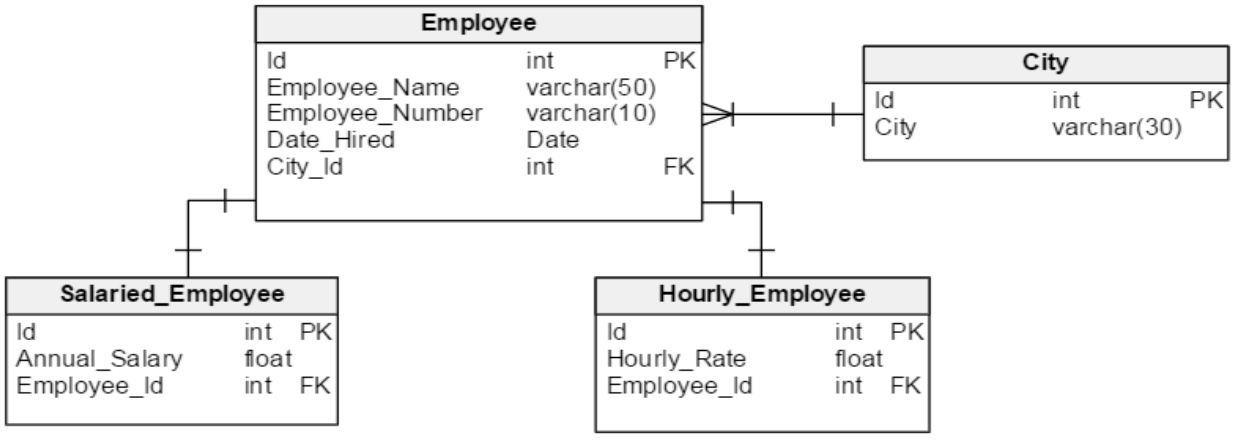
Amazon DynamoDB

DynamoDB is a fully managed NoSQL database service provided by Amazon. It provides fast and consistent performance, highly scalable architecture, flexible data structure, event driven programmability, and fine-grained access control.

Before we get into details about DynamoDB,let us understand fundamental characteristics about RDBMS/SQL and NoSQL databases.

What is an RDBMS?

RDBMS enables you to create databases in the form of tables which stores related data .As you can see we have 4 tables here and are connected using a unique primary key for each table. Inside the table ,data is stored here in rows and columns.



Examples of RDBMS:

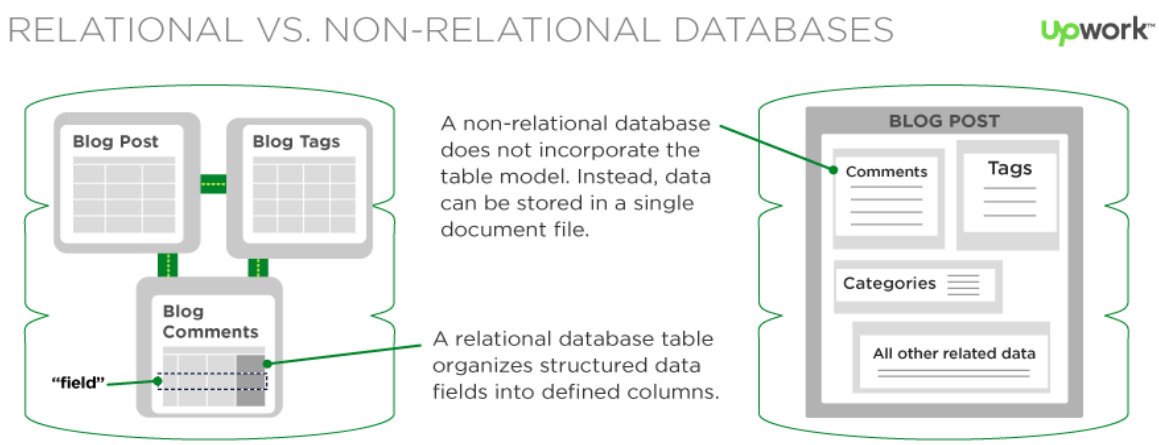
What is SQL?

SQL is a standardized language to interact with relational databases. It can execute query against a database and retrieve data from one or more tables. It can insert, update, delete and retrieve data and can perform many database related activities.

What is NoSQL?

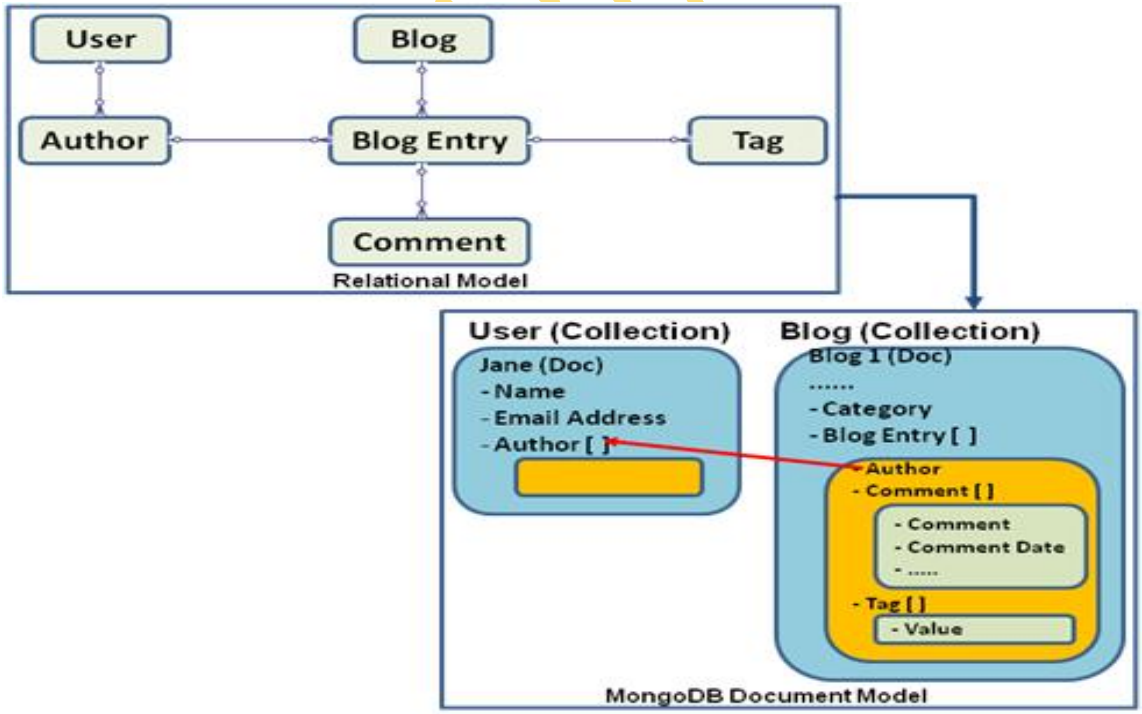
A NoSQL database provides a way to store and retrieve data that is in a non-tabular format. It is also referred to as NonSQL, Non-Relational or Not only SQL database.

NoSQL databases are used for managing large sets of data that are frequently updated in a distributed system. It eliminates the need for rigid schema associated with an RDBMS.



If you notice the above diagram for a Blogpost in RDBMS we need to write separate tables for Blog Post,Tags and Comments but where as in NoSQL all data can be written in one document.

The below digaram explains you the difference between a relational model and NoSQL(MongoDB) model.



So, in sum:

SQL deals with structured data and NoSQL deals with unstructured data.

SQL has a static schema and NoSQL has a dynamic Schema, which is why is very flexible.

Types of NoSQL databases:

1.Key-value pair database

2.Document Databases

3.Graph Databases

4.Wide column stores

1.Key-Value pair databases:

It uses a very simple data model that stores data in a pair of unique keys and the associated value. Commonly, it is used for storing time series data, click stream data and application logs.

Example of key value pairs: DynamoDB,Redis,and Aerospike.

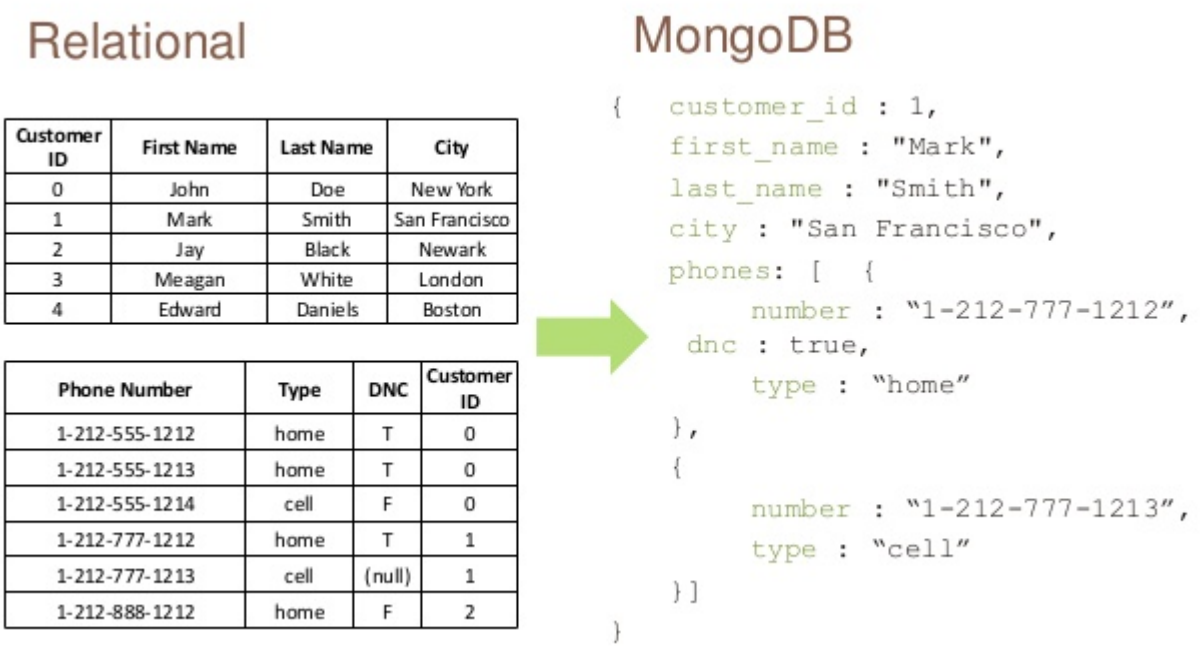
key	value
firstName	Bugs
lastName	Bunny
location	Earth

2.Document databases:

It stores data in a structure that represents a document-like format such as JSON, XML and YAML. Document databases are used for content management and monitoring applications.

Examples of document databases: MongoDB,CouchDB,MarkLogic ,and so on.

MongoDB schema written in JSON:



Customer ID	First Name	Last Name	City
0	John	Doe	New York
1	Mark	Smith	San Francisco
2	Jay	Black	Newark
3	Meagan	White	London
4	Edward	Daniels	Boston

Phone Number	Type	DNC	Customer ID
1-212-555-1212	home	T	0
1-212-555-1213	home	T	0
1-212-555-1214	cell	F	0
1-212-777-1212	home	T	1
1-212-777-1213	cell	(null)	1
1-212-888-1212	home	F	2

Tables in MongoDB are referred as collections.

You can see how different tables in RDBMS is written as a single schema in MongoDB.In this way NoSQL offers flexibility in writing a schema.

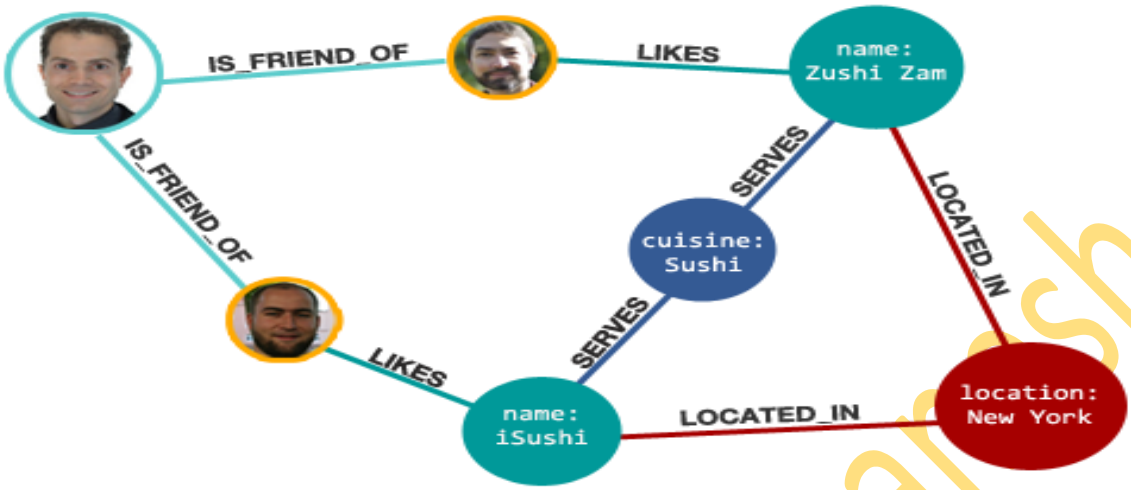
3. Graph Databases:

A graph database is a NoSQL database that uses graph structures and stores related data in nodes. It emphasizes on the connection between the data elements to accelerate query performance.

It is mainly used to store geographical data and recommendation search engines.

Examples of Graph databases: Allegrograph, IBM graph,Neo4J

Graph databases illustration:

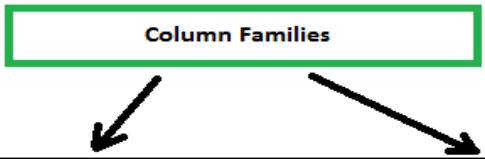


The relationships allow data in the nodes to be linked together directly, and in many cases retrieved with one operation.

4. Wide column databases:

This database stores data using a column oriented model. It is also called table-like database or column store database. It stores data in a table-like structure and it can store large number of columns.

Wide column databases are generally used for storing data related to internet search and other similar large-scale web applications



row key	personal data		professional data	
employee ID	Name	City	Title	Salary
1342	Joseph	New York City	Product Manager	$150,000
1543	Frank	Boston	Software Engineer	$160,000
7643	David	San Francisco	Data Scientist	$130,000

Examples: HBase,Cassandra,SimpleDB etc

In Wide column database, each column is stored in a separate file as depicted here.

Introducing DynamoDB:

What is DynamoDB?

DynamoDB is a fully-managed NoSQL database provided by AWS. Fully-managed means:

- It requires no database admin
- It requires no servers to manage and no levers to tune
- It requires no manual backup.

Everything is taken care of AWS

All you have to do is :

- Setup tables and,
- configure the level of **provision throughput** that each table should have

Provision throughput refers to the level of read and write capacity that you want AWS to reserve for the table. You're charged for the total amount of throughput that you configure for tables and storage space you used for the table.

DynamoDB is a key value store NoSQL. A key value store is a collection of items. You can look up to the data using **primary keys or indexes**.

It also takes care of fault tolerance by replicating the data in DynamoDB in **3 regions.**

DynamoDB components:

There are basically 3 components in a DynamoDB table: tables, items, and attributes.

1.Tables:

DynamoDB stores data in tables. This tables consists of items, which forms a group of attributes

2.Item:

A table consists of multiple items .An item is just like a record or row in RDBMS.

3.Attributes:

Each item consists of group of attributes. It is similar to 'fields' in RDBMS.

If you see the table 'People' here:

People

An each Item consists of several attributes like 'Person ID' , 'Last Name' ,'First Name' and 'Phone','Address' and 'Favorite Color'

As you can see attribute '**Address'** is not in **first Item** and **'Favorite Color'** is not in **second item.**This is what DynamoDB is famous for: **flexible schema**

Primary Key:

Primary key uniquely identifies each item in the table.There are two types of primary keys:

1.Partition key

2.Partition key and sort key

1.Partition key (also called as Hash key):

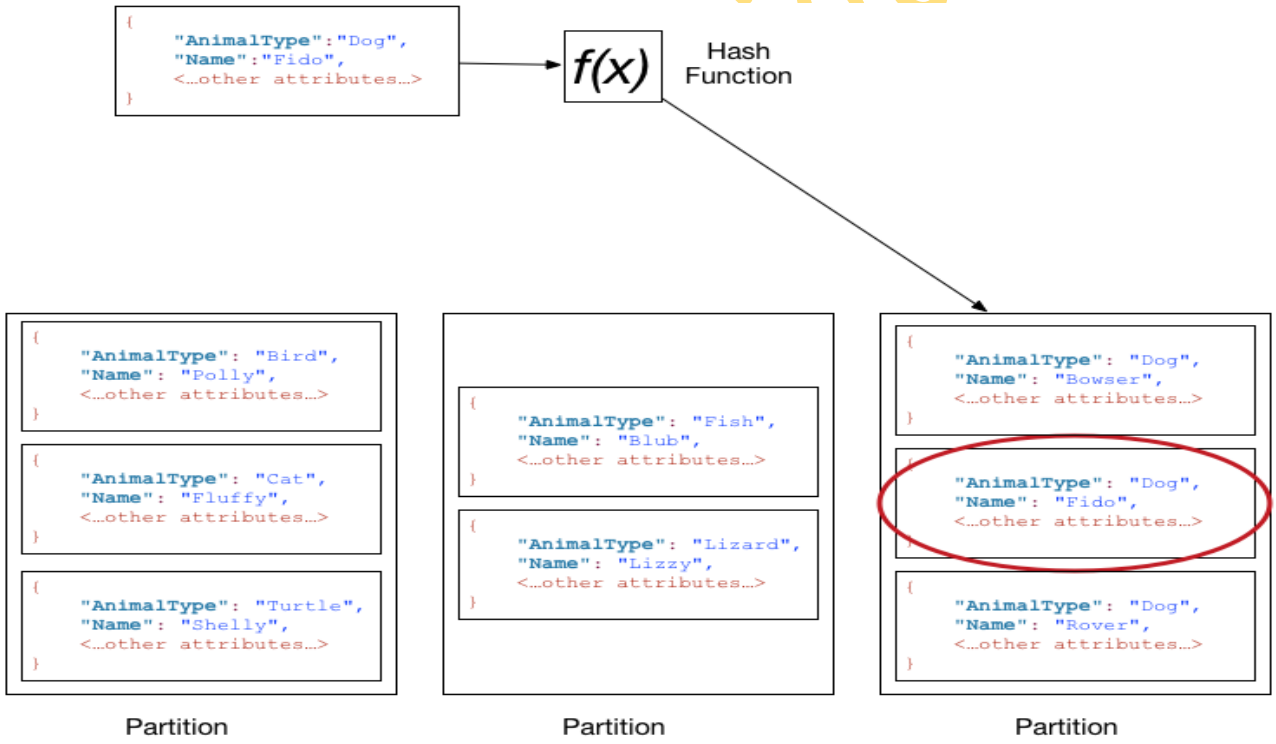
a. DynamoDB partitions data in sections based on partition key value.

b.Partition key value is used an input to an internal hash function,which determines in which partition the data is stored.

c.Which is why it is also called as hash key

d.No two items in a table can have same partition key

illustration:



AnimalType is the partition key and the value is '**dog**' which is the input to the hash function f(x) and this f(x) determines in which partition '**AnimalType:dog'** is stored. So, retrieval of data is easy.

2.Partition key and sort key:

a.It is composed of two attributes as its name says

b.It is also called as composite key

c.Just like the partition key,the composite key also uses partition key as input to internal hash function.This hash fucntion determines the place of the item in partition.

d.In partitions,the items are stored based on a sort key value.A sort key is also called as **range key**.No items can have same sort key but need not have an unique partition key.

Illustration:

```
{
Department_id: ”D91007”
Employee_id : “20001”
Department_name :”R & D”
Employee_name : “Sampath”
Joiningdate: “2016-04-04”
}
```

In the above table:

Partition key : Department_id

Sort key : Employee_id

As you can see,data retrival is fast with the use of both keys.

A table with both partition key and sort key can have more than one item with the same partition ey,but it must have a **different sort key.**

Here you can the department_id can be **same** for many employees but employment_id must be **unique**.

Indexes:

DynamoDb allows you to create secondary indexes(which are optional) on a table.It is an alternative way to query table data in addition to querying it using primary key.

DynamoDB supports two types of secondary indexes:

Local secondary index:

1. It has the same partition key but different sort key.

2. Can only be created when creating a table.

3. lets you query over a single partition, as specified by the partition key value in the query.

4. you can choose either eventual consistency or strong consistency.

5. For each partition key value, the total size of all indexed items must be 10 GB or less.

Global secondary index:

1. It has different partiton key and different sort key.

2. Can be created at table creation or later.

3. lets you query over the entire table, across all partitions.

4. support eventual consistency only

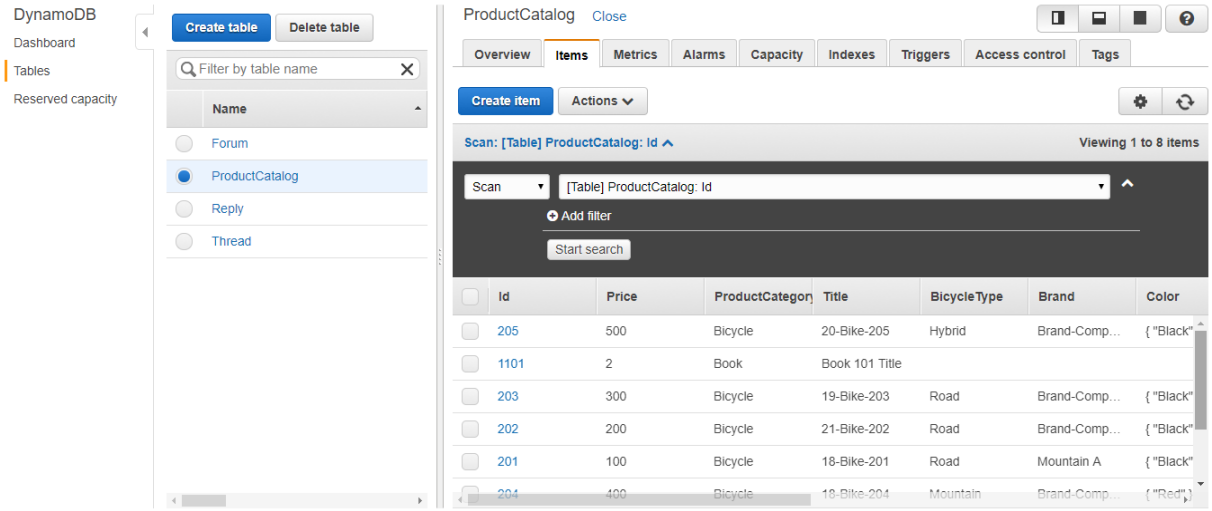
5. no size restrictions for global secondary indexes

You can create up to 5 global secondary indexes and up to 5 local secondary indexes per table.

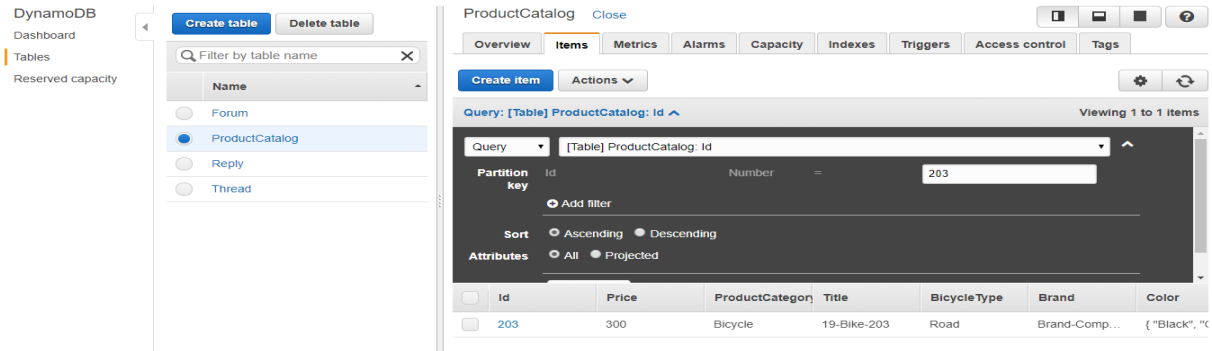
Query :

A query operation finds items in a table using only primary key attribute values.You must provide a partition attribute name and a distinct value to search for.

If you notice the DynamDB table ‘Product Catalog’,you can search the items of the Product Catalog using the primary key ‘id’ and provding value to it



And in this table I searched for the item 203 as shown below,the id is the partition key.



However,I can provide sort key value and use comparison operator to refine my search,but it's optional.

As you can see that query returned all the attributes in that item,however you can use **projection expression** to retrieve only few attributes.

By default,Query is eventually consistent but can be chnged.

Scan:

A scan operation performs every item in the table.By default,a scan returns all of the data attributes for every item;however,you can use Projection Expression parameter so that scan only returns some of the attributes but not all of them.

Query vs Scan: which one is best

A scan operation scans entire table,then it produces the result.For large tables,a scan opeartion can use up the provision throughput for a single operation resulting in latency.

So,query is more effcieint that scan.

Provisoned throughput:

DynamoDB allows us to set Read and Write Provision throughput.By default,AWS provisions 5 Read capacity and 5 write capacity units.

Read capacity:

1 read capacity = 1 strongly consistent read

1 read capacity = 2 eventual consistent reads

1 read operation process = ietm upto 4 KB in size

If an item is more than 4 KB,it requires additional write capacity

If an item is less than 1 KB,it still requires 1 read capacity units

Write capacity:

1 write capacity = 1 write operation upto 1 KB in size

If an item is larger than 1 KB,it requires additional write capacity units

If an item is less than 1 KB ,it still requires 1 write capacity

So, if you create a table(by default it comes with a throughput of 5 Read capcity and 5 Write capcity units)

Strongly consistent reads:

Since 1 Read capcity = 1 strongly consistent read of 4KB

So,5 read capacity units each of 4 KB = 5 x 1 x 4KB = 20 KB per second

Hence,one table can perform a strongly consistent read of upto 20 KB per second

Eventual consistent reads:

Since 1 read capacity = 2 eventual consistent reads

So, 5 Read capacity units of 4 KB = 5 x 2 x 4 KB = 40 KB per second

Hence,one table can perform an eventual consistent read of upto 40 KB per second

Write capacity:

Since,1 write capacity = 1 write operation upto 1 KB in size

5 write capacity units can process = 5 x 1 x 1KB = 5 KB per second

Examples:

1**. You have an application that requires reading 15 items per second.Each item is of 3 KB in size.If the application requires strongly consistent reads,what is the read capacity required to address this need?**

Sol: Since, 1 Read capcity = 1 strongly consistent read of 4KB

Here Item size = 3 KB, but still it requires 1 read capcity to process that read.

So item size is rounded-off to multiple of 4. So, item size = 4K

Read throughput for strongly consistent reads= (item size rounded-up in multiples of 4 KB)/4KB x number of items

=> Read throughput = 4/4 x 15 (Item size is 3 B but rounded up to 4)

= 1 x 15 = 15/1 = 15

The answer is 15 read capacity units.

2. You have an application that requires reading 80 items per second.Each item is 5 KB in size.If the application requires using strongly consistent read,what is the read capacity?

Sol:

Item size = 5KB. Now, Item size should be rounded to multiples of 4KB .

Since,item size is more than 4KB .So,nearest number is 8

Hence ,item size after rounding up = 8 KB

Since it is a **strongly consistent read**:

Read throughput = (item size rounded-up in multiples of 4 KB)/4KB x number of items

Therefore, for strongly consistent reads

Read throughput = 8 (item size rounded-up) /4 x 80 = 160

The answer is 160 read capacity units.

3. You have an application that requires reading 60 items per second .Each item is 3 KB size and an application requires eventual consistent read.What is the read capacity?

Sol:

item size = 3KB ,if rounded then item size = 4KB

therefore for **eventual consistency,**

Read throughput = [(item size rounded-up in multiples of 4 KB)/4KB x no.of items] /2

= (4/4 x 60) / 2 = 30

The answer is 30 read capacity units.

4. You have an application that writes 10 items per second with each item being 8 KB in size.How many write capacity units are required to address this need?

Ans:

1 write capacity = 1 write operation up to 1 KB in size

Hence write throughput = (Item size rounded in multiples of 1 KB)/ 1KB x number of items

So write throughput = 8/1 x 10 = 80

The answer is 80 write capacity units.

More examples:

5.You have an application that requires to read 5 items of 10 KB per second using

(i) What is the read throughput :

a) strong consistency b) eventual consistency

(ii) What is the write capacity?

What is the read throughput

Ans: Item size = 10 KB ,if rounded up to nearest multiples of 4

Then, item size = 12 KB

(i) (a) read capacity for strongly consistent read = 12/4 x 5 = 15 read capacity units

so read capacity for strongly consistent = 15 units

(b) read capacity for eventual consistent read = (12/4 x 5) / 2 = 7.5 read capacity but read capacity units are always integers

So read capacity for eventual consistent= 8 units

(ii) since 1 write capacity unit = 1 write operation upto 1 KB

Therefore, write throughput = 10(rounded upto nearest multiples of 1 KB)/1 x 5 = 50

So, write capacity = 50 units

6.You have an application that requires to write 12 items of 100 KB per item each second.What is the write throughput?

Ans: **since 1 write capacity unit = 1 write operation upto 1 KB**

Therefore,Write capacity = 100(rounded to neartest multiples of 1 KB)/1 x 12

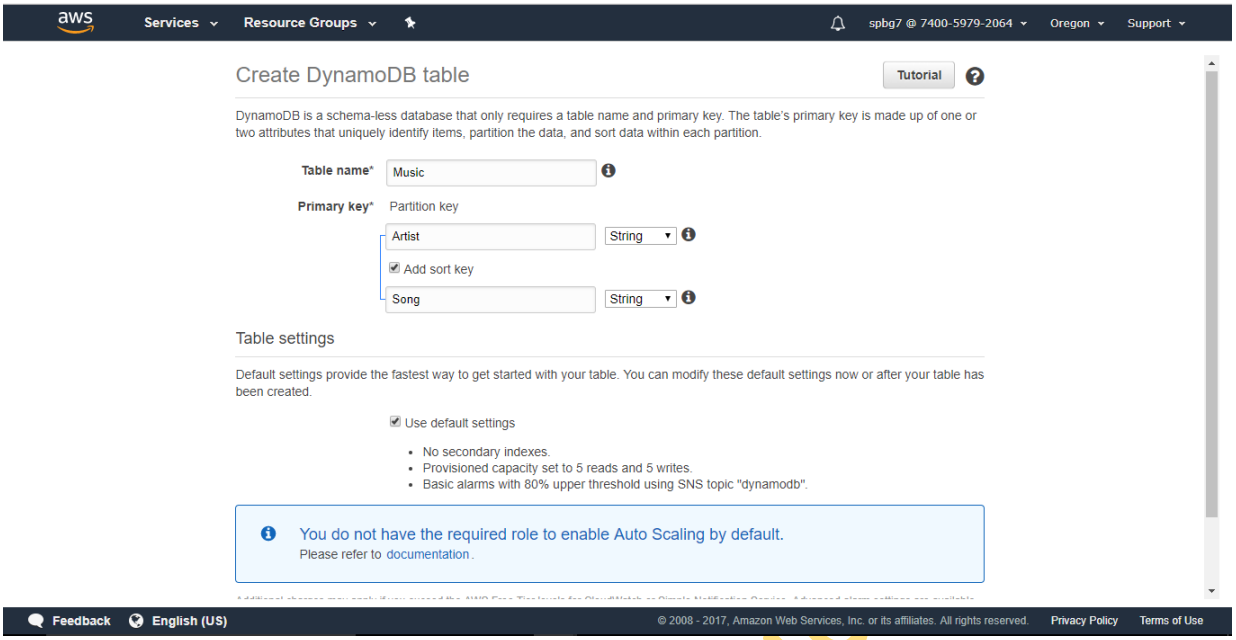
So,write capacity = 1200 units

400 HTTP Status code – ProvisionedThroughputExceededException

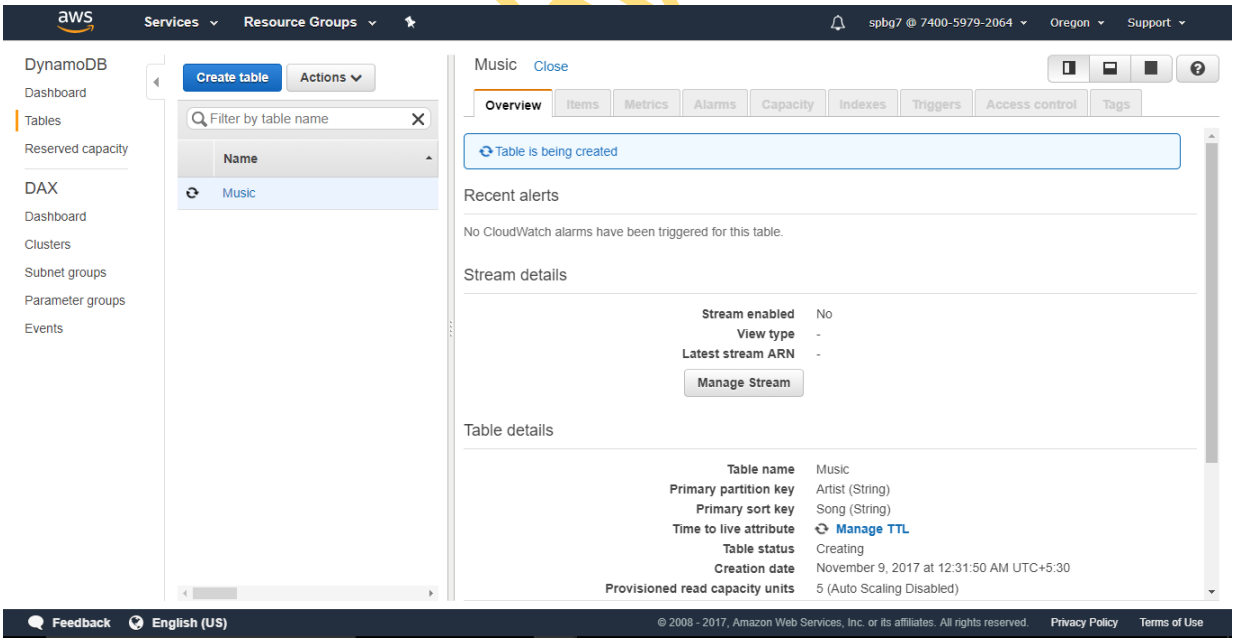
You'll get this error message when you exceed your maximum allowed provisoned throughput for a table or for one or more GSI

Lab 1 :Intro to DynamoDb

Step:1 Create a DynamoDB table named 'Music' with primary key 'Artist' and sort key 'Song' and select 'string' for both keys and click Create.



The table will be created in less than a minute.

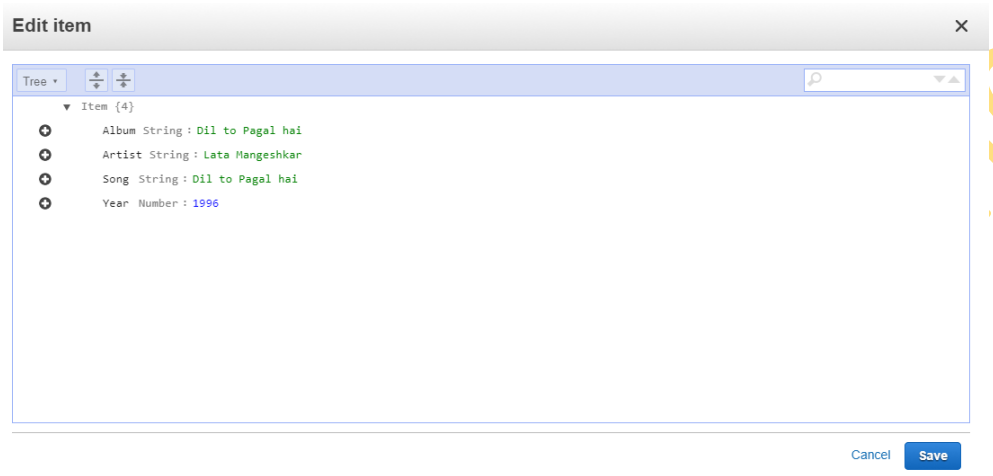


Step 2: Add data:

We have a table named 'Music' now we'll add **items.**Each table consists of multiple items. **Items** are collections of individual records called **'attributes'.**

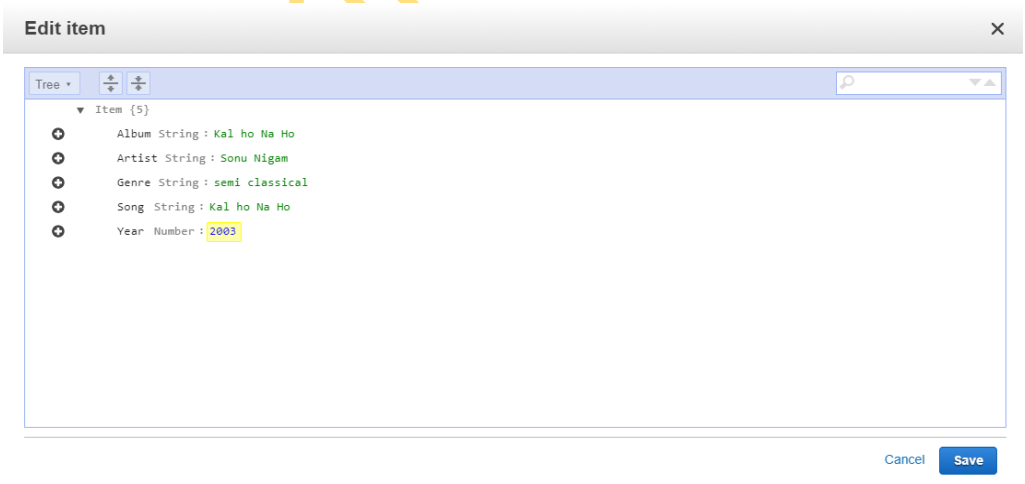
Now click on items tab and click create item.

You will already notice Artist and Song value.Now fill the data as shown in below screenshot.To append **additional data** as shown below click on Append and keep 'string' as the setting and 'number'for the year and click on **save.**

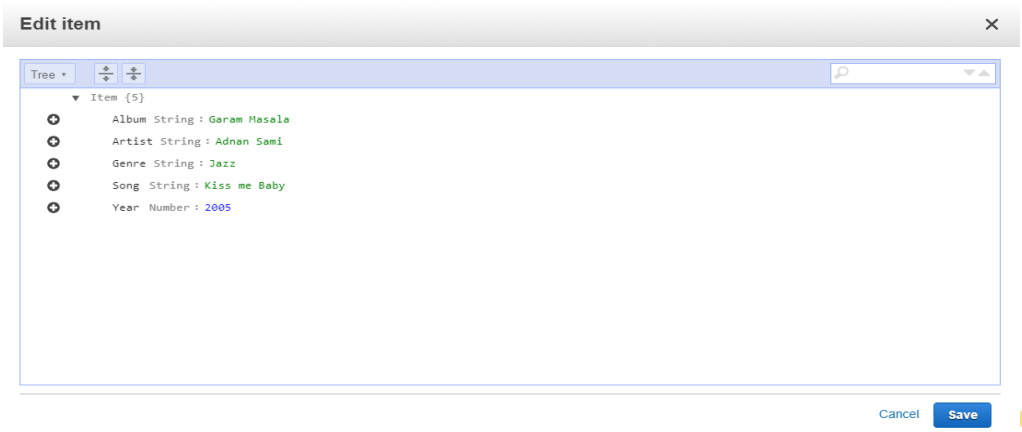


Now add three more items as shown:

Item 2:



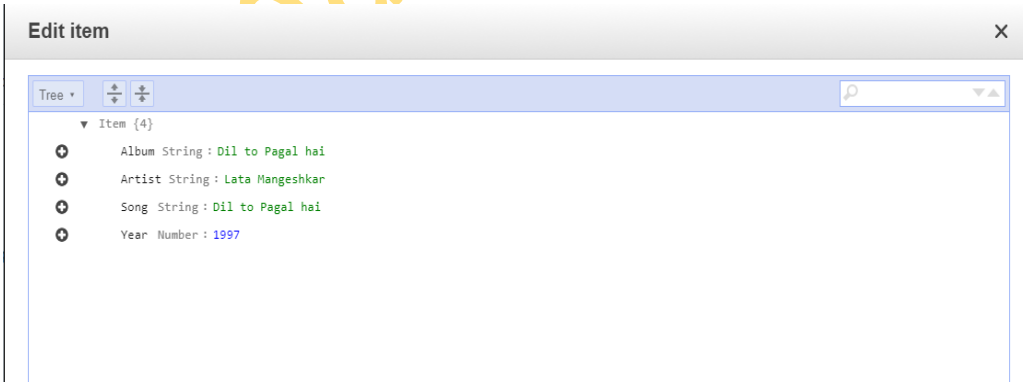
Item 3:



Item 4: New attribute 'Lengthseconds' with data type Number is created.This is the advanatge of haiving a schemaless database design.

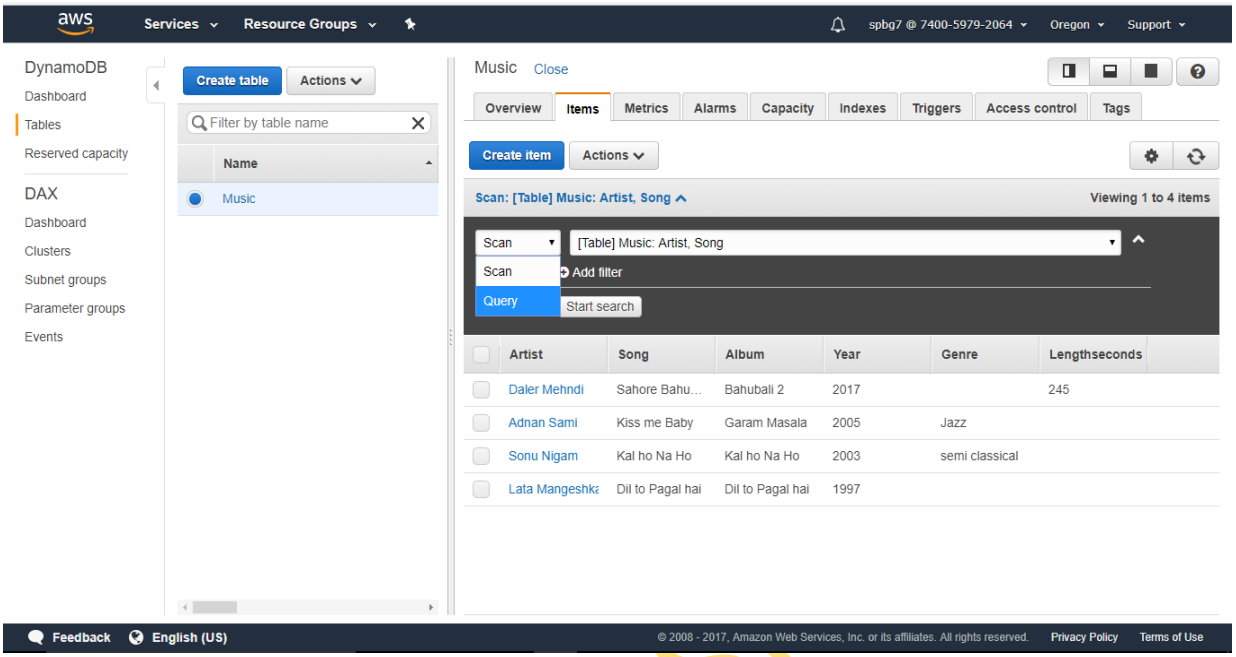
Step 3: Now modify the data

Modify the table Lata Mangeshkar and change the year from 1996 to 1997



Step 4: Now query the table

Now click on the scan below the create item tab and change it to ‘query’



Now fields for **partiton key and sort key** will appear in that enter the details:

Partition key : Sonu Nigam

Sort key : Kal ho Na ho

And click start search the item you asked for is retreived.

Alternatively, you can **scan** the element too.Now change the mode to scan and you will see this tab

Now for enter the attribute type ‘year’

Change the string to ‘number’ and enter the value as ‘2017’

Click start ‘search’ and You will get the output.

Step5 :Delete the table

Now delete the table by clicking on **Action** menu beside Create table and click **Delete table**

Conclusion: So,you have ab idea about CRUD operations in DynamoDB table

C -Create U-Update

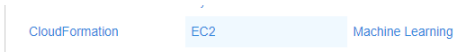
R- Read D-Delete

Lab 2 – Creating DynamoDB table using AWS SDK(PHP)

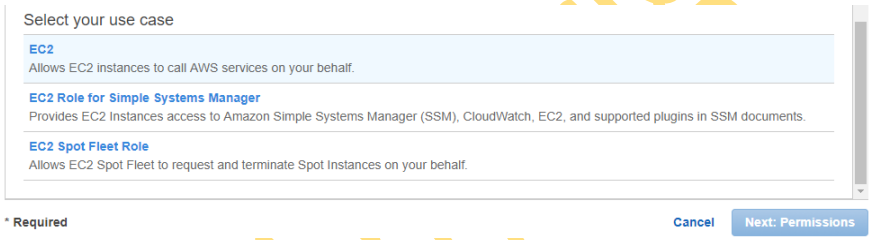
Step 1: Create an IAM role

Login to AWS console and navigate to IAM and create a role and assign DynamoDB fullaccesspolicy to the role.

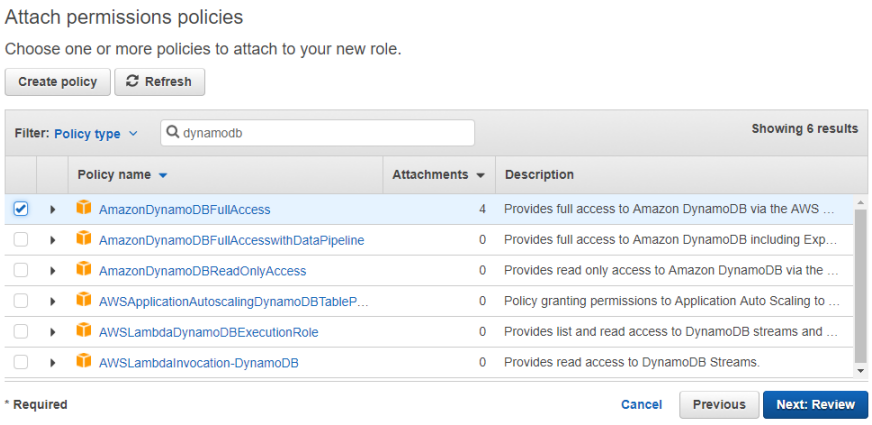
Click on Roles in IAM and click on Create Role and chose the service as EC2



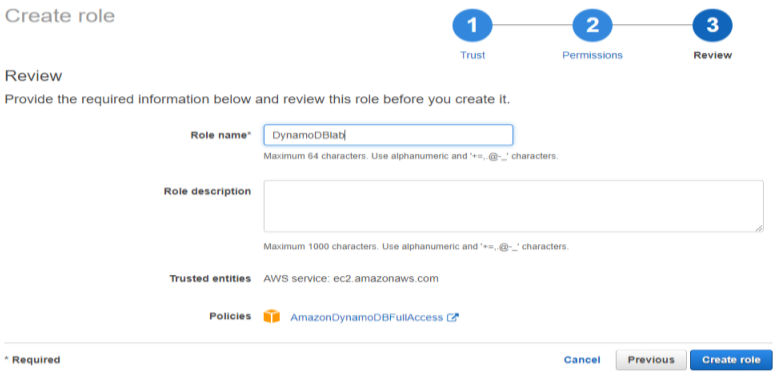
And select your usecase as EC2 and click Next permissions



Now in the permissions search ‘dynamoDb’ and attach AmazonDynamoDBFullAccess policy

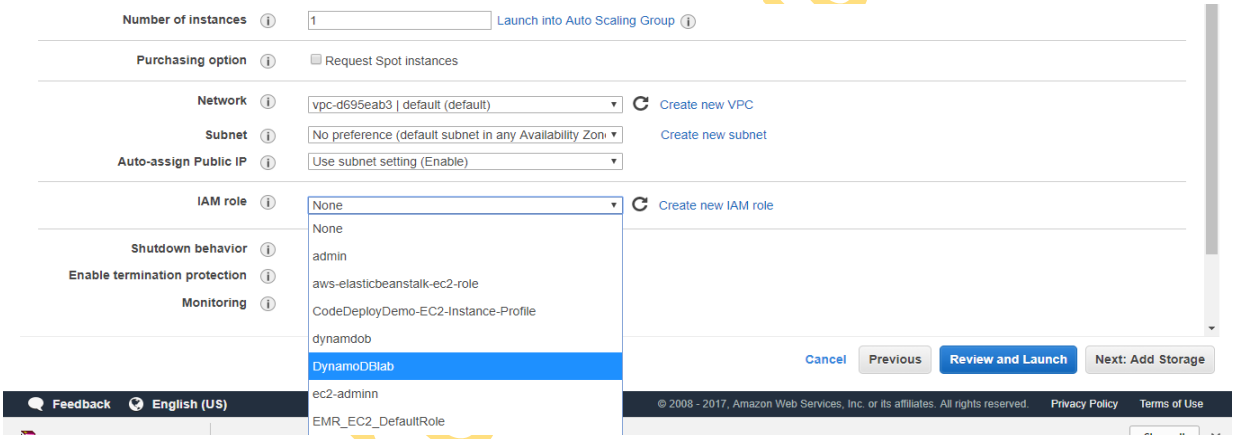


Now enter the role name and click ‘Create Role’

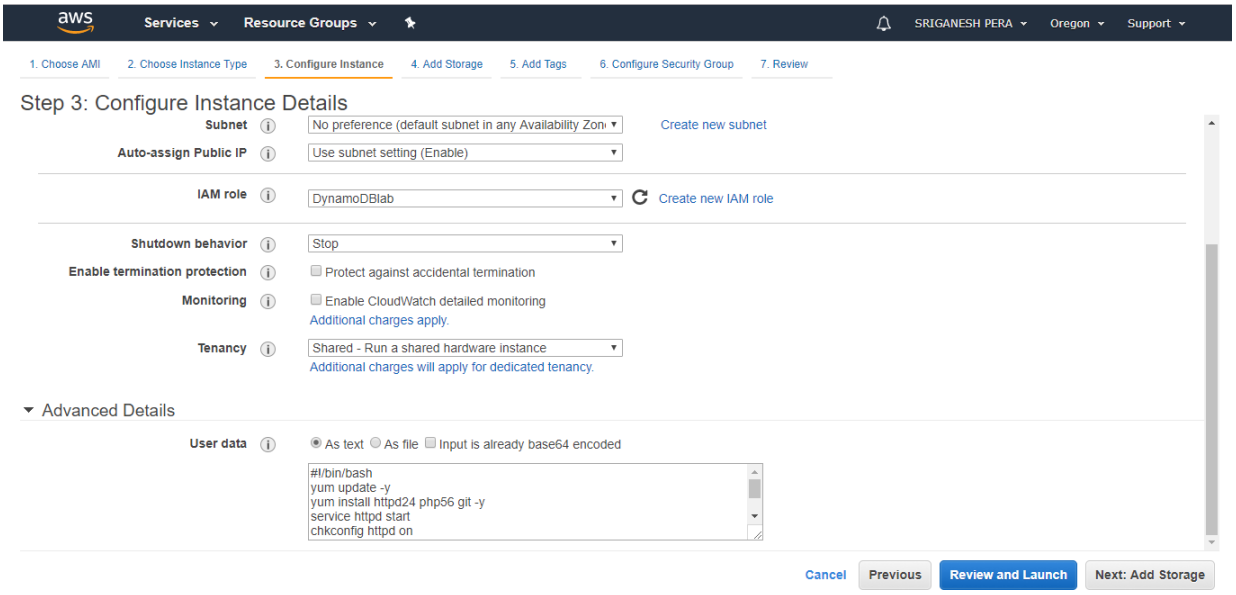


Step 2: Launch an EC2 instance which uses IAM role and bash script(installs LAMP and stores createtables.php and uploaddata.php)

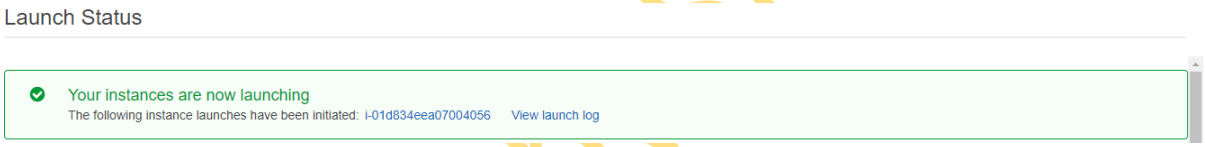
In configure instance details chose IAM role as the one we create now



And click on Advanced details underneath Tenancy in the same page and paste the info given in .txt file



Now click on Next:Add Storage ,Next:Add tags and Next:Add security and click on Configure security group and enable HTTP on port 80.Then launch the instance



Step 3: SSH into the instance

Now connect to your instance using putty or ubuntu on VMWare

```
spbg7@ubuntu:~/Downloads$ chmod 400 a1.pem
spbg7@ubuntu:~/Downloads$ ssh -i "a1.pem" ec2-user@ec2-52-34-92-161.us-west-2.co
mpute.amazonaws.com
The authenticity of host 'ec2-52-34-92-161.us-west-2.compute.amazonaws.com (52.3
4.92.161)' can't be established.
ECDSA key fingerprint is SHA256:iCimt7LtqcTQbMx6bhwUnQBqo7K5PwQDQ5VXJDTrzuI.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'ec2-52-34-92-161.us-west-2.compute.amazonaws.com,52.
34.92.161' (ECDSA) to the list of known hosts.

       __|  __|_  )
       _|  (     /   Amazon Linux AMI
      ___|\___|___|

https://aws.amazon.com/amazon-linux-ami/2017.09-release-notes/
[ec2-user@ip-172-31-20-66 ~]$
```

Now as you can see in /var/www/html/ I have two files one is test.php and other one is dynamodb

```
[ec2-user@ip-172-31-20-66 ~]$ cd /var/www/html/
[ec2-user@ip-172-31-20-66 html]$ ls
dynamodb  test.php
[ec2-user@ip-172-31-20-66 html]$
```

Now install and run php composer by pasting the following links on Command Line

```
Install composer : curl -sS https://getcomposer.org/installer | php


Run Composer: php composer.phar require aws/aws-sdk-php
```

```
[ec2-user@ip-172-31-20-66 html]$ sudo su
[root@ip-172-31-20-66 html]# curl -sS https://getcomposer.org/installer | php
All settings correct for using Composer
Downloading...
```

```
[root@ip-172-31-20-66 html]# php composer.phar require aws/aws-sdk-php
Do not run Composer as root/super user! See https://getcomposer.org/root for det
ails
```

As you can see composer is installed and running

Step 4: Edit the DynamoDb files

Now goto dynamdb directory using cd command as shown and you will find 3 files like this:

```
[root@ip-172-31-20-66 html]# ls
composer.json  composer.lock  composer.phar  dynamodb  test.php  vendor
[root@ip-172-31-20-66 html]# cd dynamodb
[root@ip-172-31-20-66 dynamodb]# ls
createtables.php  README.md  uploaddata.php
[root@ip-172-31-20-66 dynamodb]# nano createtables.php
[root@ip-172-31-20-66 dynamodb]#
```

As you can see from the screenshot there are 3 .php files:

1. createtables.php : php code for creating a table

2. README.md : Introduction file

3. uploaddata.php : php code for uploading data into those tables as created from createtables.php

Now edit createtables.php by using nano editior by typing command nano createtables.php as shown above and it will take you to that file

Now edit the region as per your requirement.

```
// Find out what the issues are:
ini_set('display_errors',1);
ini_set('display_startup_errors',1);
error_reporting(-1);

require '/var/www/html/vendor/autoload.php';
use Aws\DynamoDb\DynamoDbClient;

$client = DynamoDbClient::factory(array(
    'region' => 'eu-west-2',  // replace with your desired region visit htt$
    'version' => '2012-08-10' // Now needs a version
));
```

After editing the php file save and exit from the file by typing ctrl o and ctrl x

Now edit the same for uploaddata.php by typing nano uploaddata.php.Make sure that regions in createtables.php and uploaddata.php reflects the same region.

Step 5: Run those files using browser

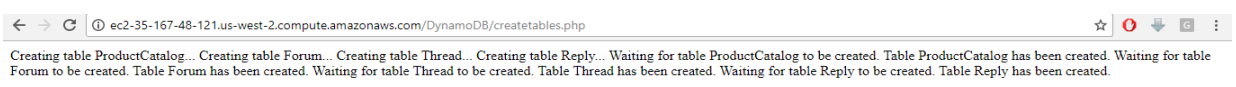
Now copy the DNS of your EC2 instance and paste it in a different browser window and navigate the path of DynamoDB as shown:

http://ec2-35-167-48-121.us-west-2.compute.amazonaws.com/DynamoDB/createtables.php

in the above link DNS name should be replaced with yours but the path ec2-name/DynamoDB/createtables.php should be kep the same way

and hit Enter.

You will see that tables are created as that script gets executed.

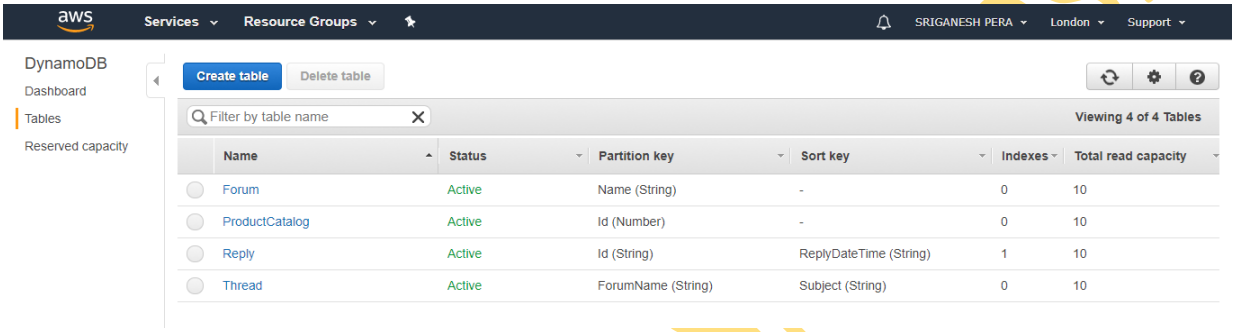


Now run the uploaddata.php script the same way as shown:

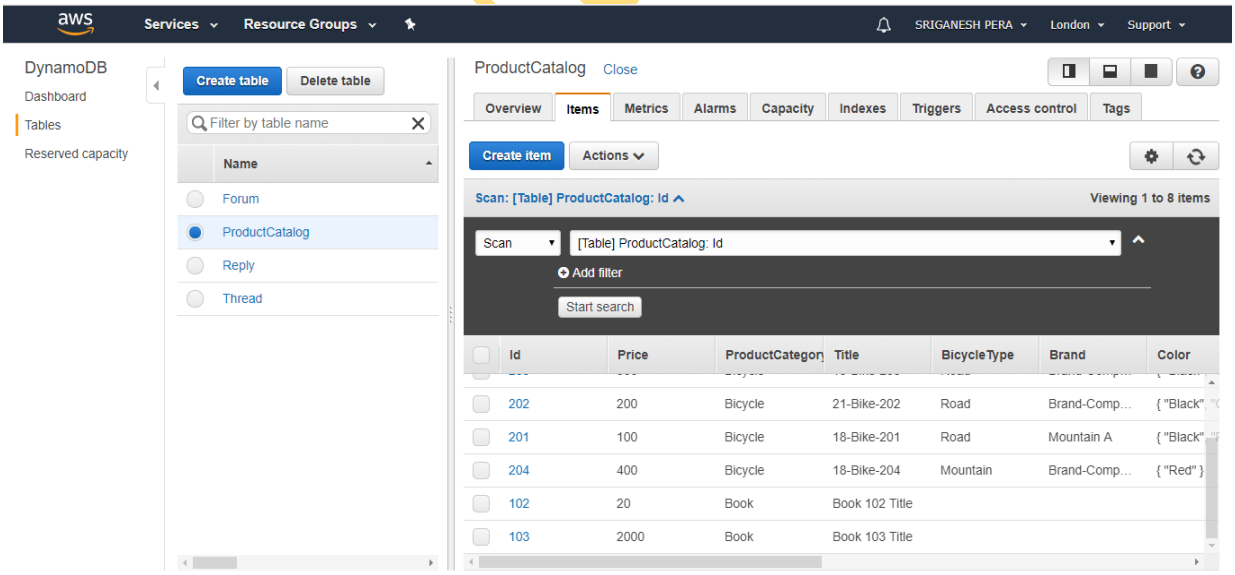
Now change the region to London and you will see your table created with data uploaded in it.

Mindcheck: Why London region? Why not US region?

As you can see I've 4 tables created in London Region.



Feel free to check in the items of the tables,and try to create global indexes to REPLY table and also play on with Capacity Tab,Metrics Tab and Access Control tab.Also try to know the difference between Scan and Query.



Step 6: Terminate the instances

After you've played around on DynamoDb delete the instance we have created.

~~~~~~~~~~~~~~~~~~~~~~~~~ End of Lab sessions ~~~~~~~~~~~~~~~~~~~~~~~~~
~~~~~~~~~~~~~~~~~~~~~~~~~