# Your First MongoDB Application

Michael Lynn, October 2017

**Wifi: WeWork Guest (pw: ...)**

# Preparing for Beginner MongoDB MUG

1. Install MongoDB
   a. See here: https://docs.mongodb.com/manual/installation/
2. Test Launching MongoDB
   a. See here: https://docs.mongodb.com/manual/tutorial/manage-mongodb-processes/
3. Load Some Data
   a. http://bit.ly/2xmQMYl
   b. Once you have restaurants.json downloaded, use mongoimport to import the collection.
   c. http://bit.ly/2xZpUdX

# GOALS
# We are here to:

1. **Introduce you to NoSQL 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.

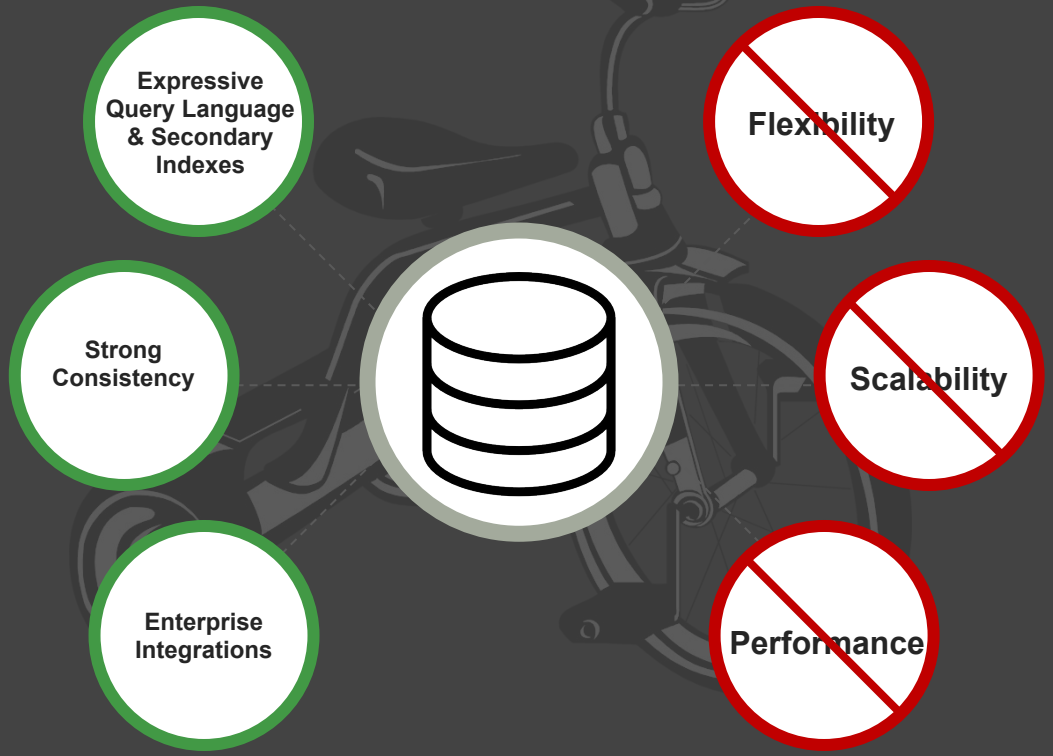
# AGENDA

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


Expressive Query Language & Secondary Indexes
Flexibility
Strong Consistency
Scalability
Enterprise Integrations
Performance

# The World Has Changed

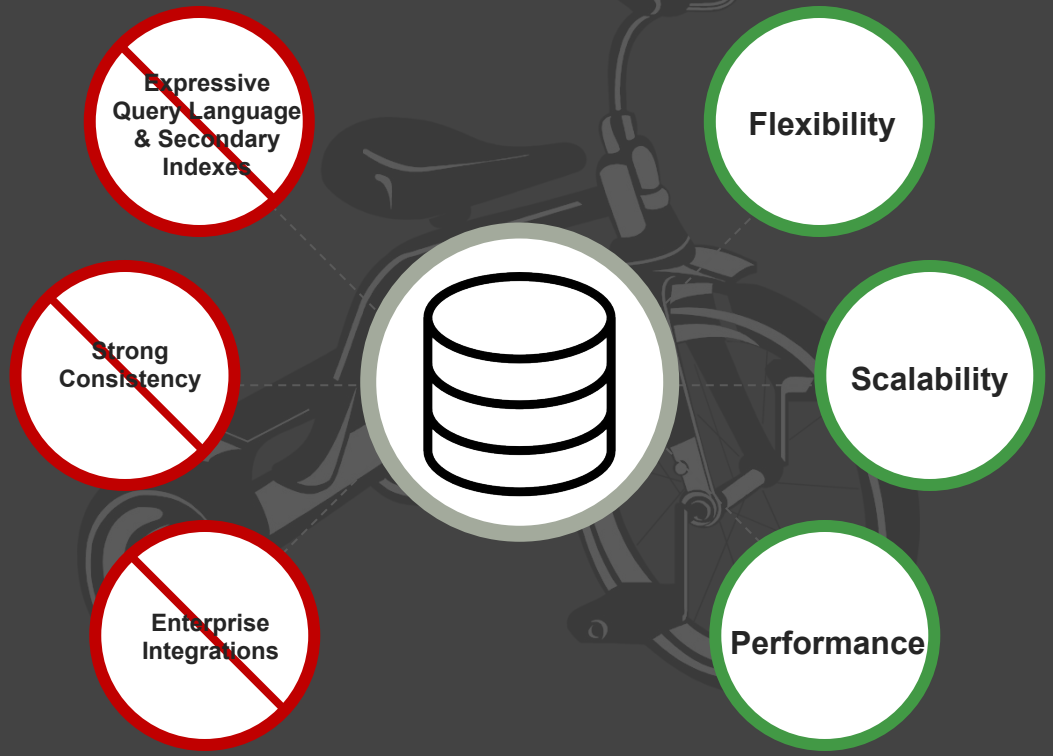
## Data
- Volume
- Velocity
- Variety

## Time
- Iterative
- Agile
- Short Cycles

## Risk
- Always On
- Scale
- Global

## Cost
- Open-Source
- Cloud
- Commodity

# NoSQL


Expressive Query Language & Secondary Indexes
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Performance

# Nexus Architecture

## Relational + NoSQL

Relational

Expressive Query Language & Secondary Indexes

Strong Consistency

Enterprise Integrations

Flexibility

Scalability

Performance

NoSQL

# 5th Most Popular Database - Fastest Growing

| RANK | DBMS | MODEL | SCORE | GROWTH (20 MO) |
|---|---|---|---|---|
| 1. | **Oracle** | **Relational DBMS** | 1359.09 | -8.78 |
| 2. | **MySQL** | **Relational DBMS** | 1312.61 | -27.69 |
| 3. | **Microsoft SQL Server** | **Relational DBMS** | 1212.54 | -12.93 |
| 4. | **PostgreSQL** | **Relational DBMS** | 372.36 | +2.60 |
| 5. | **MongoDB** | **Document store** | 332.73 | +2.24 |
| 6. | **DB2** | **Relational DBMS** | 198.34 | +0.87 |
| 7. | **Microsoft Access** | **Relational DBMS** | 128.81 | +1.78 |
| 8. | **Cassandra** | **Wide column store** | 126.20 | -0.52 |
| 9. | **Redis** | **Key-value store** | 120.41 | -1.49 |

*Source: DB-engines database popularity rankings; October 2017*

# 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: “19th Floor”,
        city: “Philadelphia”,
        state: “PA”,
        zipcode: “19123”
    },
    expertise: [ “MongoDB”, “Python”, “Javascript” ],
    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”,
        eircode: “D08 NC3”
    },
    expertise: [ “MongoDB”, “Python”, “Javascript” ],
    employee_number: 326,
    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](MongoDB Download Center).

You can also download directly from the command line:

```
curl -O https://fastdl.mongodb.org/osx/mongodb-osx-x86_64-3.4.9.tgz
```

Once you have the archive downloaded, extract it:

```
tar -zxvf mongodb-osx-x86_64-3.4.9.tgz
```

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

```
mkdir -p mongodb
cp -R -n mongodb-osx-x86_64-3.4.9/ 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
```

# Running Mongod

```
Michaels-MBP-3:data 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,compres
sor=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] **          Read and write
access to data and 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]
```

# Inserting your first record

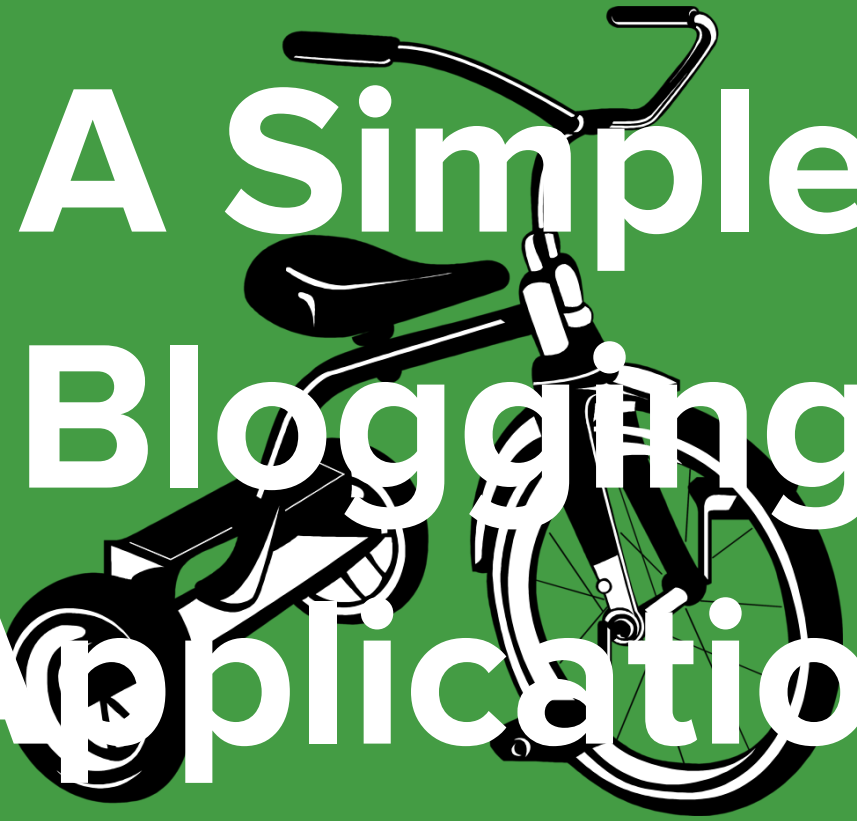
```
> show databases
local  0.000GB
> use test
switched to db test
> show databases
local  0.000GB
> db.demo.insert( { "key" : "value" } )
WriteResult({ "nInserted" : 1 })
> show databases
local  0.000GB
test   0.000GB
> show collections
demo
> db.demo.findOne()
{ "_id" : ObjectId("573af7085ee4be80385332a6"),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

# Object ID

573af7085ee4be80385332a6

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

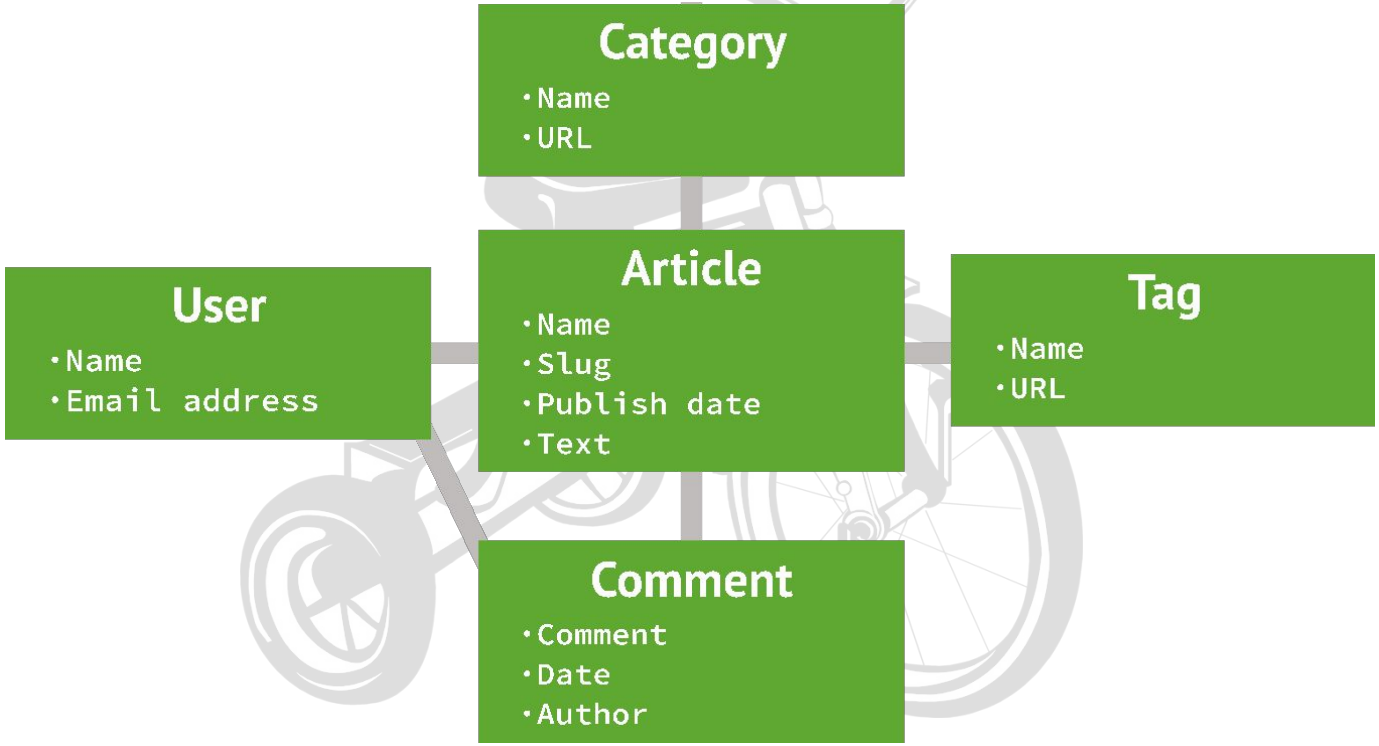
# A Simple Blogging Application



# 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"
}
```

# Installing Python

Mac OS X 10.8 comes with Python 2.7 pre-installed by Apple.

# How do we do this in a program?

```
import pymongo
# client defaults to localhost and port 27017. eg MongoClient('localhost', 27017)
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 defaults to localhost and port 27017. eg MongoClient('localhost', 27017)
#
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

```
'''
Created on 08 Oct 2017
@author: mlynn
'''
import pymongo
#
# client defaults to localhost and port 27017. eg MongoClient('localhost', 27017)
#
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" : "vTlILbGWLt",
    "karma" : 448
}
> db.users.find( { "username" : "VHXDAUUFJW_45" } ).pretty()
{
    "_id" : ObjectId("5742da5bb26a88bc00e94206"),
    "username" : "VHXDAUUFJW_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" : 19 } ).pretty()
{
    "_id" : 19,
    "body" :
"nTzOofOcnHKkJxpjKAyqTTnKZMFzzkWFeXtBRuEKsctuGBgWIrEBrYdvFIVHJWaXLUTVUXblOZZgUqWu",
    "postdate" : ISODate("2016-05-23T12:02:46.830Z"),
    "author" : "ASWTOMMABN_19",
    "title" : "CPMaqHtAdRwLXhlUvsej"
}
> 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" :
"KmwFSIMQGcIsRNTDBFPuclwcVJkoMcrIPwTiSZDYyatoKzeQiKvJkiVSrndXqrALVIYZxGpaMjucgXUV",
    "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" :
"KmwFSIMQGcIsRNTDBFPuclwcVJkoMcrIPwTiSZDYyatoKzeQiKvJkiVSrndXqrALVIYZxGpaMjucgXUV",
    "postdate" : ISODate("2016-05-23T16:04:39.497Z"),
    "author" : "USER_18",
    "title" : "wTLreIEyPfovEkBhJZZe",
    "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" : "kGIxPxqKGJ",
    "karma" : 266
}
> db.articles.findOne()
{
    "_id" : 0,
    "body" :
"hvJLnrrfZQurmtjPfUWbMhaQWbNjXLzjpuGLZjsxHXbUycmJVZTeOZesTnZtojThrebRcUoiYwivjpwG",
    "postdate" : ISODate("2016-05-23T16:04:39.246Z"),
    "author" : "USER_0",
    "title" : "gpNIoPxpfTAxWjzAVoTJ"
}
>
```

# 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







MEAN Stack



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

# Next Webinar : Thinking in Documents

- Rather than normalisation we look at a hybrid approach to schema that provides a coherent mapping between objects in your application and objects in your database.
- Then we will optimise that schema for query purposes based on the pattern of queries we expect to see.
- Finally we will show how dynamic schema and schema validation allow you to extend your schema in a controlled fashion

# Q&A

# Big Thanks to WeWork!

# Wifi: WeWorkGuest (pw: ...)