

# CSP 554 Project Experiments and Outputs

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## Apache Cassandra:

For YCSB benchmarking and implementation, we start by installing Cassandra and YCSB on the EMR cluster by following the command below,

## Step 1:

## Install Cassandra :

## Wget

```
https://archive.apache.org/dist/cassandra/3.11.2/apache-cassandra-3.11.2-bin.tar.gz
tar -xzvf apache-cassandra-3.11.2-bin.tar.gz
```

```
Last login: Fri Nov 18 18:15:13 on ttys002
(base) hrishikashelar@hrishikashelar-MacBook-Air ~ % ssh -i /Users/hrishikashelar/Desktop/atharva/emr-key-pair.pem hadoop@ec2-100-24-106-169.compute-1.amazonaws.com
The authenticity of host 'ec2-100-24-106-169.compute-1.amazonaws.com (100.24.106.169)' can't be established.
ED25519 key fingerprint is SHA256:DfJhCoauRr-nSurDae7fdEUgvEE0NJKNFWP9rM+wYBm.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'ec2-100-24-106-169.compute-1.amazonaws.com' (ED25519) to the list of known hosts.

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 _\ ( _| /   Amazon Linux 2 AMI
 ___\|\_||_--|_

https://aws.amazon.com/amazon-linux-2/
22 package(s) needed for security, out of 32 available
Run "sudo yum update" to apply all updates.

EEEEEEEEEEEEEEEEEE MMMMMMM MBBBBBBBBB RRRRRRRRRRRRRRR
E:::::::E M:::::::M M:::::::M R:::::::::::R
EE:::::EEEEE EEEEEE M:::::::M M:::::::M R:::::RRRRRRR:::R
E:::::E EEEEEE M:::::::M M:::::::M R:::R R:::R
E:::::E M:::::::M M:::M:::M M:::::::M R:::::RRRRRRR:::R
E:::::E M:::::::E M:::::::M M:::::::M M:::::::M R:::::::::::RR
E:::::E EEEEEE M:::::::M M:::::::M M:::::::M R:::::RRRRRRR:::R
E:::::E M:::::::M M:::M:::M M:::::::M R:::R R:::R
E:::::E EEEEEE M:::::::M MMMM M:::::::M R:::R R:::R
EE:::::EEEEE EEEEEE M:::::::M M:::::::M R:::::::R R:::::R
E:::::E M:::::::M M:::::::M RR:::R R:::::::R
EEEEEEEEEEEEEEEEE MMMMMMM RRRRRRR RRRRRR

[hadoop@ip-172-31-12-169 ~]$ wget https://archive.apache.org/dist/cassandra/3.11.2/apache-cassandra-3.11.2-bin.tar.gz
--2022-12-04 20:32:02-- https://archive.apache.org/dist/cassandra/3.11.2/apache-cassandra-3.11.2-bin.tar.gz
Resolving archive.apache.org (archive.apache.org)... 138.201.131.134, 2a01:4f8:172:2ec5::2
Connecting to archive.apache.org (archive.apache.org)|138.201.131.134|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 38436262 (37M) [application/x-gzip]
Saving to: 'apache-cassandra-3.11.2-bin.tar.gz'

100%[=====>] 38,436,262 20.0MB/s in 1.8s

2022-12-04 20:32:04 (20.0 MB/s) - 'apache-cassandra-3.11.2-bin.tar.gz' saved [38436262/38436262]

[hadoop@ip-172-31-12-169 ~]$ tar -xvf apache-cassandra-3.11.2-bin.tar.gz
apache-cassandra-3.11.2/bin/
apache-cassandra-3.11.2/conf/
apache-cassandra-3.11.2/conf/triggers/
apache-cassandra-3.11.2/doc/
apache-cassandra-3.11.2/doc/cql3/
apache-cassandra-3.11.2/doc/html/
apache-cassandra-3.11.2/doc/html/_images/
apache-cassandra-3.11.2/doc/html/_sources/
apache-cassandra-3.11.2/doc/html/_sources/architecture/
apache-cassandra-3.11.2/doc/html/_sources/configuration/
apache-cassandra-3.11.2/doc/html/_sources/cql/
apache-cassandra-3.11.2/doc/html/_sources/data_modeling/
apache-cassandra-3.11.2/doc/html/_sources/development/
```

## Install YCSB:

```
curl -O --location
https://github.com/brianfrankcooper/YCSB/releases/download/0.17.0/ycsb
-0.17.0.tar.gz
tar xfvz ycsb-0.17.0.tar.gz
cd ycsb-0.17.0

apache-cassandra-3.11.2/bin/sstablescrub
apache-cassandra-3.11.2/bin/sstablescrub.bat
apache-cassandra-3.11.2/bin/sstableupgrade
apache-cassandra-3.11.2/bin/sstableupgrade.bat
apache-cassandra-3.11.2/bin/sstableutil
apache-cassandra-3.11.2/bin/sstableutil.bat
apache-cassandra-3.11.2/bin/sstableverify
apache-cassandra-3.11.2/bin/sstableverify.bat
apache-cassandra-3.11.2/bin/stop-server
apache-cassandra-3.11.2/bin/stop-server.bat
apache-cassandra-3.11.2/bin/stop-server.ps1
apache-cassandra-3.11.2/tools/bin/cassandra-stress
apache-cassandra-3.11.2/tools/bin/cassandra-stressd
apache-cassandra-3.11.2/tools/bin/cassandra.in.bat
apache-cassandra-3.11.2/tools/bin/cassandra.in.sh
apache-cassandra-3.11.2/tools/bin/compactionstress
apache-cassandra-3.11.2/tools/bin/sstabledump
apache-cassandra-3.11.2/tools/bin/sstableload
apache-cassandra-3.11.2/tools/bin/sstableexpiredblocks
apache-cassandra-3.11.2/tools/bin/sstableexpiredblocks.bat
apache-cassandra-3.11.2/tools/bin/sstablelevelreset
apache-cassandra-3.11.2/tools/bin/sstablelevelreset.bat
apache-cassandra-3.11.2/tools/bin/sstablemetadata
apache-cassandra-3.11.2/tools/bin/sstablemetadata.bat
apache-cassandra-3.11.2/tools/bin/sstableofflinelvel
apache-cassandra-3.11.2/tools/bin/sstableofflinelvel.bat
apache-cassandra-3.11.2/tools/bin/sstablerepaireset
apache-cassandra-3.11.2/tools/bin/sstablerepaireset.bat
apache-cassandra-3.11.2/tools/bin/sstablesplit
apache-cassandra-3.11.2/tools/bin/sstablesplit.bat
[hadoop01ip-172-31-12-168 ~]$ curl -O --location https://github.com/brianfrankcooper/YCSB/releases/download/0.17.0/ycsb-0.17.0.tar.gz
Warning: The file name argument '--location' looks like a flag.
% Total % Received % Xferd Average Speed Time Time Current
          Dload Upload Total Spent Left Speed
0     0    0    0    0    0   0:--:--:--:--:--:--:--:--:--:--:0
[hadoop01ip-172-31-12-168 ~]$ curl -O --location https://github.com/brianfrankcooper/YCSB/releases/download/0.17.0/ycsb-0.17.0.tar.gz
% Total % Received % Xferd Average Speed Time Time Current
          Dload Upload Total Spent Left Speed
100  675M 100  675M  0    0 62.8M      0:00:10 0:00:10 68.8M
[hadoop01ip-172-31-12-168 ~]$ tar xfvz ycsb-0.17.0.tar.gz
ycsb-0.17.0/NOTICE.txt
ycsb-0.17.0/LICENSE.txt
ycsb-0.17.0/bin/ycsb.sh
ycsb-0.17.0/bin/ycsb.bat
ycsb-0.17.0/bin/ycsb
ycsb-0.17.0/bin/bindings.properties
ycsb-0.17.0/workloads/
ycsb-0.17.0/workloads/workload
ycsb-0.17.0/workloads/workloadb
ycsb-0.17.0/workloads/workloadc
ycsb-0.17.0/workloads/workload_template
ycsb-0.17.0/workloads/workloadd
ycsb-0.17.0/workloads/tsworkload_template
ycsb-0.17.0/workloads/workloada
```

## Step 2:

Create a keyspace and table in Cassandra. We first start Cassandra.

```
apache-cassandra-3.11.2/bin/cassandra &
```

Open another terminal and start CQLSH query interpreter and create a keyspace ycsb and table,

```
apache-cassandra-3.11.2/bin/cqlsh
```

```
CREATE KEYSPACE ycsb WITH REPLICATION =
{'class':'SimpleStrategy','replication_factor': 3 };
```

```
USE ycsb;
```

```
CREATE TABLE ycsb.usertable(y_id VARCHAR, field0 VARCHAR, field1  
VARCHAR,  
field2 VARCHAR, field3 VARCHAR, field4 VARCHAR, field5 VARCHAR, field6  
VARCHAR, field7 VARCHAR, field8 VARCHAR, field9 VARCHAR, PRIMARY  
KEY(y_id));
```

```
Last login: Sun Dec 4 14:21:29 on ttys000
(harishtkashelar@Harishikashelar-MacBook-Air ~ % ssh -i /Users/hrishikashelar/Desktop/atharva/emr-key-pair.pem hadoop@ec2-100-24-106-169.compute-1.amazonaws.com
Last login: Sun Dec 4 20:46:59 2022

_ _| ( --|_ )
_ _| ( --|_ ) Amazon Linux 2 AMI
_ _\|_--|_ |

https://aws.amazon.com/amazon-linux-2/
22 package(s) needed for security, out of 32 available
Run "sudo yum update" to apply all updates.

EEEEEEEEEEEEEEEEEE MMMMMMMMM RRRRRRRRRRRRRRRR
E:::::::-----:E M:::----:M M::::----:M R::::----:R
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E:::::E EEEE M:::----:M M::::----:M RR:::R R:::R
E:::E M:::----:M M:::----:M R:::R R:::R
E:::::EEEEE EEEE M:::----:M M::::----:M R::::RRRRR:----:R
E:::::::-----:E M:::----:M M:::----:M M::::----:M R::::----:RR
E:::::EEEEE EEEE M:::----:M M::::----:M R::::----:RR
E:::::EEEEE EEEE M:::----:M M::::----:M R::::RRRRR:----:R
E:::E M:::----:M M:::----:M M::::----:M R::::R R::::R
E:::::E EEEE M:::----:M MMMM M::::----:M R::::R R::::R
E:::::::-----:E M:::----:M M::::----:M R::::R R::::R
E:::::-----:E M:::----:M M::::----:M RR:::R R:::R
EEEEEEEEEEEEEEEEE MMMMMMMMM MMMMMMM RRRRRRRR RRRRRR

[hadoop@ip-172-31-12-169 ~]$ apache-cassandra-3.11.2/bin/cqlsh
Connected to Test Cluster at 127.0.0.1:9042.
[cqlsh 5.0.1 | Cassandra 3.11.2 | CQL spec 3.4.4 | Native protocol v4]
Use HELP for help.
[cqlsh] CREATE KEYSPACE ycsb WITH REPLICATION = {'class':'SimpleStrategy','replication_factor':3};
[cqlsh] USE ycsb;
[cqlsh:ycsb]> CREATE TABLE ycsb.usertable(y_id VARCHAR, field0 VARCHAR, field1 VARCHAR, field2 VARCHAR, field3 VARCHAR, field4 VARCHAR, field5 VARCHAR, field6 VARCHAR, field7 VARCHAR, field8 VARCHAR, field9 VARCHAR,PRIMARY KEY(y_id));
[cqlsh:ycsb]
```

Inside ycsb, create a folder called large.dat and mention the record count. The record count is our parameter for ycsb and we will use this for both workloads.

*recordcount = 100000 (for 100k)*  
*recordcount = 1000000 (for 1000k)*

### **Step 3:**

In this step, we will be working with 100k data. Load and run all the workloads (a, b and c) and store the results in a file.

## Workload A:

```
./bin/ycsb load cassandra-cql -p hosts="127.0.0.1" -P workloads/workloada -P large.dat -s > load.dat
```

```
./bin/ycsb run cassandra-cql -p hosts="127.0.0.1" -P  
workloads/workloada -P large.dat -s -threads 10 -target 100 >  
transactions.dat
```

**Workload B:**

```
./bin/ycsb load cassandra-cql -p hosts="127.0.0.1" -P  
workloads/workloadb -P large.dat -s > loadb.dat
```

```
./bin/ycsb run cassandra-cql -p hosts="127.0.0.1" -P  
workloads/workloadb -P large.dat -s -threads 10 -target 100 >  
transactions_b.dat
```

**Workload C:**

```
./bin/ycsb load cassandra-cql -p hosts="127.0.0.1" -P  
workloads/workloadc -P large.dat -s > loadc.dat
```

```
./bin/ycsb run cassandra-cql -p hosts="127.0.0.1" -P  
workloads/workloadc -P large.dat -s -threads 10 -target 100 >  
transactions_c.dat
```





## Following are the output files:

Workload A:

GNU nano 2.9.8

```
[OVERALL], RunTime(ms), 73210
[OVERALL], Throughput(ops/sec), 1365.9336156262805
[TOTAL_GCS_PS_Scavenge], Count, 51
[TOTAL_GC_TIME_PS_Scavenge], Time(ms), 175
[TOTAL_GC_TIME_%_PS_Scavenge], Time(%), 0.2390383827345991
[TOTAL_GCS_PS_MarkSweep], Count, 0
[TOTAL_GC_TIME_PS_MarkSweep], Time(ms), 0
[TOTAL_GC_TIME_%_PS_MarkSweep], Time(%), 0.0
[TOTAL_GCs], Count, 51
[TOTAL_GC_TIMEI], Time(ms), 175
[TOTAL_GC_TIME_%], Time(%), 0.2390383827345991
[CLEANUP], Operations, 1
[CLEANUP], AverageLatency(us), 2251776.0
[CLEANUP], MinLatency(us), 2250752
[CLEANUP], MaxLatency(us), 2252799
[CLEANUP], 95thPercentileLatency(us), 2252799
[CLEANUP], 99thPercentileLatency(us), 2252799
[INSERT], Operations, 100000
[INSERT], AverageLatency(us), 687.08964
[INSERT], MinLatency(us), 292
[INSERT], MaxLatency(us), 163455
[INSERT], 95thPercentileLatency(us), 1103
[INSERT], 99thPercentileLatency(us), 2763
[INSERT], Return=OK, 100000
```

```
[OVERALL], RunTime(ms), 14672
[OVERALL], Throughput(ops/sec), 68.15703380588877
[TOTAL_GCS_PS_Scavenge], Count, 1
[TOTAL_GC_TIME_PS_Scavenge], Time(ms), 25
[TOTAL_GC_TIME_%_PS_Scavenge], Time(%), 0.17039258451472192
[TOTAL_GCS_PS_MarkSweep], Count, 0
[TOTAL_GC_TIME_PS_MarkSweep], Time(ms), 0
[TOTAL_GC_TIME_%_PS_MarkSweep], Time(%), 0.0
[TOTAL_GCs], Count, 1
[TOTAL_GC_TIMEI], Time(ms), 25
[TOTAL_GC_TIME_%], Time(%), 0.17039258451472192
[READ], Operations, 470
[READ], AverageLatency(us), 4431.2851063829785
[READ], MinLatency(us), 850
[READ], MaxLatency(us), 133887
[READ], 95thPercentileLatency(us), 9119
[READ], 99thPercentileLatency(us), 34079
[READ], Return=OK, 470
[CLEANUP], Operations, 10
[CLEANUP], AverageLatency(us), 224566.2
[CLEANUP], MinLatency(us), 2
[CLEANUP], MaxLatency(us), 2246655
[CLEANUP], 95thPercentileLatency(us), 2246655
[CLEANUP], 99thPercentileLatency(us), 2246655
[UPDATE], Operations, 530
[UPDATE], AverageLatency(us), 3484.567924528302
[UPDATE], MinLatency(us), 696
[UPDATE], MaxLatency(us), 122495
[UPDATE], 95thPercentileLatency(us), 8351
[UPDATE], 99thPercentileLatency(us), 41087
[UPDATE], Return=OK, 530
```

## Workload B:

```
[OVERALL], RunTime(ms), 74753
[OVERALL], Throughput(ops/sec), 1337.7389536205906
[TOTAL_GCS_PS_Scavenge], Count, 24
[TOTAL_GC_TIME_PS_Scavenge], Time(ms), 167
[TOTAL_GC_TIME_%_PS_Scavenge], Time(%), 0.2234024052546386
[TOTAL_GCS_PS_MarkSweep], Count, 0
[TOTAL_GC_TIME_PS_MarkSweep], Time(ms), 0
[TOTAL_GC_TIME_%_PS_MarkSweep], Time(%), 0.0
[TOTAL_GCs], Count, 24
[TOTAL_GC_TIME], Time(ms), 167
[TOTAL_GC_TIME_%], Time(%), 0.2234024052546386
[CLEANUP], Operations, 1
[CLEANUP], AverageLatency(us), 2239488.0
[CLEANUP], MinLatency(us), 2238464
[CLEANUP], MaxLatency(us), 2240511
[CLEANUP], 95thPercentileLatency(us), 2240511
[CLEANUP], 99thPercentileLatency(us), 2240511
[INSERT], Operations, 100000
[INSERT], AverageLatency(us), 705.27806
[INSERT], MinLatency(us), 303
[INSERT], MaxLatency(us), 183679
[INSERT], 95thPercentileLatency(us), 1240
[INSERT], 99thPercentileLatency(us), 2823
[INSERT], Return=OK, 100000

[OVERALL], RunTime(ms), 13766
[OVERALL], Throughput(ops/sec), 72.6427429899753
[TOTAL_GCS_PS_Scavenge], Count, 1
[TOTAL_GC_TIME_PS_Scavenge], Time(ms), 17
[TOTAL_GC_TIME_%_PS_Scavenge], Time(%), 0.123492663082958
[TOTAL_GCS_PS_MarkSweep], Count, 0
[TOTAL_GC_TIME_PS_MarkSweep], Time(ms), 0
[TOTAL_GC_TIME_%_PS_MarkSweep], Time(%), 0.0
[TOTAL_GCs], Count, 1
[TOTAL_GC_TIME], Time(ms), 17
[TOTAL_GC_TIME_%], Time(%), 0.123492663082958
[READ], Operations, 943
[READ], AverageLatency(us), 1811.457051961824
[READ], MinLatency(us), 688
[READ], MaxLatency(us), 25711
[READ], 95thPercentileLatency(us), 4859
[READ], 99thPercentileLatency(us), 10191
[READ], Return=OK, 943
[CLEANUP], Operations, 10
[CLEANUP], AverageLatency(us), 221903.3
[CLEANUP], MinLatency(us), 1
[CLEANUP], MaxLatency(us), 2220031
[CLEANUP], 95thPercentileLatency(us), 2220031
[CLEANUP], 99thPercentileLatency(us), 2220031
[UPDATE], Operations, 57
[UPDATE], AverageLatency(us), 2353.315789473684
[UPDATE], MinLatency(us), 802
[UPDATE], MaxLatency(us), 16055
[UPDATE], 95thPercentileLatency(us), 7623
[UPDATE], 99thPercentileLatency(us), 11791
[UPDATE], Return=OK, 57
```

### Workload C:

```
[OVERALL], RunTime(ms), 76424
[OVERALL], Throughput(ops/sec), 1308.489479744583
[TOTAL_GCS_PS_Scavenge], Count, 50
[TOTAL_GC_TIME_PS_Scavenge], Time(ms), 217
[TOTAL_GC_TIME_%_PS_Scavenge], Time(%), 0.28394221710457446
[TOTAL_GCS_PS_MarkSweep], Count, 0
[TOTAL_GC_TIME_PS_MarkSweep], Time(ms), 0
[TOTAL_GC_TIME_%_PS_MarkSweep], Time(%), 0.0
[TOTAL_GCs], Count, 50
[TOTAL_GC_TIME], Time(ms), 217
[TOTAL_GC_TIME_%], Time(%), 0.28394221710457446
[CLEANUP], Operations, 1
[CLEANUP], AverageLatency(us), 2229248.0
[CLEANUP], MinLatency(us), 2228224
[CLEANUP], MaxLatency(us), 2230271
[CLEANUP], 95thPercentileLatency(us), 2230271
[CLEANUP], 99thPercentileLatency(us), 2230271
[INSERT], Operations, 100000
[INSERT], AverageLatency(us), 721.92004
[INSERT], MinLatency(us), 300
[INSERT], MaxLatency(us), 192383
[INSERT], 95thPercentileLatency(us), 1102
[INSERT], 99thPercentileLatency(us), 3013
[INSERT], Return=OK, 100000
```

```
[OVERALL], RunTime(ms), 13414
[OVERALL], Throughput(ops/sec), 74.5489786789921
[TOTAL_GCS_PS_Scavenge], Count, 1
[TOTAL_GC_TIME_PS_Scavenge], Time(ms), 11
[TOTAL_GC_TIME_%_PS_Scavenge], Time(%), 0.08200387654689131
[TOTAL_GCS_PS_MarkSweep], Count, 0
[TOTAL_GC_TIME_PS_MarkSweep], Time(ms), 0
[TOTAL_GC_TIME_%_PS_MarkSweep], Time(%), 0.0
[TOTAL_GCs], Count, 1
[TOTAL_GC_TIME], Time(ms), 11
[TOTAL_GC_TIME_%], Time(%), 0.08200387654689131
[READ], Operations, 1000
[READ], AverageLatency(us), 2032.418
[READ], MinLatency(us), 644
[READ], MaxLatency(us), 38879
[READ], 95thPercentileLatency(us), 4951
[READ], 99thPercentileLatency(us), 9135
[READ], Return=OK, 1000
[CLEANUP], Operations, 10
[CLEANUP], AverageLatency(us), 224565.9
[CLEANUP], MinLatency(us), 1
[CLEANUP], MaxLatency(us), 2246655
[CLEANUP], 95thPercentileLatency(us), 2246655
[CLEANUP], 99thPercentileLatency(us), 2246655
```

### Step 4:

In this step, we will be working with 1000k data. Change the record count in the large.dat file. Load and run all the workloads (a, b and c) and store the results in a file.

### Workload A:

```
./bin/ycsb load cassandra-cql -p hosts="127.0.0.1" -P  
workloads/workloada -P large.dat -s > load_1000k_a.dat
```

```
./bin/ycsb run cassandra-cql -p hosts="127.0.0.1" -P  
workloads/workloada -P large.dat -s -threads 10 -target 100 >  
transactions_1000k_a.dat
```

#### Workload B:

```
./bin/ycsb load cassandra-cql -p hosts="127.0.0.1" -P  
workloads/workloadb -P large.dat -s > load_1000k_b.dat
```

```
./bin/ycsb run cassandra-cql -p hosts="127.0.0.1" -P  
workloads/workloadb -P large.dat -s -threads 10 -target 100 >  
transactions_1000k_b.dat
```

#### Workload C:

```
./bin/ycsb load cassandra-cql -p hosts="127.0.0.1" -P  
workloads/workloadc -P large.dat -s > load_1000k_c.dat
```

```
./bin/ycsb run cassandra-cql -p hosts="127.0.0.1" -P  
workloads/workloadc -P large.dat -s -threads 10 -target 100 >  
transactions_1000k_c.dat
```



## Following are the output files:

Workload A:

---

```
[OVERALL], RunTime(ms), 658411
[OVERALL], Throughput(ops/sec), 1518.8081608600098
[TOTAL_GCS_PS_Scavengel], Count, 816
[TOTAL_GC_TIME_PS_Scavengel], Time(ms), 1808
[TOTAL_GC_TIME_%_PS_Scavengel], Time(%), 0.2746005154834898
[TOTAL_GCS_PS_MarkSweep], Count, 0
[TOTAL_GC_TIME_PS_MarkSweep], Time(ms), 0
[TOTAL_GC_TIME_%_PS_MarkSweep], Time(%), 0.0
[TOTAL_GCs], Count, 816
[TOTAL_GC_TIME], Time(ms), 1808
[TOTAL_GC_TIME_%], Time(%), 0.2746005154834898
[CLEANUP], Operations, 1
[CLEANUP], AverageLatency(us), 2274304.0
[CLEANUP], MinLatency(us), 2273280
[CLEANUP], MaxLatency(us), 2275327
[CLEANUP], 95thPercentileLatency(us), 2275327
[CLEANUP], 99thPercentileLatency(us), 2275327
[INSERT], Operations, 1000000
[INSERT], AverageLatency(us), 648.692853
[INSERT], MinLatency(us), 289
[INSERT], MaxLatency(us), 198783
[INSERT], 95thPercentileLatency(us), 948
[INSERT], 99thPercentileLatency(us), 2505
[INSERT], Return=OK, 1000000
```

```
[OVERALL], RunTime(ms), 14193
[OVERALL], Throughput(ops/sec), 70.45726766715987
[TOTAL_GCS_PS_Scavengel], Count, 1
[TOTAL_GC_TIME_PS_Scavengel], Time(ms), 18
[TOTAL_GC_TIME_%_PS_Scavengel], Time(%), 0.12682308180088775
[TOTAL_GCS_PS_MarkSweep], Count, 0
[TOTAL_GC_TIME_PS_MarkSweep], Time(ms), 0
[TOTAL_GC_TIME_%_PS_MarkSweep], Time(%), 0.0
[TOTAL_GCs], Count, 1
[TOTAL_GC_TIME], Time(ms), 18
[TOTAL_GC_TIME_%], Time(%), 0.12682308180088775
[READ], Operations, 493
[READ], AverageLatency(us), 8315.62677484787
[READ], MinLatency(us), 935
[READ], MaxLatency(us), 172031
[READ], 95thPercentileLatency(us), 22015
[READ], 99thPercentileLatency(us), 102527
[READ], Return=OK, 493
[CLEANUP], Operations, 10
[CLEANUP], AverageLatency(us), 223337.6
[CLEANUP], MinLatency(us), 2
[CLEANUP], MaxLatency(us), 2234367
[CLEANUP], 95thPercentileLatency(us), 2234367
[CLEANUP], 99thPercentileLatency(us), 2234367
[UPDATE], Operations, 507
[UPDATE], AverageLatency(us), 4093.621301775148
[UPDATE], MinLatency(us), 648
[UPDATE], MaxLatency(us), 159487
[UPDATE], 95thPercentileLatency(us), 8711
[UPDATE], 99thPercentileLatency(us), 85375
[UPDATE], Return=OK, 507
```

## Workload B:

```
[OVERALL], RunTime(ms), 736272
[OVERALL], Throughput(ops/sec), 1358.1937110198405
[TOTAL_GCS_PS_Scavenge], Count, 814
[TOTAL_GC_TIME_PS_Scavenge], Time(ms), 2195
[TOTAL_GC_TIME_%_PS_Scavenge], Time(%), 0.298123519568855
[TOTAL_GCS_PS_MarkSweep], Count, 0
[TOTAL_GC_TIME_PS_MarkSweep], Time(ms), 0
[TOTAL_GC_TIME_%_PS_MarkSweep], Time(%), 0.0
[TOTAL_GCs], Count, 814
[TOTAL_GC_TIME], Time(ms), 2195
[TOTAL_GC_TIME_%], Time(%), 0.298123519568855
[CLEANUP], Operations, 1
[CLEANUP], AverageLatency(us), 2233344.0
[CLEANUP], MinLatency(us), 2232320
[CLEANUP], MaxLatency(us), 2234367
[CLEANUP], 95thPercentileLatency(us), 2234367
[CLEANUP], 99thPercentileLatency(us), 2234367
[INSERT], Operations, 1000000
[INSERT], AverageLatency(us), 726.701254
[INSERT], MinLatency(us), 282
[INSERT], MaxLatency(us), 254335
[INSERT], 95thPercentileLatency(us), 1253
[INSERT], 99thPercentileLatency(us), 3441
[INSERT], Return=OK, 1000000
~

[OVERALL], RunTime(ms), 14425
[OVERALL], Throughput(ops/sec), 69.32409012131716
[TOTAL_GCS_PS_Scavenge], Count, 1
[TOTAL_GC_TIME_PS_Scavenge], Time(ms), 22
[TOTAL_GC_TIME_%_PS_Scavenge], Time(%), 0.15251299826689774
[TOTAL_GCS_PS_MarkSweep], Count, 0
[TOTAL_GC_TIME_PS_MarkSweep], Time(ms), 0
[TOTAL_GC_TIME_%_PS_MarkSweep], Time(%), 0.0
[TOTAL_GCs], Count, 1
[TOTAL_GC_TIME], Time(ms), 22
[TOTAL_GC_TIME_%], Time(%), 0.15251299826689774
[READ], Operations, 941
[READ], AverageLatency(us), 5761.360255047822
[READ], MinLatency(us), 809
[READ], MaxLatency(us), 181247
[READ], 95thPercentileLatency(us), 12983
[READ], 99thPercentileLatency(us), 46815
[READ], Return=OK, 941
[CLEANUP], Operations, 10
[CLEANUP], AverageLatency(us), 222313.4
[CLEANUP], MinLatency(us), 2
[CLEANUP], MaxLatency(us), 2224127
[CLEANUP], 95thPercentileLatency(us), 2224127
[CLEANUP], 99thPercentileLatency(us), 2224127
[UPDATE], Operations, 59
[UPDATE], AverageLatency(us), 4290.237288135593
[UPDATE], MinLatency(us), 887
[UPDATE], MaxLatency(us), 56063
[UPDATE], 95thPercentileLatency(us), 13703
"transactions_1000k_b.dat" 31L, 11398
```

## Workload C:

```
[OVERALL], RunTime(ms), 239579
[OVERALL], Throughput(ops/sec), 1393.9702561576767
[TOTAL_GCS_PS_Scavengel], Count, 249
[TOTAL_GC_TIME_PS_Scavengel], Time(ms), 682
[TOTAL_GC_TIME_%_PS_Scavengel], Time(%), 0.28466601830711374
[TOTAL_GCS_PS_MarkSweep], Count, 0
[TOTAL_GC_TIME_PS_MarkSweep], Time(ms), 0
[TOTAL_GC_TIME_%_PS_MarkSweep], Time(%), 0.0
[TOTAL_GCs], Count, 249
[TOTAL_GC_TIME], Time(ms), 682
[TOTAL_GC_TIME_%], Time(%), 0.28466601830711374
[CLEANUP], Operations, 1
[CLEANUP], AverageLatency(us), 2235392.0
[CLEANUP], MinLatency(us), 2234368
[CLEANUP], MaxLatency(us), 2236415
[CLEANUP], 95thPercentileLatency(us), 2236415
[CLEANUP], 99thPercentileLatency(us), 2236415
[INSERT], Operations, 333966
[INSERT], AverageLatency(us), 698.7809507554662
[INSERT], MinLatency(us), 291
[INSERT], MaxLatency(us), 186239
[INSERT], 95thPercentileLatency(us), 1102
[INSERT], 99thPercentileLatency(us), 2969
[INSERT], Return=OK, 333966
[INSERT], Return=ERROR, 1
[INSERT-FAILED], Operations, 1
[INSERT-FAILED], AverageLatency(us), 471680.0
[INSERT-FAILED], MinLatency(us), 471552
[INSERT-FAILED], MaxLatency(us), 471807
"load_1000k_c.dat" 31L, 1211B
```

```
[OVERALL], RunTime(ms), 13570
[OVERALL], Throughput(ops/sec), 73.69196757553426
[TOTAL_GCS_PS_Scavengel], Count, 1
[TOTAL_GC_TIME_PS_Scavengel], Time(ms), 10
[TOTAL_GC_TIME_%_PS_Scavengel], Time(%), 0.07369196757553427
[TOTAL_GCS_PS_MarkSweep], Count, 0
[TOTAL_GC_TIME_PS_MarkSweep], Time(ms), 0
[TOTAL_GC_TIME_%_PS_MarkSweep], Time(%), 0.0
[TOTAL_GCs], Count, 1
[TOTAL_GC_TIME], Time(ms), 10
[TOTAL_GC_TIME_%], Time(%), 0.07369196757553427
[READ], Operations, 0
[READ], AverageLatency(us), NaN
[READ], MinLatency(us), 9223372036854775807
[READ], MaxLatency(us), 0
[READ], 95thPercentileLatency(us), 0
[READ], 99thPercentileLatency(us), 0
[READ], Return=NOT_FOUND, 1000
[CLEANUP], Operations, 10
[CLEANUP], AverageLatency(us), 224566.0
[CLEANUP], MinLatency(us), 2
[CLEANUP], MaxLatency(us), 2246655
[CLEANUP], 95thPercentileLatency(us), 2246655
[CLEANUP], 99thPercentileLatency(us), 2246655
[READ-FAILED], Operations, 1000
[READ-FAILED], AverageLatency(us), 2688.526
[READ-FAILED], MinLatency(us), 778
[READ-FAILED], MaxLatency(us), 96447
[READ-FAILED], 95thPercentileLatency(us), 5947
[READ-FAILED], 99thPercentileLatency(us), 14415
```

## AWS DynamoDB:

The data sets and python code used is in the dynamo DB folder. The code basically creates table, loads the data sets, perform queries and records the outputs.

Following are the screenshots of table creation and datasets being loaded in dynamoDB in IAM user account.

The screenshot shows the AWS DynamoDB console interface. On the left, there's a navigation sidebar with options like Dashboard, Tables, Update settings, Explore items, PartiQL editor, Backups, Exports to S3, Imports from S3, Reserved capacity, Settings, DAX, Clusters, Subnet groups, Parameter groups, and Events. The 'Tables' option is selected. In the main content area, the path 'DynamoDB > Tables > Applemusic' is shown. A sub-menu titled 'Tables (2)' lists 'Applemusic' and 'movies'. The 'Applemusic' table is selected and detailed in the main pane. The 'General information' section shows the Partition key as 'collectionId (Number)' and the Sort key as 'artistName (String)'. Capacity mode is set to 'Provisioned'. The Table status is 'Active' with 'No active alarms'. Below this, there's an 'Additional info' section with a small screenshot of the table's item list. The 'Items summary' section indicates that DynamoDB updates information approximately every six hours, with a button to 'Get live item count'.

Items returned (50)						Actions ▾	Create item
	movielid	userId	rating	timestamp			
<input type="checkbox"/>	4666	15	1	997937539			
<input type="checkbox"/>	107978	56	5	1467003921			
<input type="checkbox"/>	27904	15	2.5	1347936774			
<input type="checkbox"/>	2289	4	5	949919556			
<input type="checkbox"/>	2289	15	4	997938322			
<input type="checkbox"/>	2289	23	4	1148671976			
<input type="checkbox"/>	2289	30	5	945114406			
<input type="checkbox"/>	2289	34	5	973746929			

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Items returned (50)				Actions ▾	Create item
	collectionId	artistName	trackName		
<input type="checkbox"/>	263588771	The Lullaby Ensemble			
<input type="checkbox"/>	1456774037	PENNYFORTHOUGHT			
<input type="checkbox"/>	1343961535	D-Dre the Giant			
<input type="checkbox"/>	1334838135	Joey Vantes			
<input type="checkbox"/>	1452802799	Guns N' Roses			
<input type="checkbox"/>	1205801810	Luis Rey			
<input type="checkbox"/>	56187534	Ariana Grande	Masked Chritmas		
<input type="checkbox"/>	1442978012	JAY-Z			
<input type="checkbox"/>	1064976803	Evil Ebenezer			

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