/

```
./bin/mongod --dbpath /var/tmp/<login>/data
--logpath /var/tmp/<login>/mongo.log &
```

MongoDB Shell

stratus

- Connect to a running MongoDB database: doc
  - run mongo shell: `$ mongo local`
- MongoDB shell basic features & commands
  - use `tab` for command completion
  - use `up/down` arrows for command history
  - use `ctrl+R` for reverse command search
  - JavaScript syntax
    - `var record = { "_id": 1, "name": "david" }`

```
> help
> show dbs
> use mydb
```

To create a new database, just type:
`> use newdbname`

Insert

Follow: http://docs.mongodb.org/manual/core/write-operations-introduction/
Or http://docs.mongodb.org/manual/applications/crud/

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

insertOne and insertMany are recommended.

```
db.inventory.insertOne( { _id: 10, type: "misc", item: "card", qty: 15 } )
```

- Inserts a document with three fields into collection inventory
  - User-specified _id field

JSON Schema of Inventory


```
{
  "$schema": "http://json-schema.org/draft-04/schema#",
  "type": "object",
  "properties": {
    "_id": { "type": "string" },
    "item": { "type": "string" },
    "type": { "type": "string", "enum": [ "food", "snacks", "accessories",
"misc" ] },
    "price": { "type": "number" },
    "qty": { "type": "number" },
    "producer": {
      "type": "object",
      "properties": {
        "company": { "type": "string" },
        "address": { "type": "string" }
      },
      "required": [ "company" ]
    }
  },
  "required": [ "item", "type" ]
}
```

- May set a validator when creating a collection
  - It is JSON schema

```
db.createCollection( "inventory",
   { validator: { $jsonSchema: {
                    ...
                }
   } )
```

OR

```
db.createCollection( "inventory", { validator:
  { $and:
     [
         { item: { $type: "string" } },
         { price: { $type: "number" } },
         { type: { $in: ["food", "snacks", "accessories", "misc"] } }
     ]
   },
   validationLevel: "strict",
   validationAction: "error"
  }
)
```

Task 1

- Create 5-10 JSON objects according to the schema
  - of all types, i.e., `"food", "snacks", "accessories", "misc"`
  - Use an online editor + validator: http://www.jsonschemavalidator.net/

- Insert these JSON documents into your database
  - into collection `inventory`

Update


```
db.inventory.updateOne(
    { type: "book", item: "journal" },
    { $set: { qty: 10 } },
    { upsert: true }  )
```

- May create a new doc.
  - if no document in the inventory collection contains `{ type: "books", item: "journal" }`
  - Adds the _id field with a generated value a unique ObjectId
  - Result contains fields type, item, qty, _id

Delete


```
db.inventory.deleteOne({ type: "food" })
```

- Deletes first matching record

```
db.inventory.deleteMany({ type: "food" })
```

- Deletes all matching records

Task 2

- Insert these items into the database:

```
var macdonalds = [
  {item: "burger", type: "snacks", price: 0.99, qty: 200 },
  {item: "coke", type: "food", price: 1.99, qty: 500 },
  {item: "french fries", type: "snacks", price: 1.0, qty: 5},
  {item: "six pack", type: "food", price: 11.99, qty: 60 },
  {item: "cup", type: "accessories", price: 0.05, qty: 1000,
     producer: { address: '123 Street', company: 'ABC123'} },
  {item: "straws", type: "accessories", price: 0.9, qty: 300,
     producer: { company: 'ABC123', address: '123 Street'} }
]

db.inventory.insertMany(macdonalds)
```

- Update items “burger” and increment quantity by 50.

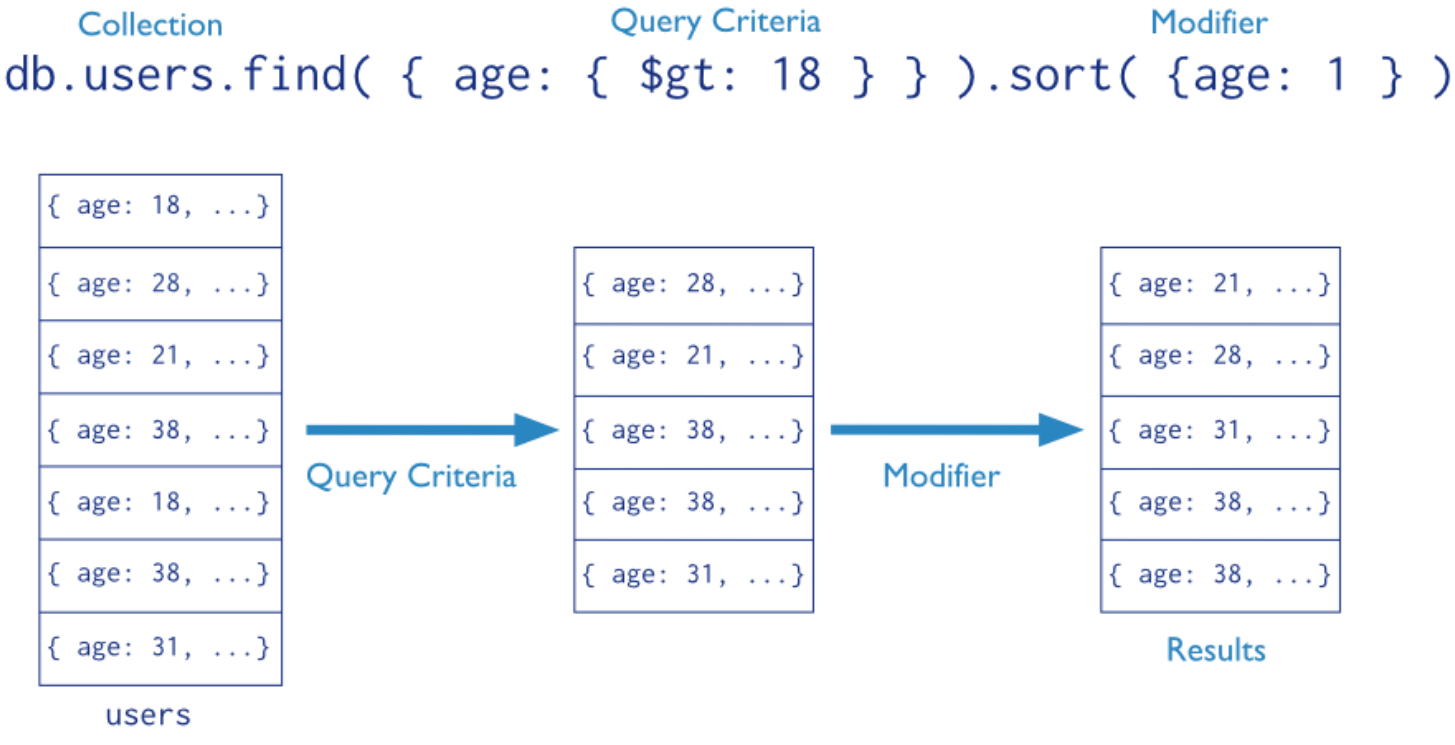
Querying

- A MongoDB query:
  - Targets a specific collection of documents
  - Specifies criteria that identify the returned documents
  - May include a projection to specify returned fields
  - May impose limits, sort, orders, …

- Basic query - all documents in the collection:

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

Querying (2)



- Mongo query language

Querying (3)


```
db.inventory.find({ type: "snacks" })
```

- All documents from inventory where the type field has the value snacks

```
db.inventory.find({ type: { $in: [ 'food', 'snacks' ] } } )
```

- All inventory docs where the type field is either food or snacks

```
db.inventory.find( { type: 'food', price: { $lt: 9.95 } } )
```

- All … where the type field is food and the price is less than 9.95

Querying (4)


```
db.inventory.find({ $or: [
                { qty: { $gt: 100 } },
                { price: { $lt: 9.95 } }     ] } )
```

- All inventory docs where the qty field is greater than ($gt) 100 OR the price is less than ($lt) 9.95

```
db.inventory.find( { type: 'food', $or: [
                { qty: { $gt: 100 } },
                { price: { $lt: 9.95 } } ]     } )
```

- All inventory docs where the type field is food AND EITHER the qty is greater than ($gt) 100 OR the price is less than ($lt) 9.95

Querying (5)


```
db.inventory.find({ type:'accessories' },
                  {item:1, price:1, _id:0 })
```

- Find the relevant documents and projects selected attributes

Querying (6): Nested Values


```
db.inventory.find( { producer: {
                         company: 'ABC123',
                         address: '123 Street'
                       } } )
```

- All docs where the value of the field producer is a subdocument that contains only the field company with the value ABC123 and the field address with the value 123 Street, in the exact order

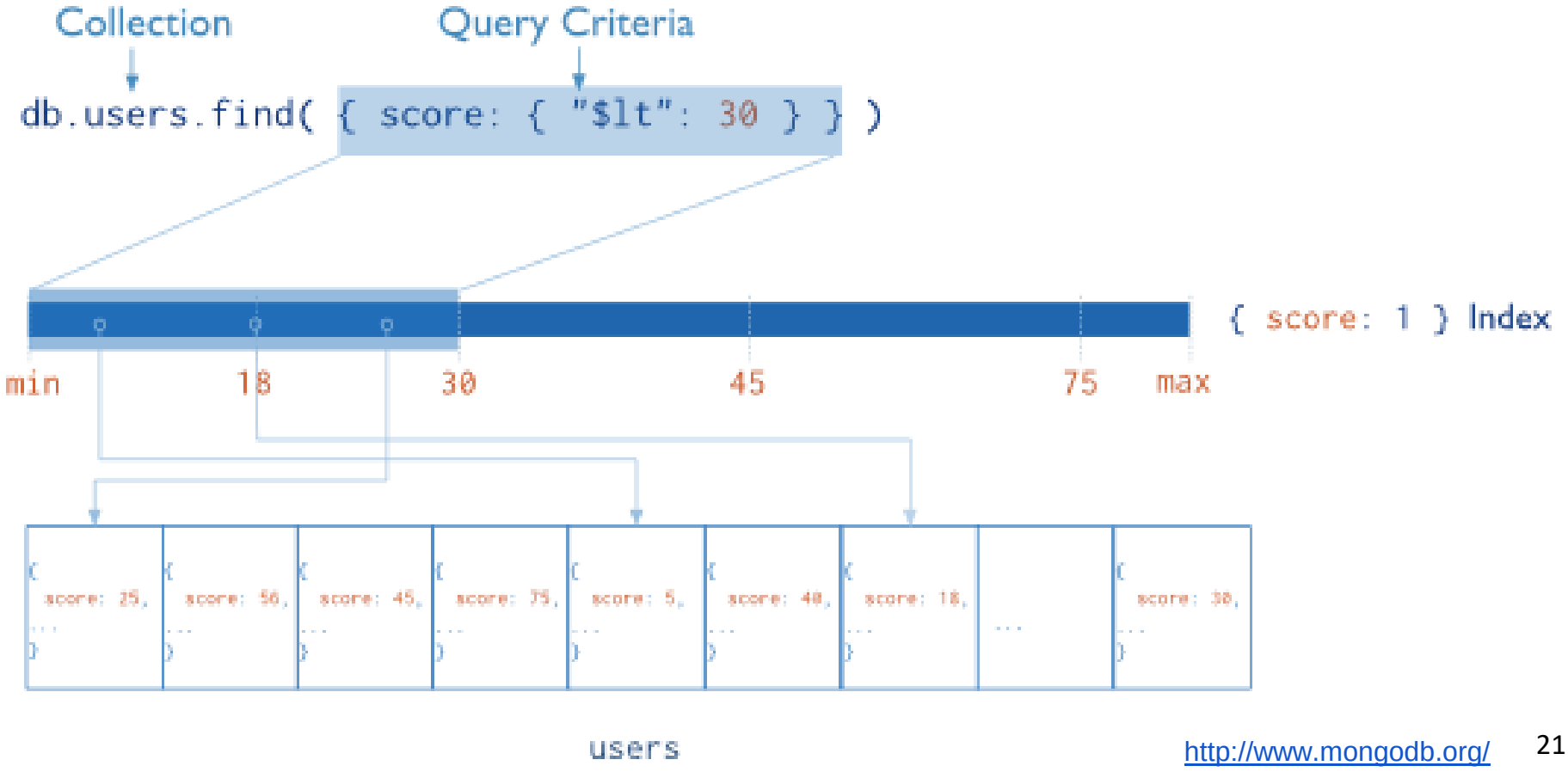
```
db.inventory.find( { 'producer.company':
'ABC123' } )
```

- All docs where the field producer is a subdocument containing field company with value ABC123 (and may contain other fields)

Indexes

- Indexes are key for MongoDB performance
  - Without indexes, MongoDB must scan every document in a collection to select matching documents
- Indexes store some fields in easily accessible form
  - Stores the value of a specific field(s) ordered by the value of the field
- Defined per collection
- Purpose:
  - To speed up common queries
  - To optimize performance of other specific operations

Indexes: Example of Use



Index Types by Attributes

- **Default: _id**
  - Exists by default
    - If applications do not specify _id, it is created.
  - Unique
- **Single Field**
  - User-defined indexes on a single field of a document
- **Compound**
  - User-defined indexes on multiple fields
- **Multikey index**
  - To index the content stored in arrays
  - Creates separate index entry for each array element

Index Types by Technique

- **Ordered** Index
  - B-Tree (see above)
- **Hash** Indexes ("hashed")
  - Fast *O*(1) indexes the hash of the value of a field
    - Only equality matches
- **Geospatial** Index
  - "2d" = use planar geometry when returning results
    - For data representing points on a two-dimensional plane
  - "2dsphere" = spherical (Earth-like) geometry
    - For data representing longitude, latitude
- **Text** Indexes ("text")
  - Searching for string content in a collection

Indexes: Management

https://docs.mongodb.org/manual/core/indexes-introduction/

- Basic command:

```
db.inventory.createIndex( { type: 1 })
```

  - The number controls ordering (1:asc, -1:desc)
- Check indexes & create hashed index

```
db.inventory.stats()
db.inventory.dropIndex({type:1})
db.inventory.createIndex({type:"hashed"})
db.inventory.dropIndex({type:"hashed"})
```

Indexes: Management (2)

- Query execution plan (is index used?):

```
db.inventory.find({item: "burger"}).explain()
```

- In real application, all queries should use indexes

MongoDB Management

- Installation & **running**
  - `service mongod start/stop/status`
- **Configuration** file
  - `/etc/mongod.conf`
- **Data** files
  - `dbpath=/var/lib/mongo`
- **Log** file
  - `logpath=/var/log/mongodb/mongod.log`
- MongoDB **tools**:
  - `mongo<TAB>`
- Admin GUI interfaces: `link`

Task 3: Import Large Data

- generate JSON data:
  - http://jsongen.pykaso.net/
- or use generated file at

```
# ~/mongo/people.json
```

  - or download from study materials

```
{
"_id" : "%index%",
"surname" : "%surname%",
"fullname" : "%fullname%",
"email" : "%email%",
"salary": "%randFloat(10,50000)%",
"address" : {
   "city" : "%name%",
   "street" : "%name%",
   "number" : "%randInt(0,50)%",
   "location" : {
      "type": "Point",
      "coordinates": [
         "%randFloat(0,180)%",
         "%randFloat(0,90)%"
      ]
   }
}
}
```

Generate GPS coordinates (GeoJSON)

Task 3 (cont.)


```
mongoimport --db <name> --collection <col> --
type json --file <path> --jsonArray
```

- **database**: <name> (use "local")
- **collection**: <col> (use "people")
- **file type**: JSON (default)
- file **path**: <path> (use "~/mongo/people.json")
- assuming that the file contains an array of JSON documents

Task 4: Querying

- Find people living in the city “Andrew”
- Find people with salary greater than 3000
  - list their names and salary only
- Find people with email from the domain “kaplan.il”
- Count records in people collection (it is 10,000)
  - count distinct last names (it is 640)

Using an aggregate function?

Monitor Performance

- Monitor performance of operations
  - Change MongoDB option in `/etc/mongod.conf`

```
operationProfiling:
  slowOpThresholdMs: 5
```

  - drop operation system disk caches
    - Only root can do:

```
# echo 1 > /proc/sys/vm/drop_caches
```

  - run queries, index, and monitor MongoDB log file

```
# tail -f /var/log/mongodb/mongod.log
```

Geospatial Indexes

- GeoSpatial index and queries

```
db.people.ensureIndex({"address.location": "2dsphere"})

db.people.find(
    { "address.location":  { $near :
        { $geometry :
            { type : "Point" ,
              coordinates : [ 128.4, 48.13 ]
            }, $maxDistance: 10000
}}})
```

In meters for GeoJSON type

Connectors from Languages

- Python
  - **Pymongo**: basic operations with the database
    - like MongoDB shell encapsulated in Python
  - **Mongoengine**: Object-Document Mapper
    - transparent storing of object data
    - http://mongoengine.org/

- Example in

```
# ~/mongo/student.py
# ./student.py --help
```

https://is.muni.cz/auth/el/fi/podzim2021/PA195/um/seminar-3/student.py

Questions?

Please, any questions?

References

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- Sadalage, P. J., & Fowler, M. (2012). NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence. Addison-Wesley Professional, 192 p.

- RNDr. Irena Holubova, Ph.D. MMF UK course NDBI040: Big Data Management and NoSQL Databases

- MongoDB Manual: http://docs.mongodb.org/manual/