

MongoDB and NoSQL Databases

```
{  
    "id": ObjectId("5146bb52d8524270060001f3"),  
    "course": "csc443",  
    "campus": "Byblos",  
    "semester": "Fall 2016",  
    "instructor": "Haidar Harmanani"  
}
```

A look at the Database Market

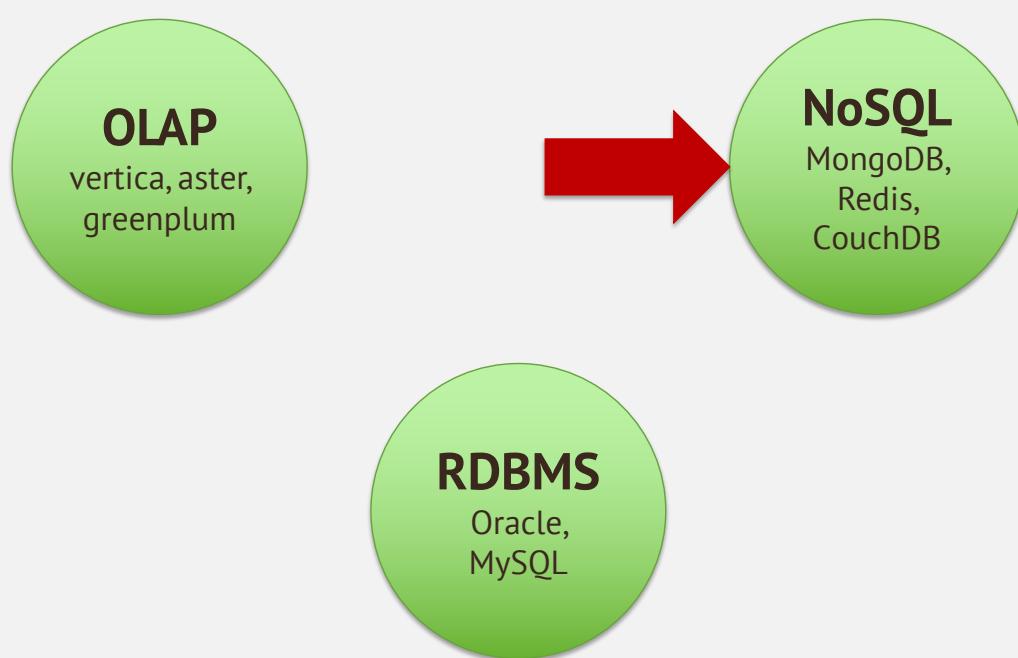


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- MongoDB
 - Powerful and mature NoSQL database
 - MongoLab: managed MongoDB in the cloud

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What is NoSQL Database?

- Work extremely well on the web
- NoSQL (cloud) databases
 - Use document-based model (non-relational)
 - Schema-free document storage
 - Still support indexing and querying
 - Still support CRUD operations (create, read, update, delete)
 - Still supports concurrency and transactions
 - No joins
 - No complex transactions
 - Horizontally scalable
 - Highly optimized for append / retrieve
 - Great performance and scalability
 - NoSQL == “No SQL” or “Not Only SQL”?

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Relational vs. NoSQL Databases

- Relational databases
 - Data stored as table rows
 - Relationships between related rows
 - Single entity spans multiple tables
 - RDBMS systems are very mature, rock solid
- NoSQL databases
 - Data stored as documents
 - Single entity (document) is a single record
 - Documents do not have a fixed structure

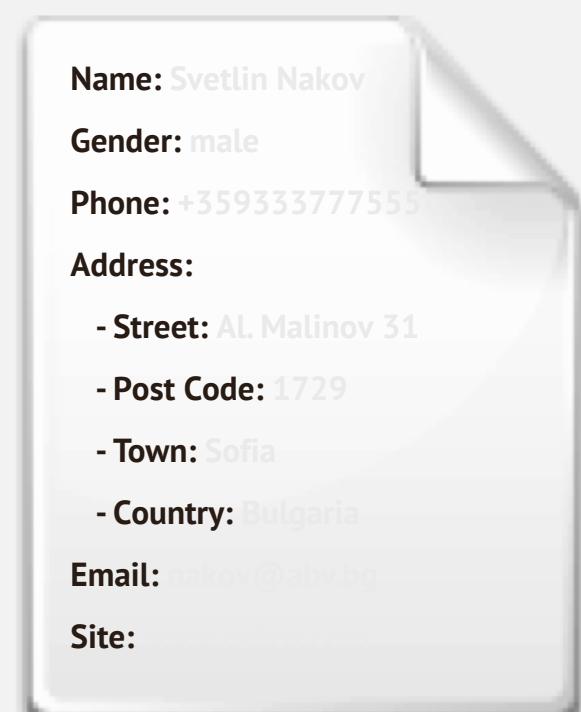
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Relational vs. NoSQL Models

Relational Model

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Town	Sofia * 1
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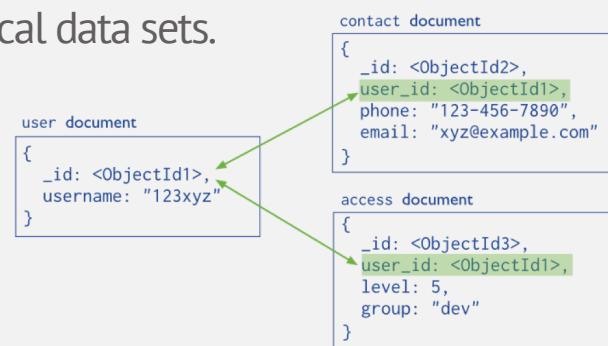
Document Model



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Document oriented database – Normalized data model

- When to use:
 - When embedding would result in duplication of data but would not provide sufficient read performance advantages to outweigh the implications of the duplication.
 - To represent more complex many-to-many relationships.
 - To model large hierarchical data sets.
 - Multiple queries!



Redis

What is Redis?

- Redis is
 - Ultra-fast in-memory key-value data store
 - Powerful data structures server
 - Open-source software: <http://redis.io>
- Redis stores data structures:
 - Strings
 - Lists
 - Hash tables
 - Sets / sorted sets

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Hosted Redis Providers

- Redis Cloud
 - Fully managed Redis instance in the cloud
 - Highly scalable, highly available
 - Free 1 GB instance, stored in the Amazon cloud
 - Supports data persistence and replication
 - <http://redis-cloud.com>
- Redis To Go
 - 5 MB free non-persistent Redis instance
 - <http://redistogo.com>

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CouchDB

What is CouchDB?

- Apache CouchDB
 - Open-source NoSQL database
 - Document-based: stored JSON documents
 - HTTP-based API
 - Query, combine, and transform documents with JavaScript
 - On-the-fly document transformation
 - Real-time change notifications
 - Highly available and partition tolerant

Hosted CouchDB Providers

- Cloudant
 - Managed CouchDB instances in the cloud
 - Free \$5 account – unclear what this means
 - <https://cloudant.com>
 - Has nice web-based administration UI

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“Big Data” is two problems

- The analysis problem
 - How to extract useful info, using modeling, ML and stats.
- The storage problem
 - How to store and manipulate huge amounts of data to facilitate fast queries and analysis
- Problems with traditional (relational) storage
 - Not flexible
 - Hard to partition, i.e. place different segments on different machines

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Example: E-Commerce

- Problem: Product catalogs store different types of objects with different sets of attributes.
- This is not easily done within the relational model, need a more “flexible schema”
- Relational Solutions
 - Create a table for each product category
 - Put everything in one table
 - Use inheritance
 - Entity-Attribute-Value
 - Put everything in a BLOB

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RDBMS (1): Table per Product

```
CREATE TABLE `product_audio_album`  
  ( `sku` char(8) NOT NULL, ...  
    `artist` varchar(255) DEFAULT NULL,  
    `genre_0` varchar(255) DEFAULT NULL,  
    `genre_1` varchar(255) DEFAULT NULL, ...  
    PRIMARY KEY(`sku`)) ...  
  
CREATE TABLE `product_film`  
  ( `sku` char(8) NOT NULL, ...  
    `title` varchar(255) DEFAULT NULL,  
    `rating` char(8) DEFAULT NULL, ...  
    PRIMARY KEY(`sku`)) ...
```

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RDBMS (2): Single table for all

```
CREATE TABLE `product`  
  ( `sku` char(8) NOT NULL, ...  
    `artist` varchar(255) DEFAULT NULL,  
    `genre_0` varchar(255) DEFAULT NULL,  
    `genre_1` varchar(255) DEFAULT NULL, ...  
    `title` varchar(255) DEFAULT NULL,  
    `rating` char(8) DEFAULT NULL, ...  
    PRIMARY KEY(`sku`))
```

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RDBMS (3): Inheritance

```
CREATE TABLE `product`  
(`sku` char(8) NOT NULL,  
 `title` varchar(255) DEFAULT NULL,  
 `description` varchar(255) DEFAULT NULL,  
 `price`, ...  
 PRIMARY KEY(`sku`))  
  
CREATE TABLE `product_audio_album`  
(`sku` char(8) NOT NULL, ...  
 `artist` varchar(255) DEFAULT NULL,  
 `genre_0` varchar(255) DEFAULT NULL,  
 `genre_1` varchar(255) DEFAULT NULL, ...  
 PRIMARY KEY(`sku`),  
 FOREIGN KEY(`sku`) REFERENCES `product`(`sku`))  
...
```

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RDBMS (4): Entity Attribute Value

Entity	Attribute	Value
sku_00e8da9b	Type	Audio Album
sku_00e8da9b	Title	A Love Supreme
sku_00e8da9b
sku_00e8da9b	Artist	John Coltrane
sku_00e8da9b	Genre	Jazz
sku_00e8da9b	Genre	General

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MongoDB Solution

- A “collection” can contain heterogeneous “documents”, e.g. for an audio album we could store as

```
{ sku: "ooe8dagb",
  type: "Audio Album",
  title: "A Love Supreme",
  description: "by John Coltrane",
  shipping: { weight: 6,
    dimensions: { width: 10, height: 10, depth: 1 } },
  pricing: { list: 1200, retail: 1100, savings: 100 },
  details: { title: "A Love Supreme [Original Recording]",
    artist: "John Coltrane",
    genre: [ "Jazz", "General" ] }
}
```

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Hosted MongoDB Providers

- MongoLab
 - Free 0.5 GB instance
 - <https://mongolab.com>
- MongoHQ
 - Free 0.5 GB instance (sandbox)
 - <https://www.mongohq.com>
- MongoOd
 - Free 100 MB instance
 - <https://www.mongoood.com>



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History

- mongoDB = “Humongous DB”
 - Open-source
 - Document-based
 - “High performance, high availability”
 - Automatic scaling
 - C-P on CAP

History

- 2007 - First developed (by 10gen)
- 2009 - Became Open Source
- 2010 - Considered production ready (v 1.4 >)
- 2013 - MongoDB closes \$150 Million in Funding
- 2015 - version 3 released (v 3.0.7)
- 2016 – Latest stable version (v. 3.2.10)
- Today- More than \$231 million in total investment since 2007

History

THE WALL STREET JOURNAL

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Dyn Says
Cyberattack Has
Ended, Investigation
Continues



Visa Taps
Blockchain for Cross-
Border Payment Plan



Airbnb I
New York Ru
Possible Leg

19. MongoDB

Better uses for big data

Founders: Eliot Horowitz, Dwight Merriman, Kevin P. Ryan

Launched: 2007

Funding: \$31.5 million

Valuation: \$1.8 billion

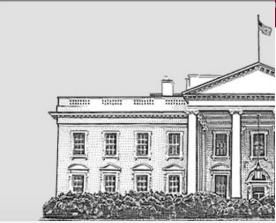
Disrupting: Big data

Rival: Oracle

DIGITS

Big-Data Startup MongoDB Is Now Valued at \$1.6 Billion

InfoWorld
FROM IDG



Home > Application Development



STRATEGIC DEVELOPER

By Andrew C. Oliver | Follow

INSI

Why MongoDB is worth \$1.2 billion

If document database startup MongoDB is looking to thank someone for its hefty valuation, Larry Ellison should be first in line

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Motivations

- Problems with SQL
 - Rigid schema
 - Not easily scalable (designed for 90's technology or worse)
 - Requires unintuitive joins
- Perks of mongoDB
 - Easy interface with common languages (Java, Javascript, PHP, etc.)
 - DB tech should run anywhere (VM's, cloud, etc.)
 - Keeps essential features of RDBMS's while learning from key-value noSQL systems

Design Goals

- Scale horizontally over commodity systems
- Incorporate what works for RDBMSs
 - Rich data models, ad-hoc queries, full indexes
- Move away from what doesn't scale easily
 - Multi-row transactions, complex joins
- Use idiomatic development APIs
- Match agile development and deployment workflows

To scale horizontally (or scale out/in) means to add more nodes to (or remove nodes from) a system, such as adding a new computer to a distributed software application. An example might involve scaling out from one Web server system to three.

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Key Features

- Data stored as documents (JSON)
 - Dynamic-schema
- Full CRUD support (Create, Read, Update, Delete)
 - Ad-hoc queries: Equality, RegEx, Ranges, Geospatial
 - Atomic in-place updates
- Full secondary indexes
 - Unique, sparse, TTL
- Replication – redundancy, failover
- Sharding – partitioning for read/write scalability

Key Features

- All indexes in MongoDB are B-Tree indexes
- Index Types:
 - Single field index
 - Compound Index: more than one field in the collection
 - Multikey index: index on array fields
 - Geospatial index and queries.
 - Text index: Index
 - TTL index: (Time to live) index will contain entities for a limited time.
 - Unique index: the entry in the field has to be unique.
 - Sparse index: stores an index entry only for entities with the given field.

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MongoDB Drivers and Shell

Drivers

Drivers for most popular programming languages and frameworks



Shell

Command-line shell for interacting directly with database

```
> db.collection.insert({product:"MongoDB",
  type:"Document Database"})
>
> db.collection.findOne()
{
    "_id"          : ObjectId("5106c1c2fc629bfe52792e86"),
    "product"      : "MongoDB",
    "type"         : "Document Database"
}
```

Getting Started with Mongo

Installation

- Install Mongo from: <http://www.mongodb.org/downloads>
 - Extract the files
 - Create a data directory for Mongo to use
- Open your mongodb/bin directory and run the binary file (name depends on the architecture) to start the database server.
- To establish a connection to the server, open another command prompt window and go to the same directory, entering in mongo.exe or mongo for macs and Linuxes.
- This engages the mongodb shell – it's that easy!

MongoDB Design Model

Database

Table

Row

Database

Collection

Document



Mongo Data Model

- Document-Based (max 16 MB)
- Documents are in BSON format, consisting of field-value pairs
- Each document stored in a collection
- Collections
 - Have index set in common
 - Like tables of relational db's.
 - Documents do not have to have uniform structure

JSON

- “JavaScript Object Notation”
- Easy for humans to write/read, easy for computers to parse/generate
- Objects can be nested
- Built on
 - name/value pairs
 - Ordered list of values

BSON

- “Binary JSON”
- Binary-encoded serialization of JSON-like docs
- Also allows “referencing”
- Embedded structure reduces need for joins
- Goals
 - Lightweight
 - Traversable
 - Efficient (decoding and encoding)

BSON Example

```
{  
  "_id": "37010",  
  "city": "ADAMS",  
  "pop": 2660,  
  "state": "TN",  
  "councilman": {  
    "name": "John Smith",  
    "address": "13 Scenic Way"  
  }  
}
```

BSON Types

Type	Number
Double	1
String	2
Object	3
Array	4
Binary data	5
Object id	7
Boolean	8
Date	9
Null	10
Regular Expression	11
JavaScript	13
Symbol	14
JavaScript (with scope)	15
32-bit integer	16
Timestamp	17
64-bit integer	18
Min key	255
Max key	127

The number can
be used with the
\$type operator to
query by type!

<http://docs.mongodb.org/manual/reference/bson-types/>

The _id Field

- By default, each document contains an _id field. This field has a number of special characteristics:
 - Value serves as primary key for collection.
 - Value is unique, immutable, and may be any non-array type.
 - Default data type is ObjectId, which is “small, likely unique, fast to generate, and ordered.”
 - Sorting on an ObjectId value is roughly equivalent to sorting on creation time.

MongoDB vs. Relational Databases

Why Databases Exist in the First Place?

- Why can't we just write programs that operate on objects?
 - Memory limit
 - We cannot swap back from disk merely by OS for the page based memory management mechanism
- Why can't we have the database operating on the same data structure as in program?
 - That is where Mongo comes in

Mongo is basically schema-free

- The purpose of schema in SQL is for meeting the requirements of tables and quirky SQL implementation
- Every “row” in a database “table” is a data structure, much like a “struct” in C, or a “class” in Java.
 - A table is then an array (or list) of such data structures
- So what we design in Mongo is basically similar to how we design a compound data type binding in JSON

RDBMS		MongoDB
Database	→	Database
Table	→	Collection
Row	→	Document
Index	→	Index
Join	→	Embedded Document
Foreign Key	→	Reference

mongoDB vs. SQL

MongoDB	SQL
Document	Tuple
Collection	Table/View
PK: <code>_id</code> Field	PK: Any Attribute(s)
Uniformity not Required	Uniform Relation Schema
Index	Index
Embedded Structure	Joins
Shard	Partition

Document Oriented, Dynamic Schema

Relational

Person:

Pers_ID	Surname	First_Name	City
0	Miller	Paul	London
1	Ortega	Alvaro	Valencia
2	Huber	Urs	Zurich
3	Blanc	Gaston	Paris
4	Bertolini	Fabrizio	Rom

Car:

Car_ID	Model	Year	Value	Pers_ID
101	Bentley	1973	100000	0
102	Rolls Royce	1965	330000	0
103	Peugeot	1993	500	3
104	Ferrari	2005	150000	4
105	Renault	1998	2000	3
106	Renault	2001	7000	3
107	Smart	1999	2000	2

MongoDB

```
{
  first_name: 'Paul',
  surname: 'Miller',
  city: 'London',
  location: [45.123, 47.232],
  cars: [
    { model: 'Bentley',
      year: 1973,
      value: 100000, ... },
    { model: 'Rolls Royce',
      year: 1965,
      value: 330000, ... }
  ]
}
```

MongoDB Marketing Spiel

- MongoDB (from "humongous") is a scalable, high-performance, open source, document-oriented database.
 - Fast querying & In-place updates
 - Full Secondary Index Support
 - Replication & High Availability
 - Auto-Sharding
- Currently used in a number of different applications
 - Craigslist, ebay, New York Times, Shutterfly, Chicago Tribune, Github, Disney...

4

CRUD:

Create, Read, Update, Delete

CRUD: Using the Shell

- To check which db you're using → db
- Show all databases → show dbs
- Switch db's/make a new one → use <name>
- See what collections exist → show collections
- Note: db's are not actually created until you insert data!

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CRUD: Using the Shell (cont.)

- To insert documents into a collection/make a new collection:

• db.<collection>.insert(<document>)

• <=>

• INSERT INTO <table>

• VALUES(<attributevalues>);

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CRUD: Inserting Data

- Insert one document
 - `db.<collection>.insert({<field>:<value>})`
- Inserting a document with a field name new to the collection is inherently supported by the BSON model.
- To insert multiple documents, use an array.

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CRUD: Querying

- Done on collections.
- Get all docs: `db.<collection>.find()`
 - Returns a cursor, which is iterated over shell to display first 20 results.
 - Add `$limit(<number>)` to limit results
 - `SELECT * FROM <table>;`
- Get one doc: `db.<collection>.findOne()`

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CRUD: Querying

To match a specific value:

```
db.<collection>.find({<field>:<value>})  
“AND”  
db.<collection>.find({<field1>:<value1>, <field2>:<value2>  
})
```

```
SELECT *  
FROM <table>  
WHERE <field1> = <value1> AND <field2> = <value2>;
```

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CRUD: Querying

OR

```
db.<collection>.find({ $or: [  
<field>:<value1>  
<field>:<value2>      ]  
})
```

```
SELECT *  
FROM <table>  
WHERE <field> = <value1> OR <field> = <value2>;
```

Checking for multiple values of same field

```
db.<collection>.find({<field>: {$in [<value>, <value>]} })
```

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CRUD: Querying

Excluding document fields

```
db.<collection>.find({<field1>:<value>}, {<field2>: 0})
```

```
SELECT field1  
FROM <table>;
```

Including document fields

```
db.<collection>.find({<field>:<value>}, {<field2>: 1})
```

Find documents with or w/o field

```
db.<collection>.find({<field>: { $exists: true}})
```

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CRUD: Updating

```
db.<collection>.update(  
  {<field1>:<value1>},    //all docs in which field = value  
  {$set: {<field2>:<value2>}},    //set field to value  
  {multi:true} )    //update multiple docs
```

bulk.find.upsert(): if true, creates a new doc when none matches search criteria.

```
UPDATE <table>  
SET <field2> = <value2>  
WHERE <field1> = <value1>;
```

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CRUD: Updating

To remove a field

```
db.<collection>.update({<field>:<value>},  
    { $unset: { <field>: 1}})
```

Replace all field-value pairs

```
db.<collection>.update({<field>:<value>},  
    { <field>:<value>, <field>:<value>})
```

*NOTE: This overwrites ALL the contents of a document, even removing fields.

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CRUD: Removal

Remove all records where field = value

```
db.<collection>.remove({<field>:<value>})
```

```
DELETE FROM <table>  
WHERE <field> = <value>;
```

As above, but only remove first document

```
db.<collection>.remove({<field>:<value>}, true)
```

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CRUD: Isolation

- By default, all writes are atomic only on the level of a single document.
- This means that, by default, all writes can be interleaved with other operations.
- You can isolate writes on an unsharded collection by adding `$isolated:1` in the query area:

– `db.<collection>.remove({<field>:<value>, $isolated: 1})`

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MongoDB Example II

```

db.users.insertMany(
  [
    {
      _id: 1,
      name: "sue",
      age: 19,
      type: 1,
      status: "P",
      favorites: { artist: "Picasso", food: "pizza" },
      finished: [ 17, 3 ],
      badges: ["blue", "black"],
      points: [
        { points: 85, bonus: 20 },
        { points: 85, bonus: 10 }
      ]
    },
    {
      _id: 2,
      name: "bob",
      age: 42,
      type: 1,
      status: "A",
      favorites: { artist: "Miro", food: "meringue" },
      finished: [ 11, 25 ],
      badges: ["green"],
      points: [
        { points: 85, bonus: 20 },
        { points: 64, bonus: 12 }
      ]
    },
    {
      _id: 3,
      name: "ahn",
      age: 22,
      type: 2,
      status: "A",
      favorites: { artist: "Cassatt", food: "cake" },
      finished: [ 6 ],
      badges: ["blue", "red"],
      points: [
        { points: 81, bonus: 8 },
        { points: 55, bonus: 20 }
      ]
    },
    {
      _id: 4,
      name: "xi",
      age: 34,
      type: 2,
      status: "D",
      favorites: { artist: "Chagall", food: "chocolate" },
      finished: [ 5, 11 ],
      badges: ["red", "black"],
      points: [
        { points: 53, bonus: 15 },
        { points: 51, bonus: 15 }
      ]
    }
  ]
)

```

Insert

- db.collection.insertOne()
- db.collection.insertMany()
- db.collection.insert()

- Example

```

db.users.insertMany(
  [
    { name: "bob", age: 42, status: "A" },
    { name: "ahn", age: 22, status: "A" },
    { name: "xi", age: 34, status: "D" }
  ]
)

```

Update

- db.collection.updateOne()
- db.collection.updateMany()
- db.collection.replaceOne()
- db.collection.update()

- Example

```
db.users.updateOne(  
  { "favorites.artist": "Picasso" },  
  {  
    $set: { "favorites.food": "pie", type: 3 },  
    $currentDate: { lastModified: true }  
  }  
)
```

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Return All Fields in Matching Documents

- Retrieve from the users collection all documents where the status equals "A"
 - db.users.find({ status: "A" })

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Return the Specified Fields and the `_id` Field Only

- A projection can explicitly include several fields
 - Return all documents that match the query
 - `db.users.find({ status: "A" }, { name: 1, status: 1 })`
- This will result in the following:

```
{ "_id": 2, "name": "bob", "status": "A" }
{ "_id": 3, "name": "ahn", "status": "A" }
```

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Return the Specified Fields

- Remove the `_id` field from the results by specifying its exclusion in the projection
 - `db.users.find({ status: "A" }, { name: 1, status: 1, _id: 0 })`
- This will result in the following:

```
{ "name": "bob", "status": "A" }
{ "name": "ahn", "status": "A" }
{ "name": "abc", "status": "A" }
```

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Return All But the Excluded Field

- Use a projection to exclude specific fields
 - db.users.find({ status: "A" }, { favorites: 0, points: 0 })

- Returns

```
{  
  "_id": 2,  
  "name": "bob",  
  "age": 42,  
  "type": 1,  
  "status": "A",  
  "finished": [ 11, 25 ],  
  "badges": [ "green" ]  
}  
...
```

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Return Specific Fields in Embedded Documents

- Use the dot notation to return specific fields in an embedded document
 - db.users.find({ status: "A" }, { name: 1, status: 1, "favorites.food": 1 })
- Returns the following fields inside the favorites document

```
{ "_id": 2, "name": "bob", "status": "A", "favorites": { "food": "meringue" } }  
{ "_id": 3, "name": "ahn", "status": "A", "favorites": { "food": "cake" } }
```

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Suppress Specific Fields in Embedded Documents

- Exclude the food field inside the favorites document

```
db.users.find(  
  { status:"A"},  
  { "favorites.food":0 }  
)
```

- Returns

```
{  
  "_id":2,  
  "name":"bob",  
  "age":42,  
  "type":1,  
  "status":"A",  
  "favorites":{ "artist":"Miro"},  
  "finished":[11,25],  
  "badges":["green"],  
  "points":[{ "points":85,"bonus":20 },{ "points":64,"bonus":12 }]  
}  
...
```

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SQL Schema Statements

```
CREATE TABLE users (  
  id MEDIUMINT NOT NULL  
    AUTO_INCREMENT,  
  user_id Varchar(30),  
  age Number,  
  status char(1),  
  PRIMARY KEY (id)  
)
```

```
ALTER TABLE users  
ADD join_date DATETIME
```

MongoDB Schema Statements

Implicitly created on first [insert\(\)](#) operation. The primary key `_id` is automatically added if `_id` field is not specified.

```
db.users.insert( {  
  user_id: "abc123",  
  age: 55,  
  status: "A"  
} )
```

However, you can also explicitly create a collection:

```
db.createCollection("users")
```

Collections do not describe or enforce the structure of its documents; i.e. there is no structural alteration at the collection level.

However, at the document level, [update\(\)](#) operations can add fields to existing documents using the `$set` operator.

```
db.users.update(  
  { },  
  { $set: { join_date: new Date() } },  
  { multi: true }  
)
```

CSC443/CSC375

```
ALTER TABLE users
DROP COLUMN join_date

Collections do not describe or enforce the structure of its
documents; i.e. there is no structural alteration at the collection
level.

However, at the document level, update\(\) operations can
remove fields from documents using the \$unset operator.

db.users.update(
    { },
    { $unset: { join_date: "" } },
    { multi: true }
)
CREATE INDEX idx_user_id_asc
ON users(user_id)
CREATE INDEX
    idx_user_id_asc_age_des
C
ON users(user_id, age DESC)
DROP TABLE users
db.users.createIndex( { user_id: 1 } )
db.users.createIndex( { user_id: 1, age: -1 } )
db.users.drop()
```

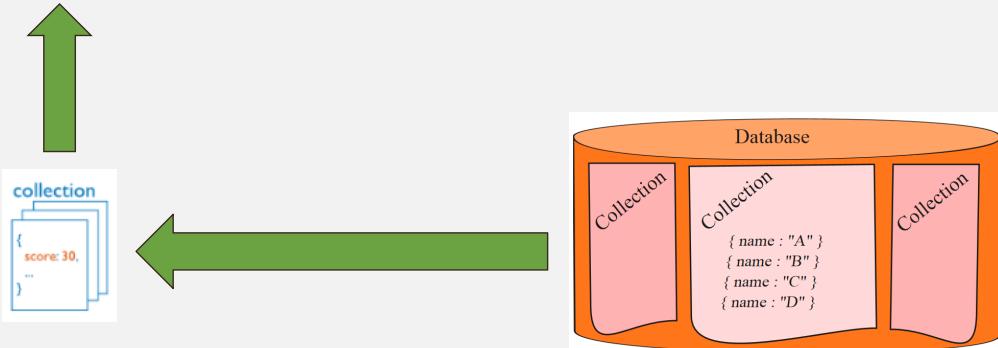
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Index in MongoDB

Before Index

- What does database normally do when we query?
 - MongoDB must scan every document.
 - Inefficient because process large volume of data

```
db.users.find( { score: { "$lt": 30 } } )
```



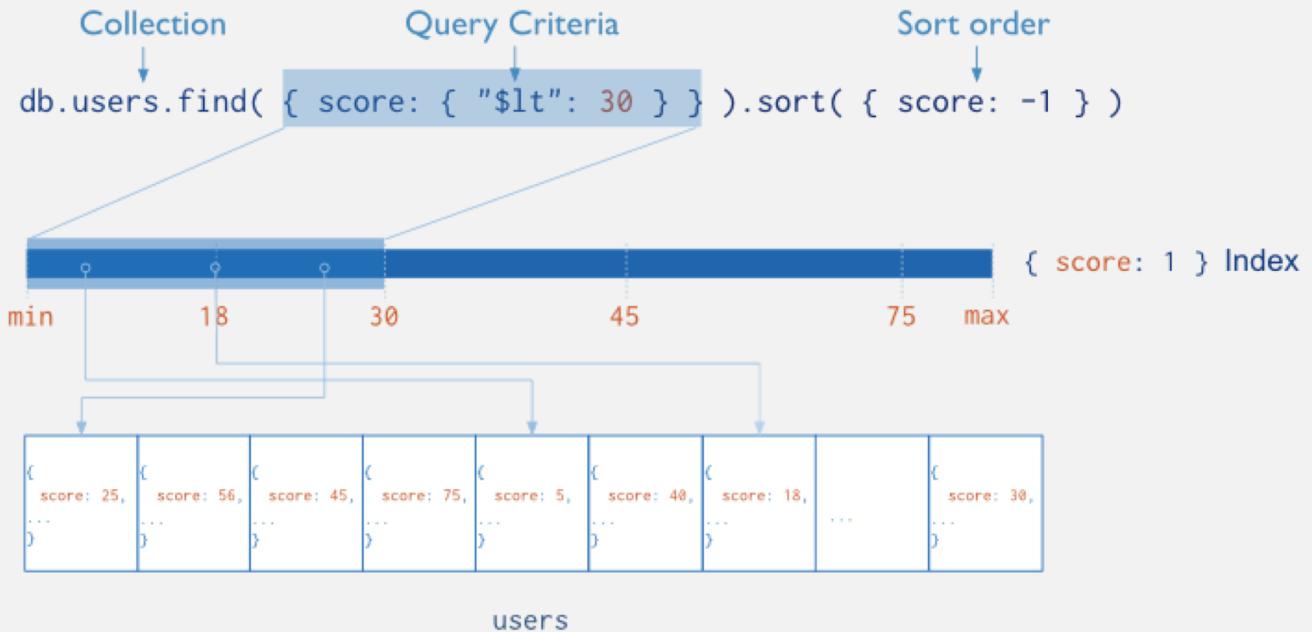
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Index in MongoDB: Operations

- Creation index
 - db.users.ensureIndex({ score:1 })
 - db.people.createIndex({ zipcode:1 }, {background:true})
- Show existing indexes
 - db.users.getIndexes()
- Drop index
 - db.users.dropIndex({score:1})
- Explain—Explain
 - db.users.find().explain()
 - Returns a document that describes the process and indexes
- Hint
 - db.users.find().hint({score:1})
 - Override MongoDB's default index selection

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Index in MongoDB: Operations



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Index in MongoDB

- Types
 - **Single Field Indexes**
 - Compound Field Indexes
 - Multikey Indexes
- Single Field Indexes
 - `db.users.ensureIndex({ score: 1 })`

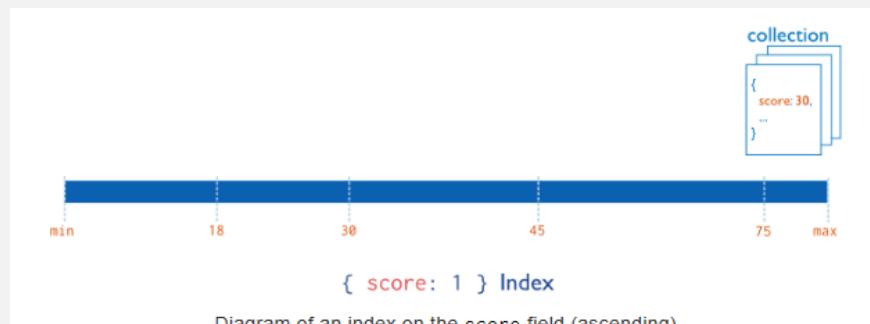


Diagram of an index on the `score` field (ascending).

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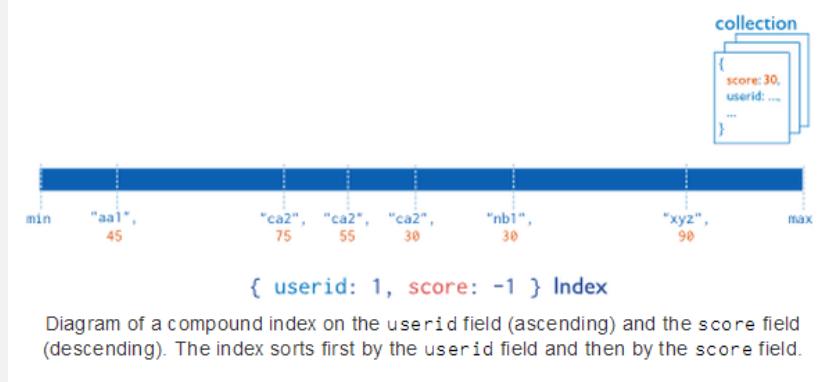
Index in MongoDB

- Types

- Single Field Indexes
- **Compound Field Indexes**
- Multikey Indexes

- Compound Field Indexes

- db.users.ensureIndex({ userid:1, score:-1 })



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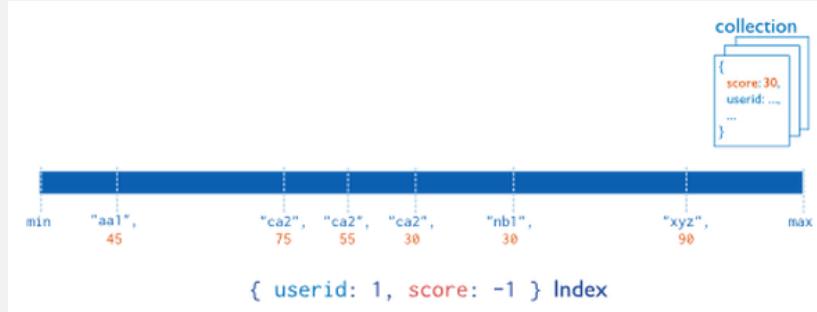
Index in MongoDB

- Types

- Single Field Indexes
- Compound Field Indexes
- **Multikey Indexes**

- Multikey Indexes

- db.users.ensureIndex({ addr.zip:1 })



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Other Indexes in MongoDB

- Geospatial Index
- Text Indexes
- Hashed Indexes

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Mongo Example I

Documents

```
> var new_entry = {  
  firstname: "John",  
  lastname: "Smith",  
  age: 25,  
  address: {  
    street: "21 2nd Street",  
    city: "New York",  
    state: "NY",  
    zipcode: 10021  
  }  
}  
> db.addressBook.save(new_entry)
```

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Querying

```
> db.addressBook.find()  
{  
  _id: ObjectId("4c4ba5c0672c685e5e8aabf3"),  
  firstname: "John",  
  lastname: "Smith",  
  age: 25,  
  address: {  
    street: "21 2nd Street", city: "New York",  
    state: "NY", zipcode: 10021  
  }  
}  
// _id is unique but can be anything you like
```

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Indexes

```
// create an ascending index on “state”
> db.addressBook.ensureIndex({state:1})

> db.addressBook.find({state:"NY"})
{
  _id: ObjectId("4c4ba5c0672c685e5e8aabf3"),
  firstname: "John",
  ...
}

> db.addressBook.find({state:"NY", zip: 10021})
```

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Queries

```
// Query Operators:
// $all, $exists, $mod, $ne, $in, $nin, $nor, $or,
// $size, $type, $lt, $lte, $gt, $gte

// find contacts with any age
> db.addressBook.find({age: {$exists: true}})

// find entries matching a regular expression
> db.addressBook.find( {lastname: /^smi*/i} ) )

// count entries with “John”
> db.addressBook.find( {firstname: 'John'} ).count()
```

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Updates

```
// Update operators
// $set, $unset, $inc, $push, $pushAll, $pull,
// $pullAll, $bit

> var new_phonenumber = {
  type: "mobile",
  number: "646-555-4567"
}

> db.addressBook.update({ _id: "..." }, {
  $push: {phonenumbers: new_phonenumber}
});
```

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Nested Documents

```
{
  _id: ObjectId("4c4ba5c0672c685e5e8aabf3"),
  firstname: "John", lastname: "Smith",
  age: 25,
  address: {
    street: "21 2nd Street", city: "New York",
    state: "NY", zipcode: 10021
  }
  phonenumbers : [ {
    type: "mobile", number: "646-555-4567"
  } ]
}
```

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Secondary Indexes

```
// Index nested documents
> db.addressBook.ensureIndex({"phonenumbers.type":1})

// Geospatial indexes, 2d or 2dsphere
> db.addressBook.ensureIndex({location: "2d"})
> db.addressBook.find({location: {$near: [22,42]}})

// Unique and Sparse indexes
> db.addressBook.ensureIndex({field:1}, {unique:true})
> db.addressBook.ensureIndex({field:1}, {sparse:true})
```

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Additional Features

- Geospatial queries
 - Simple 2D plane
 - Or accounting for the surface of the earth (ellipsoid)
- Full Text Search
- Aggregation Framework
 - Similar to SQL GROUP BY operator
- Javascript MapReduce
 - Complex aggregation tasks

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Mongo Example II

Another Sample Document

```
d={  
    _id : ObjectId("4c4ba5c0672c685e5e8aabf3"),  
    author : "Kevin",  
    date : new Date("February 2, 2012"),  
    text : "About MongoDB...",  
    birthyear: 1980,  
    tags : [ "tech", "databases" ]  
}
```

```
> db.posts.insert(d)
```

Find

- db.posts.find()
 - returns entire collection in posts
- db.posts.find({ “author” : “Kevin” , “birthyear” : 1980})

```
{  
    _id : ObjectId("4c4ba5c0672c685e5e8aabf3"),  
    author : "Kevin",  
    date : Date("February 2, 2012"),  
    birthyear: 1980,  
    text : "About MongoDB...",  
    tags : [ "tech", "databases" ]  
}
```

9

Specifying Which Keys to Return

- db.mydoc.find({}, { “name” , “contribs” })

```
{  
    _id: 1,  
    name: { first:“John”, last:“Backus” },  
    contribs: [ “Fortran”, “ALGOL”, “Backus-Naur Form”, “FP” ]  
}
```
- db.mydoc.find({}, { “_id” :0, “name” :1})

```
{  
    name: { first:“John”, last:“Backus” }  
}
```

9

Ranges, Negation, OR-clauses

- Comparison operators: \$lt, \$lte, \$gt, \$gte
 - db.posts.find({ “birthyear” :{ “\$gte” :1970, “\$lte” :1990}})
- Negation: \$ne
 - db.posts.find({ “birthyear” :{ “\$ne” :1982}})
- Or queries: \$in (single key), \$or (different keys)
 - db.posts.find({ “birthyear” :{ “\$in” :[1982,1985]}})
 - db.posts.find({ “\$or” :[{ “birthyear” :1982},{ “name” :“John” }]}))

9

Arrays

- db.posts.find({ “tags” : “tech” })
 - Print complete information about posts which are tagged “tech”
- db.posts.find({ “tags” :{\$all:[“tech” , “databases”]},{ “author” :1, “tags” :1})
 - Print author and tags of posts which are tagged with both “tech” and “databases” (among other things)
 - Contrast this with:
 - db.posts.find({ “tags” :[“databases” , “tech”]})

9

Querying Embedded Documents

- db.people.find({ "name.first" : "John" })
 - Finds all people with first name John
- db.people.find({ "name.first" : "John" , "name.last" : "Smith" })
 - Finds all people with first name John and last name Smith.
 - Contrast with (order is now important):
 - db.people.find({ "name" :{ "first" : "John" , "last" : "Smith" }})

9

Limits, Skips, Sort, Count

- db.posts.find().limit(3)
 - Limits the number of results to 3
- db.posts.find().skip(3)
 - Skips the first three results and returns the rest
- db.posts.find().sort({ "author" :1, "title" :-1})
 - Sorts by author ascending (1) and title descending (-1)
- db.people.find(...).count()
 - Counts the number of documents in the people collection matching the find(...)

9

Revisiting Sample Document

```
mydoc = {  
    _id: 1,  
    name: { first: "John", last: "Backus" },  
    birthyear: 1924,  
    contribs: [ "Fortran", "ALGOL", "Backus-Naur Form", "FP" ],  
    awards: [ { award_id: "NMS001",  
                year: 1975 },  
              { award_id: "TA99",  
                year: 1977 } ]  
}  
> db.people.insert(mydoc)
```

97

Also assume...

```
award1=  
{  
    _id: "NMS001",  
    title: "National Medal of Science",  
    by: "National Science Foundation"  
}  
award2=  
{  
    _id: "TA99",  
    title: "Turing Award",  
    by: "ACM"  
}  
db.awards.insert(award1)  
db.awards.insert(award2)
```

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“SemiJoins”

- Suppose you want to print people who have won Turing Awards
 - Problem: object id of Turing Award is in collection “awards”, collection “people” references it.

```
turing= db.awards.findOne({title:"Turing Award"})
db.people.find({"awards.award_id": turing["_id"]})
```

9

Aggregation

- A framework to provide “group-by” and aggregate functionality without the overhead of map-reduce.
- Conceptually, documents from a collection pass through an aggregation pipeline, which transforms the objects as they pass through (similar to UNIX pipe “|”)
- Operators include: \$project, \$match, \$limit, \$skip, \$sort, \$unwind, \$group

[http://www.10gen.com/presentations/mongosv-2011/
mongodbs-new-aggregation-framework](http://www.10gen.com/presentations/mongosv-2011/mongodbs-new-aggregation-framework)

1

Unwind

- db.article.aggregate({ \$project :{ author :1,tags :1 }}, { \$unwind :"\$tags" })

```
{ "result": [ { "_id": ObjectId("4e6e4ef557b77501a49233f6"),  
    "author": "bob",  
    "tags": "fun" },  
    { "_id": ObjectId("4e6e4ef557b77501a49233f6"),  
    "author": "bob",  
    "tags": "good" },  
    { "_id": ObjectId("4e6e4ef557b77501a49233f6"),  
    "author": "bob",  
    "tags": "fun" } ],  
"OK": 1 }
```

1

\$group

- Every group expression must specify an _id field.
- For example, suppose you wanted to print the number of people born in each year

```
> db.people.aggregate( { $group :  
    { _id : "$birthyear", birthsPerYear : { $sum : 1 } } } )  
{ "result": [ { "_id": 1924, "count": 1 } ], "ok": 1 }
```

1

MongoDB Development

Open Source

- MongoDB source code is on Github
 - <https://github.com/mongodb/mongo>
- Issue tracking for MongoDB and drivers
 - <http://jira.mongodb.org>

Summary of MongoDB

- MongoDB is an example of a document-oriented NoSQL solution
- The query language is limited, and oriented around “collection” (relation) at a time processing
 - Joins are done via a query language
- The power of the solution lies in the distributed, parallel nature of query processing
 - Replication and sharding