Topic: Document Databases

Description

Document databases allow users to store data in text-based documents. Binary objects and non-textual data (e.g., images, video, etc.) can be wrapped in MongoDB documents. However, they do not take advantage of the powerful retrieval methods built in to the document databases. It is most useful to use a searchable, semi-structured form such as JSON, BSON, or XML. With semi-structured data, the database can be searched for documents with specific properties.

Like most NoSQL database systems, document databases are used when consistency is not as important as availability and constant updates. Advantages of document databases are that content schemas are flexible, documents are easy to store, applications are easy to write, and the documents are independent units. The last point is important to having the database replicate and shard the data – for distributed, parallel processing of independent documents.

A document database can be used for a wide range of applications (e.g., mobile apps and websites). They are often used in cloud applications because they can be housed on inexpensive hardware and replicated easily. You might imagine a forum being hosted on a document database. Each entry could be formatted in JSON/XML to have an author, subject, date and text of post. Queries could search in parallel for the posts of a particular author, postings with certain title or for specific keywords in the text.

Learning objectives

- become familiar with document databases
- experience manipulating data from a shell interface (command line)
- learn how to execute queries in a document database
- (future) learn how to use a programming API to interact with a document database

Components

For this assignment, you will be installing MongoDB Compass (GUI) software on your personal computers. This will connect to MongoDB Atlas (cloud storage) for basic data storage and retrieval via the mongo shell.

Background Resources

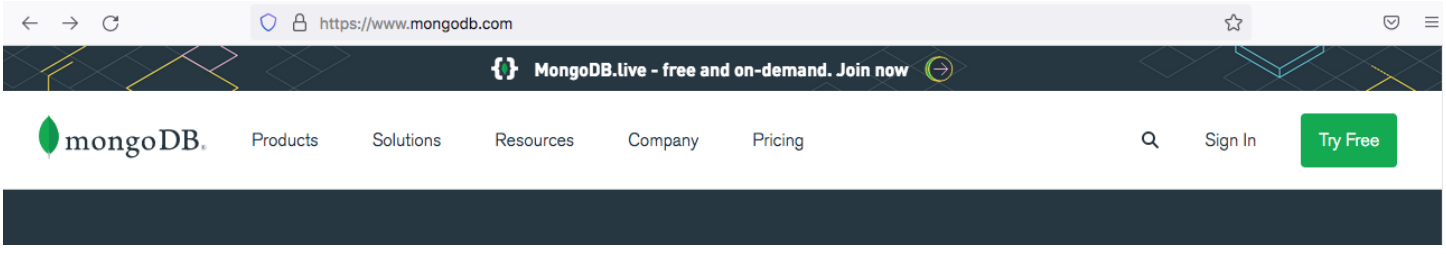
http://nosql-database.org
http://www.mongodb.com/document-databases

Setup

To do these exercises, you will need to install MongoDB Compass on your computer to connect to the cloud DB.

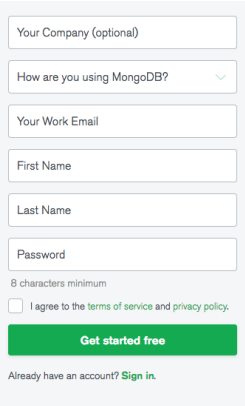
Step #0: *Setup a MongoDB cloud instance*

Visit https://www.mongodb.com and use the Try Free option to create a new account for MongoDB Atlas. Alternatively, you could install MongoDB on your own machine and not connect to the cloud, but this requires more installation.



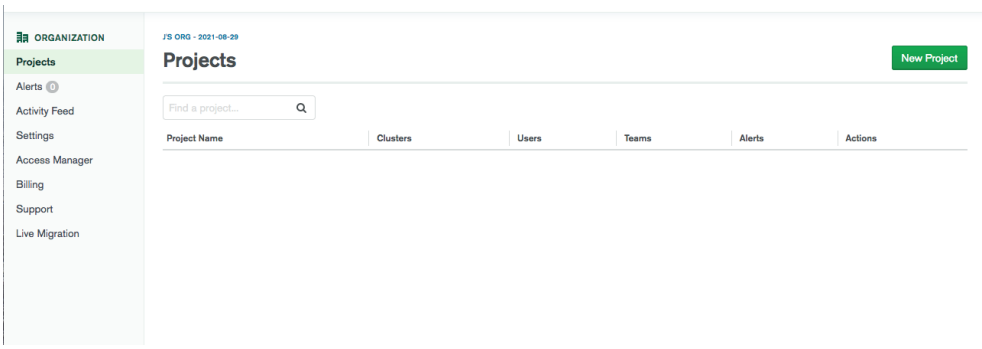
Fill in the form to get a free account. NEVER type in your credit card details. You do not need to give any credit card data

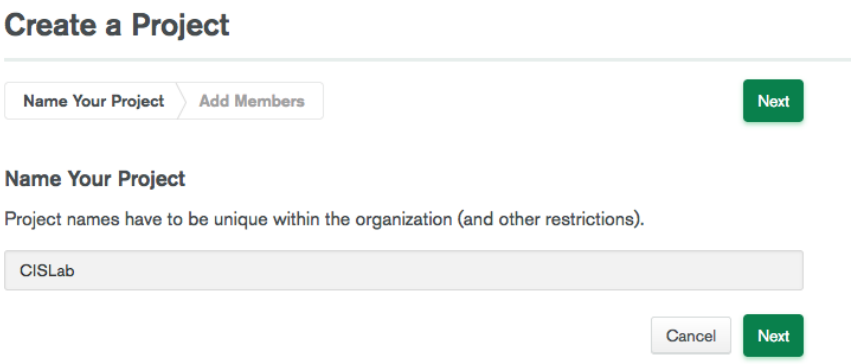
to use the free tier.

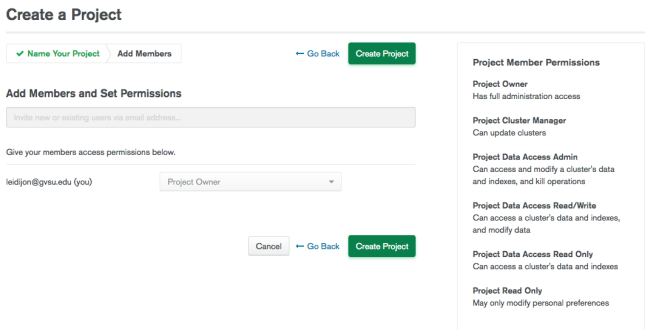


Use your new account email and password to login to https://cloud.mongodb.com.

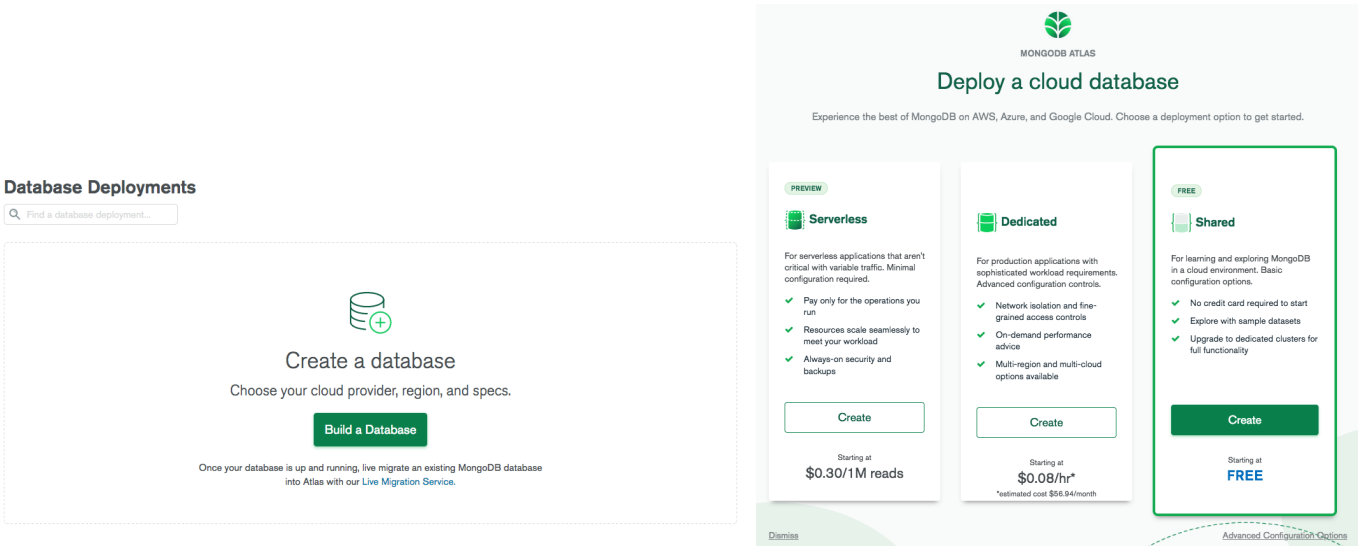
Step #0.1**: **Create a new project with any project name (e.g., CISLab) and create the project with default settings.



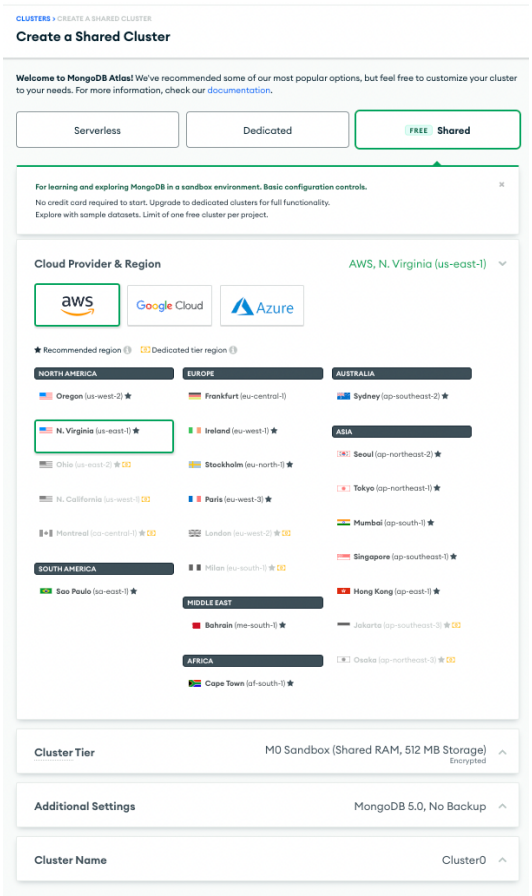




Step #0.2: Build a new database which will be hosted in the MongoDB cloud. **Make sure to only select the *free/shared* DB option.** Let's just use the default options – simply click the *Create* button. You could have selected whether you want to use Amazon (aws), GoogleCloud, or Microsoft cloud (Azure) in Advanced Configuration Options.

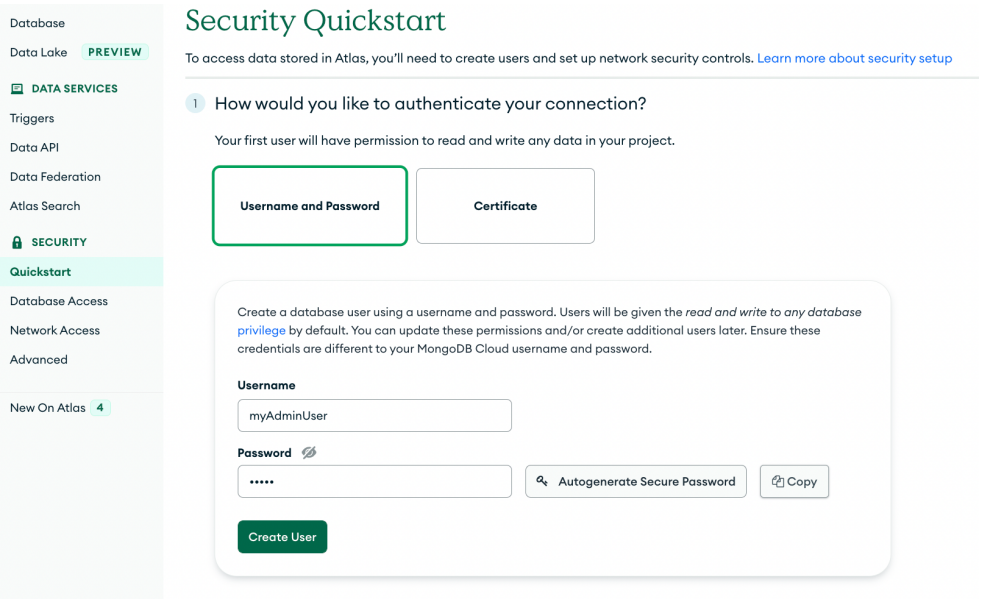


Step #0.3: Deploy a new cluster. Again, simply use the default options to create a free Shared Cluster0 with no backup.

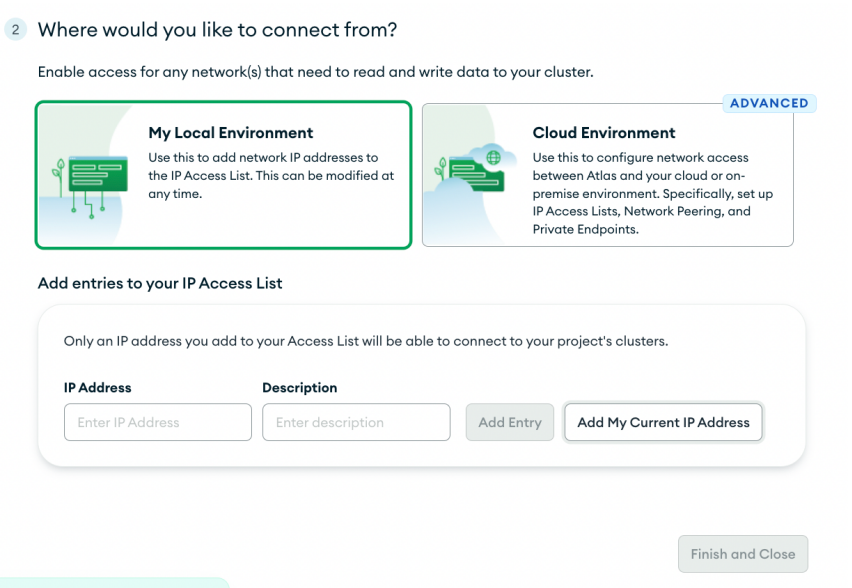


After a few minutes, your cluster will be created on the Amazon cloud and you will now be able to connect to your database to store and retrieve data. Let's setup a username (e.g., myAdminUser) and a password for this cluster so that Compass (on your local computer) can connect and login to your DB. Click *Create User*.

Step #0.4: Configure users and access permissions.



Click on “Add My Current IP Address”. This will allow only applications (such as MongoDB Compass) installed on your computer at your location to login to the DB.

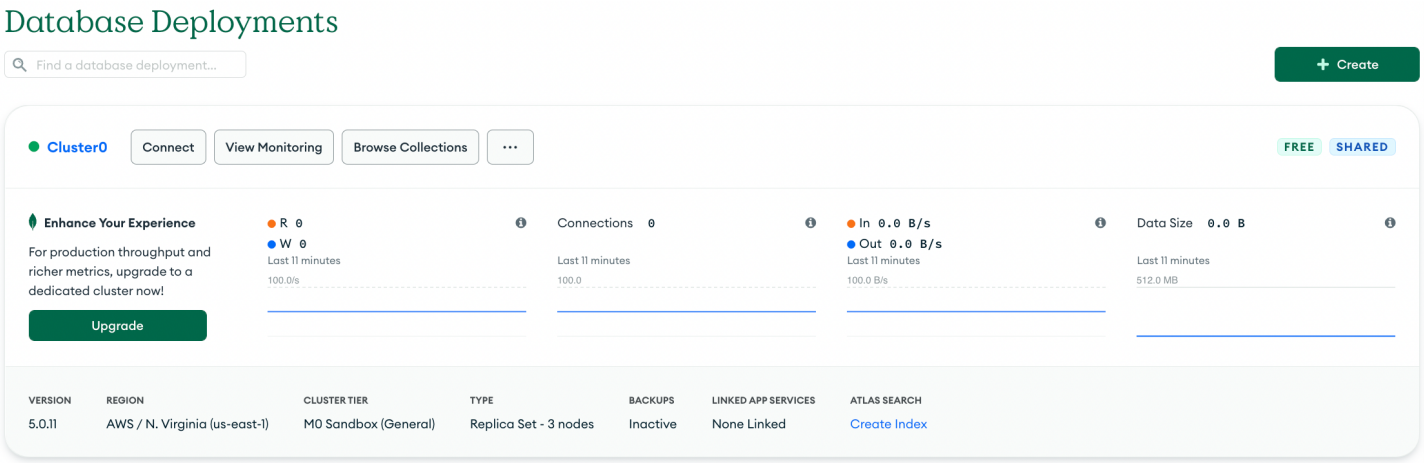


Click “Finish and Close” after adding your IP address.

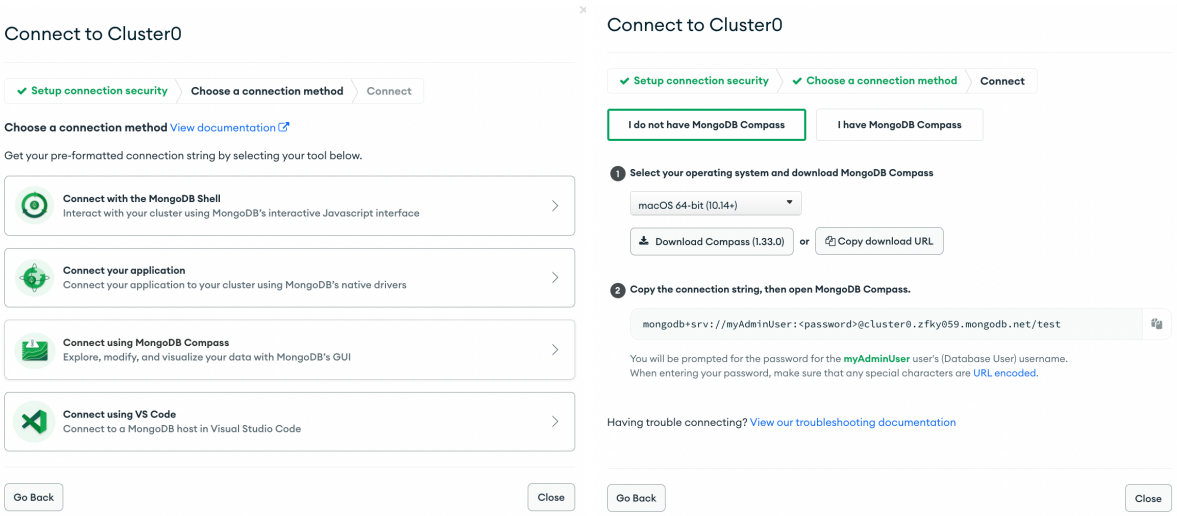
At this point, you could develop a application/program/website to store data on this cluster in the cloud. Common programming languages such as Java, Python, and R have APIs and libraries that allow you to connect to the DB. You could also login to the DB via a command line tool to run commands. We will simply choose to install and connect to the DB *using MongoDB Compass* tool on your computer to interact with your DB.

***Step #1.0: Downloading MongoDB Atlas* from the cloud to your machine.**

For this step, you will have to download and install MongoDB Compass on your own computer. See the instructor in office hours or after class if you have difficulties with this step. From MongoDB Atlas, menus, click “Connect” within your Cluster0 instance.



From the Connect popup window, select “Connect using MongoDB Compass”, “Download Compass”, and then install MongoDB compass on your personal computer.

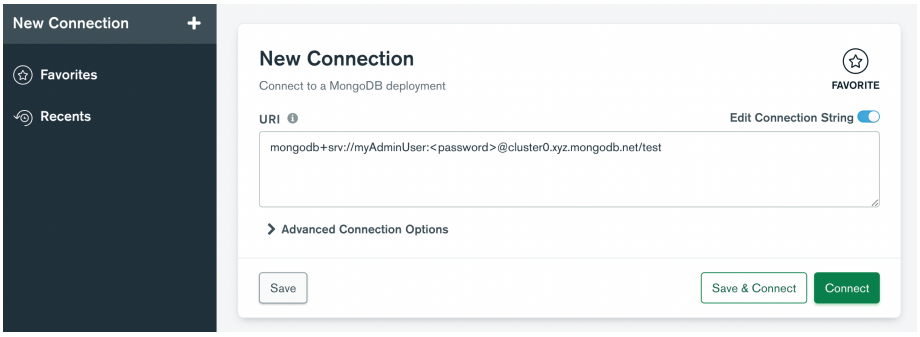


Question 1 to turn-in: what is your DB connection string? 5% of your grade.

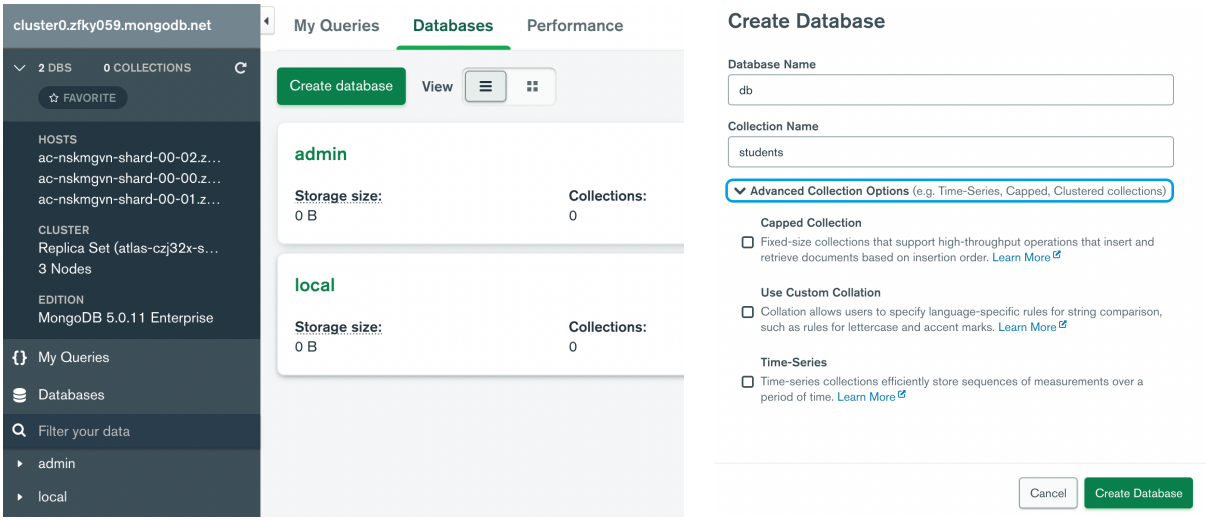
e.g., mongodb+srv://myAdminUser:<password>@cluster0.crjd1.mongodb.net/test

Step #1.1: ***Connecting MongoDB Compass*** on your personal computer to the MongoDB Atlas Cloud.

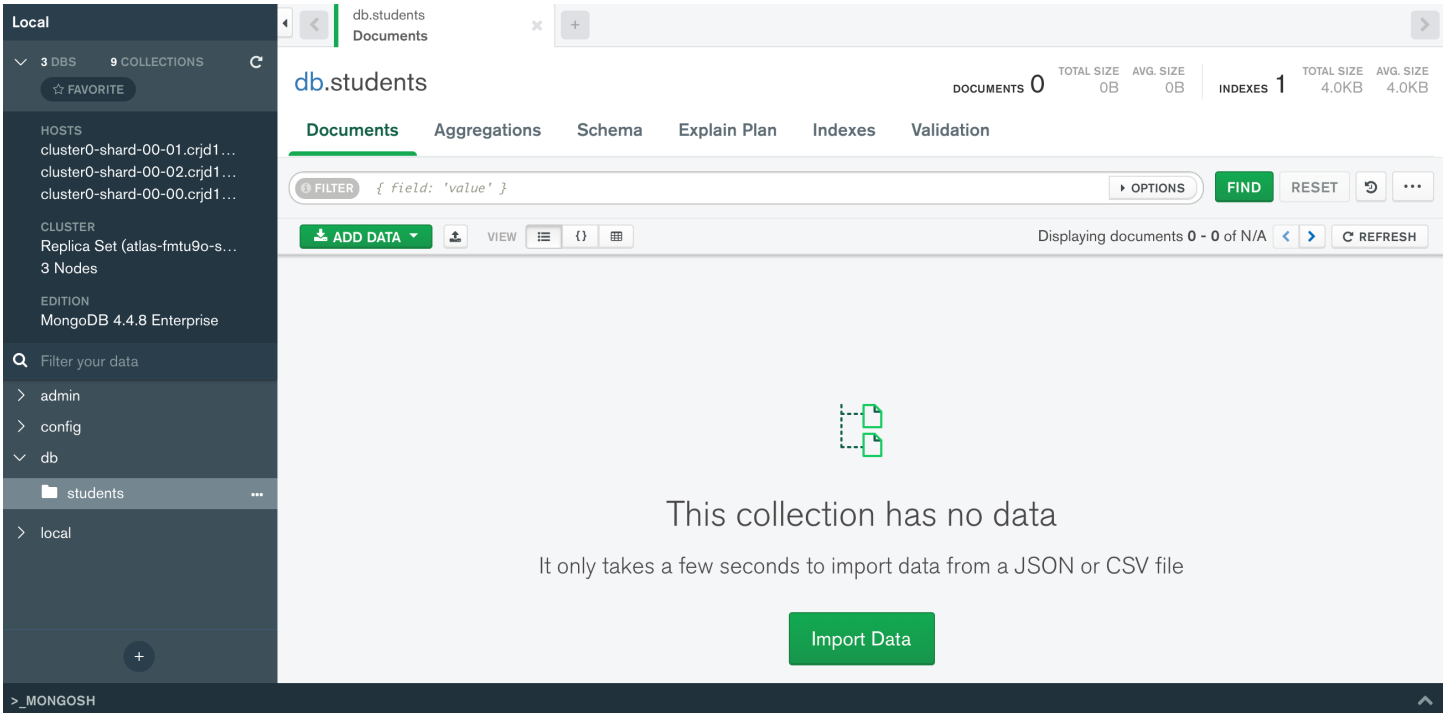
In these steps, we will practice interacting with the database using the GUI interface. There are other ways to interact with the database, e.g., via commands from a command shell or within a Python or Java program. After downloading and installing Compass, run the new application. Use your connection string to *connect* to your Atlas Cloud cluster. In this connection string, replace the default “<*password*>” with your cluster’s actual password, e.g., “myAdminUser:someGreatPassword”.



Now, let's use the Compass GUI to create a new DB. Note that the actual DB and documents will be hosted in the Atlas cloud. Compass is simply an interface to add, change, search, and delete the documents currently in the cloud. Create a new document DB (*db*) and the first collection for it to contain (*students*). Click Create Database.



Navigate to the *db.students* collection on the left menu. From here, we can manually add data, upload a large dataset from a file, run queries, modify documnts, etc. We could try doing this by the GUI *(ADD DATA*) or by the command line shell (the shell is locaated at the bottom of your screen, *>_mongosh*).



Step #2.0: ***Try CRUD commands***

Data is organized within (mostly similar) documents, with multiple independent documents stored within a collection within a larger database. We will use the command line to add several documents to this database. The shell client is an avenue for you to manually enter a CRUD command to MongoDB and view the output results. See the help/documentation: https://docs.mongodb.com/manual

Step #2.1: ***Verification of your cloud connection***

Let's try to a new doc to the *students* collection inside the *db* database, be careful with smart quotes and regular quotes “” versus "". First, use the command line to navigate through your database and collections. In practice, you might have multiple DBs and collections for different applications, datasets, etc.

> show dbs displays available dbs
> db shows current db
> use ___ switch the current db
> show collections displays collections

```
>_MONGOSH
> show dbs
< db     8.19 kB
  admin   377 kB
  local  6.55 GB
> db
< test
> use db
< 'switched to db db'
> show collections
< students
Atlas atlas-fmtu9o-shard-0 [primary] db>
```

Step #2.2: ***Create several documents***

Try to insert your first student document from the command line. Note the success message that is returned from the cloud server (<) with your document's auto-generated ID.

> db.students.insertOne({"gnumber":"G00000001"});

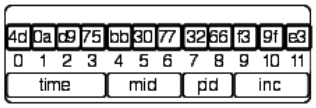
The console will provide output acknowledging the new document and its new unique identifier.

```
> db.students.insertOne({"gnumber":"G00000001"});
< { acknowledged: true,
    insertedId: ObjectId("6137a683b4486e2c5076c52d") }
Atlas atlas-fmtu9o-shard-0 [primary] db>
```

Create another new document in the *students* collection. Note an arbitrary unique ObjectID was generated.

```
> db.students.insertOne(
{
"gnum":"G0001234",
"firstname":"Jonathan",
"middlename":null,
"lastname":"Smith",
"hobbies":["SCUBA", "Falconry", "Gardening", "Outdoorsing",0,null],
"age":25,
"gpa":3.9,
"gradstudent":true,
"currentlyenrolled":false,
"cars":[
        { "make":"Ford", "model":["F150 (Red)", "F150 Crew Cab (Black)"] },
        { "make":"Chevy", "model":["Equinox (Silver)"] }
        ],
"x":[{"key1":"val1"},{"key2":"val2","key3":"val3"}]
})
```

The unique ObjectID is generated by MongoDB for each new document based on its creation timestamp, client machine id, client process id, and counter, e.g., `ObjectId("6137a77cb4486e2c5076c52e").`



Each MongoDB document organizes data into separate key-value pairs ("gnum":"G0001234"), arrays ("hobbies":["SCUBA", "Falconry", "Gardening", "Outdoorsing",0,null]), and nestled sub-documents ({"key1":"val1"}).

Question 2 to turn-in: what is your second document's ObjectId? 5% of your grade.

e.g., { acknowledged: true, insertedId: ObjectId("6137a77cb4486e2c5076c52e") }

Step #2.3: *Read*

MongoDB queries were originally aimed at finding a set of independent documents without joining any independent documents together on a server. Thus, the documents could be distributed on multiple resources and queried efficiently in parallel. Later, the $lookup command was added to allow joins (e.g., left joins/uncorrelated subqueries). The *find* command will list all the documents in a collection, specific documents, or subsets of a full documents.

Try the following three queries. Remember to use your second document's ObjectID instead of mine.

Find all documents

```
> db.students.find()
```

Find a specific document by id

```
> db.students.find({ "_id" : ObjectId("63164be0e9b02764d2761d16") })
```

Find a document and only return two fields (by marking attributes as either 1=returned or 0=hidden in the query result)

```
> db.students.find({ "_id" : ObjectId("63164c38e9b02764d2761d17") }, {firstname:1,age:1})
```

Boolean clauses can also be used to specify conditions to check against every document to filter out undesired documents. This is done by selecting a field, conditional operator, and value. E.g., *population : { $lte : 2000000 }* filters out documents that do not have a population less than or equal to 2000000.

These clauses can be logically joined as Boolean conjunctions (X AND Y must both be true). Commas between clauses indicate that the following three conditions must be true to retrieve a document.

```
> db.students.find(
        {
        "gradstudent":true,
        age: {$lt: 26},
        lastname : {$in: ["Smith", "Brown", "Jones"]}
        }
)
```

These clauses can also be logically joined as disjunctions (either X OR Y must be true). The three indices of the array hold three different clauses, where one or more of the clauses must be true to add the document to the query result.

```
> db.students.find(
        {
                $or: [
                        {"gradstudent":true},
                        {age: {$lt: 26}},
                        {lastname : {$in: ["Smith", "Brown", "Jones"]}}
                ]
        }
)
```

Boolean expressions for queries can also be used in the same query. As you may expect, query clauses can contain operators such as greater than, less than, in, etc. See more details on queries options at:
https://docs.mongodb.com/manual/reference/operator/query

Arrays values can be queried to find exact matches for the full array:

```
> db.students.find( { hobbies:
["SCUBA","Falconry","Gardening","Outdoorsing",0,null]
} )
```

Arrays values can be queried to find partial matches for the array, either at any position or in a specific index position.

```
> db.students.find( { hobbies: "SCUBA" } )              (search within all positions of the array)
> db.students.find( { "hobbies.2": "Gardening" } )      (Gardening search only at index #2 in the array)
> db.students.find( { "hobbies.3": "Gardening" } )      (no results? Gardening is not stored at index #3)
```

Step #2.4: ***Update***

Documents can be modified or replaced using update, updateOne (the first document that matches the query), updateMany, or replaceOne. Let's add skills to our student's document. modifiedCount reports how many documents were changed. Use your own ObjectId.

```
> db.students.updateMany({
       _id :ObjectId("63164c38e9b02764d2761d17")},
       {$set:{"skills":
       {db:"MongoDB", version:5, nosql:"document"}
       }
})
```

Did the document get modified, check?> `db.students.find({ "_id" : ObjectId("63164c38e9b02764d2761d17")})`

Updates require criteria (i.e., a filter) that is used to locate the documents to change and the updated data. $set specifies which portions of the document to change.

```
> db.students.updateOne(
{"_id":ObjectId("63164c38e9b02764d2761d17")},
{$set:{"middlename":"B"}})
```

updateMany changes all documents that match the query (e.g., a GPA range).

```
> db.students.updateMany(
{gpa:{$gt:3.782}},
{$set:{"status":"Cum Laude"}}
)
```

Verify the document has changed *skills, middlename,* and *status* values.

```
> db.students.find({ "_id" : ObjectId("63164c38e9b02764d2761d17") })
```

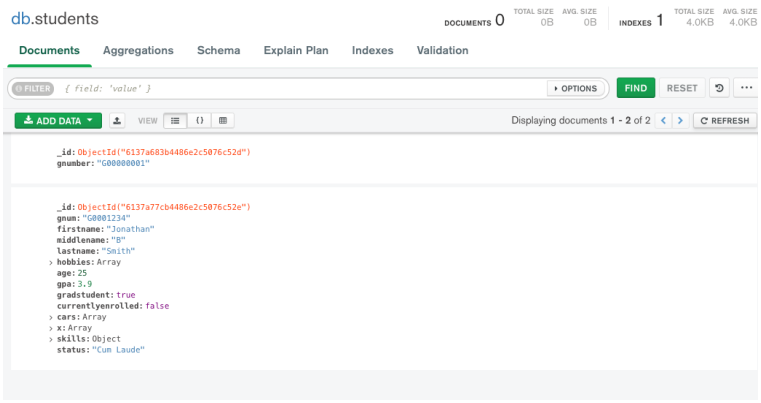
Step #2.5: ***Delete***

Deleting documents (via delete, deleteOne, and deleteMany) follows the same query logic as the find and update commands. The operation also reports how many documents were deleted.

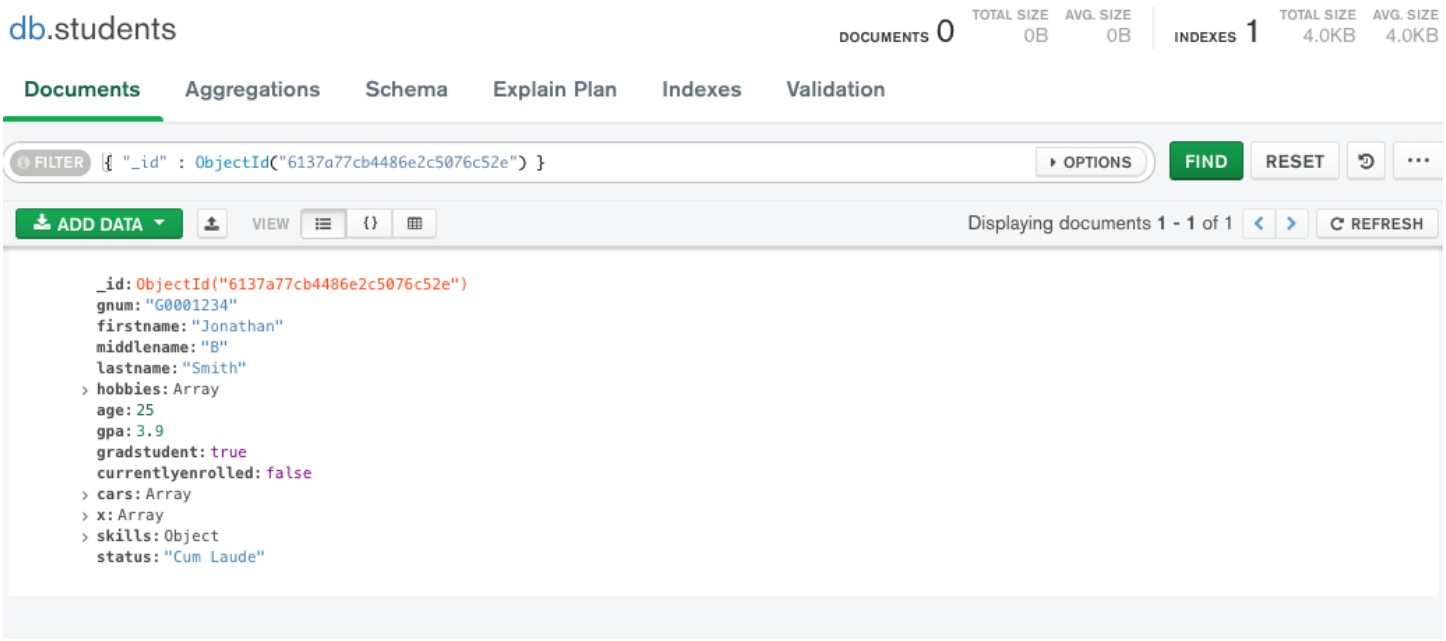
```
> db.students.insertOne({hello:"world"})
> db.students.deleteMany({hello:"world"})
```

Step #2.6: ***GUI Interactions***

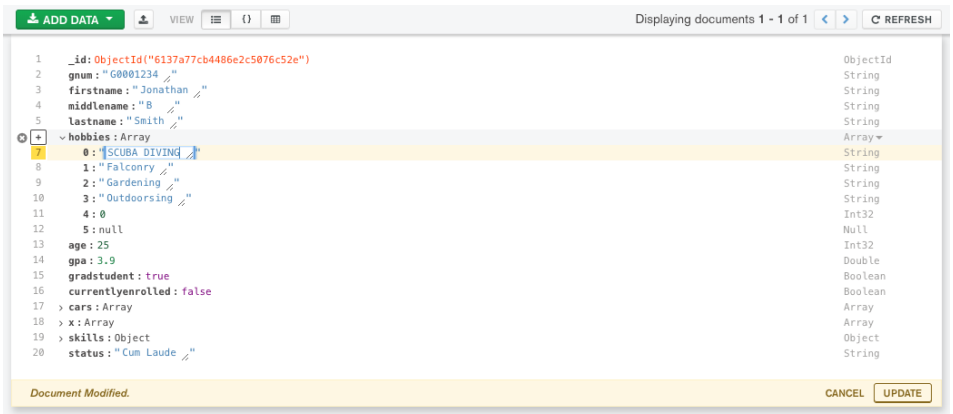
If you refresh your GUI (above your console), you will see these two documents.



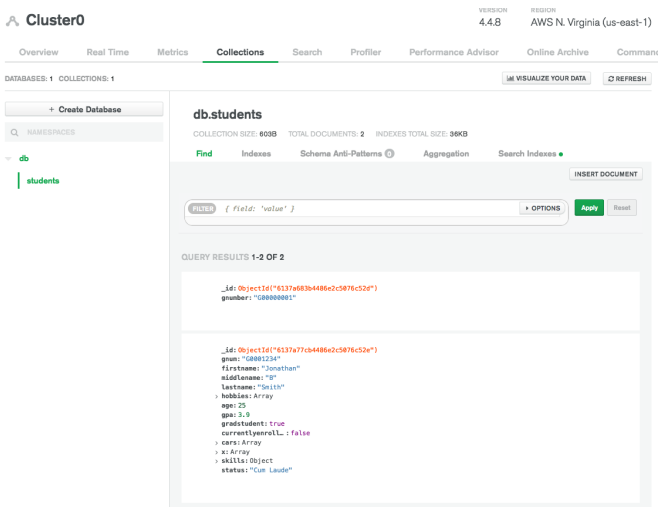
Try using the GUI's *FILTER* and *FIND* query options to search for one of your documents. Note that you can review the results in either a list, JSON document file, or tabular form



You can manually edit or delete document, e.g., changing SCUBA to SCUBA DIVING, by double clicking a key-value.



At this point, you can also go back to your web browser, browse your new *db.student* collection, and query your dataset in the cloud via the Atlas interface. Atlas with provide similar results to Compass.



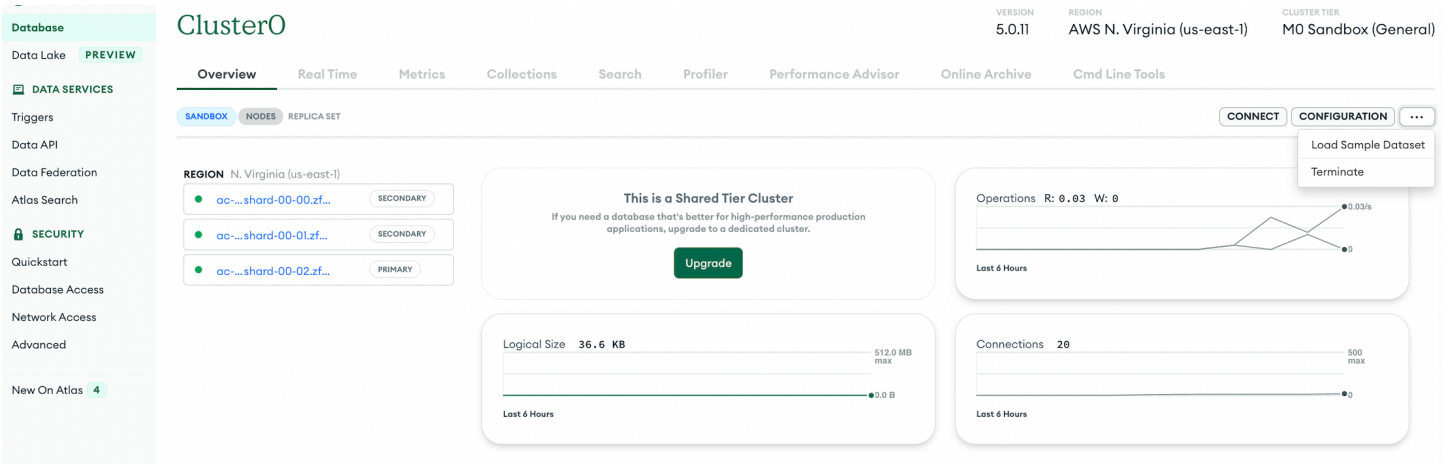
Step #3: ***Use MongoDB CRUD commands to store and manipulate a custom dataset***

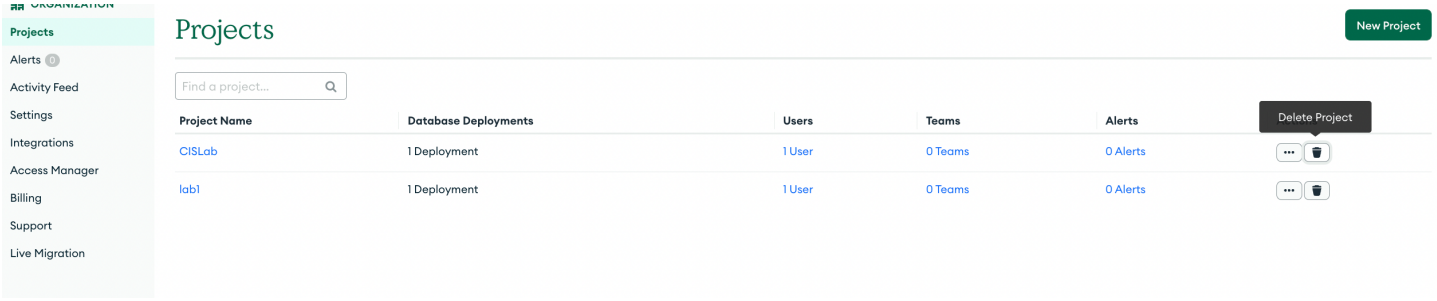
Refer to these MongoDB examples. Keep a copy of all of your commands to turn in. Execute the commands and record the output from each step.

1. Download a simple, small dataset of JSON documents of your choice. As an example:
   U.S. Government data - https://catalog.data.gov/dataset?res_format=JSON
2. Add at least five SEPARATE documents based on a subset of your dataset – 10% grade.
   Note to yourself: how is this different than inserting one document that contains five sub-documents?
   Hint: DO NOT insert one big document that contains five nestled sub-documents! Each document should get its own document ID.
3. Generate a query that retrieves a document based on its unique id – 20% grade.
4. Generate a query that utilizes an 'and' condition – 20% grade.
5. Generate a query that utilizes an 'or' condition – 20% grade.
6. Update one document by adding a new field based on an updateOne or updateMany statement – 10% grade.
7. Delete one or more documents – 10% grade.

TURN IN: A script (text file) that contains your answers from question 1 and 2 as well as all of your commands from steps 3.2-3.7 along with their output.

You are now welcome to *terminate* your Cluster0 and *delete* your CISLab project.





Done for the day!

Want to learn more about MongoDB for your own benefit?
Optional Step #1: Aggregation and Analysis – 0% of grade

Try out:

```
db.students.aggregate([
       {$match:{ which documents? }},
       {$group:{ how to group?, what to calculate} }
])
```

As an example, count all of the students with an interest in SCUBA DIVING for Professor Leidig's club.

Optional Step #2: Embedded Programming API – 0% of grade

Note: MongoDB has great APIs for programming and connectivity.

Most applications and projects require the use of programs to interact with the API instead of the shell client. The API defines how you can send requests (e.g., to add a document or run a query) from a program you are writing to the DB. As an example of an application that would benefit from an API, imagine a web-based program that allows customers to order products and check on these orders.

Download and install the MongoDB libraries/packages required by a programming language such as Java, Python, etc. Develop a program that inserts, queries, updates, and deletes documents from database collection.