

Your First MongoDB Application



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June 2018

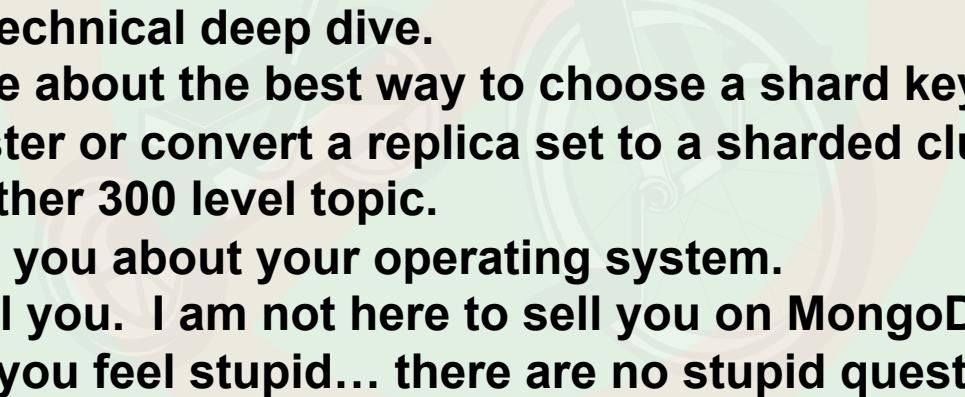
GOALS

We are here to:

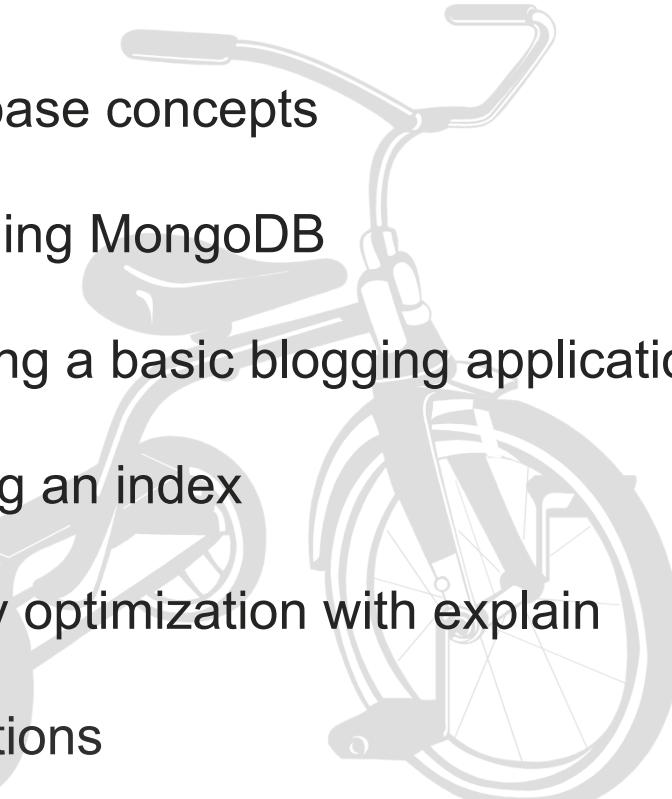
1. Introduce you to MongoDB and related concepts
2. Increase your understanding of MongoDB through exposure and exercise of the following activities
 - a. Install MongoDB
 - b. Create a Database, Collection, Document
 - c. Read from a Database, Collection, Document
 - d. Update a Document
 - e. Delete a Document



We are not here to:

- 
1. Do a technical deep dive.
 2. Debate about the best way to choose a shard key, deploy a cluster or convert a replica set to a sharded cluster or any other 300 level topic.
 3. Teach you about your operating system.
 4. To sell you. I am not here to sell you on MongoDB.
 5. Make you feel stupid... there are no stupid questions.

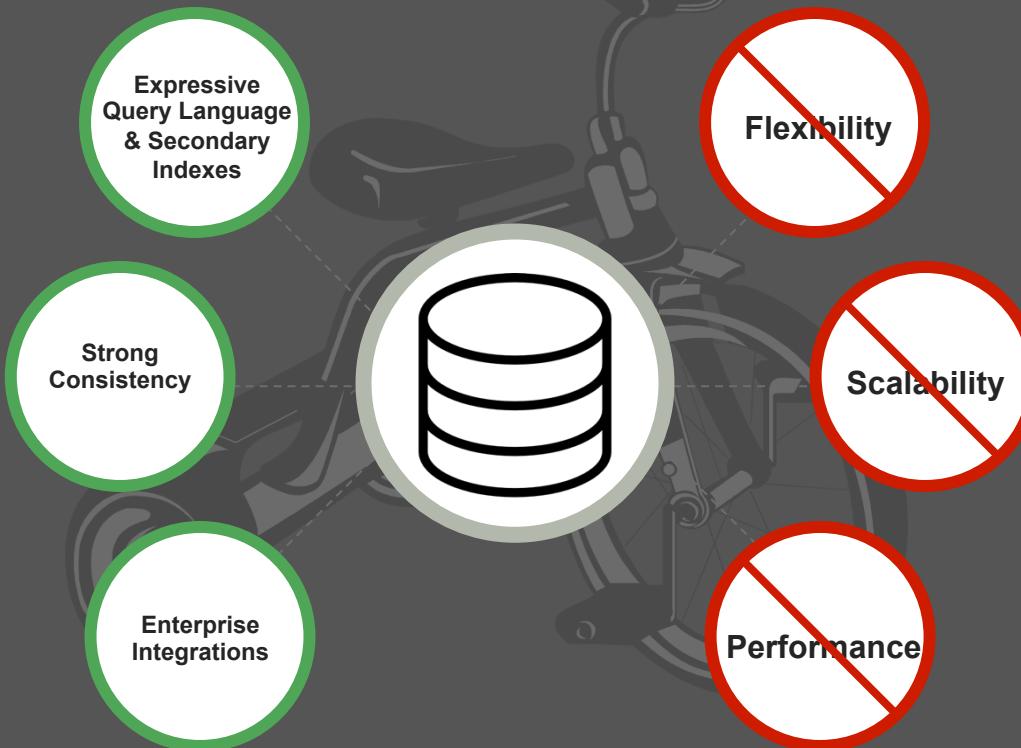
AGENDA

- 
- 1 Database concepts
 - 2 Installing MongoDB
 - 3 Building a basic blogging application
 - 4 Adding an index
 - 5 Query optimization with explain
 - 6 Questions

Summary of Database Concepts

- Why NoSQL exists
- The types of NoSQL database
- The key features of MongoDB
- Data durability in MongoDB – Replica Sets
- Scalability in MongoDB - Sharding

Relational



The World Has Changed

Data

- Volume
- Velocity
- Variety

Time

- Iterative
- Agile
- Short Cycles

Risk

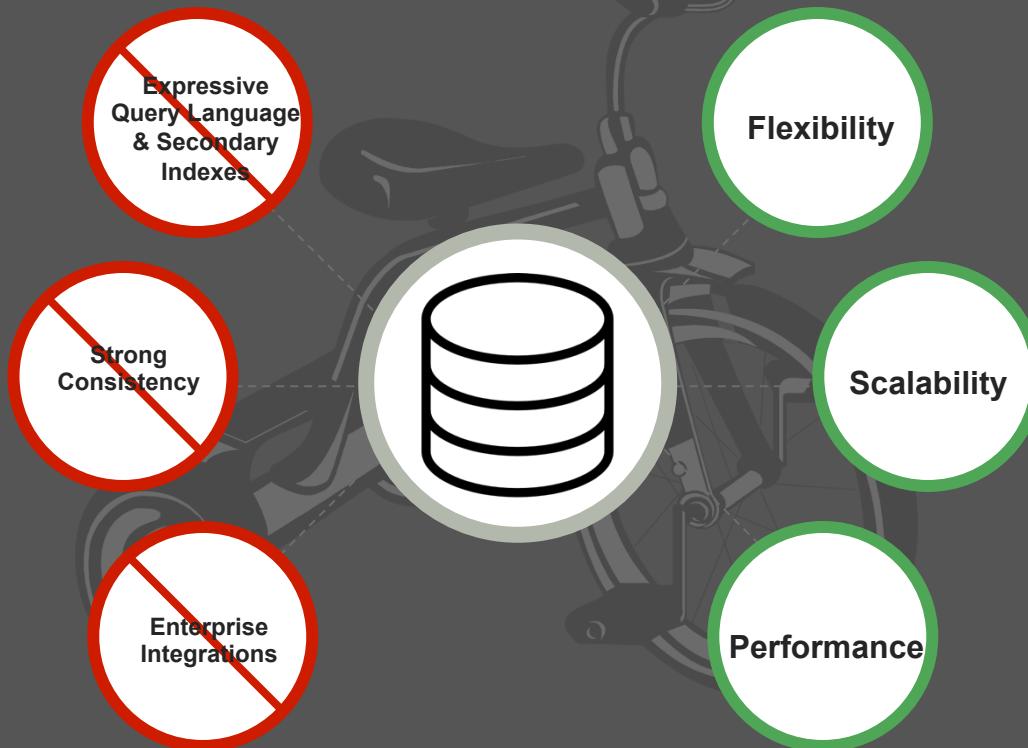
- Always On
- Scale
- Global

Cost

- Open-Source
- Cloud
- Commodity



NoSQL



Nexus Architecture

Relational

Relational + NoSQL

NoSQL

Expressive
Query Language
& Secondary
Indexes

Strong
Consistency

Enterprise
Integrations

Flexibility

Scalability

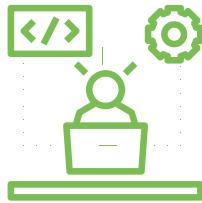
Performance





Why MongoDB?

Intelligent Operational Data Platform



**Best way to
work with data**



**Intelligently put data
where you need it**



**Freedom
to run anywhere**

Atlas

unlocks **agility**
and **reduces**
cost



Self-service and
elastic



Global and highly
available



Secure by default



Comprehensive
monitoring



Managed backup



Cloud agnostic

Concepts

Relational	MongoDB
Database	Database
Table	Collection
Row	Document
Index	Index
Join	Lookup
Foreign Key	Reference
Multi-table transaction	Single document transaction

Document Store

```
{  
  name: "Michael Lynn",  
  title: "Sr. Solutions Architect",  
  address: {  
    address1: "1601 Market Street",  
    address2: "19th Floor",  
    city: "Philadelphia",  
    state: "PA",  
    zipcode: "19123"  
  },  
  expertise: [ "MongoDB", "Python", "Javascript" ],  
  employee_number: 798,  
  location: {  
    type: "point",  
    coords: [ 39.953097, -75.167352]  
  }  
}
```

Document Store

{

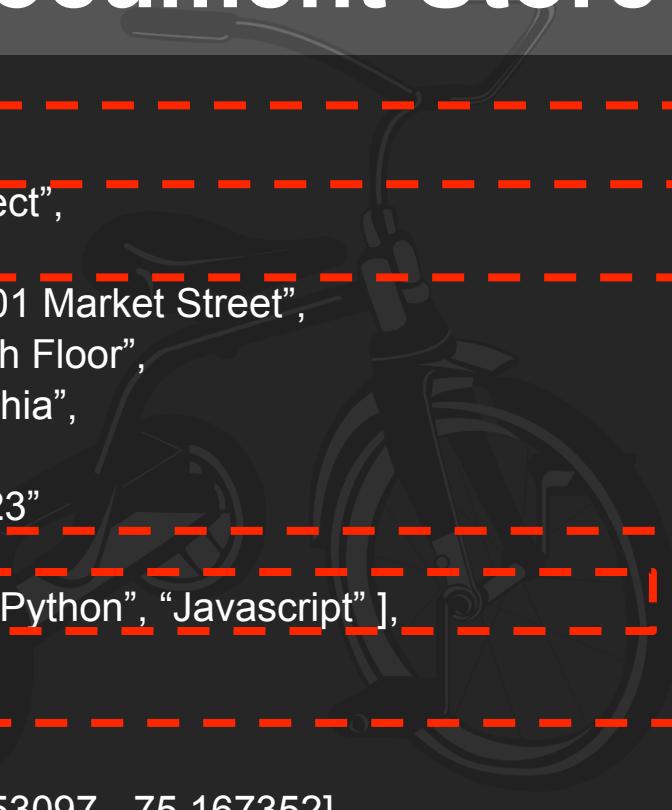
```
  name: "Michael Lynn",
  title: "Sr. Solutions Architect",
  address: {
    address1: "1601 Market Street",
    address2: "10th Floor",
    city: "Philadelphia",
    state: "PA",
    zipcode: "19103"
  },
  expertise: ["MongoDB", "Python", "Java Script"],
  employee_number: 798,
  location: {
    type: "point",
    coords: [ 39.953097, -75.167352]
  }
}
```

```
{
  name: "Joe Drumgoole",
  title: "Director of Developer Advocacy",
  address: {
    address1: "Latin Hall",
    address2: "Golden Lane",
    city: "London",
    state: "UK",
    zipcode: "E1 623"
  },
  expertise: ["MongoDB", "Python", "Javascript"],
  employee_number: 320,
  location: {
    type: "point",
    coords: [ 53.34, -6.26 ]
  }
}
```

POLYMORPHISM

Document Store

```
{  
  name: "Michael Lynn",  
  title: "Sr. Solutions Architect",  
  address: {  
    address1: "1601 Market Street",  
    address2: "19th Floor",  
    city: "Philadelphia",  
    state: "PA",  
    zipcode: "19123"  
  },  
  expertise: [ "MongoDB", "Python", "Javascript" ],  
  employee_number: 798,  
  location: {  
    type: "point",  
    coords: [ 39.953097, -75.167352]  
  }  
}
```



Strings

Nested Document

Array

Geo Location

Installing MongoDB

Download the binaries from the [MongoDB Download Center](#).

You can also download directly from the command line:

```
curl -O https://fastdl.mongodb.org/osx/mongodb-osx-x86_64-3.6.5.tgz
```

Once you have the archive downloaded, extract it:

```
tar -zxvf mongodb-osx-x86_64-3.6.5.tgz
```

Copy the extracted folder to the location from which MongoDB will run.

```
mkdir -p mongodb
```

```
cp -R -n mongodb-osx-x86_64-3.6.5/ mongodb
```

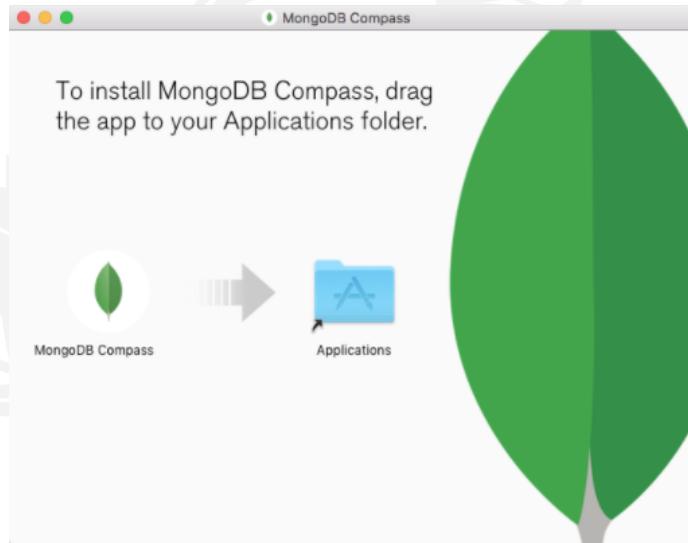
The MongoDB binaries are in the bin/ directory of the archive. To ensure that the binaries are in your PATH, you can modify your PATH.

For example, you can add the following line to your shell's rc file (e.g. ~/.bashrc):

```
export PATH=<mongodb-install-directory>/bin:$PATH
```

Download the binaries from the [MongoDB Download Center](#).

<https://docs.mongodb.com/compass/master/install/>



Compass

MongoDB Compass Dev - signin.phillymug.org:27017 STANDALONE MongoDB 3.4.9 Community

My Cluster

3 DBS 2 COLLECTIONS

filter

DATABASES PERFORMANCE CREATE DATABASE

Database Name	Storage Size	Collections	Indexes
admin	16.0KB	0	2
local	16.0KB	1	1
phillymug	36.0KB	1	1

A screenshot of the MongoDB Compass Dev interface. The title bar shows "MongoDB Compass Dev - signin.phillymug.org:27017" and "STANDALONE". The top navigation bar includes "Databases" (selected), "Performance", and a "CREATE DATABASE" button. On the left, a sidebar titled "My Cluster" shows "3 DBS" and "2 COLLECTIONS". A search bar is labeled "filter". The main content area displays a table of databases with columns: Database Name, Storage Size, Collections, and Indexes. Three databases are listed: "admin" (16.0KB, 0 collections, 2 indexes), "local" (16.0KB, 1 collection, 1 index), and "phillymug" (36.0KB, 1 collection, 1 index). Each database row has a delete icon in the last column.

Running Mongod

Michaels-MBP-3:~ mlynn\$ mongod --dbpath /data/phillymug

```
2017-10-08T13:11:31.050-0400 I CONTROL [initandlisten] MongoDB starting : pid=64082 port=27017 dbpath=/data/phillymug 64-bit host=Michaels-MBP-3.fios-router.home
2017-10-08T13:11:31.051-0400 I CONTROL [initandlisten] db version v3.4.9
2017-10-08T13:11:31.051-0400 I CONTROL [initandlisten] git version: 876ebee8c7dd0e2d992f36a848ff4dc50ee6603e
2017-10-08T13:11:31.051-0400 I CONTROL [initandlisten] OpenSSL version: OpenSSL 0.9.8zh 14 Jan 2016
2017-10-08T13:11:31.051-0400 I CONTROL [initandlisten] allocator: system
2017-10-08T13:11:31.051-0400 I CONTROL [initandlisten] modules: enterprise
2017-10-08T13:11:31.051-0400 I CONTROL [initandlisten] build environment:
2017-10-08T13:11:31.051-0400 I CONTROL [initandlisten]   distarch: x86_64
2017-10-08T13:11:31.051-0400 I CONTROL [initandlisten]   target_arch: x86_64
2017-10-08T13:11:31.051-0400 I CONTROL [initandlisten] options: { storage: { dbPath: "/data/phillymug" } }
2017-10-08T13:11:31.051-0400 I STORAGE [initandlisten] wiredtiger_open config:
create,cache_size=7680M,session_max=20000,eviction=(threads_min=4,threads_max=4),config_base=false,statistics=(fast),log=(enabled=true,archive=true,path=journal,compressor=snappy),file_manager=(close_idle_time=100000),checkpoint=(wait=60,log_size=2GB),statistics_log=(wait=0),
2017-10-08T13:11:31.811-0400 I CONTROL [initandlisten]
2017-10-08T13:11:31.811-0400 I CONTROL [initandlisten] ** WARNING: Access control is not enabled for the database.
2017-10-08T13:11:31.811-0400 I CONTROL [initandlisten] **          Read and write access to data and configuration is unrestricted.
2017-10-08T13:11:31.811-0400 I CONTROL [initandlisten]
2017-10-08T13:11:31.970-0400 I FTDC [initandlisten] Initializing full-time diagnostic data capture with directory '/data/phillymug/diagnostic.data'
2017-10-08T13:11:32.294-0400 I INDEX [initandlisten] build index on: admin.system.version properties: { v: 2, key: { version: 1 }, name: "incompatible_with_version_32", ns: "admin.system.version" }
2017-10-08T13:11:32.294-0400 I INDEX [initandlisten]   building index using bulk method; build may temporarily use up to 500 megabytes of RAM
2017-10-08T13:11:32.306-0400 I INDEX [initandlisten] build index done. scanned 0 total records. 0 secs
2017-10-08T13:11:32.306-0400 I COMMAND [initandlisten] setting featureCompatibilityVersion to 3.4
2017-10-08T13:11:32.307-0400 I NETWORK [thread1] waiting for connections on port 27017
2017-10-08T13:11:32.644-0400 I NETWORK [thread1] connection accepted from 127.0.0.1:60241 #1 (1 connection now open)
```

Connecting Via The Shell

```
Michaels-MBP-3:phillymug-october-2017 mlynn$ mongo
```

```
MongoDB shell version v3.4.9
```

```
connecting to: mongodb://127.0.0.1:27017
```

```
MongoDB server version: 3.4.9
```

```
Server has startup warnings:
```

```
2017-10-08T13:12:42.791-0400 I CONTROL [initandlisten]
```

```
2017-10-08T13:12:42.791-0400 I CONTROL [initandlisten] ** WARNING: Access control is not enabled for the database.
```

```
2017-10-08T13:12:42.791-0400 I CONTROL [initandlisten] ** configuration is unrestricted.
```

```
2017-10-08T13:12:42.791-0400 I CONTROL [initandlisten]
```

```
2017-10-08T13:12:59.746-0400 E QUERY [thread1] uncaught exception: don't know how to show [automationNotices]
```

Read and write access to data and

Inserting your first record

```
> show databases
local 0.000GB
> use test
switched to db test
> show databases
local 0.000GB
> db.demo.insert( { "key" : "value" } )
WriteResult({ "nInserted" : 1 })
> show databases
local 0.000GB
test 0.000GB
> show collections
demo
> db.demo.findOne()
{ "_id" : ObjectId("573af7085ee4be80385332a6"), "key" : "value" }
>
```

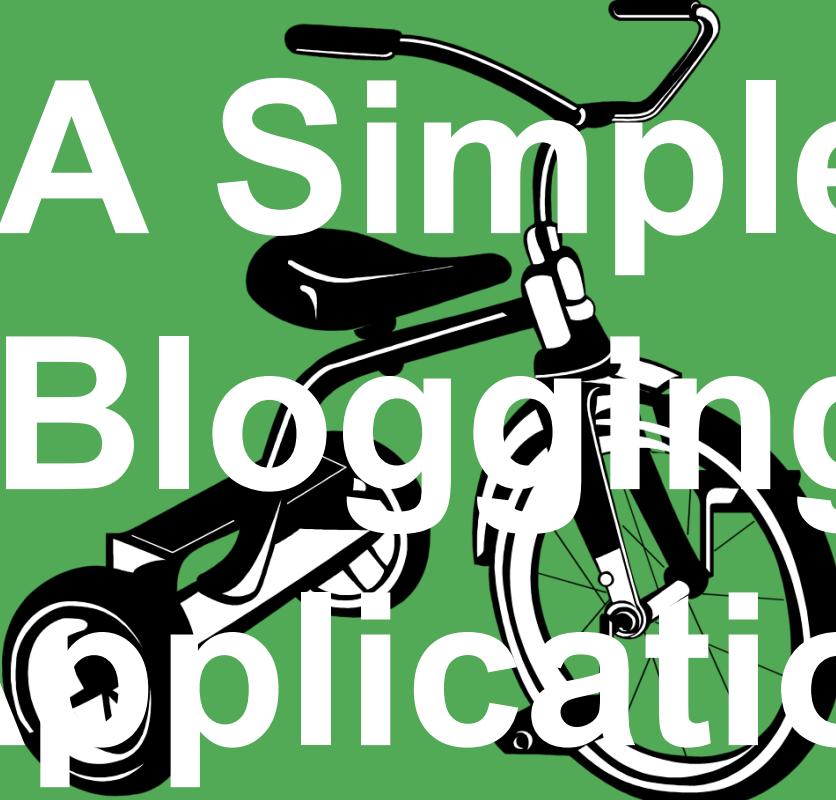


Object ID

573af7085ee4be80385332a6

TS-----ID----PID-Count-

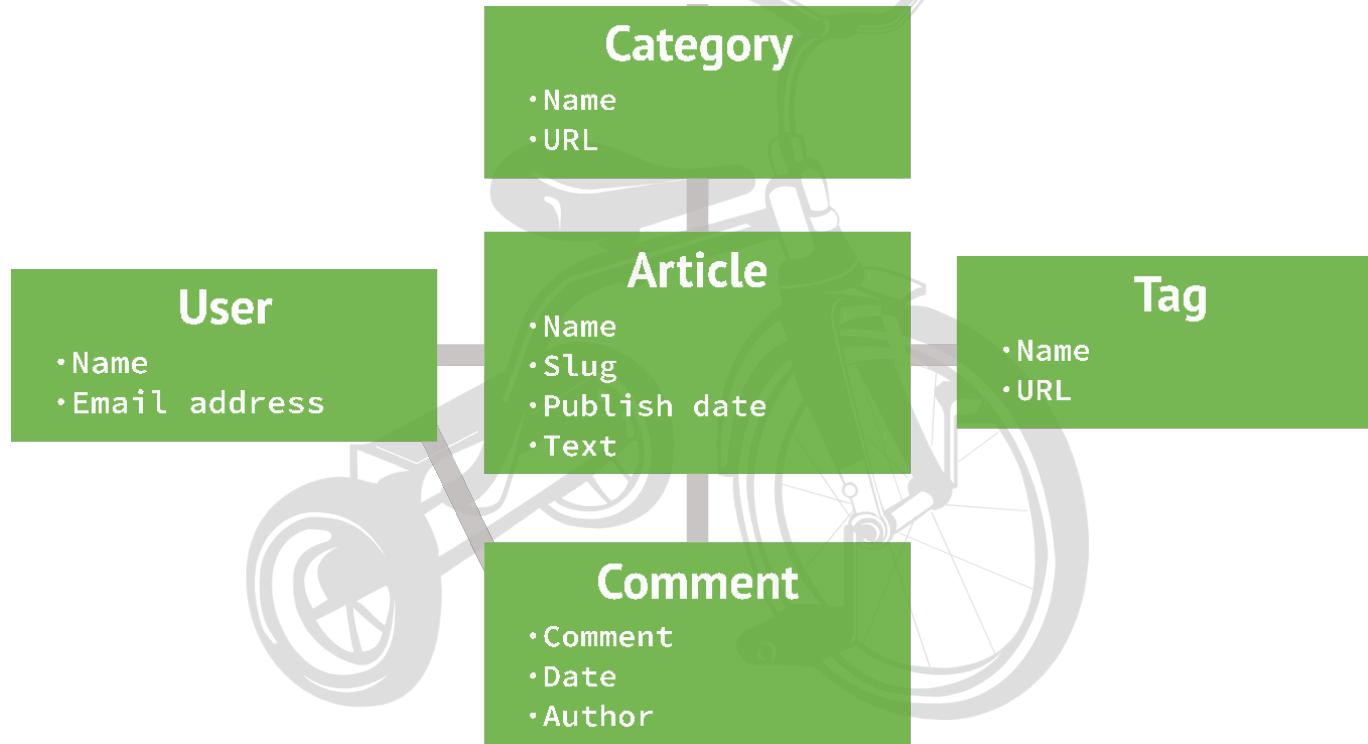
A Simple Blogging Application



A Simple Blog Application

- Lets create a blogging application with:
 - Articles
 - Users
 - Comments

Typical Entity Relation Diagram



In MongoDB we can build organically

```
test> use blog
switched to db blog

blog> db.users.insert( { "username" : "mlynn", "password" : "no peeking", "lang" : "EN" } )

Inserted 1 record(s) in 2ms

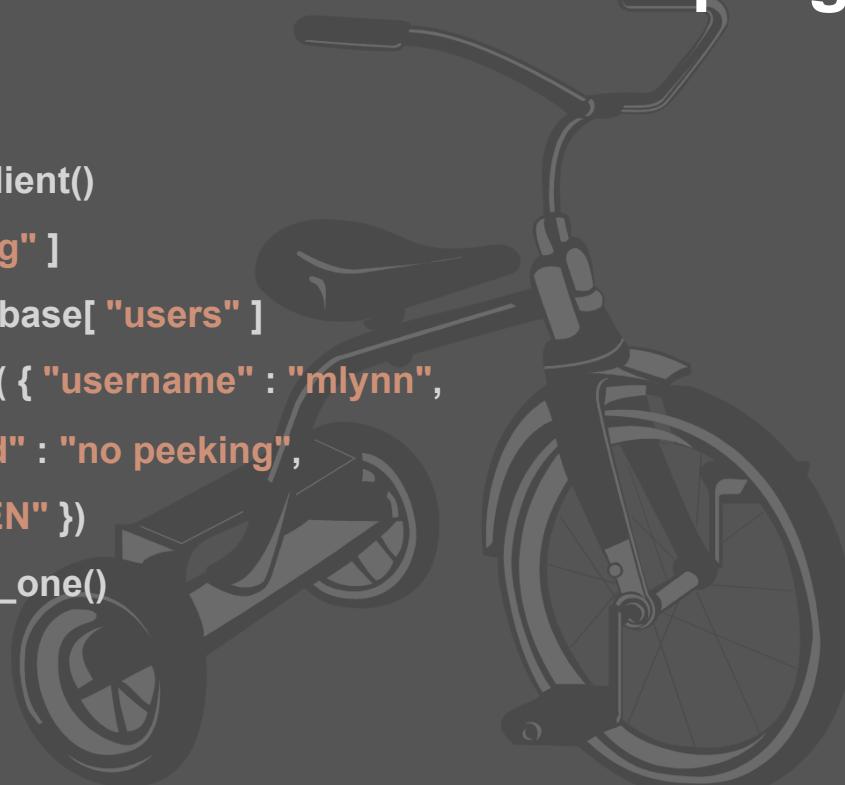
WriteResult({
  "nInserted": 1
})

blog> db.users.findOne({'username': 'mlynn'})
{
  "_id": ObjectId("59da3361491e1ce463e18564"),
  "username": "mlynn",
  "lang": "EN",
  "password": "no peeking"
}
```



How do we do this in a program?

```
import pymongo  
  
client = pymongo.MongoClient()  
  
blogDatabase = client[ "blog" ]  
  
usersCollection = blogDatabase[ "users" ]  
  
usersCollection.insert_one( { "username" : "mlynn",  
                            "password" : "no peeking",  
                            "lang" : "EN" })  
  
user = usersCollection.find_one()  
print( user )
```



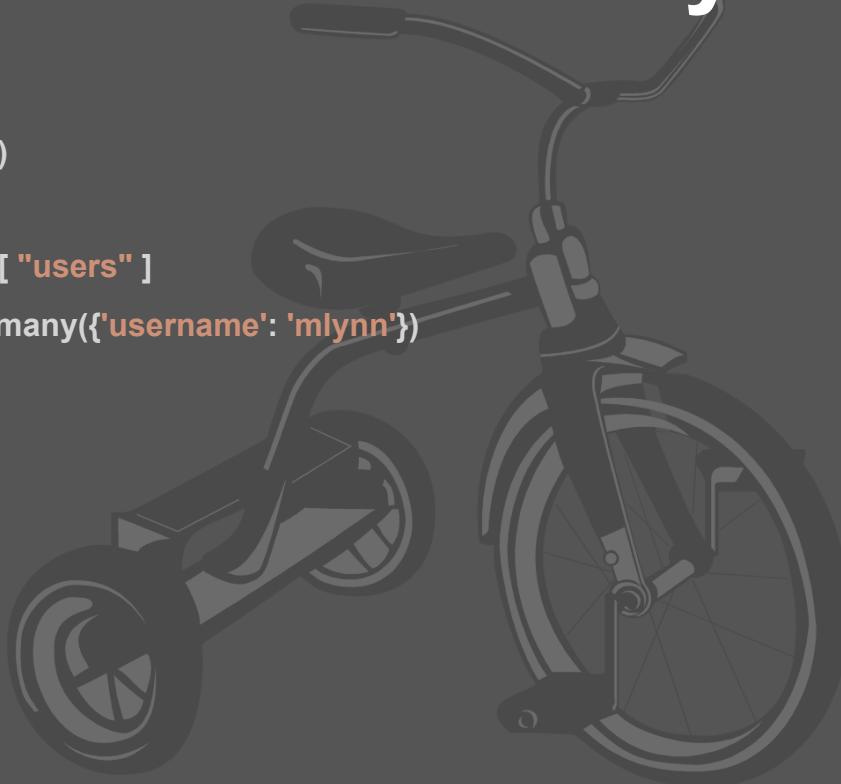
Ok - now let's find it

```
import pymongo  
  
client = pymongo.MongoClient()  
  
blogDatabase = client[ "blog" ]  
  
usersCollection = blogDatabase[ "users" ]  
  
user = usersCollection.find_one({'username': 'mlynn'})  
  
print( user )
```

Michaels-MBP-3:code mlynn\$ python 1a-find-user.py
{u'username': u'mlynn', u'lang': u'EN', u'password': u'no peeking', u'_id': ObjectId('59da5dac491e1cfb5e0abe6b')}

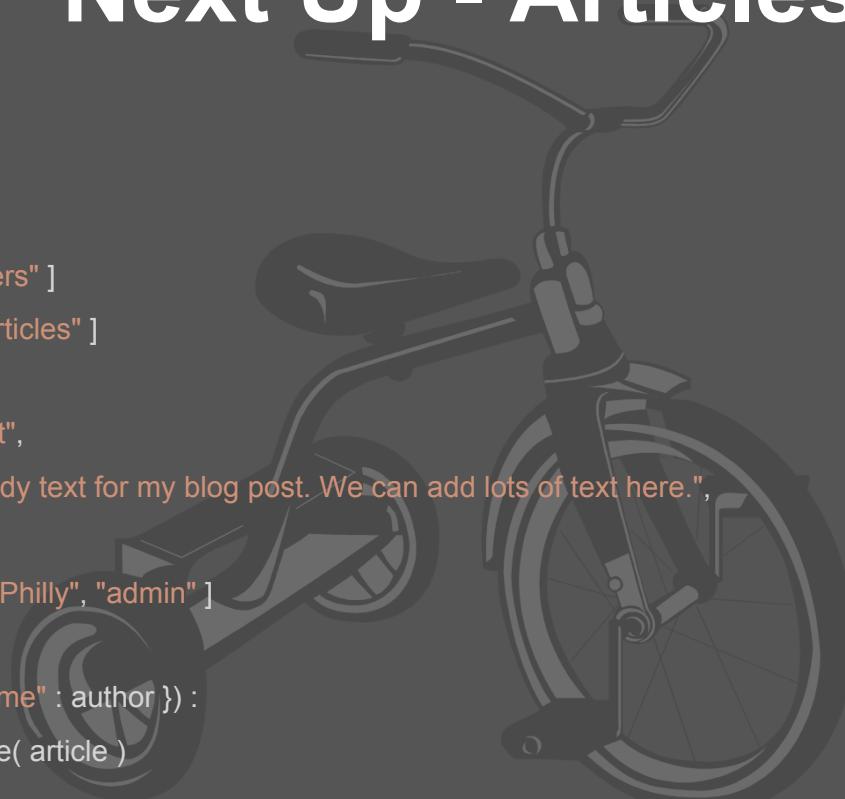
Now you see it... now you delete it

```
import pymongo
client = pymongo.MongoClient()
blogDatabase = client[ "blog" ]
usersCollection = blogDatabase[ "users" ]
result = usersCollection.delete_many({'username': 'mlynn'})
print( result )
```



Next Up - Articles

```
import pymongo
client = pymongo.MongoClient()
blogDatabase = client[ "blog" ]
usersCollection = blogDatabase[ "users" ]
articlesCollection = blogDatabase[ "articles" ]
author = "mlynn"
article = { "title" : "This is my first post",
            "body" : "The is the longer body text for my blog post. We can add lots of text here.",
            "author" : author,
            "tags" : [ "mlynn", "general", "Philly", "admin" ]
        }
if usersCollection.find_one( { "username" : author } ):
    result = articlesCollection.insert_one( article )
    print result
else:
    raise ValueError( "Author %s does not exist" % author )
```



Create a new type of article

```
import pymongo
import datetime

client = pymongo.MongoClient()
blogDatabase = client[ "blog" ]
usersCollection = blogDatabase[ "users" ]
articlesCollection = blogDatabase[ "articles" ]
author = "mlynn"
title = "This is a post on MongoDB"
newPost = { "title" : title,
            "body" : "MongoDB is the worlds most popular NoSQL database. It is a document database",
            "author" : author,
            "tags" : [ "mike", "mongodb", "Philly" ],
            "section" : "technology",
            "postDate" : datetime.datetime.now(),
        }
if usersCollection.find_one( { "username" : author } ):
    articlesCollection.insert_one( newPost )
```

Create a new type of article

```
import pymongo
import string
import datetime
import random

def randomString( size, letters = string.letters ):
    return "".join( [random.choice( letters ) for _ in xrange( size )] )

client = pymongo.MongoClient()
def makeArticle( count, author, timestamp ):
    return { "_id" : count,
             "title" : randomString( 20 ),
             "body" : randomString( 80 ),
             "author" : author,
             "postdate" : timestamp }

def makeUser( username ):
    return { "username" : username,
             "password" : randomString( 10 ),
             "karma" : random.randint( 0, 500 ),
             "lang" : "EN" }

blogDatabase = client[ "blog" ]
usersCollection = blogDatabase[ "users" ]
articlesCollection = blogDatabase[ "articles" ]
bulkUsers = usersCollection.initialize_ordered_bulk_op()
bulkArticles = articlesCollection.initialize_ordered_bulk_op()
```

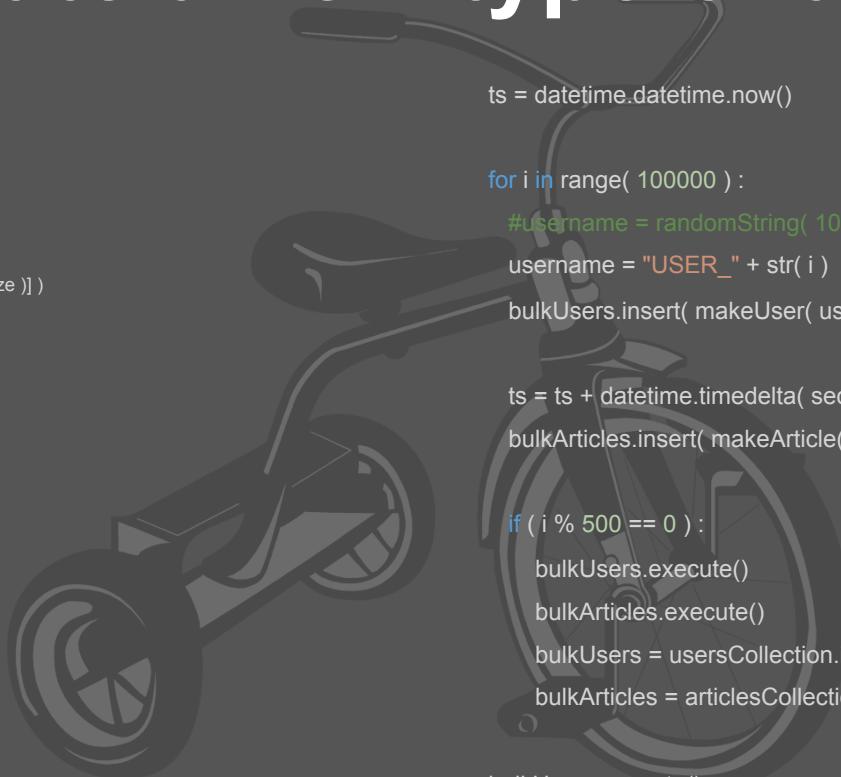
```
ts = datetime.datetime.now()

for i in range( 100000 ):
    #username = randomString( 10, string.ascii_uppercase ) + "_" + str( i )
    username = "USER_" + str( i )
    bulkUsers.insert( makeUser( username ) )

    ts = ts + datetime.timedelta( seconds = 1 )
    bulkArticles.insert( makeArticle( i, username, ts ) )

    if ( i % 500 == 0 ):
        bulkUsers.execute()
        bulkArticles.execute()
        bulkUsers = usersCollection.initialize_ordered_bulk_op()
        bulkArticles = articlesCollection.initialize_ordered_bulk_op()

bulkUsers.execute()
bulkArticles.execute()
```



Find a User

```
> db.users.findOne()
{
  "_id" : ObjectId("5742da5bb26a88bc00e941ac"),
  "username" : "FLFZQLSRWZ_0",
  "lang" : "EN",
  "password" : "vTIIILbGWLt",
  "karma" : 448
}
> db.users.find( { "username" : "VHXDAUUUFJW_45" } ).pretty()
{
  "_id" : ObjectId("5742da5bb26a88bc00e94206"),
  "username" : "VHXDAUUUFJW_45",
  "lang" : "EN",
  "password" : "GmRLnCeKvp",
  "karma" : 284
}
```

Find Users with high Karma

```
> db.users.find( { "karma" : { $gte : 450 } } ).pretty()  
{  
  "_id" : ObjectId("5742da5bb26a88bc00e941ae"),  
  "username" : "JALLFRKBWD_1",  
  "lang" : "EN",  
  "password" : "bCSKSKvUeb",  
  "karma" : 487  
}  
  
{  
  "_id" : ObjectId("5742da5bb26a88bc00e941e4"),  
  "username" : "OTKWJJBNBU_28",  
  "lang" : "EN",  
  "password" : "HAWpiATCBN",  
  "karma" : 473  
}  
...  
}
```



Using projection

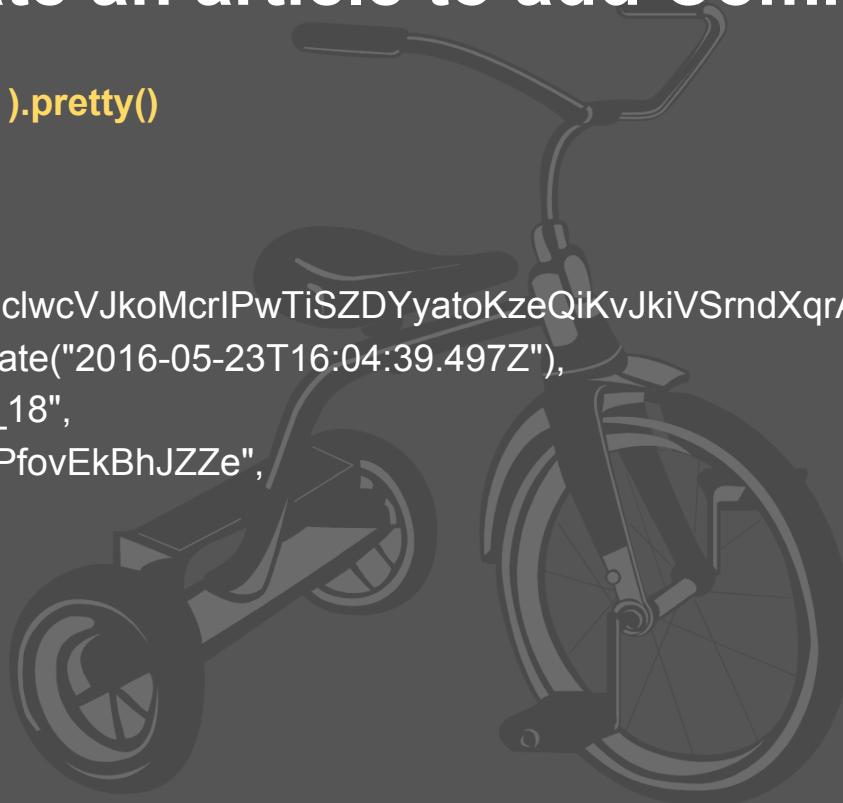
```
> db.users.find( { "karma" : { $gte : 450 }}, { "_id" : 0, username : 1, karma : 1 } )  
{ "username" : "JALLFRKBWD_1", "karma" : 487 }  
{ "username" : "OTKWJJBNBU_28", "karma" : 473 }  
{ "username" : "RVVHLKTWHU_31", "karma" : 493 }  
{ "username" : "JBNESEOOEP_48", "karma" : 464 }  
{ "username" : "VSTBDZLKQQ_51", "karma" : 487 }  
{ "username" : "UKYDTQJCLO_61", "karma" : 493 }  
{ "username" : "HZFZZMZHYB_106", "karma" : 493 }  
{ "username" : "AAYLPJJNHO_113", "karma" : 455 }  
{ "username" : "CXZZMHLBXE_128", "karma" : 460 }  
{ "username" : "KKJXBACBVN_134", "karma" : 460 }  
{ "username" : "PTNTIBGAJV_165", "karma" : 461 }  
{ "username" : "PVLCQJIGDY_169", "karma" : 463 }
```

Update an Article to Add Comments 1

```
> db.articles.find( { "_id" : 18 } ).pretty()
{
  "_id" : 18,
  "body" :
"nTzOofOcnHKkJxpjKAyqTTnKZMFzzkWFeXtBRuEKsctuGBgWIrEBrYdvFIVHJWaXLUTVUXbIOZZgUqWu",
  "postdate" : ISODate("2016-05-23T12:02:46.830Z"),
  "author" : "ASWTOMMABN_19",
  "title" : "CPMaqHtAdRwLXhiUvsej"
}
> db.articles.update( { _id : 18 }, { $set : { comments : [] } })
WriteResult({ "nMatched" : 1, "nUpserted" : 0, "nModified" : 1 })
```

Update an article to add Comments 2

```
> db.articles.find( { _id :18 } ).pretty()
{
  "_id" : 18,
  "body" :
"KmwFSIMQGclsRNTDBFPuclwcVJkoMcrIPwTiSZDYyatoKzeQiKvJkiVSrndXqrALVIYZxGpaMjucgXUV",
  "postdate" : ISODate("2016-05-23T16:04:39.497Z"),
  "author" : "USER_18",
  "title" : "wTLreIEyPfovEkBhJZZe",
  "comments" : []
}
>
```



Update an Article to Add Comments 3

```
> db.articles.update( { _id : 18 }, { $push : { comments : { username : "mlynn", comment : "hey first post" } } } )  
WriteResult({ "nMatched" : 1, "nUpserted" : 0, "nModified" : 1 })  
  
> db.articles.find( { _id : 18 } ).pretty()  
{  
    "_id" : 18,  
    "body" : "KmwFSIMQGclsRNTDBFPuciwcVJkoMcrlPwTiSZDYyatoKzeQiKvJkiVSrndXqrALVIYZxGpaMjucgXUV",  
    "postdate" : ISODate("2016-05-23T16:04:39.497Z"),  
    "author" : "USER_18",  
    "title" : "wTLrelEyPfovEkBhJZZe",  
    "comments" : [  
        {  
            "username" : "mlynn",  
            "comment" : "hey first post"  
        }  
    ]  
}  
>
```

Delete an Article

```
> db.articles.remove( { "_id" : 25 } )
```

```
WriteResult({ "nRemoved" : 1 })
```

```
> db.articles.remove( { "_id" : 25 } )
```

```
WriteResult({ "nRemoved" : 0 })
```

```
> db.articles.remove( { "_id" : { $lte : 5 } } )
```

```
WriteResult({ "nRemoved" : 6 })
```

- Deletion leaves holes
- Dropping a collection is cheaper than deleting a large collection element by element

A Quick Look at Users and Articles Again

```
> db.users.findOne()
{
  "_id" : ObjectId("57431c07b26a88bf060e10cb"),
  "username" : "USER_0",
  "lang" : "EN",
  "password" : "kGlxPxqKGJ",
  "karma" : 266
}
> db.articles.findOne()
{
  "_id" : 0,
  "body" : "hvJLnrrfZQurmtjPfUWbMhaQWbNjXLzjpuGLZjsxHXbUycmJVZTeOZesTnZtojThrebRcUoiYwivjpwG",
  "postdate" : ISODate("2016-05-23T16:04:39.246Z"),
  "author" : "USER_0",
  "title" : "gpNloPxpfTAxWjzAVoTJ"
}
>
```

Find a User

```
> db.users.find( { "username" : "ABOXHWKBYS_199" } ).explain()
{
  "queryPlanner" : {
    "plannerVersion" : 1,
    "namespace" : "blog.users",
    "indexFilterSet" : false,
    "parsedQuery" : {
      "username" : {
        "$eq" : "ABOXHWKBYS_199"
      }
    },
    "winningPlan" : {
      "stage" : "COLLSCAN",
      "filter" : {
        "username" : {
          "$eq" : "ABOXHWKBYS_199"
        }
      },
      "direction" : "forward"
    },
    "rejectedPlans" : []
  },
  "serverInfo" : {
    "host" : "JD10Gen.local",
    "port" : 27017,
    "version" : "3.2.6",
    "gitVersion" : "05552b562c7a0b3143a729aaa0838e558dc49b25"
  },
  "ok" : 1
}
```

Find a User - Execution Stats

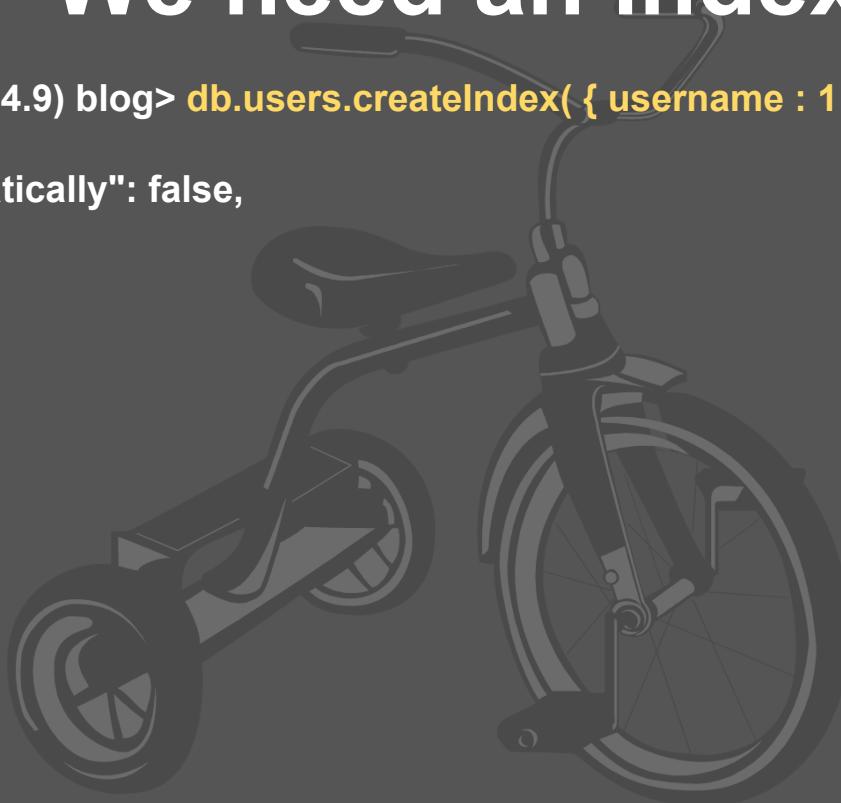
```
Michaels-MBP-3(mongod-3.4.9) blog> db.users.find({username: "USER_99"}).explain("executionStats").executionStats;  
{  
  "executionSuccess": true,  
  "nReturned": 1,  
  "executionTimeMillis": 37,  
  "totalKeysExamined": 0,  
  "totalDocsExamined": 100001,  
  "executionStages": {  
    "stage": "COLLSCAN",  
    "filter": {  
      "username": {  
        "$eq": "USER_99"  
      }  
    },  
    "nReturned": 1,  
    "executionTimeMillisEstimate": 33,  
    "works": 100003,  
    "advanced": 1,  
    "needTime": 100001,  
    "needYield": 0,  
    "saveState": 781,  
    "restoreState": 781,  
    "isEOF": 1,  
    "invalidates": 0,  
    "direction": "forward",  
    "docsExamined": 100001  
  }  
}
```



We need an index

```
Michaels-MBP-3(mongod-3.4.9) blog> db.users.createIndex( { username : 1 } )
```

```
{  
  "createdCollectionAutomatically": false,  
  "numIndexesBefore": 1,  
  "numIndexesAfter": 2,  
  "ok": 1  
}
```



Indexes Overview

- **Parameters**
 - **Background** : Create an index in the background as opposed to locking the database
 - **Unique** : All keys in the collection must be unique. Duplicate key insertions will be rejected with an error.
 - **Name** : explicitly name an index. Otherwise the index name is autogenerated from the index field.
- Deleting an Index
 - `db.users.dropIndex({ "username" : 1 })`
- Get All the Indexes on a collection
 - `db.users.getIndexes()`

Query Plan Execution Stages

- **COLLSCAN** : for a collection scan
- **IXSCAN** : for scanning index keys
- **FETCH** : for retrieving documents
- **SHARD_MERGE** : for merging results from shards

Add an Index

```
> db.users.find( {"username" : "USER_999999"} ).explain("executionStats").executionStats
{
  "executionSuccess" : true,
  "nReturned" : 1,
  "executionTimeMillis" : 0,
  "totalKeysExamined" : 1,
  "totalDocsExamined" : 1,
...
}
```



Find a User - Execution Stats

```
Michaels-MBP-3(mongod-3.4.9) blog> db.users.find({username: "USER_99"}).explain("executionStats").executionStats;
```

```
{
```

```
    "username": [ ],
},
"isUnique": false,
"isSparse": false,
"isPartial": false,
"indexVersion": 2,
"direction": "forward",
"indexBounds": {
    "username": [
        "[\"USER_99\", \"USER_99\"]"
    ]
},
"keysExamined": 1,
"seeks": 1,
"dupsTested": 0,
"dupsDropped": 0,
"seenInvalidated": 0
}
}
```

Drivers and Frameworks



C++

C

Scala

node.js

MEAN Stack

ANGULARJS
by Google

HIBERNATE

spring

express™

django

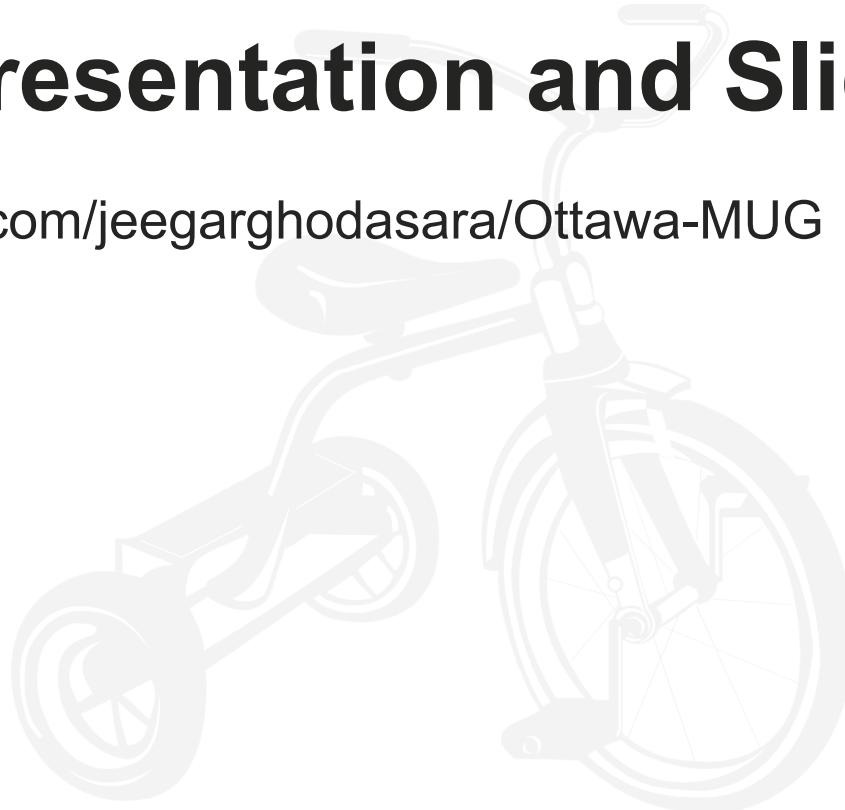
Morphia

What we have learned

- How to create a database and a collection
- How to insert content into that collection
- How to query the collection
- How to update a document in place
- How to delete a document
- How to check the efficiency of an operation
- How to add an index
- How to check an index is being used in an operation

Presentation and Slides

<https://github.com/jeegarghodasara/Ottawa-MUG>



Q&A