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*comparison
of databases*

**student information
system**

TABLE OF CONTENTS

1.Introduction

2.Explanation of databases

3.Generating data

4.inserting data

5.Queries

6.Histograms

7.Conclusion

8.References

INTRODUCTION

Student Information Systems (SIS) are vital for educational institutions but face challenges like outdated data management and limited accessibility.

This report compares diverse database systems for SIS, including Redis, Cassandra, Neo4j, MongoDB, and MySQL. We assess performance, scalability, flexibility, and query capabilities within the SIS context.

We use a representative dataset with information about students, courses, grades, and academic records, with record sizes of 250,000, 500,000, 750,000, and 1 million. Multiple complex queries are executed and automated for reliable data, each test run at least 30 times.

Our findings are presented through histograms, showing response times in milliseconds. The goal is to identify the database system demonstrating superior query execution under consistent hardware and software conditions.

EXPLANATION OF DATABASES



MySQL is an open-source relational database management system (RDBMS) that is widely used for storing and managing structured data. It is a popular choice for web applications and is often used in conjunction with scripting languages like PHP, Python, and Ruby.



MongoDB is a popular open-source NoSQL (non-relational) database management system. It is designed to handle large volumes of unstructured and semi-structured data, making it particularly suitable for modern applications that require flexible and scalable data storage.



Redis is a high-speed, open-source, in-memory data store known for its lightning-fast data access and low-latency performance. It serves as a versatile solution for various applications, including caching, real-time analytics, and messaging. Redis's support for advanced data structures and ease of use make it a valuable asset for enhancing the efficiency of modern software systems.



Cassandra is a highly scalable, distributed NoSQL database system known for its exceptional fault tolerance and data availability. This open-source solution is tailored for handling large datasets and distributed data management. Developed by Facebook and open-sourced, Cassandra is favored in applications demanding real-time big data analytics, time-series data, and content management systems. It offers a resilient and versatile solution for modern data storage and management.



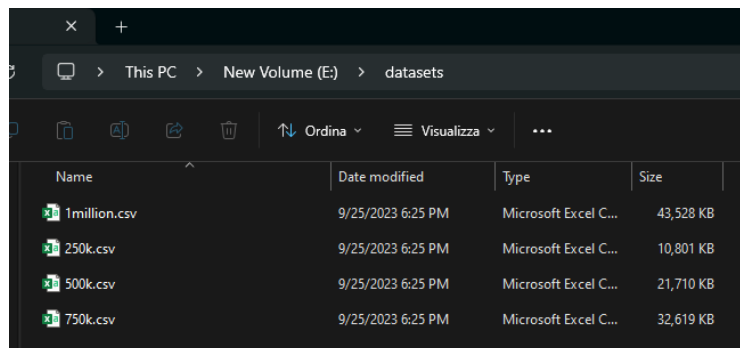
Neo4j is a distinguished graph database management system, purpose-built for handling data as nodes and relationships. It excels in managing complex, interconnected data, making it an ideal choice for applications involving intricate relationships, such as social networks and recommendation systems. Neo4j's graph-based model allows for efficient and insightful data analysis, setting it apart as a leading solution for industries that require deep exploration of connections within their datasets.

GENERATING DATA

This script generates synthetic student data for our Student Information System (SIS) and organizes it into separate CSV files. It utilizes the 'Faker' library to create fictional student information, including 'student_id,' 'first_name,' 'last_name,' 'grade,' 'result,' 'age,' 'gender,' and 'presence_percentage.' The script verifies the existence of the primary CSV file, '1million.csv,' and creates it if absent, including a header row to label the fields.

The core functionality involves generating data for one million students, capturing details such as grades, results, age, gender, and presence percentage using a dedicated function. This data is then divided into three distinct CSV files—'750k.csv,' '500k.csv,' and '250k.csv,' each tailored to house a specific number of records. This script streamlines the data preparation process for our SIS, enabling testing and development with substantial and realistic datasets. Upon completion, the script confirms the successful generation and distribution of synthetic data.


```
pythonProject  Version control
generate_data.py
1 import os
2 import csv
3 from faker import Faker
4 import random
5
6 fake = Faker()
7
8 fields = ['student_id', 'first_name', 'last_name', 'grade', 'result', 'age', 'gender', 'presence_percentage']
9
10 csv_file_path = 'E:\\datasets\\1million.csv'
11 if not os.path.exists(csv_file_path):
12     with open(csv_file_path, 'w', newline='') as file:
13         writer = csv.writer(file)
14         writer.writerow(fields)
15
16 # usage
17 def generate_student_data(student_id):
18     first_name = fake.first_name()
19     last_name = fake.last_name()
20     grade = fake.random_int(min=0, max=30)
21     result = 'Pass' if grade > 18 else 'Fail'
22     age = fake.random_int(min=18, max=25)
23     gender = fake.random_element(elements=['Male', 'Female'])
24     presence_percentage = round(random.uniform(70, 100), 2)
25     return [student_id, first_name, last_name, grade, result, age, gender, presence_percentage]
26
27 num_records_1million = 1000000
28
29 with open(csv_file_path, 'w', newline='') as csvfile_1million:
30     writer_1million = csv.writer(csvfile_1million)
31     writer_1million.writerow(fields)
32     for student_id in range(1, num_records_1million + 1):
33         data = generate_student_data(student_id)
34         writer_1million.writerow(data)
35
36 csv_data = []
37 with open(csv_file_path, 'r') as csvfile_1million:
38     reader = csv.reader(csvfile_1million)
39     next(reader)
40     csv_data = list(reader)
```



Name	Date modified	Type	Size
1million.csv	9/25/2023 6:25 PM	Microsoft Excel C...	43,528 KB
250k.csv	9/25/2023 6:25 PM	Microsoft Excel C...	10,801 KB
500k.csv	9/25/2023 6:25 PM	Microsoft Excel C...	21,710 KB
750k.csv	9/25/2023 6:25 PM	Microsoft Excel C...	32,619 KB

as you see the fake data is generated and saved as 4 csv files in
E:\\datasets\\1million.csv

INSERTING DATA

MySQL:

A local MySQL server connection is established with host, user, password, port, and 'students_db' database parameters.

If the database doesn't exist, it's created. Inside 'students_db,' four tables ('1million,' '750k,' '500k,' and '250k') are made for CSV data.

The script's core function is importing data from CSV files into MySQL tables using Pandas and SQLAlchemy for insertion, with error handling for data integrity.

Successful insertions are committed, and the script closes the cursor and connection for efficiency.

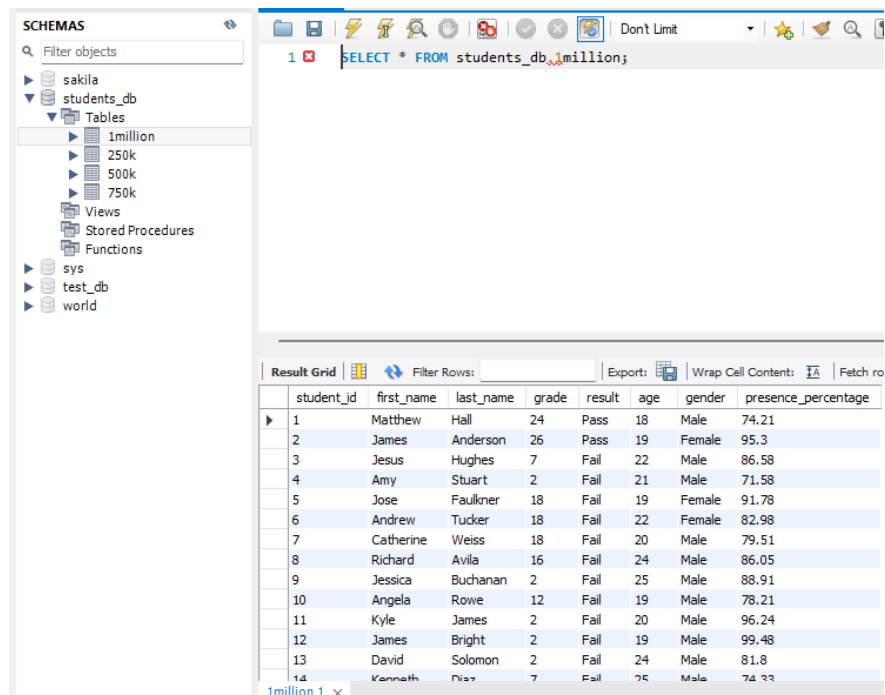
This script is vital for managing diverse data in our Student Information System.

the engine is a central component of SQLAlchemy that provides a standardized and efficient way to connect to databases, execute SQL queries, and manage database connections.

```

pythonProject Version control
MySQL_Insertion.py
1 import mysql.connector
2 import pandas as pd
3 from sqlalchemy import create_engine
4
5 connection = mysql.connector.connect(
6     host="localhost",
7     user="root",
8     password="ARYA_2003",
9     port="3309",
10    database="students_db",
11    connect_timeout=120
12 )
13
14 cursor = connection.cursor()
15
16 database_name = "students_db"
17 check_database_query = f"SHOW DATABASES LIKE '{database_name}';"
18 cursor.execute(check_database_query)
19
20 database_exists = False
21 for (database,) in cursor:
22     if database == database_name:
23         database_exists = True
24         break
25
26 if not database_exists:
27     create_database_query = f"CREATE DATABASE {database_name};"
28     cursor.execute(create_database_query)
29
30 use_database_query = f"USE {database_name};"
31 cursor.execute(use_database_query)
32
33 create_table_query = """
34 CREATE TABLE IF NOT EXISTS imillion (
35     student_id INT PRIMARY KEY,
36     first_name VARCHAR(255),
37     last_name VARCHAR(255),
38     grade INT,
39     result VARCHAR(255),
40     age INT,
41     gender VARCHAR(255),
42     presence_percentage DECIMAL(5, 2)
43 );
44 """
45 cursor.execute(create_table_query)
46
47 create_table_query = """
48 CREATE TABLE IF NOT EXISTS 500k (
49     student_id INT PRIMARY KEY,
50     first_name VARCHAR(255),
51     last_name VARCHAR(255),
52     grade INT,
53     result VARCHAR(255),
54     age INT,
55     gender VARCHAR(255),
56     presence_percentage DECIMAL(5, 2)
57 );
58 """
59 cursor.execute(create_table_query)
60
61 create_table_query = """
62 CREATE TABLE IF NOT EXISTS 750k (
63     student_id INT PRIMARY KEY,
64     first_name VARCHAR(255),
65     last_name VARCHAR(255),
66     grade INT,
67     result VARCHAR(255),
68     age INT,
69     gender VARCHAR(255),
70     presence_percentage DECIMAL(5, 2)
71 );
72 """
73 cursor.execute(create_table_query)
74
75 create_table_query = """
76 CREATE TABLE IF NOT EXISTS 250k (
77     student_id INT PRIMARY KEY,
78     first_name VARCHAR(255),
79     last_name VARCHAR(255),
80     grade INT,
81     result VARCHAR(255),
82     age INT,
83     gender VARCHAR(255),
84     presence_percentage DECIMAL(5, 2)
85 );
86 """
87 cursor.execute(create_table_query)
88
89 csv_files = [
90     'E:\\datasets\\imillion.csv',
91     'E:\\datasets\\750k.csv',
92     'E:\\datasets\\500k.csv',
93     'E:\\datasets\\250k.csv'
94 ]
95
96 engine = create_engine('mysql+mysqlconnector://root:ARYA_2003@localhost:3309/students_db')
97
98 for i, csv_file_path in enumerate(csv_files):
99     table_name = ['imillion', '750k', '500k', '250k'][i]
100
101     df = pd.read_csv(csv_file_path)
102
103     try:
104         df.to_sql(table_name, engine, if_exists='replace', index=False)
105         print(f"Data inserted successfully into table: {table_name}")
106     except Exception as e:
107         print(f"Error inserting data into table: {table_name}. Error: {str(e)}")
108
109 connection.commit()
110
111 cursor.close()
112 connection.close()

```



Now you can see the output that 4 tables are created and the data is inserted into each table

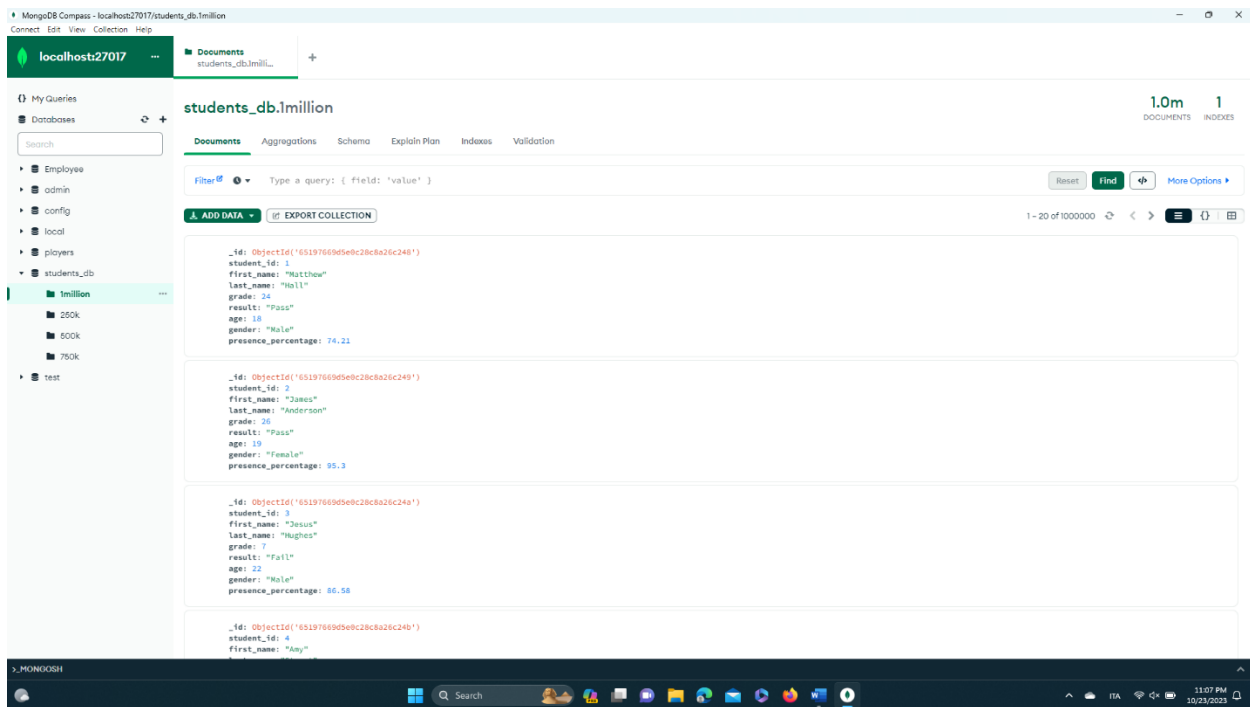
mongoDB:

This script facilitates the insertion of data from CSV files into a MongoDB database. Using the 'pymongo' library, it establishes a connection to a MongoDB server and creates or accesses the 'students_db' database. The script then defines a list of CSV file paths, each representing a different dataset.

The core function 'insert_data_mongodb' is responsible for inserting data from each CSV file into the MongoDB database. The script iterates through the list of CSV files, reads the data using Pandas, extracts the collection name from the file path, and inserts the data into the corresponding MongoDB collection.

Upon successful data insertion, the script efficiently closes the MongoDB connection. This script streamlines the process of populating a MongoDB database with data from various CSV sources, making it a valuable tool for data management in your project.

```
pythonProject Version control
mongoDB_insertion.py
1 from pymongo import MongoClient
2 import pandas as pd
3
4 mongo_client = MongoClient()
5 mongo_db = mongo_client['students_db']
6
7 csv_files = ['E:\\datasets\\1million.csv', 'E:\\datasets\\750k.csv', 'E:\\datasets\\500k.csv', 'E:\\datasets\\250k.csv']
8
9 usage
10 def insert_data_mongodb(data, collection):
11     collection.insert_many(data)
12
13 for csv_file in csv_files:
14     with open(csv_file, 'r') as file:
15         data = pd.read_csv(file)
16
17     collection_name = csv_file.split('\\')[1].split('.')[0] # Extract the collection name from the file path
18     insert_data_mongodb(data.to_dict('records'), mongo_db[collection_name])
19     print(f'Data inserted successfully into collection: {collection_name}')
20
21 mongo_client.close()
```



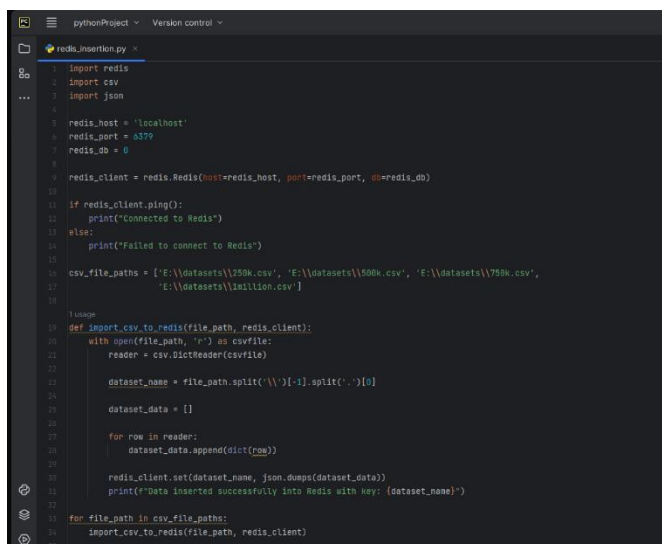
Now we have for collections are created with the corresponding data.

Redis:

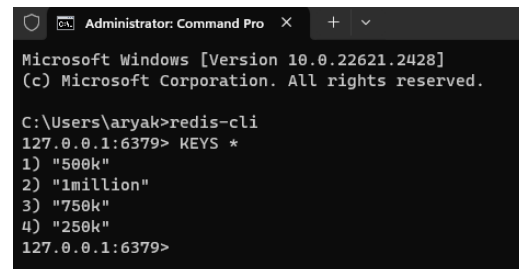
This script streamlines the process of inserting data from CSV files into a Redis database. It establishes a connection with Redis using the provided connection details and checks for a successful connection. The CSV file paths are specified, representing distinct datasets.

The core function 'import_csv_to_redis' reads each CSV file, extracts the dataset name from the file path, and stores the data as a JSON string in Redis with a specific key. This approach enables the script to insert data into Redis with clear distinction. After successful insertion, it provides a confirmation message.

By looping through the CSV files, the script imports each dataset into Redis with separate keys. Subsequently, it allows data retrieval from Redis based on the designated keys. This script simplifies the process of integrating data from various sources into Redis, offering an efficient and organized method for data storage and retrieval in your project.



```
pythonProject - Version control -
redis_insertion.py
1 import redis
2 import csv
3 import json
4
5 redis_host = 'localhost'
6 redis_port = 6379
7 redis_db = 0
8
9 redis_client = redis.Redis(host=redis_host, port=redis_port, db=redis_db)
10
11 if redis_client.ping():
12     print("Connected to Redis")
13 else:
14     print("Failed to connect to Redis")
15
16 csv_file_paths = ['E:\\datasets\\250k.csv', 'E:\\datasets\\500k.csv', 'E:\\datasets\\750k.csv',
17                  'E:\\datasets\\1million.csv']
18
19
20
21 def import_csv_to_redis(file_path, redis_client):
22     with open(file_path, 'r') as csvfile:
23         reader = csv.DictReader(csvfile)
24
25         dataset_name = file_path.split('\\')[1].split('.')[0]
26
27         dataset_data = []
28
29         for row in reader:
30             dataset_data.append(dict(row))
31
32         redis_client.set(dataset_name, json.dumps(dataset_data))
33         print(f"Data inserted successfully into Redis with key: {dataset_name}")
34
35
36 for file_path in csv_file_paths:
37     import_csv_to_redis(file_path, redis_client)
```



```
Administrator: Command Prompt
Microsoft Windows [Version 10.0.22621.2428]
(c) Microsoft Corporation. All rights reserved.

C:\Users\aryak>redis-cli
127.0.0.1:6379> KEYS *
1) "500k"
2) "1million"
3) "750k"
4) "250k"
127.0.0.1:6379>
```

After the code execution you can run redis client in command prompt to see the created keys

CASSANDRA:

This script simplifies the process of inserting data into a Cassandra database, leveraging Docker for containerization. It connects to Cassandra, defines a keyspace, and creates tables to accommodate data from various CSV files. The CSV data is then loaded using Pandas, and the script inserts the data into the corresponding Cassandra tables.

To ensure data consistency and integrity, each table's schema is predefined, and data is inserted while adhering to the defined structure. The script neatly handles the creation of keyspace, tables, and data insertion for different datasets. Upon successful insertion, it provides informative progress messages, streamlining the data integration process in your project. It's a valuable tool for efficiently managing data in a Cassandra database, especially when dealing with multiple datasets.

Cassandra uses a replication strategy to determine how data is distributed across multiple nodes in a cluster. In this code, a simple replication strategy (SimpleStrategy) is used. This strategy is suitable for single-node or small-scale deployments. The replication_factor is set to 1, which means that each piece of data is replicated to one node in the cluster.

```
pythonProject Version control acsis_neo4j
cassandra_insertion.py
1 from cassandra.cluster import Cluster
2 import pandas as pd
3
4 cassandra_host = 'localhost'
5
6 cluster = Cluster([cassandra_host])
7 session = cluster.connect()
8
9 keyspace_name = 'students'
10 replication_strategy = {
11     'class': 'SimpleStrategy',
12     'replication_factor': 1
13 }
14
15 create_keyspace_query = """
16 CREATE KEYSPACE IF NOT EXISTS (keyspace_name)
17 WITH REPLICATION = {str(replication_strategy)};
18 """
19 session.execute(create_keyspace_query)
20 session.set_keyspace(keyspace_name)
21
22 tables = [
23     {'table_name': 'table_250k', 'csv_file_path': 'E:\\datasets\\250k.csv'},
24     {'table_name': 'table_500k', 'csv_file_path': 'E:\\datasets\\500k.csv'},
25     {'table_name': 'table_750k', 'csv_file_path': 'E:\\datasets\\750k.csv'},
26     {'table_name': 'table_1million', 'csv_file_path': 'E:\\datasets\\1million.csv'}
27 ]
28
29 for table in tables:
30     create_table_query = """
31     CREATE TABLE IF NOT EXISTS (table['table_name']) (
32         student_id UUID PRIMARY KEY,
33         first_name TEXT,
34         last_name TEXT,
35         grade DOUBLE,
36         result TEXT,
37         age INT,
38         gender TEXT,
39         presence_percentage DOUBLE
40     );
41     """
42     session.execute(create_table_query)
43
44 for table in tables:
45     csv_file_path = table['csv_file_path']
46     table_name = table['table_name']
47
48     df = pd.read_csv(csv_file_path)
49     count = 0
50
51     for _, row in df.iterrows():
52         insert_query = """
53         INSERT INTO (table_name) (student_id, first_name, last_name, grade, result, age, gender, presence_percentage)
54         VALUES (UUID(), '{row['first_name']}', '{row['last_name']}', {row['grade']}', '{row['result']}', {row['age']}, '{row['gender']}', {row['presence_percentage']});
55         """
56         session.execute(insert_query)
57         count += 1
58     print(f"[count]Data from {table['csv_file_path']} has been inserted.")
59     print("-----")
60
61 session.shutdown()
62 cluster.shutdown()
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```


After executing the code you can connect your container to cqlsh in command prompt and to see the keyspaces, tables and retrieving the data in them

Neo4j:

This script serves as a fundamental tool for inserting data into a Neo4j database. It establishes a connection to the Neo4j instance, creates a database named 'studentsdb,' and imports data from CSV files into it. The script utilizes the Cypher query language with the 'LOAD CSV' command to seamlessly integrate data from the CSV files into the Neo4j database.

The script is designed to efficiently handle data insertion for various datasets, and it is well-suited for scenarios where you need to work with different datasets in Neo4j. It simplifies the process of data integration and ensures the seamless storage of information in your Neo4j 'studentsdb' database, making it a valuable asset for your project's data management.

```
pythonProject  Version control
neo4j_insertion.py x
1 from py2neo import Graph
2
3 uri = "bolt://localhost:7687"
4 username = "neo4j"
5 password = "ARVA_2003"
6
7 graph = Graph(uri, auth=(username, password))
8
9 database_name = 'studentsdb'
10
11 uri_with_db = f'{uri}/db/{database_name}'
12 graph_db = Graph(uri_with_db, auth=(username, password))
13
14 csv_files_and_labels = [
15     ('E:/datasets/250k.csv', 'd250k'),
16     ('E:/datasets/500k.csv', 'd500k'),
17     ('E:/datasets/750k.csv', 'd750k'),
18     ('E:/datasets/1million.csv', 'd1million')
19 ]
20
21 for csv_file_path, label in csv_files_and_labels:
22     cypher_query = """
23     LOAD CSV WITH HEADERS FROM 'file://{csv_file_path}' AS row
24     CREATE (:Student:{label}) {{
25         student_id: row.student_id,
26         first_name: row.first_name,
27         last_name: row.last_name,
28         grade: row.grade,
29         result: row.result,
30         age: toInteger(row.age),
31         gender: row.gender,
32         presence_percentage: toFloat(row.presence_percentage)
33     }}
34     """
35
36     graph_db.run(cypher_query)
37     print(f"Data from {csv_file_path} inserted successfully.")
38
39 print("Data inserted into 'studentsdb' database.")
40 |
```

QUERIES

The provided code samples implement query execution on four different database systems: MySQL, MongoDB, Redis, and Cassandra. Each code sample contains four progressively complex queries designed to retrieve and analyze data from their respective databases. These queries are designed to assess and optimize the performance of each database in handling different levels of complexity in data retrieval and analysis.

The queries used in all databases are as follows:

1. **Query 1: Retrieve records for females with a presence percentage greater than 80% who failed:** This query selects all columns from a specified table where the gender is 'Female,' the presence percentage is greater than 80, and the result is 'Fail.'
2. **Query 2: Retrieve records for males who passed:** This query selects all columns from a specified table where the gender is 'Male' and the result is 'Pass.'
3. **Query 3: Retrieve records for individuals whose first names start with 'A':** This query selects all columns from a specified table where the first name starts with the letter 'A.'
4. **Query 4: Retrieve all records from the specified table:** This query selects all columns from a specified table without applying any specific conditions, essentially fetching all available records.

These queries collectively provide a comprehensive assessment of each database's ability to handle varying levels of data retrieval complexity.

MySQL Code:

- The MySQL code connects to a MySQL database and executes four progressively complex SQL queries. It measures query execution times on different tables, allowing for performance evaluation and optimization.

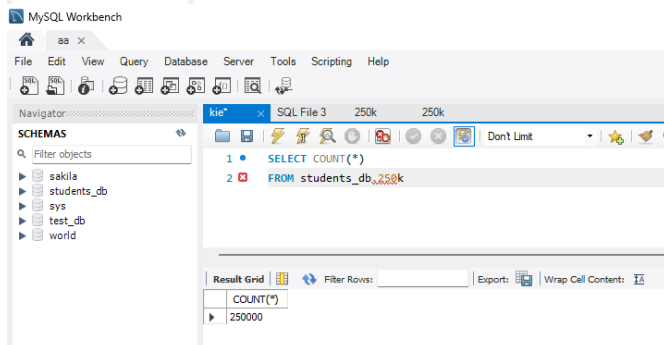
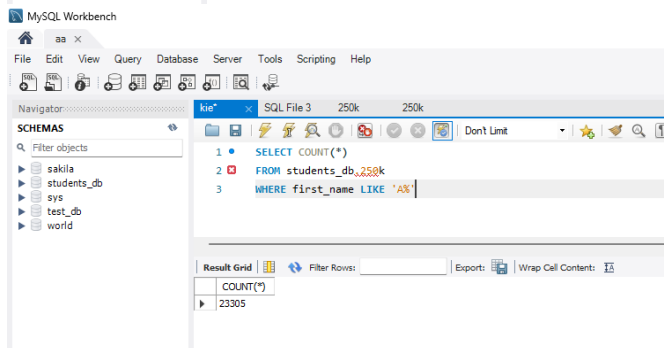
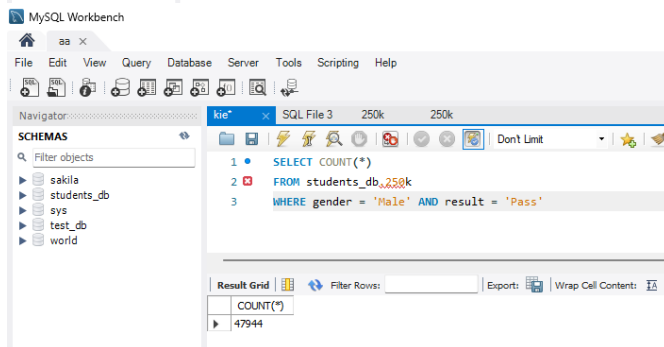
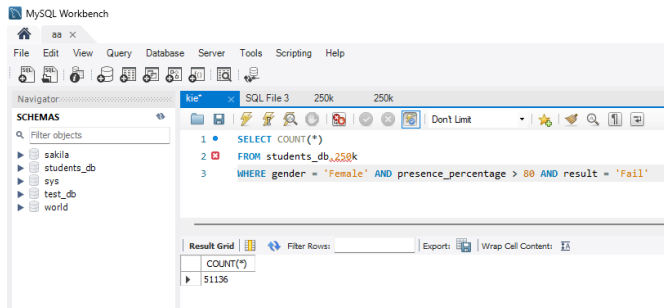
```
pythonProject Version control
MySQL_query.py
1 import os
2 import csv
3 import mysql.connector
4 import time
5
6 base_directory = 'E:\\query_results\\MySQL'
7
8 table_names = ['250k', '500k', '750k', '1million']
9
10 queries = [
11     "SELECT * FROM {} WHERE gender = 'Female' AND presence_percentage > 80 AND result = 'Fail'",
12     "SELECT * FROM {} WHERE gender = 'Male' AND result = 'Pass'",
13     "SELECT * FROM {} WHERE first_name LIKE 'A%'",
14     "SELECT * FROM {}"
15 ]
16
17 query_execution_times = {"Query {}: {}".format(i+1, "execution times") for i in range(len(queries))}
18
19 connection = mysql.connector.connect(
20     host="localhost",
21     user="root",
22     password="AWA_2003",
23     port="3306",
24     database="students_db",
25     connect_timeout=120
26 )
27
28 cursor = connection.cursor()
29
30 for table_name in table_names:
31     dataset_results = {"Query {}: {}".format(i+1, "execution times") for i in range(len(queries))}
32     for i, query in enumerate(queries):
33         formatted_query = query.format(table_name)
34         execution_times = []
35         for j in range(30):
36             start_time = time.time()
37             cursor.execute(formatted_query)
38             for _ in cursor:
39                 pass
40             end_time = time.time()
41
42             execution_time = int((end_time - start_time) * 1e9)
43             execution_times.append(execution_time)
44
45             if j == 0:
46                 print(f"Table: {table_name}, Query {i+1}, First Execution Time: {execution_time} nanoseconds")
47             if j == 29:
48                 avg_execution_time = sum(execution_times) // len(execution_times)
49                 print(f"Table: {table_name}, Query {i+1}, Average Execution Time: {avg_execution_time} nanoseconds")
50
51             query_execution_times["Query {}: {}".format(i+1, "execution times")].append(execution_times)
52             dataset_results["Query {}: {}".format(i+1, "execution times")] = execution_times
53
54 filename = os.path.join(base_directory, f"results_{table_name}.csv")
55 with open(filename, 'w', newline='') as result_file:
56     csv_writer = csv.writer(result_file)
57     csv_writer.writerow(['Query', 'Execution Times'])
58     for query_num in range(1, 5):
59         query_label = f"Query {query_num}"
60         response_times = dataset_results[query_label]
61         csv_writer.writerow([query_label] + response_times)
62
63 cursor.close()
64 connection.close()
```

SELECT * FROM students_db.250k WHERE gender = 'Female' AND presence_percentage > 80 AND result = 'Fail';

SELECT COUNT(*)

FROM students_db.250k

WHERE gender = 'Female' AND presence_percentage > 80 AND result = 'Fail';



MongoDB Code:

- The MongoDB code connects to a MongoDB database and runs four queries with increasing complexity. It times the execution of these queries and saves the results for performance analysis.

```
pythonProject Version control
mongoDB_query.py
1 import time
2 from pymongo import MongoClient
3 import os
4 import re
5 import csv
6
7 mongo_client = MongoClient()
8 mongo_db = mongo_client['students_db']
9
10 table_names = ['250k', '500k', '750k', '1million']
11
12 queries = [
13     ('Q1', {'gender': 'Female', 'attendance': {'$gt': 80}, 'result': 'Fail'}),
14     ('Q2', {'gender': 'Male', 'result': 'Pass'}),
15     ('Q3', {'name': {'$regex': 'A'}}),
16     ('Q4', {})
17 ]
18
19 base_directory = 'E:\\query_results\\mongoDB'
20
21 os.makedirs(base_directory, exist_ok=True)
22
23 @uamgms
24 def sanitize_query_description(description):
25     return re.sub(r '[^a-zA-Z0-9]', '', description)
26
27 for table_name in table_names:
28     collection = mongo_db[table_name]
29     print(f'Table: {table_name} DATASET')
30
31     total_time = 0
32     execution_times = []
33
34     for query_description, query_filter in queries:
35         sanitized_query_description = sanitize_query_description(query_description)
36
37         for i in range(10):
38             start_time = time.time_ns()
39             result = collection.find(query_filter)
40             for document in result:
41
42                 pass
43             end_time = time.time_ns()
44             execution_time = int(end_time - start_time)
45             execution_times.append(execution_time)
46             total_time += execution_time
47
48             if i == 0:
49                 print(f'Table: {table_name}, Query: {sanitized_query_description}, First Execution Time: {execution_time} nanoseconds')
50             if i == 20:
51                 avg_execution_time = total_time // 50
52                 print(f'Table: {table_name}, Query: {sanitized_query_description}, Average Execution Time: {avg_execution_time} nanoseconds')
53
54 filename = os.path.join(base_directory, f'results_{table_name}.csv')
55 with open(filename, 'w', newline='') as result_file:
56     csv_writer = csv.writer(result_file)
57     csv_writer.writerow(['Query', 'Execution Times'])
58     for query_num, (query_description, _) in enumerate(queries, start=1):
59         sanitized_query_description = sanitize_query_description(query_description)
60         response_times = execution_times[query_num - 1::len(queries)]
61         csv_writer.writerow([sanitized_query_description] + response_times)
62
63 mongo_client.close()
```

students_db.1million

Documents Aggregations Schema **Explain Plan** Indexes Validation

Filter ⓘ ⓘ • {"gender": "Female", "presence_percentage": {"\$gt": 90}, "result": "Fail"}

Query Performance Summary [Learn more ⓘ](#)

Documents Returned: 204331
Index Keys Examined: 0
Documents Examined: 1000000

Actual Query Execution Time (ms): 2488
Sorted in Memory: no
⚠ No index available for this query.

COLLSCAN

nReturned 204331
Documents Examined: 1000000

Execution Time 244 ms

DETAILS

students_db.1million

Documents Aggregations Schema **Explain Plan** Indexes Validation

Filter ⓘ ⓘ • {"gender": "Male", "result": "Pass"}

Query Performance Summary [Learn more ⓘ](#)

Documents Returned: 192870
Index Keys Examined: 0
Documents Examined: 1000000

Actual Query Execution Time (ms): 2498
Sorted in Memory: no
⚠ No index available for this query.

COLLSCAN

nReturned 192870
Documents Examined: 1000000

Execution Time 385 ms

DETAILS

students_db.1million

Documents Aggregations Schema **Explain Plan** Indexes Validation

Filter ⓘ ⓘ • {"first_name": {"\$regex": "A"}}

Query Performance Summary [Learn more ⓘ](#)

Documents Returned: 92904
Index Keys Examined: 0
Documents Examined: 1000000

Actual Query Execution Time (ms): 2106
Sorted in Memory: no
⚠ No index available for this query.

COLLSCAN

nReturned 92904
Documents Examined: 1000000

Execution Time 252 ms

DETAILS

students_db.1million

Documents Aggregations Schema **Explain Plan** Indexes Validation

Filter ⓘ ⓘ • {}

Query Performance Summary [Learn more ⓘ](#)

Documents Returned: 1000000
Index Keys Examined: 0
Documents Examined: 1000000

Actual Query Execution Time (ms): 1101
Sorted in Memory: no
⚠ No index available for this query.

COLLSCAN

nReturned 1000000
Documents Examined: 1000000

Execution Time 91 ms

DETAILS

Redis Code:

- The Redis code connects to a Redis database and executes four queries. It measures query execution times for various datasets, aiding in performance assessment.

```
pythonProject Version control
redis_query.py
import time
import redis
import os
import csv

redis_host = 'localhost'
redis_port = 6379
redis_db = 0

redis_client = redis.Redis(host=redis_host, port=redis_port, db=redis_db)

if redis_client.ping():
    print("Connected to Redis")
else:
    print("Failed to connect to Redis")

datasets = [
    {'name': '250k', 'file_path': 'E:\\datasets\\250k.csv'},
    {'name': '500k', 'file_path': 'E:\\datasets\\500k.csv'},
    {'name': '750k', 'file_path': 'E:\\datasets\\750k.csv'},
    {'name': '1million', 'file_path': 'E:\\datasets\\1million.csv'}
]

base_directory = 'E:\\query_results\\redis'
os.makedirs(base_directory, exist_ok=True)

def sanitize_query_description(description):
    return ''.join(char if char.isalnum() else '.' for char in description)

for dataset in datasets:
    set_name = dataset['name']
    print(f'Dataset: {set_name}')

    total_time = 0
    execution_times = []

    for query_index, query_description in enumerate(['Q1', 'Q2', 'Q3', 'Q4']):
        sanitized_query_description = sanitize_query_description(query_description)

        for i in range(10):
            start_time = time.perf_counter_ns()

            if query_index == 0:
                all_students = redis_client.smembers(f'student:{set_name}')
            elif query_index == 1:
                name_prefix = 'A'
                students_with_name_prefix = [
                    student for student in redis_client.smembers(f'student:{set_name}')
                    if student.decode('utf-8').startswith(name_prefix)
                ]
            elif query_index == 2:
                gender = 'male'
                result = 'pass'
                students_with_gender_and_result = [
                    student for student in redis_client.smembers(f'student:{set_name}')
                    if redis_client.hget(f'student:{student.decode("utf-8")}:{set_name}', 'gender').decode('utf-8') == gender and
                    redis_client.hget(f'student:{student.decode("utf-8")}:{set_name}', 'result').decode('utf-8') == result
                ]
            elif query_index == 3:
                gender = 'female'
                min_presence_percentage = 80
                result = 'fail'
                students_with_criteria = [
                    student for student in redis_client.smembers(f'student:{set_name}')
                    if redis_client.hget(f'student:{student.decode("utf-8")}:{set_name}', 'gender').decode('utf-8') == gender and
                    int(redis_client.hget(f'student:{student.decode("utf-8")}:{set_name}', 'presence_percentage').decode('utf-8')) > min_presence_percentage and
                    redis_client.hget(f'student:{student.decode("utf-8")}:{set_name}', 'result').decode('utf-8') == result
                ]

            end_time = time.perf_counter_ns()
            execution_time = int(end_time - start_time) #
            execution_times.append(execution_time)
            total_time += execution_time

        if i == 0:
            print(f'Query {query_index + 1}, First Execution Time: {execution_time} nanoseconds')
        if i == 29:
            avg_execution_time = total_time // 30
            print(f'Query {query_index + 1}, Average Execution Time: {avg_execution_time} nanoseconds')

    filename = os.path.join(base_directory, f'results_{set_name}.csv')
    with open(filename, 'w', newline='') as result_file:
        csv_writer = csv.writer(result_file)
        csv_writer.writerow(['query', 'Execution Times'])
        for query_num in range(1, 5):
            query_label = f'Query {query_num}'
            response_times = execution_times[(query_num - 1) * 30: query_num * 30]
            csv_writer.writerow([query_label] + response_times)
```


Cassandra Code:

- The Cassandra code connects to a Cassandra cluster and performs four queries, each with a different level of complexity. It measures the execution times and handles query retries for performance evaluation.

```
pythonProject Version control
cassandra_query.py
1 from cassandra.cluster import Cluster
2 from cassandra.query import SimpleStatement, ConsistencyLevel
3 from cassandra import ReadFailure
4 import time
5 import os
6 import csv
7
8 base_directory = r'E:\query_results\Cassandra'
9
10 tables = ['table_250k', 'table_500k', 'table_750k', 'table_1million']
11
12 queries = [
13     "SELECT * FROM {} WHERE gender = 'Female' AND presence.percentage > 80 AND result = 'Fail' ALLOW FILTERING;",
14     "SELECT * FROM {} WHERE age > 20 AND grade <= 6 ALLOW FILTERING;",
15     "SELECT * FROM {} WHERE first_name = 'A' ALLOW FILTERING;",
16     "SELECT * FROM {};"
17 ]
18
19 max_retries = 3
20 delay_seconds = 1
21
22 query_execution_times = {"Query (i + 1) execution times": [] for i in range(len(queries))}
23
24 cluster = Cluster(['localhost'])
25 session = cluster.connect('students')
26
27 for table in tables:
28     dataset_results = {"Query (i + 1)": [] for i in range(len(queries))}
29
30     for i, query_template in enumerate(queries):
31         execution_times = []
32
33         query = query_template.format(table)
34         statement = SimpleStatement(query, consistency_level=ConsistencyLevel.QUORUM)
35
36         for j in range(30):
37             retries = 0
38             total_execution_time = 0
39
40             while retries < max_retries:
41
42                 try:
43                     start_time = time.time()
44                     result = session.execute(statement)
45                     for row in result:
46                         pass
47                     end_time = time.time()
48                     execution_time = int((end_time - start_time) * 1e9)
49                     execution_times.append(execution_time)
50                     total_execution_time += execution_time
51                     break
52                 except ReadFailure as e:
53                     print(f"ReadFailure on execution (j + 1) of Query (i + 1): {e}")
54                     retries += 1
55                     if retries < max_retries:
56                         delay = delay_seconds * (2 ** (retries - 1))
57                         print(f"Retrying in {delay} seconds...")
58                         time.sleep(delay)
59                     else:
60                         print(f"Failed after retries: {e}")
61
62             if j == 0:
63                 print(f"Table: {table}, Query (i + 1), First Execution Time: {execution_time} nanoseconds")
64             if j == 29:
65                 avg_execution_time = total_execution_time // (retries + 1)
66                 print(f"Table: {table}, Query (i + 1), Average Execution Time: {avg_execution_time} nanoseconds")
67
68             query_execution_times["Query (i + 1) execution times"].append(execution_times)
69             dataset_results["Query (i + 1)"] = execution_times
70
71 filename = os.path.join(base_directory, f'results_{table.replace("table_", "")}.csv')
72 with open(filename, 'w', newline='') as result_file:
73     csv_writer = csv.writer(result_file)
74     csv_writer.writerow(['Query', 'Execution Times'])
75     for query_num in range(1, 5):
76         query_label = f"Query {query_num}"
77         response_times = dataset_results[query_label]
78         csv_writer.writerow([query_label] + response_times)
79
80 session.shutdown()
81 cluster.shutdown()
```

```
Administrator Command Prompt
Microsoft Windows [Version 10.0.22621.3807]
(c) Microsoft Corporation. All rights reserved.

C:\Users\aryak>docker ps
CONTAINER ID   IMAGE      COMMAND                  CREATED        STATUS        PORTS                               NAMES
8e0456b2b28a   cassandra  "docker-entrypoint.s..." 3 months ago  Up 7 hours   7000-7001/tcp, 7199/tcp, 9160/tcp, 0.0.0.0:9042->9042/tcp  cassandra-container

C:\Users\aryak>docker exec -it cassandra-container cqlsh
Connected to Test Cluster at 127.0.0.1:9042
[cqlsh 6.1.0 | Cassandra 4.1.3 | CQL spec 3.4.6 | Native protocol v5]
Use HELP for help.
cqlsh> DESCRIBE KEYSPACES;

students      system_distributed  system_views
system        system_schema      system_virtual_schema
system_auth   system_traces      your_keyspace_name

cqlsh> USE students;
cqlsh:students> SELECT COUNT(*) FROM students."table_750k" WHERE gender = 'Female' AND presence_percentage > 80 AND result = 'Fail' ALLOW FILTERING;

count
-----
153049
(1 rows)

Warnings :
Aggregation query used without partition key

cqlsh:students> SELECT COUNT(*) FROM students."table_750k" WHERE age > 20 AND grade <= 6 ALLOW FILTERING;

count
-----
105803
(1 rows)

Warnings :
Aggregation query used without partition key

cqlsh:students> SELECT COUNT(*) FROM students."table_750k" ALLOW FILTERING;

count
-----
750000
(1 rows)

Warnings :
Aggregation query used without partition key
```

Neo4j Code:

- The Neo4j code connects to a Neo4j database and runs four queries on nodes with different labels. It times the execution of these queries and saves the results for performance analysis.

```
pythonProject Version control
neo4j_query.py
1 from py2neo import Graph, DatabaseError
2 import time
3 import os
4 import csv
5
6 url = "bolt://localhost:7687"
7 username = "neo4j"
8 password = "ARVA_2003"
9
10 graph = Graph(url, auth=(username, password))
11
12 labels = ['d250k', 'd500k', 'd750k', 'd1million']
13 datasets = ['250k', '500k', '750k', '1million']
14
15 base_directory = 'E:\\Query_results\\neo4j'
16
17 os.makedirs(base_directory, exist_ok=True)
18
19 def sanitize_query_description(description):
20     return ''.join(char if char.isalnum() else '_' for char in description)
21
22 queries = [
23     "MATCH (s:Student{}) WHERE s.gender = 'Female' AND s.presence.percentage > 80 AND s.result = 'Fail' RETURN s",
24     "MATCH (s:Student{}) WHERE s.gender = 'Male' AND s.result = 'Pass' RETURN s",
25     "MATCH (s:Student{}) WHERE s.first_name STARTS WITH 'A' RETURN s",
26     "MATCH (s:Student{}) RETURN s"
27 ]
28
29 for label, dataset in zip(labels, datasets):
30     print(f"Queries for Label '{label}':")
31
32     dataset_results = {'Query {}:'.format(i) for i in range(1, 4)}
33
34     for query_idx, query_template in enumerate(queries, start=1):
35         total_time = 0
36         execution_times = []
37
38         for i in range(1, 31):
39             try:
40                 start_time = time.perf_counter_ns()
41                 result = graph.run(query_template.format(label))
42                 for record in result:
43                     pass
44                 end_time = time.perf_counter_ns()
45                 execution_time = int(end_time - start_time)
46                 execution_times.append(execution_time)
47                 total_time += execution_time
48
49                 if i == 1:
50                     print(f"Label: {label}, Query {query_idx}, First Execution Time: {execution_time} nanoseconds")
51                 if i == 30:
52                     avg_execution_time = total_time // 30
53                     print(f"Label: {label}, Query {query_idx}, Average Execution Time: {avg_execution_time} nanoseconds.")
54
55             except DatabaseError as e:
56                 print(f"Error executing query: {e}")
57                 time.sleep(1)
58                 continue
59
60         dataset_results[f"Query {query_idx}"] = execution_times
61
62     filename = os.path.join(base_directory, f'results_{dataset}.csv')
63     with open(filename, 'w', newline='') as result_file:
64         csv_writer = csv.writer(result_file)
65         csv_writer.writerow(['query', 'Execution Times'])
66         for query_num in range(1, 4):
67             query_label = f'Query {query_num}'
68             response_times = dataset_results[query_label]
69             csv_writer.writerow([query_label] + response_times)
```

neo4j@bolt://localhost:7687/neo4j - Neo4j Browser

File Edit View Window Help Developer

neo4j\$

```
1 MATCH (s:d250k)
2 WHERE s.first_name STARTS WITH 'A'
3 RETURN COUNT(s) AS numberOfNodes;
4
```

numberOfNodes
23305

Started streaming 1 records after 24 ms and completed after 404 ms.

neo4j@bolt://localhost:7687/neo4j - Neo4j Browser

File Edit View Window Help Developer

neo4j\$

```
1 MATCH (s:d250k)
2 WHERE s.gender = 'Male' AND s.result = 'Pass'
3 RETURN COUNT(s) AS numberOfNodes;
```

numberOfNodes
47944

Started streaming 1 records after 27 ms and completed after 493 ms.

neo4j@bolt://localhost:7687/neo4j - Neo4j Browser

File Edit View Window Help Developer

neo4j\$

```
1 MATCH (s:d250k)
2 WHERE s.first_name STARTS WITH 'A'
3 RETURN COUNT(s) AS numberOfNodes;
```

numberOfNodes
23305

Started streaming 1 records after 21 ms and completed after 330 ms.

neo4j@bolt://localhost:7687/neo4j - Neo4j Browser

File Edit View Window Help Developer

neo4j\$

```
neo4j$ MATCH (s:d250k) RETURN COUNT(s) AS numberOfNodes;
```

numberOfNodes
250000

Started streaming 1 records after 3 ms and completed after 5 ms.

To access the records we can use the following commands in neo4j browser

```
CALL db.labels();
```

```
MATCH (d:labelname)
```

```
RETURN d;
```

```
MATCH (d:labelname)
```

```
WHERE query
```

```
RETURN d;
```

```
MATCH (d:d250k)
```

```
WHERE query
```

```
RETURN d;
```

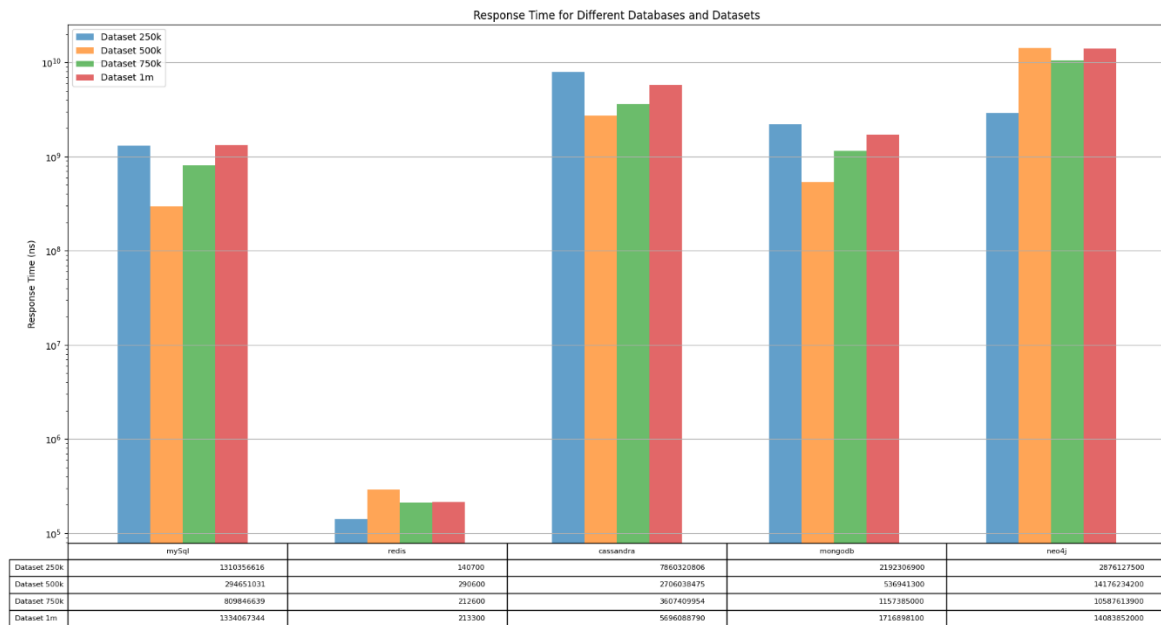
```
MATCH (d:d250k)
```

```
WHERE d.first_name STARTS WITH 'A'
```

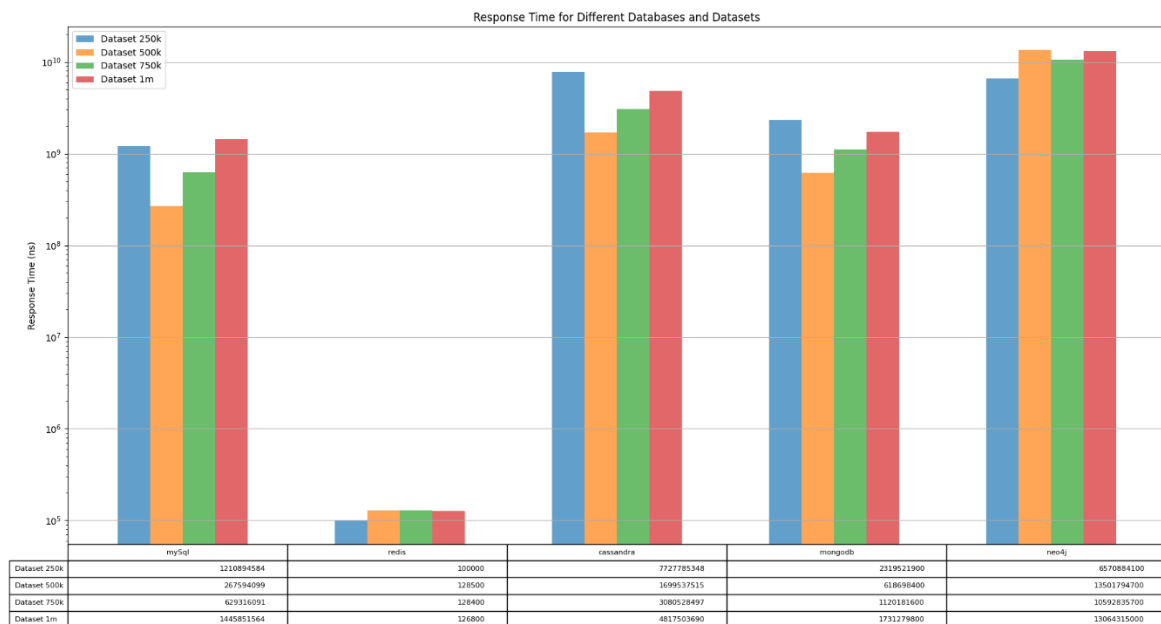
```
RETURN COUNT(d) AS numberOfNodes;
```

HISTOGRAMS

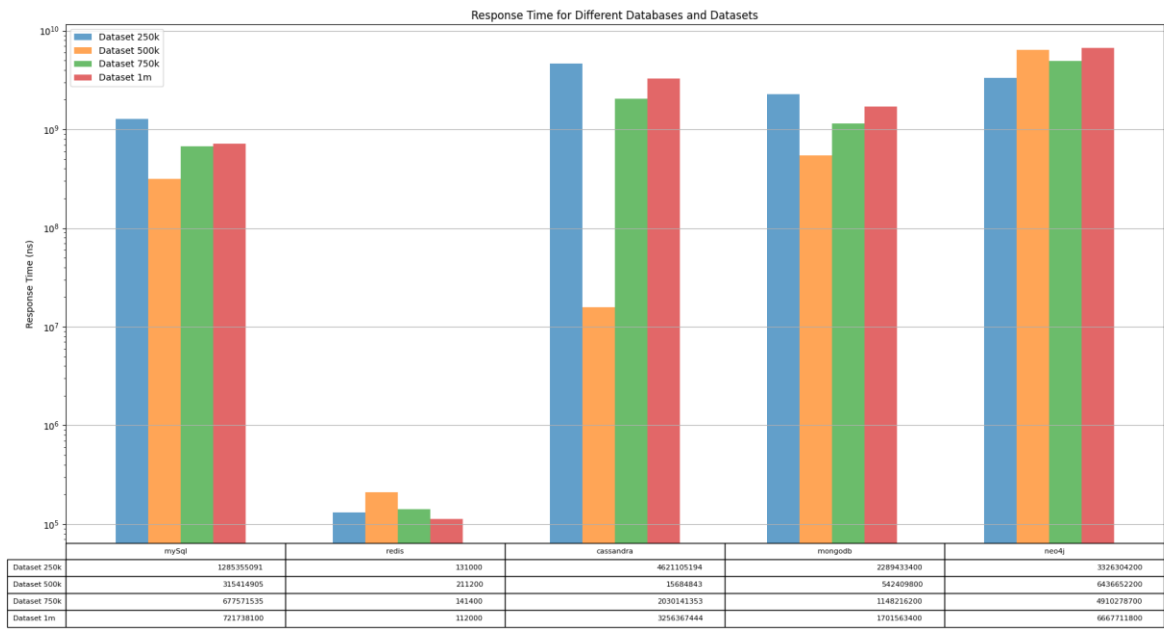
Query 1: Retrieve records for females with a presence percentage greater than 80% who failed :



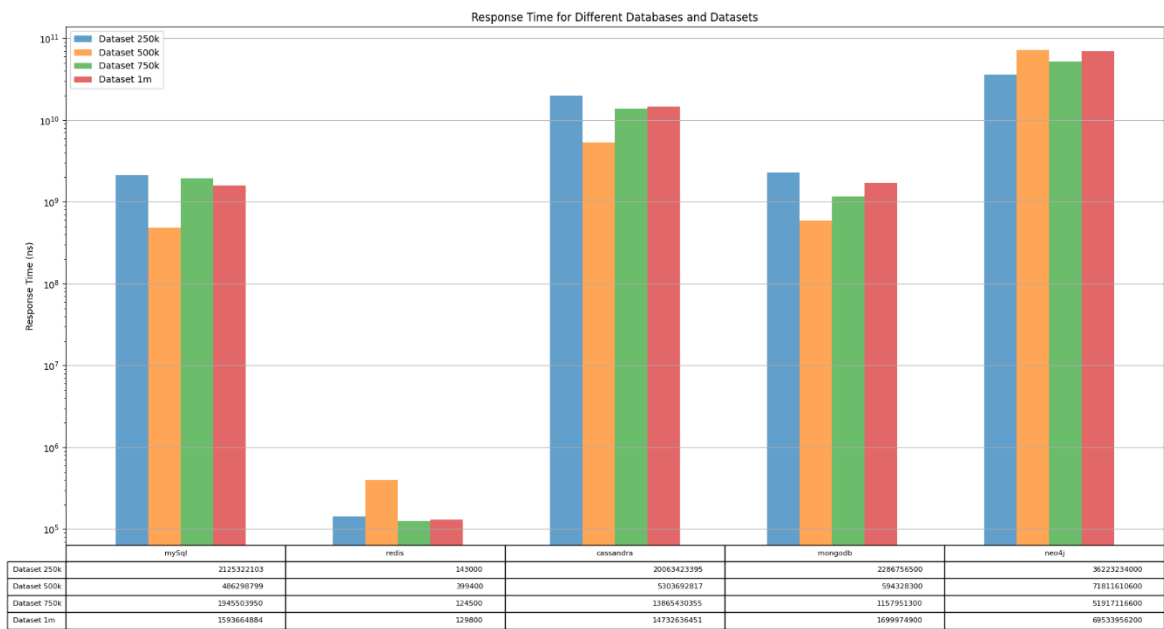
Query 2: Retrieve records for males who passed:



Query 3: Retrieve records for individuals whose first names start with 'A':



Query 4: Retrieve all records from the specified table:



CONCLUSION

The project's graphs reveal clear trends in the performance of different databases—Redis emerges as the fastest, followed by MongoDB and MySQL, which show comparable speeds. Cassandra performs a bit slower than Redis, MongoDB, and MySQL. Notably, Neo4j appears to be the slowest among the databases.

For handling larger amounts of data (1 million entries), Cassandra shows reasonable scalability, but it's crucial to consider factors like data complexity when deciding on a database.

The bar graphs provide a quick way to see which databases are consistently faster. These visualizations assist decision-makers in understanding performance patterns and making informed choices.

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7. [Python Official Documentation](#)