MongoDB

High-Level Overview

- Name comes from “Hu**mongo**us” & huge data
- Written in C++, developed in 2009
- Creator: 10gen, former doublick

MongoDB: Goal

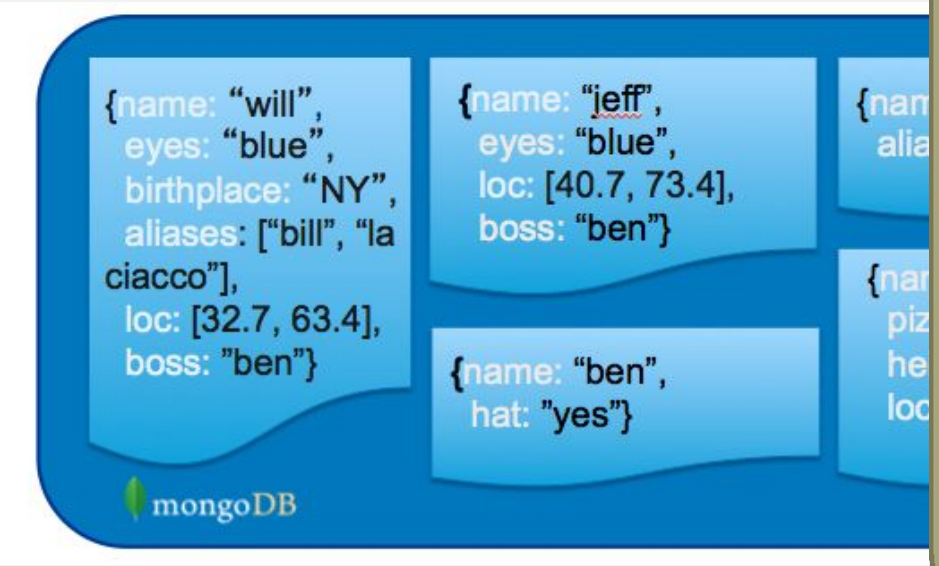
- **Goal:** bridge the gap between key-value stores (which are fast and scalable) and relational databases (which have rich functionality).

What is MongoDB?

- **Defination:** MongoDB is an **open source**, **document-oriented** database designed with both scalability and developer agility in mind.
- Instead of storing your data in tables and rows as you would with a relational database, in MongoDB you store **JSON-like documents** with **dynamic schemas (schema-free, schemaless)**.

What is MongoDB? (Cont'd)

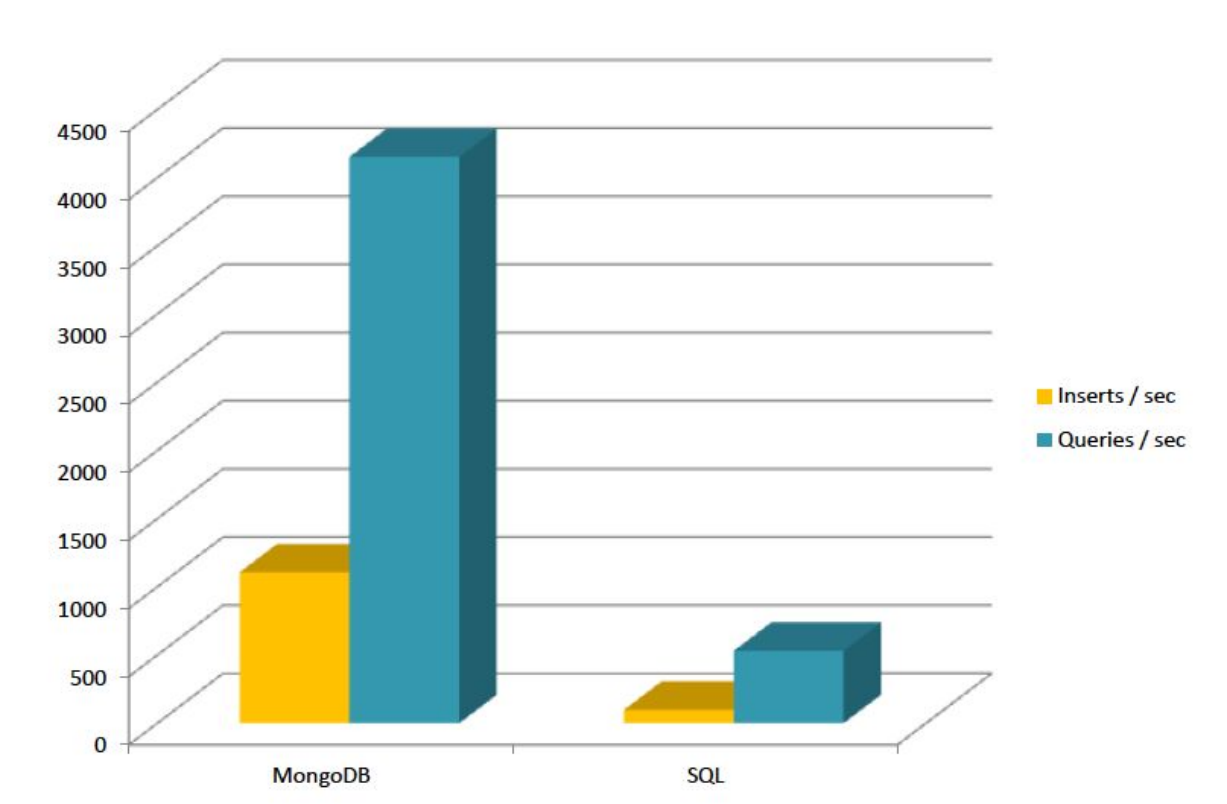
- **Document-Oriented DB**
  - Unit object is a document in
    in relational DBs




```
> db.user.findOne({age:39})
{
        "_id" : ObjectId("5114e0bd42…"),
        "first" : "John",
        "last" : "Doe",
        "age" : 39,
       "interests" : [
                "Reading",
                "Mountain Biking ]
       "favorites": {
                "color": "Blue",
                "sport": "Soccer"}
}
```

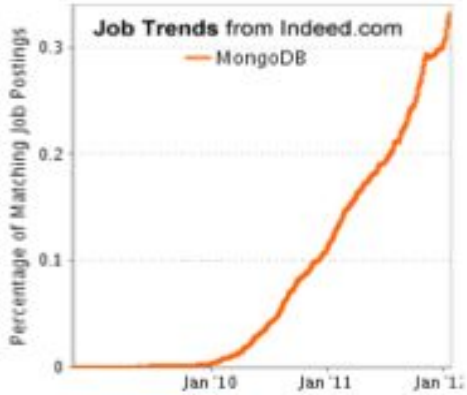
Is It Fast?

- For semi-structured & complex relationships: Yes



It is Growing Fast

#2 ON INDEED'S FASTEST GROWING JOBS



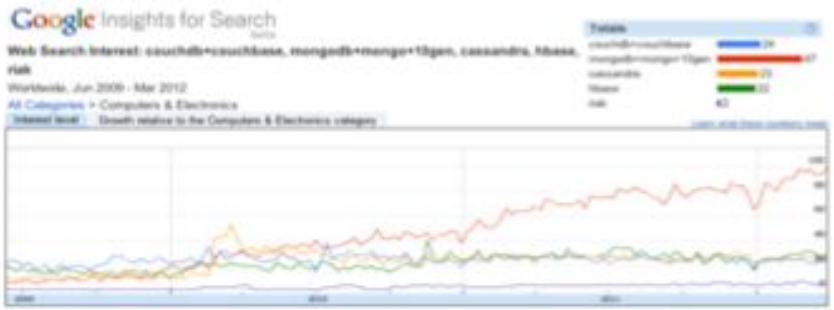
Top Job Trends

1. HTML5
2. **MongoDB**
3. iOS
4. Android
5. Mobile app
6. Puppet
7. Hadoop
8. jQuery
9. PaaS
10. Social Media

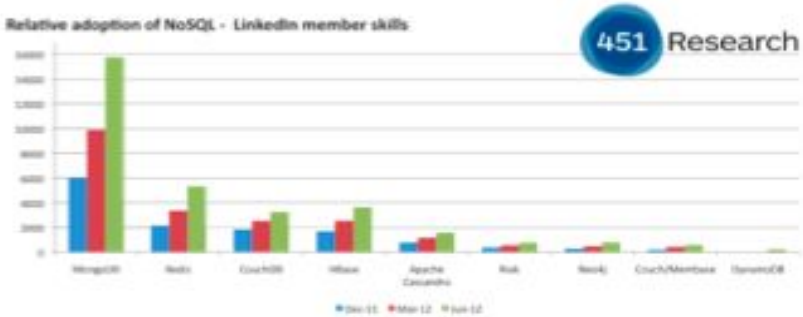
JASPERSOFT BIGDATA INDEX

Demand for MongoDB, the document-oriented NoSQL database, saw the biggest spike with over 200% growth in 2011.

GOOGLE SEARCHES



451 GROUP "MONGODB INCREASING ITS DOMINANCE"



Integration with Others

- C
- C++
- Erlang
- Haskell
- Java
- Javascript
- .NET (C# F#, PowerShe
- Node.js
- Perl
- PHP
- Python
- Ruby
- Scala

NoSQL DBs

NoSQL: Categories

- Key-value
- Graph database
- Document-oriented
- Column family

What is NoSQL

- Stands for **N**ot **O**nly **SQL**??
- Class of non-relational data storage systems
- Usually do not require a fixed table schema nor
  do they use the concept of joins
  - Distributed data storage systems
- All NoSQL offerings relax one or more of the ACID properties
  - will talk about the CAP theorem

Example of Column-Family (E.g., Hbase)

ColumnFamily: Rockets	
Key	Value

B has more
data model
ronger
g interface

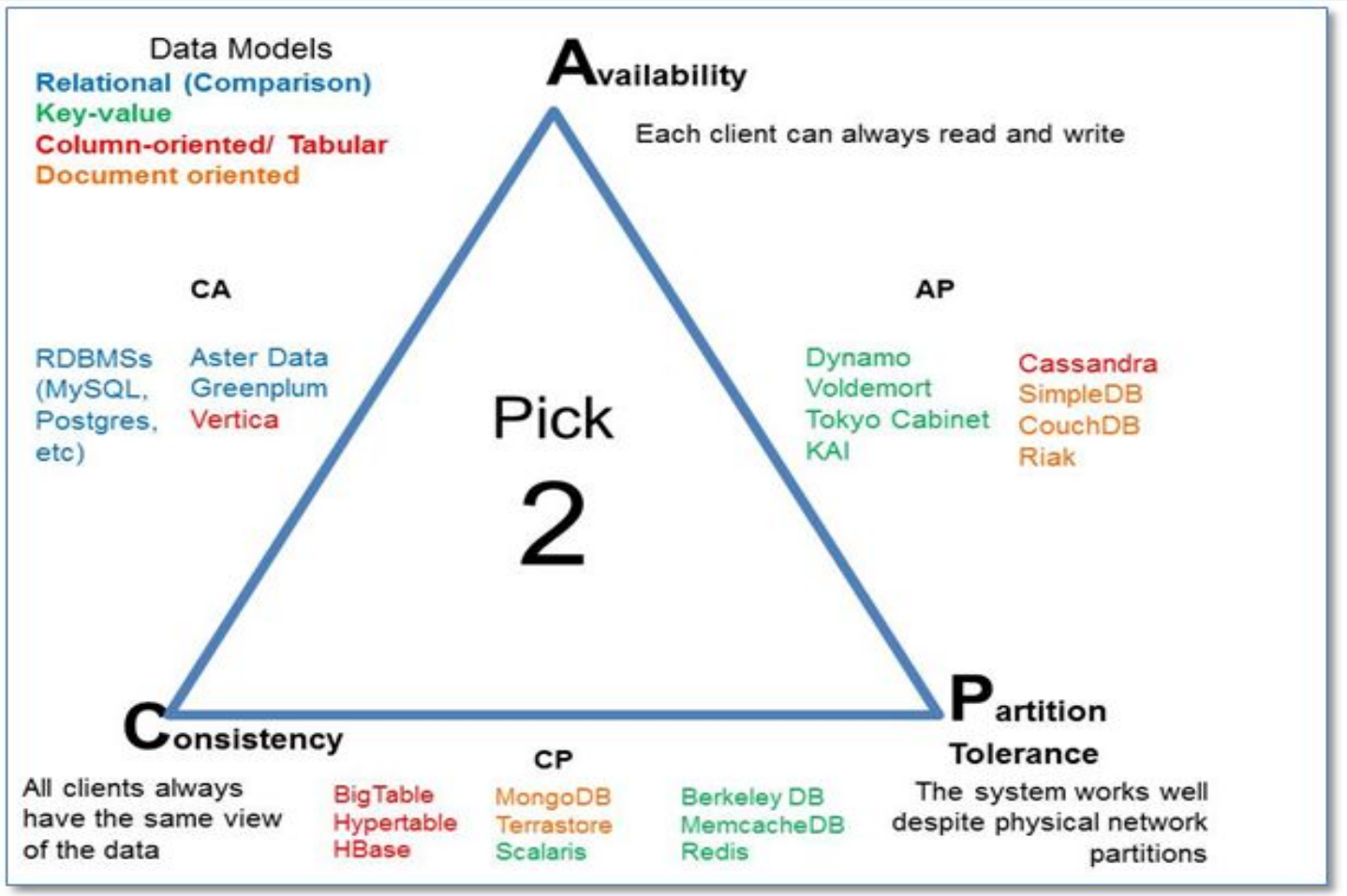
Typical APIs: get(key), put(key, value), delete(key), ...

CAP Theorem

- Three properties of a system
  - **Consistency** (all copies have same value)
  - **Availability** (system can run even if parts have failed)
    - All nodes can still accept reads and writes
  - **Partition Tolerance** (Even if part is down, others can take over)

- CAP "Theorem":
  - You can have at most two of these three properties for any system
  - Pick two !!!

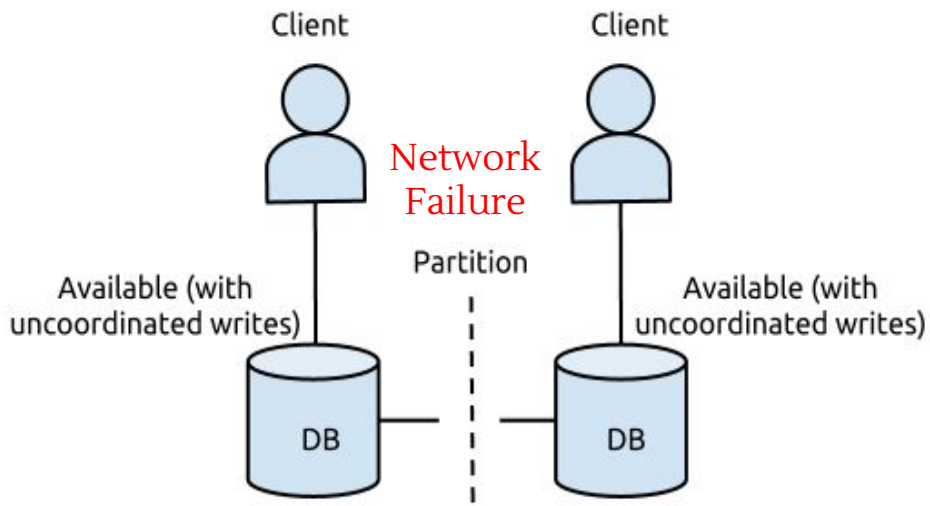
CAP Theorem


Data Models
Relational (Comparison)
Key-value
Column-oriented/ Tabular
Document oriented
Availability
Each client can always read and write
CA
RDBMSs (MySQL, Postgres, etc)
Aster Data
Greenplum
Vertica
Pick
2
AP
Dynamo
Voldemort
Tokyo Cabinet
KAI
Cassandra
SimpleDB
CouchDB
Riak
Consistency
All clients always have the same view of the data
Partition
Tolerance
The system works well despite physical network partitions
CP
BigTable
Hypertable
HBase
MongoDB
Terrastore
Scalaris
Berkeley DB
MemcacheDB
Redis

Example

In distributed systems, CA is not a choice

Either select AP or CP



Data divergence in an AP system during partition

- If select Availability Loose Consistency (AP Design)
- If select Consistency Loose Availability (CP Design)

Availability

- Traditionally, thought of as the server/process available five 9's (99.999 %).
  - Failures are rare
- In modern commodity distributed systems:
  - Want a system that is resilient in the face of network disruption
  - Use Replication

Eventual Consistency

- When no updates occur for a long period of time:
  - Eventually all updates will propagate through the system and all the nodes will be consistent
- For a given accepted update and a given node:
  - Eventually either the update reaches the node or the node is removed from service

Eventual Consistency

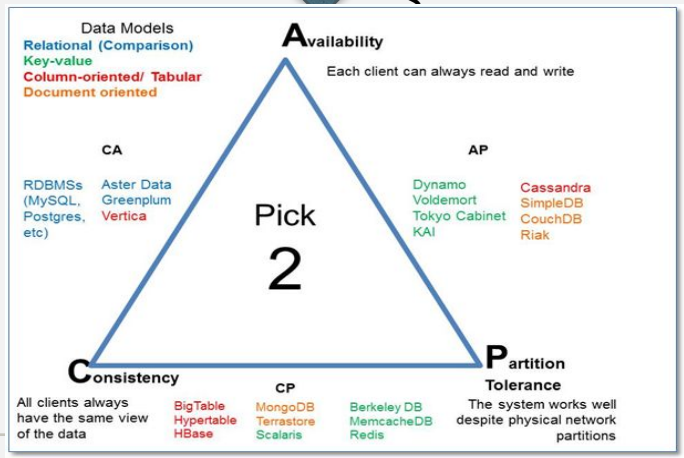
- ***BASE*** Concept
  - **B**asically **A**vailable, **S**oft state, **E**ventual consistency
    - As opposed to ACID in RDBMS
    - Soft state: copies of a data item may be inconsistent
    - Eventually Consistent – copies becomes consistent at some later time if there are no more updates to that data item

What does NoSQL Not Provide

- No built-in join
- No ACID transactions
- No SQL

ISA

Follows



Data Model

Data Model

- BSON format (binary JSON)
- Developers can easily map to modern object-oriented languages without a complicated ORM layer.
- lightweight, traversable, efficient

Terms Mapping (DB vs. MongoDB)

RDBMS	MongoDB
Database	Database
Table	Collection
Tuple/Row	Document
column	Field
Table Join	Embedded Documents
Primary Key	Primary Key (Default key _id provided by mongodb itself)
Database Server and Client	
Mysqld/Oracle	mongod
mysql/sqlplus	mongo

JSON

Field Name

Field Value

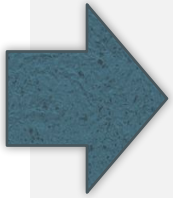
One document

```
{
  "firstName": "John",
  "lastName": "Smith",
  "isAlive": true,
  "age": 25,
  "height_cm": 167.6,
  "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"
    }
  ],
  "children": [],
  "spouse": null
}
```

- ***Field Value***
  - Scalar (Int, Boolean, String, Date, ...)
  - Document (Embedding or Nesting)
  - Array of JSON objects

Another Example

```
{ author: 'joe',
  created : new Date('03/28/2009'),
  title : 'Yet another blog post',
  text : 'Here is the text...',
  tags : [ 'example', 'joe' ],
  comments : [
              { author: 'jim',
                comment: 'I disagree'
              },
              { author: 'nancy',
                comment: 'Good post'
              }
  ]
}
```



Remember it is stored in binary formats (BSON)

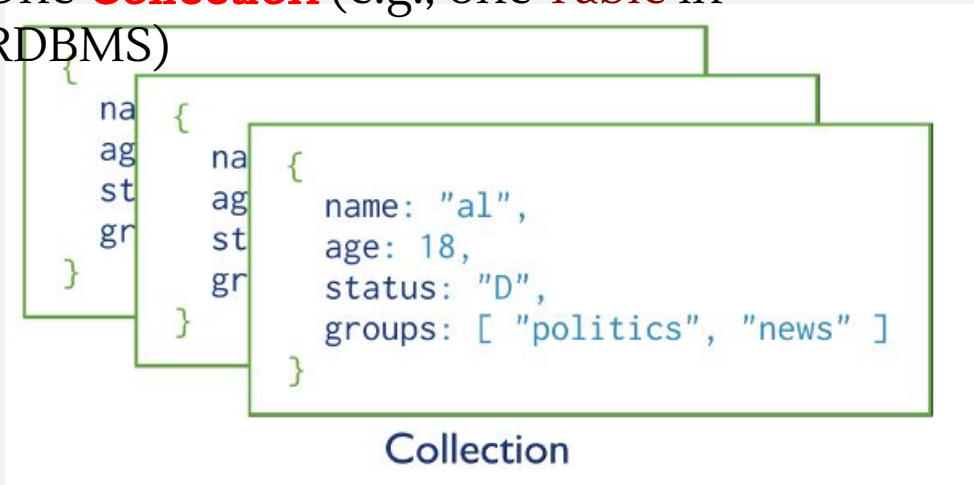
```
"\x16\x00\x00\x00\x02hello\x00
 \x06\x00\x00\x00world\x00\x00"

"1\x00\x00\x00\x04BSON\x00&\x00
 \x00\x00\x020\x00\x08\x00\x00
 \x00awesome\x00\x011\x00333333
 \x14@\x102\x00\xc2\x07\x00\x00
 \x00\x00"
```

MongoDB Model

One ***document*** (e.g., one tuple in RDBMS)

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

One ***Collection*** (e.g., one Table in RDBMS)



- **Collection** is a group of similar documents
- Within a collection, each document must have a unique Id

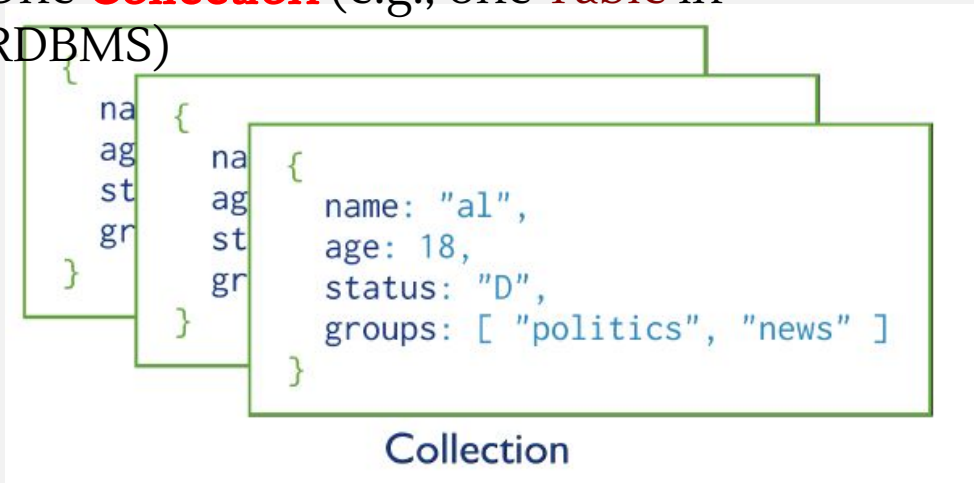
Unlike RDBMS:
No Integrity Constraints in MongoDB

MongoDB Model

One ***document*** (e.g., one tuple in RDBMS)

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

One ***Collection*** (e.g., one Table in RDBMS)



- The field names **cannot** start with the **$** character
- The field names **cannot** contain the **.** character
- Max size of single document 16MB

Example Document in MongoDB

```
{
  _id: ObjectId(7df78ad8902c)
  title: 'MongoDB Overview',
  description: 'MongoDB is no sql database',
  by: 'tutorials point',
  url: 'http://www.tutorialspoint.com',
  tags: ['mongodb', 'database', 'NoSQL'],
  likes: 100,
  comments: [
    {
      user:'user1',
      message: 'My first comment',
      dateCreated: new Date(2011,1,20,2,15),
      like: 0
    },
    {
      user:'user2',
      message: 'My second comments',
      dateCreated: new Date(2011,1,25,7,45),
      like: 5
    }
  ]
}
```

- _id is a special column in each document
- Unique within each collection
- _id Primary Key in RDBMS
- _id is 12 Bytes, you can set it yourself
- Or:
  - 1st 4 bytes timestamp
  - Next 3 bytes machine id
  - Next 2 bytes Process id
  - Last 3 bytes incremental values

No Defined Schema (Schema-free Or Schema-less)

- MongoDB does not need any defined data schema.
- Every document could have different data!

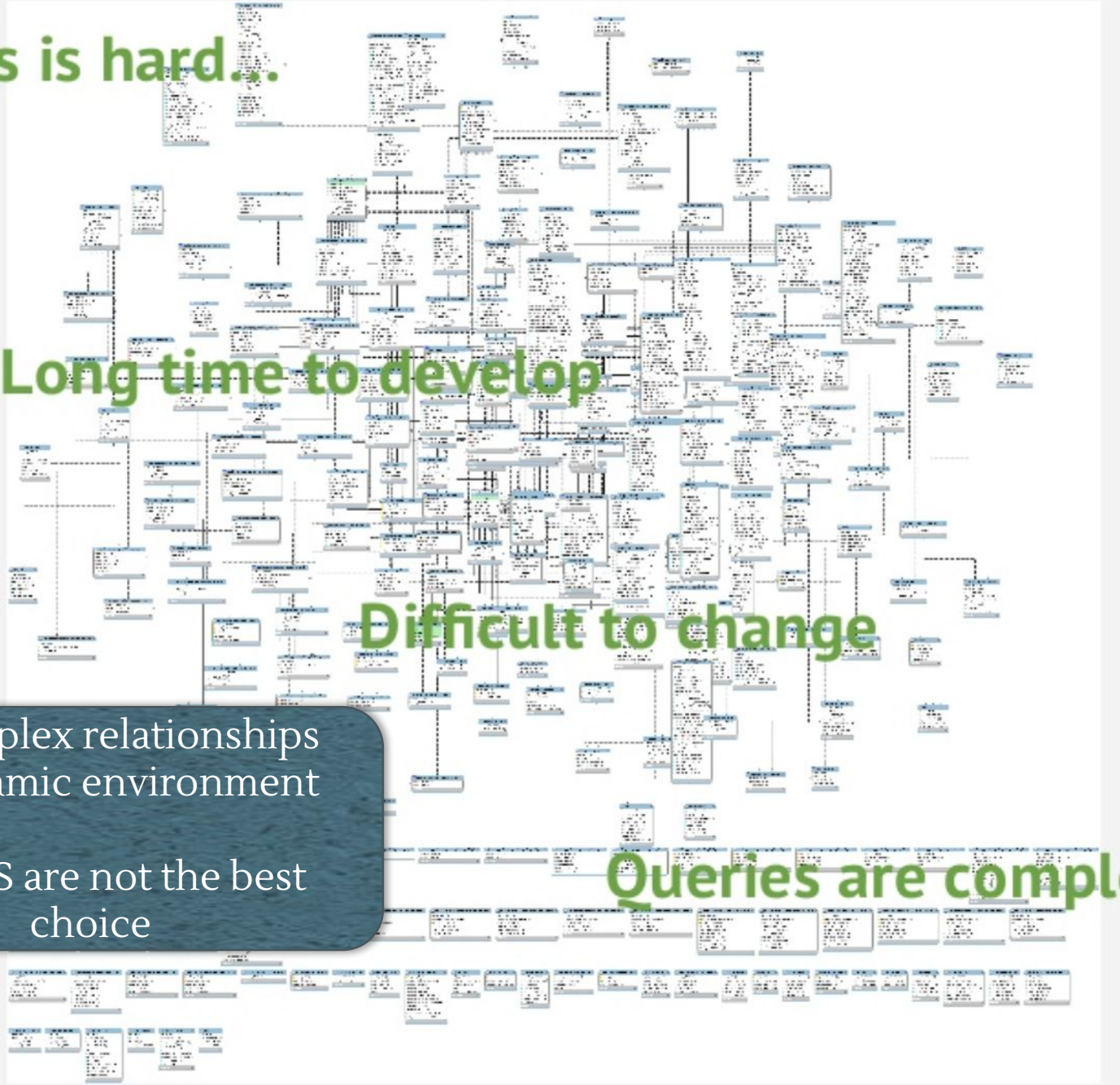
```
{name: "will",
 eyes: "blue",
 birthplace: "NY",
 aliases: ["bill", "la ciacco"],
 gender: "???",
 boss:"ben"}

{name: "jeff",
 eyes: "blue",
 height: 72,
 boss: "ben"}

{name: "brendan",
 aliases: ["el diablo"]}

{name: "ben",
 hat:"yes"}

{name: "matt",
 pizza: "DiGiorno",
 height: 72,
 boss: 555.555.1212}
```

mongoDB

Data Model Comparison

Relational DB vs. NoSQL

This is hard...



Long time to develop

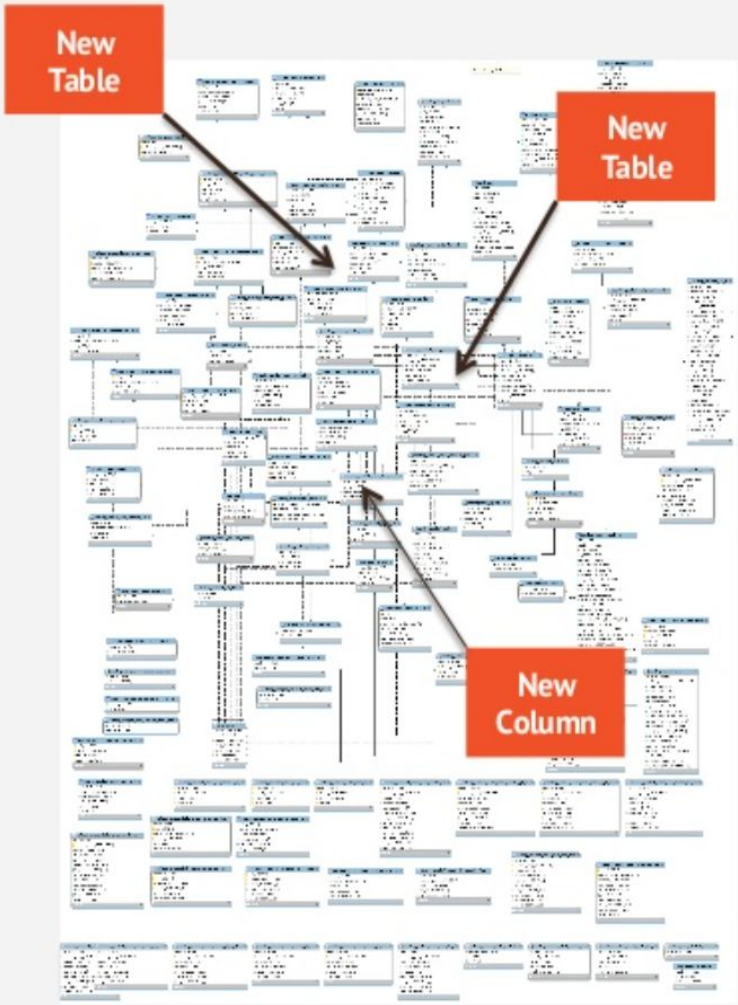
Difficult to change

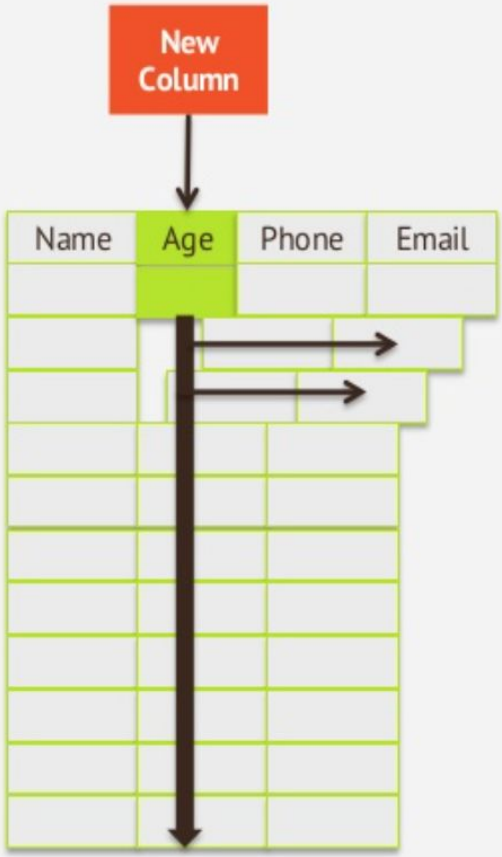
Queries are complex

- Complex relationships
- Dynamic environment

RDBMS are not the best choice

Hard to make changes

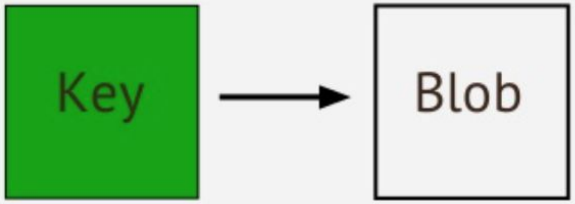




Key-Value Data Model

Key → Value store

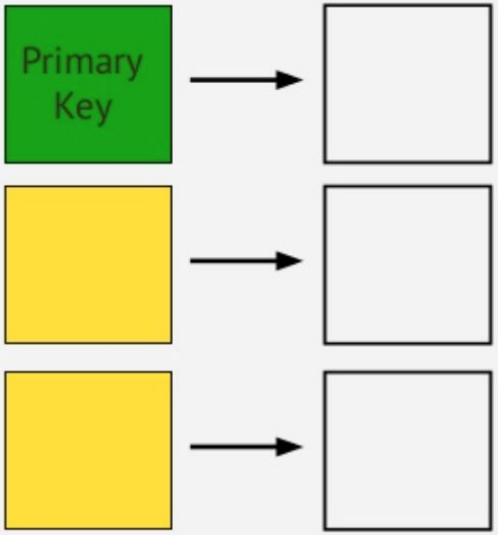
- One-dimensional storage
- Single value is a blob
- Query on key only
- No schema
- Value can be replaced but not updated



Relational Data Model

Relational Record

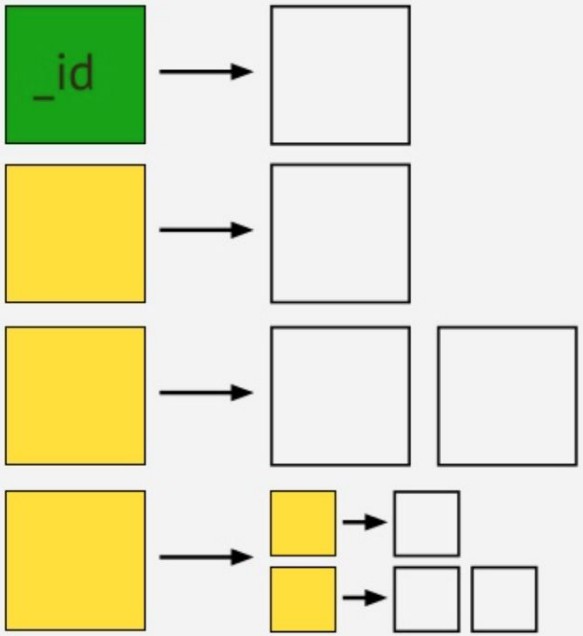
- Two-dimensional storage
- Field contains a single value
- Query on any field
- Very structured schema
- Poor data locality requires many tables, joins, and indexes.



Document Data Model

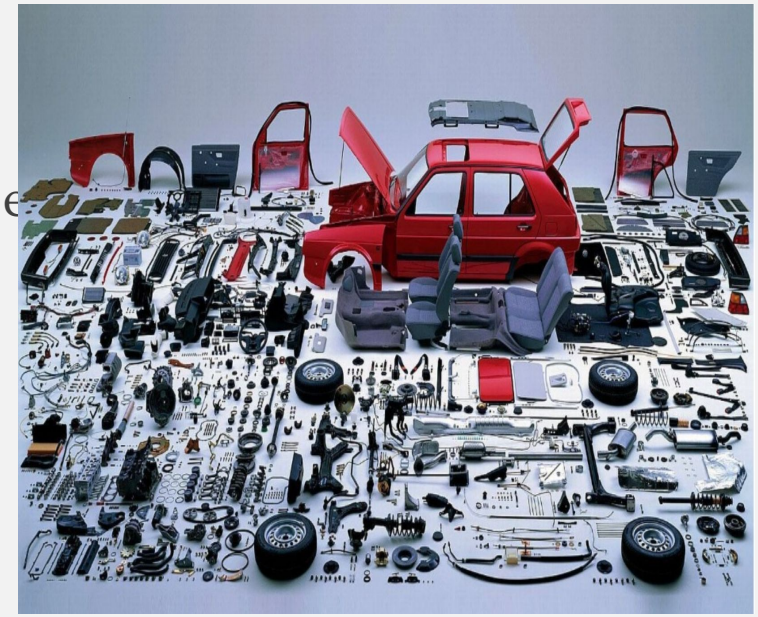
MongoDB Document

- **N-dimensional** storage
- Field can contain **many** values and **embedded** values
- Query on **any field & level**
- **Flexible** schema
- Optimal data locality requires fewer **indexes** and provides better **performance**

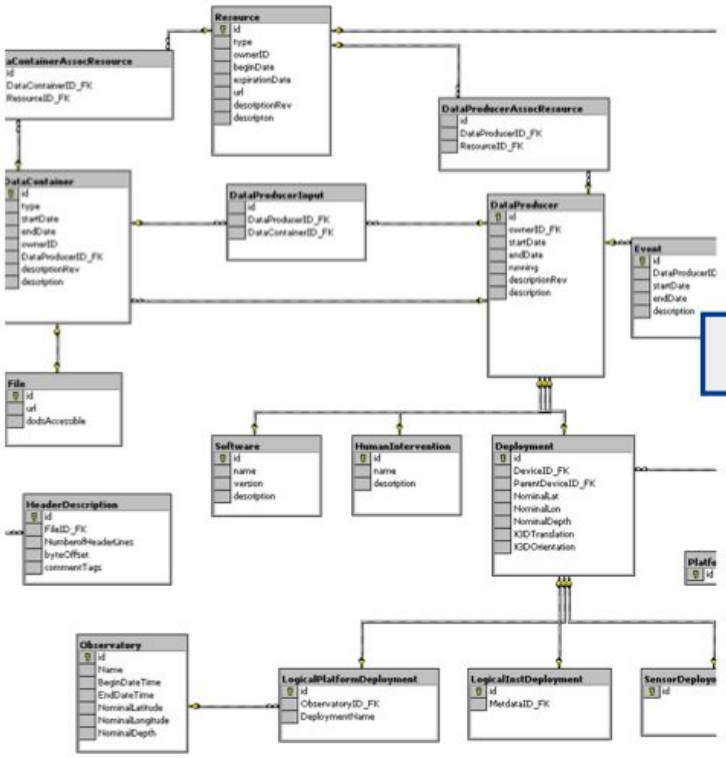


Document vs. Relational Models

- **Relational**
  - Focus on data storage
  - At query time build your business objects
- **Document**
  - Focus on data usage
  - Always maintain your business obje



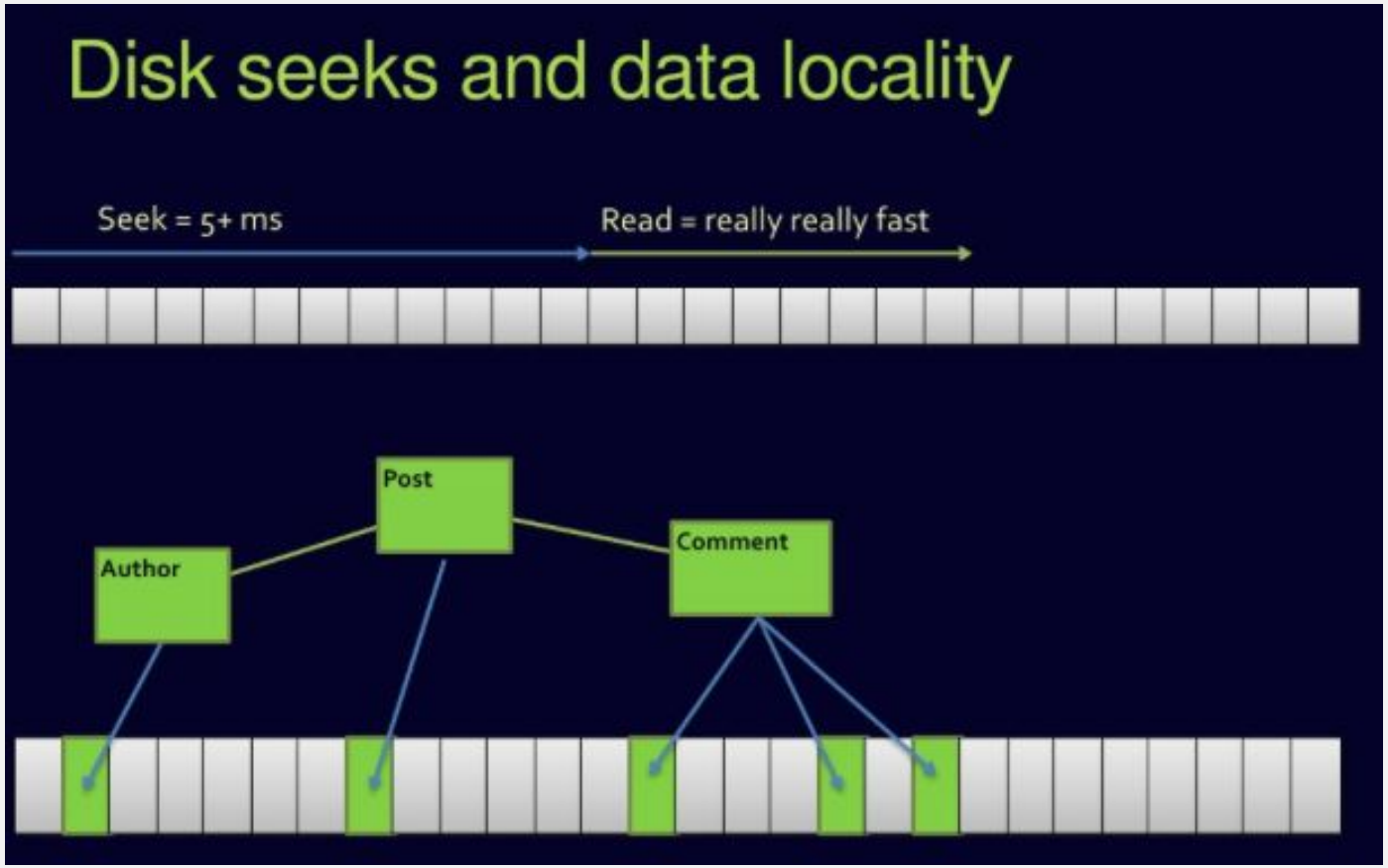
Tradeoff: Normalization vs. Easy Usage



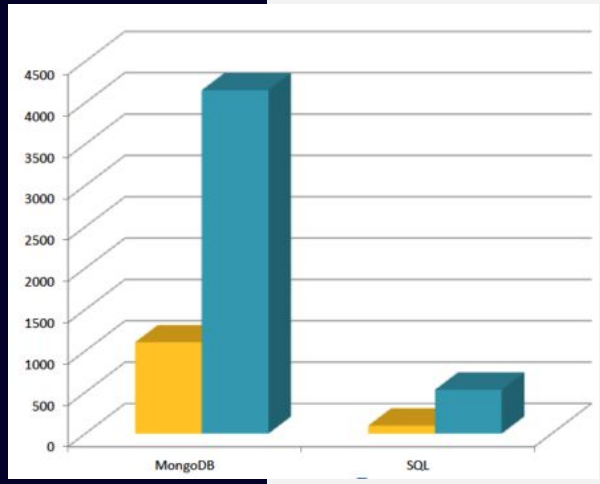

```
{
  title: 'MongoDB',
  contributors: [
    { name: 'Eliot Horowitz',
      email: 'eliot@10gen.com' },
    { name: 'Dwight Merriman',
      email: 'dwight@10gen.com' }
  ],
  model: {
    relational: false,
    awesome: true
  }
}
```

Complex Join Queries

Relational DBs



No Joins in MongoDB



Updates & Querying

Must Practice It

Install it

Practice simple stuff

Move to complex stuff

Install it from here:
http://www.mongodb.org
Manual: http://docs.mongodb.org/master/MongoDB-manual.pdf
(Focus on Ch. 3, 4 for now)

Dataset:
http://docs.mongodb.org/manual/reference/bios-example-collection/

CRUD

- **C**reate
  - db.collection.insert(<document>)
  - db.collection.save(<document>)
  - db.collection.update(<query>, <update>, { upsert: true })
- **R**ead
  - db.collection.find(<query>, <projection>)
  - db.collection.findOne(<query>, <projection>)
- **U**pdate
  - db.collection.update(<query>, <update>, <options>)
- **D**elete
  - db.collection.remove(<query>, <justOne>)

CRUD Examples

```
> db.user.insert({
        first: "John",
        last : "Doe",
        age: 39
})
```

```
> db.user.find ()
{
        "_id" : ObjectId("51…"),
        "first" : "John",
        "last" : "Doe",
        "age" : 39
}
```

```
> db.user.update(
        {"_id" : ObjectId("51…")},
        {
            $set: {
                age: 40,
                salary: 7000}
        }
)
```

```
> db.user.remove({
        "first": /^J/
})
```

Examples

In RDBMS

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

```
DROP TABLE users
```

In MongoDB

Either insert the 1st docuement

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

Or create "Users" collection explicitly

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

```
db.users.drop()
```

Insertion

Collection

Document

```
db.users.insert(
                {
                   name: "sue",
                    age: 26,
                 status: "A",
                 groups: [ "news", "sports" ]
                }
               )
```

Document

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

insert

Collection

{ name: "al", age: 18, ... }
{ name: "lee", age: 28, ... }
{ name: "jan", age: 21, ... }
{ name: "kai", age: 38, ... }
{ name: "sam", age: 18, ... }
{ name: "mel", age: 38, ... }
{ name: "ryan", age: 31, ... }
{ name: "sue", age: 26, ... }

users

- The collection “users” is created automatically if it does not exist

Multi-Document Insertion (Use of Arrays)

```
var mydocuments =
    [
      {
        item: "ABC2",
        details: { model: "14Q3", manufacturer: "M1 Corporation" },
        stock: [ { size: "M", qty: 50 } ],
        category: "clothing"
      },
      {
        item: "MNO2",
        details: { model: "14Q3", manufacturer: "ABC Company" },
        stock: [ { size: "S", qty: 5 }, { size: "M", qty: 5 }, { size: "L", qty: 1 } ],
        category: "clothing"
      },
      {
        item: "IJK2",
        details: { model: "14Q2", manufacturer: "M5 Corporation" },
        stock: [ { size: "S", qty: 5 }, { size: "L", qty: 1 } ],
        category: "houseware"
      }
    ];
```

```
db.inventory.insert( mydocuments );
```

All the documents are inserted at once

Multi-Document Insertion (Bulk Operation)

- A temporary object in memory
- Holds your insertions and uploads them at once

There is also *Bulk Ordered* object

```
var bulk = db.inventory.initializeUnorderedBulkOp();

bulk.insert(
    {
      item: "BE10",
      details: { model: "14Q2", manufacturer: "XYZ Company" },
      stock: [ { size: "L", qty: 5 } ],
      category: "clothing"
    }
);
bulk.insert(
    {
      item: "ZYT1",
      details: { model: "14Q1", manufacturer: "ABC Company"  },
      stock: [ { size: "S", qty: 5 }, { size: "M", qty: 5 } ],
      category: "houseware"
    }
);

bulk.execute();
```

_id column is added automatically

Deletion (Remove Operation)

- You can put condition on any field in the document (even _id)

```
db.users.remove(          ← collection
   { status: "D" }        ← remove criteria
)
```

The following diagram shows the same query in SQL:

```
DELETE FROM users         ← table
WHERE  status = 'D'       ← delete criteria
```

db.users.remove()

Removes all documents from *users* collection

Update

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

Otherwise, it will update only the 1st matching document

Equivalent to in SQL:

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

Update (Cont'd)

Two operators

```
db.inventory.update(
    { item: "MNO2" },
    {
      $set: {
        category: "apparel",
        details: { model: "14Q3", manufacturer: "XYZ Company" }
      },
      $currentDate: { lastModified: true }
    }
)
```

For the document with `item` equal to `"MNO2"`, use the `$set` operator to update the `category` field and the `details` field to the specified values and the `$currentDate` operator to update the field `lastModified` with the current date.

Replace a document

```
db.inventory.update(
   { item: "BE10" },
   {
     item: "BE05",
     stock: [ { size: "S", qty: 20 }, { size: "M", qty: 5 } ],
     category: "apparel"
   }
)
```

Query Condition

New doc

For the document having item = “BE10”, replace it with the given document

Insert or Replace

```
db.inventory.update(
    { item: "TBD1" },
    {
      item: "TBD1",
      details: { "model" : "14Q4", "manufacturer" : "ABC Company" },
      stock: [ { "size" : "S", "qty" : 25 } ],
      category: "houseware"
    },
    { upsert: true }
)
```

The ***upsert*** option

If the document having item = “TBD1” is in the DB, it will be replaced
Otherwise, it will be inserted.