
CSCI 5408

***Data Management, Warehousing, And
Analytics***

Assignment 2 - Problem 2

Prototype of a light-weight DBMS using Java programming language.

Prepared By

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Problem-2: Prototype of a light-weight DBMS using Java programming language (no 3rd party libraries allowed).

1. Summary:

This document outlines the requirements for developing a console-based Java application using a standard Java IDE [1]. The application is designed to accept user input in the form of SQL queries after successful login authentication. The Java code do follow JavaDocs specification for commenting styles, including annotations such as "@param" and "@return" [2]. The design principles used in the application's development is utilising the SOLID design principles [3].

Two main functionalities are there in the application. First, a two-factor authentication module which is necessary for user authentication, which involves using ID, password, and question/answer authentication [4]. The application supports multiple users, and it is designed in a separate class to handle the authentication process. Secondly, the application implements a custom-designed persistent storage system to store data, user information, logs, etc. A custom file format is used, and standard formats like JSON, XML, and CSV are not used. Custom delimiters are designed for storing and accessing data within a text file.

In addition to the required functionalities, the application also implements various SQL queries such as CREATE, SELECT, INSERT, UPDATE, and DELETE on any number of tables. Separate methods have been created for each query. Furthermore, a transaction handling logic is implemented, allowing users to initiate and end transactions. To ensure the ACID (Atomicity, Consistency, Isolation, Durability) properties, the processed queries do not immediately update the custom-made database text file. Instead, they are stored in intermediate data structures such as Lists. Only when a "Commit" operation is performed, the changes are applied to the text file.

Overall, the application's focus is on developing a console-based Java program that supports user authentication, custom storage, SQL query execution, and transaction handling following the ACID properties.

Requirements & Tasks fulfilled:

1. Use a standard **Java IDE** to develop your application. Any JDK version is acceptable [1]:

IntelliJ IDEA Community Edition is used for the entire code.

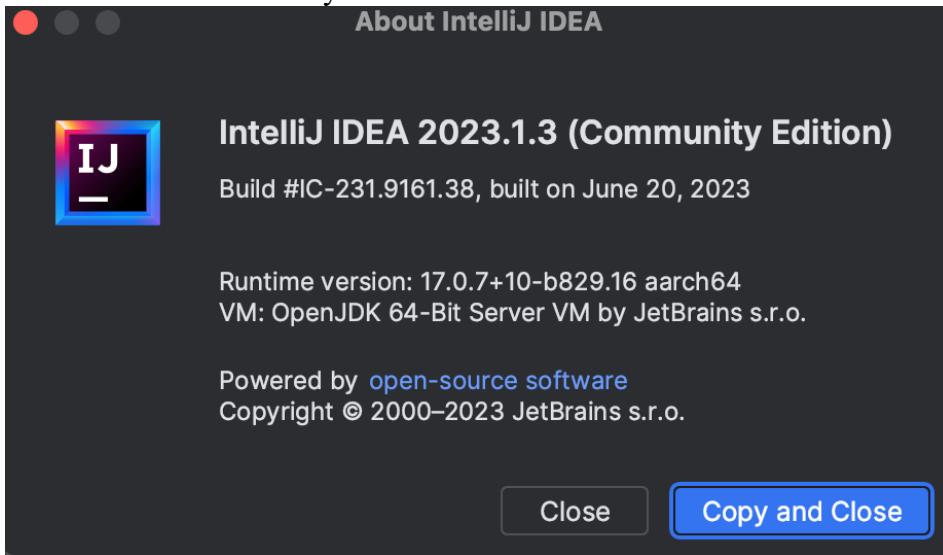


Figure 1: Java IDE setup.

2. While writing the Java code, followed the **JavaDocs specification** for commenting styles, such as @param, @return [2].

The screenshot shows the IntelliJ IDEA interface with the 'UserAuthenticationModule.java' file open. The code editor displays the following JavaDoc comments and code snippets:

```
/*
 * Module for user authentication.
 */
3 usages
public class UserAuthenticationModule {
    7 usages
    private final Map<String, User> usersMap;
    3 usages
    private final UserFileHandler fileHandler;
    11 usages
    private final Scanner scanner;
    2 usages
    private boolean isAuthenticated = false;
    // Constructor for a UserAuthenticationModule.
    1 usage
    public UserAuthenticationModule() {...}

    /**
     * Starts the user authentication module.
     *
     * @return true if authentication is successful, false otherwise
     */
    1 usage
    public boolean start() {...}

    // Displays the menu options.
    1 usage
    private void displayMenu() {...}
}
```

Figure 2: User Authentication module class- JavaDocs specification for commenting styles.

```

1 package authentication;
2
3 import java.io.*;
4 import java.util.Map;
5
6 /**
7 * Utility class for handling user file operations.
8 */
9 public class UserFileHandler {
10     private final String filePath;
11
12     /**
13      * Constructs a UserFileHandler object.
14      *
15      * @param filePath the path of the user file
16      */
17     public UserFileHandler(String filePath) {
18         this.filePath = filePath;
19     }
20
21     /**
22      * Loads user data from the user file into the provided map.
23      *
24      * @param userMap the map to store the loaded user data
25      */
26     public void loadUsers(Map<String, User> userMap) {...}

```

Figure 3: User File Handler class- JavaDocs specification for commenting styles.

```

12 /**
13  * Constructor for User object with the specified username, password, security question, and answer.
14  *
15  * @param username the username of the user
16  * @param password the password of the user
17  * @param question the security question chosen by the user
18  * @param answer the answer to the security question
19  */
20 public User(String username, String password, String question, String answer) {...}
21
22 /**
23  * Returns the username of the user.
24  *
25  * @return the username of the user
26  */
27 public String getUsername() { return username; }
28
29 /**
30  * Sets the username of the user.
31  *
32  * @param username the username of the user
33  */
34 public void setUsername(String username) { this.username = username; }
35
36 /**
37  * Returns the password of the user.
38  *
39  * @return the password of the user
40  */
41 public String getPassword() { return password; }
42
43 /**
44  * Sets the password of the user.
45  *
46  * @param password the password of the user
47  */
48 public void setPassword(String password) { this.password = password; }
49

```

Figure 4: User class- JavaDocs specification for commenting styles.

```
package database;

import java.io.FileWriter;
import java.io.IOException;
import java.io.PrintWriter;
import java.util.regex.Matcher;
import java.util.regex.Pattern;

/**
 * The CreateTable class is responsible for creating tables in a database.
 */
public class CreateTable {

    /**
     * Creates a table based on the given query.
     *
     * @param query the CREATE TABLE query
     */
    public static void createTable(String query) {
        ...
    }
}
```

Figure 5: CreateTable class- JavaDocs specification for commenting styles.

The screenshot shows the IntelliJ IDEA interface with the following details:

- Project Tree:** The left sidebar shows the project structure under "CSCI5408_A2". It includes a .idea folder, logs, src (containing main, java, authentication, database, CreateTable, DeleteTable, InsertTable, SelectTable, UpdateTable, utils, RunApplication), test, target, .gitignore, pom.xml, External Libraries, and Scratches and Consoles.
- Code Editor:** The main window displays the code for `DeleteTable.java`. The tab bar at the top has tabs for `RunApplication.java`, `SelectTable.java`, `CreateTable.java`, and `DeleteTable.java` (which is currently active).
- Code Content:** The code for `DeleteTable.java` is as follows:

```
1 usage
private static final String FILE_NAME = "delete-table_data.txt";
3 usages
private static final String DELIMITER = "\n";

/**
 * Deletes rows from a table based on the given query.
 *
 * @param query the DELETE query
 */
1 usage
public static void deleteTable(String query) {...}

/**
 * Checks if the WHERE clause matches the row.
 *
 * @param whereClause the WHERE clause of the DELETE query
 * @param columns the columns of the table
 * @param values the values of the row
 * @return true if the WHERE clause matches the row, false otherwise
 */
1 usage
private static boolean matchesWhereClause(String whereClause, String[] columns, String[] values) {...}

/**
 * Gets the index of a column in the array.
 *
 * @param columnName the name of the column
 * @param columns the array of column names
 * @return the index of the column in the array, or -1 if not found
 */

```

Figure 6: Delete Table class- JavaDocs specification for commenting styles.

The screenshot shows the IntelliJ IDEA interface. On the left, the Project tool window displays the project structure under 'CSCI5408_A2'. The 'src/main/java/authentication' package contains several classes: User, UserAuthenticationModule, UserFileHandler, CreateTable, DeleteTable, InsertTable (which is selected), SelectTable, and UpdateTable. Below these are utils, RunApplication, and resources. The 'src/test' and 'target' directories are also listed. The right side of the screen shows the code editor for 'InsertTable.java'. The code is as follows:

```
1 package database;
2
3 import java.io.*;
4 import java.util.regex.Matcher;
5 import java.util.regex.Pattern;
6
7 /**
8 * The InsertTable class is responsible for inserting values into a table in a database.
9 */
10 usage
11 public class InsertTable {
12     1 usage
13     private static final String FILE_NAME = "logs/insert-table_data.txt";
14     1 usage
15     private static final String DELIMITER = "\n";
16
17     /**
18      * Inserts values into a table based on the given query.
19      *
20      * @param query the INSERT query
21      */
22
23     1 usage
24     public static void insertTable(String query) {...}
25 }
```

Figure 7: Insert Table class- JavaDocs specification for commenting styles.

The screenshot shows the IntelliJ IDEA interface. On the left is the Project tool window with the following structure:

- Project: CSCI5408_A2 (~/IdeaProjects/CSCI5408)
- src:
 - main:
 - java:
 - authentication
 - User
 - UserAuthenticationMod
 - UserFileHandler
 - database
 - CreateTable
 - DeleteTable
 - InsertTable
 - SelectTable
 - UpdateTable
 - utils
 - RunApplication
 - resources
 - test
 - target
 - .gitignore
 - pom.xml
 - External Libraries
 - Scratches and Consoles

The SelectTable.java file is open in the code editor. The cursor is positioned at line 22, column 16, inside the `selectTable` method. The code is as follows:

```
1 usage
private static final String ROW_DELIMITER = "\n";
/***
 * Retrieves and displays table information based on the given SELECT query.
 *
 * @param query the SELECT query
 */
1 usage
public static void selectTable(String query) {
    /**
     * Evaluates the condition based on the table columns and values.
     *
     * @param condition the condition of the WHERE clause
     * @param tableColumns the columns of the table
     * @param values the values of the row
     * @return true if the condition is met, false otherwise
     */
    1 usage
    private static boolean evaluateCondition(String condition, String tableColumns, String[] values) {
        /**
         * Gets the index of the column in the table columns.
         *
         * @param columnName the name of the column
         * @param tableColumns the columns of the table
         * @return the index of the column in the table columns, or -1 if not found
         */
        2 usages
        private static int getColumnIndex(String columnName, String tableColumns) {
    }
}
```

Figure 8: Select Table class- JavaDocs specification for commenting styles.

```

Project ▾
  CSCI5408_A2 ~/IdeaProjects/CSCI540
    > .idea
    > logs
    > src
      > main
        > java
          > authentication
            < User
            < UserAuthenticationModu
            < UserFileHandler
          > database
            < CreateTable
            < DeleteTable
            < InsertTable
            < SelectTable
            < UpdateTable
          > utils
            < RunApplication
          resources
        > test
      > target
      .gitignore
      pom.xml
    > External Libraries
    Scratches and Consoles

UpdateTable.java x
 7  /**
 8   * The UpdateTable class is responsible for updating data in a table in a database.
 9   */
10  1 usage
11  public class UpdateTable {
12    1 usage
13    private static final String FILE_NAME = "logs/update-table_data.txt";
14    3 usages
15    private static final String DELIMITER = "\n";
16
17    /**
18     * Updates the data in a table based on the given query.
19     *
20     * @param query the UPDATE query
21     */
22    1 usage
23    public static void updateTable(String query) {...}
24
25    /**
26     * Checks if the WHERE clause matches the row.
27     *
28     * @param whereClause the WHERE clause of the UPDATE query
29     * @param columns the columns of the table
30     * @param values the values of the row
31     * @return true if the WHERE clause matches the row, false otherwise
32     */
33    1 usage
34    private static boolean matchesWhereClause(String whereClause, String[] columns, String[] values) {...}
35
36    /**
37     * Updates the values based on the SET clause.
38     *
39     * @param setClause the SET clause
40     */
41
42

```

Figure 9: Update Table class- JavaDocs specification for commenting styles.

```

Project ▾
  CSCI5408_A2 ~/IdeaProjects/CSCI540
    > .idea
    > logs
    > src
      > main
        > java
          > authentication
            < User
            < UserAuthenticationModu
            < UserFileHandler
          > database
            < CreateTable
            < DeleteTable
            < InsertTable
            < SelectTable
            < UpdateTable
          > utils
            < Utils
            < RunApplication
          resources
        > test
      > target
      .gitignore
      pom.xml
    > External Libraries
    Scratches and Consoles

Utils.java x
 1 package utils;
 2
 3 import java.nio.charset.StandardCharsets;
 4 import java.security.MessageDigest;
 5 import java.security.NoSuchAlgorithmException;
 6
 7 /**
 8  * Utility class for common operations.
 9  */
10 3 usages
11  public class Utils {
12
13    /**
14     * Hashes a string using the MD5 algorithm.
15     *
16     * @param input the input string to be hashed
17     * @return the hashed string
18     */
19    2 usages
20    public static String hashString(String input) {
21      try {...} catch (NoSuchAlgorithmException e) {
22        System.out.println("Error hashing string: " + e.getMessage());
23        return null;
24      }
25    }
26
27
28
29
23
30
31
32
33
34
35
36
37
38
39
30
41
42

```

Figure 10: Utils class- JavaDocs specification for commenting styles.

```

Project: CSCI5408_A2
RunApplication.java

import authentication.UserAuthenticationModule;
import database.*;
import java.io.BufferedReader;
import java.io.IOException;
import java.io.InputStreamReader;

/**
 * The RunApplication class is responsible for running the application and handling user queries.
 */
public class RunApplication {
    public static void main(String[] args) {
        // Create an instance of the UserAuthenticationModule
        UserAuthenticationModule module = new UserAuthenticationModule();

        // Start the authentication module
        module.start();
        BufferedReader reader = new BufferedReader(new InputStreamReader(System.in));
        String query;
        boolean exit = false;

        while (!exit) {
            try {
                System.out.println("-----");
                System.out.println("Enter your query in the following format:");
                System.out.println("Create Table: create table <table_name> (<column1>, <column2>, ...);");
                System.out.println("Insert Data: insert into <table_name> values (<value1>, <value2>, ...);");
                System.out.println("Select Data: select * from <table_name> where <condition>;");
                System.out.println("Update Data: update <table_name> set <column_name>=<new_value> where <condition>;");
                System.out.println("Type 'exit' to exit the application.");
                System.out.println("-----");
                query = reader.readLine();
            }

```

Figure 11: RunApplication class- JavaDocs specification for commenting styles.

3. The application code demonstrates some of the **SOLID principles** [3]. These design principles help promote code organization, maintainability, extensibility, and reusability, making the application more robust and easier to understand and maintain. The design principles used in the application program development/execution are:

a. Single Responsibility Principle (SRP):

- The UserAuthenticationModule class is responsible for handling user authentication.
- The User class represents a user with authentication information.
- The UserFileHandler class is responsible for handling user file operations.
- The CreateTable, InsertTable, SelectTable, UpdateTable, and DeleteTable classes are responsible for their respective database operations.

b. Open/Closed Principle (OCP):

- The UserAuthenticationModule class is open for extension but closed for modification. It can be extended to support additional authentication features without modifying its existing code.

c. Liskov Substitution Principle (LSP):

- The UserAuthenticationModule class uses the UserFileHandler class as a dependency, following the LSP. It can use any subclass of UserFileHandler without issues.

d. Dependency Inversion Principle (DIP):

- The UserAuthenticationModule class depends on abstractions (interfaces) like Map and Scanner, instead of concrete implementations.
- The UserAuthenticationModule class depends on the UserFileHandler class, which is an abstraction, allowing for flexibility in choosing different file handling methods.

Additionally:

- The code separates different concerns into separate classes and modules. For example, the authentication functionality is encapsulated in the UserAuthenticationModule, and the database operations are handled by separate database-related classes.
 - The code uses encapsulation to hide internal details and expose only necessary information through getters and setters. For example, the User class encapsulates the user's authentication information, and the UserAuthenticationModule provides methods for creating users, logging in, and checking authentication status.
4. The application is totally **console-based** (no GUI added) and it accept user input in the form of SQL query, once the user has successfully logged in.

```

Run RunApplication x
/Library/Java/JavaVirtualMachines/jdk-17.0.5.jdk/Contents/Home/bin/java -javaagent:/Applications/IntelliJ IDEA CE.app/Contents/lib/idea_rt.jar=51699:/Applications/I
-----
1. Create User
2. Login
3. Exit
-----
Please Enter your choice: 2
Enter username: bh0za
Enter password: Admin@123
Enter security question: your home country?
Enter answer: India
Login successful...

Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

Create table customer (id, name, age, address);
Please create the database first using the 'CREATE DATABASE' query.

Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;

```

Figure 12: Console based User authentication program.

```
Run RunApplication x

Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.
-----
Create database DMWA-Assignment2
Database created: DMWA-Assignment2
Database created successfully!
-----
Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

-----
Create table customer (id, name, age, address);
Invalid CREATE TABLE query!

-----
Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

-----
create table customer (id, name, age, address);
Table created successfully!
```

Figure 13: Console-based program which accept user input in the form of SQL query, after the user login.

5. Two factor user authentication:

The application supports multi-user authentication, which is critical for protecting sensitive data. When users create accounts, their passwords are hashed and securely stored in the database. This ensures that even if the database is compromised, the passwords remain secure.

To gain access to the database, users must enter their login credentials and answer to the security questions, which are then validated against the hashed passwords stored in the database using MD5 algorithm [4]. This adds another layer of security by preventing unauthorised access to sensitive data.

Overall, the code provides a console-based interface for user authentication and data management, ensuring the security and persistence of user information.

- a. The **UserAuthenticationModule** class handles user authentication by allowing users to create accounts, log in with their credentials, and perform various operations based on their authentication status.
 - b. The **User** class represents a user with authentication information such as username, password, security question, and answer.
 - c. The **UserFileHandler** class is responsible for loading and saving user data to a file.
 - d. The **Utils** class provides utility methods, including hashing strings using the MD5 algorithm.
 - e. `user_details.txt` file captures the user login details including the hashing for the password.

Working flow of User Authentication module:

- The application starts by executing the main method in the RunApplication class, which displays the menu options for the user: "1. Create User", "2. Login", and "3. Exit"

```
RunApplication x
/Library/Java/JavaVirtualMachines/jdk-17.0.5.jdk/Contents/Home/bin/java -javaagent:/Applications/IntelliJ IDEA CE.app/Contents/lib/idea_rt.jar=52494:/Applications/IntelliJ IDEA CE.app/Contents/bin
-----
1. Create User
2. Login
3. Exit
-----
Please Enter your choice:
```

Figure 14: Menu options for User Authentication

- Let's say the user enters "1" to create a new user. They are prompted to enter a username.

```
RunApplication x
-----
| | | : 
/Library/Java/JavaVirtualMachines/jdk-17.0.5.jdk/Contents
-----
1. Create User
2. Login
3. Exit
-----
Please Enter your choice: 1
Enter username: bhavisha
```

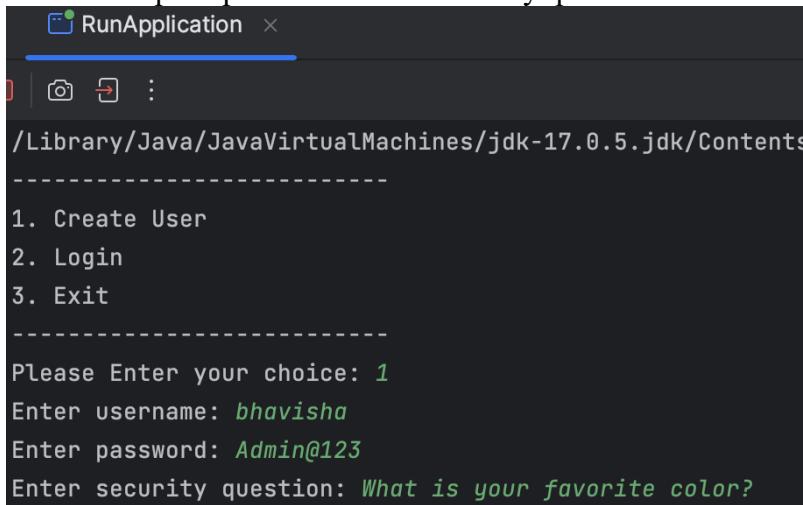
Figure 15: Starting of Register User process.

- Since it's a new user, the username is valid. The user is then prompted to enter a password. The application hashes the entered password using the Utils.hashString method for security.

```
RunApplication x
-----
| | | : 
/Library/Java/JavaVirtualMachines/jdk-17.0.5
-----
1. Create User
2. Login
3. Exit
-----
Please Enter your choice: 1
Enter username: bhavisha
Enter password: Admin@123
```

Figure 16: Username and Password entering for registration.

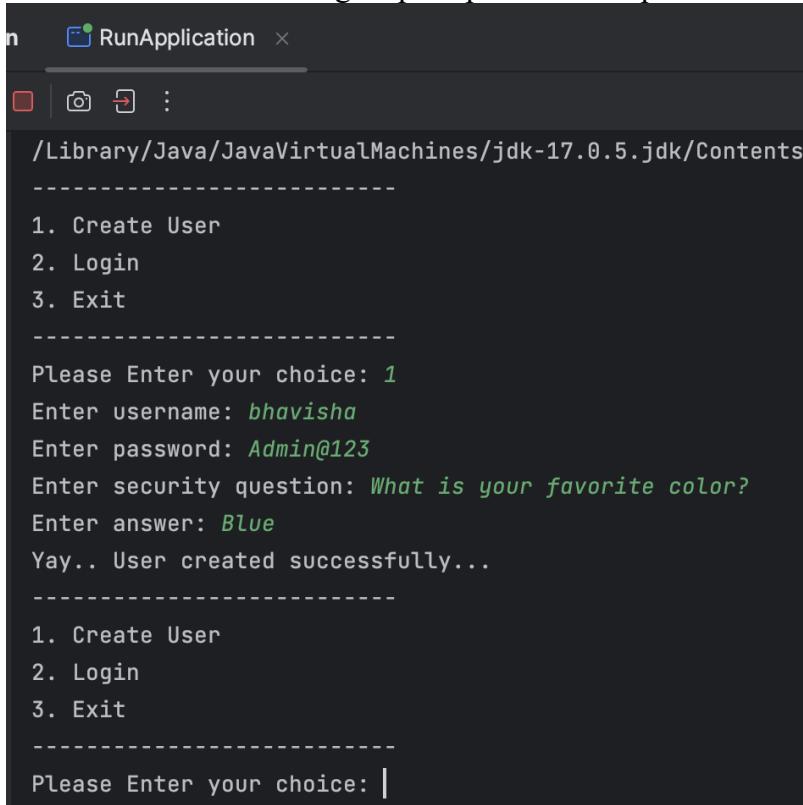
- The user is prompted to choose a security question after that.



```
/Library/Java/JavaVirtualMachines/jdk-17.0.5.jdk/Contents
-----
1. Create User
2. Login
3. Exit
-----
Please Enter your choice: 1
Enter username: bhavisha
Enter password: Admin@123
Enter security question: What is your favorite color?
```

Figure 17: Security question to enter for registration.

- Once the answer is entered, it displays a success message, indicating that the user has been created. and it will again prompt the menu options.



```
n   RunApplication ×
-----
1. Create User
2. Login
3. Exit
-----
Please Enter your choice: 1
Enter username: bhavisha
Enter password: Admin@123
Enter security question: What is your favorite color?
Enter answer: Blue
Yay.. User created successfully...
-----
1. Create User
2. Login
3. Exit
-----
Please Enter your choice: |
```

Figure 18: User registration completion

- The entered details are stored in text file named “user_details.txt” under logs directory. It supports the multiuser authentication, so it can add all data, when it is registered.

The screenshot shows the IntelliJ IDEA interface. On the left, the project tree displays a 'logs' directory containing several text files: 'create-table_data.txt', 'database.txt', 'insert-table_data.txt', 'select-table_data.txt', 'update-table_data.txt', and 'user_details.txt'. The 'user_details.txt' file is selected and open in the code editor. The content of the file is:

```

1 kp::26b568e4192a164d5b3eacdbd632bc2e::kp::kp
2 bhoza::0e7517141fb53f21ee439b355b5a1d0a::your home country?::India
3 bbhatt::c5c849c1a1cfa8b09e9241b1d3ae7884::fav food?::pav-bhaji
4 bhavisha::0e7517141fb53f21ee439b355b5a1d0a::What is your favorite color?::Blue
5

```

Figure 19: User registration data stored in text file.

- Now let's say user wants to login and enters “2” on console, they are prompted to enter their username.

The screenshot shows a terminal window titled 'Run Application'. The session starts with a menu:

```

1. Create User
2. Login
3. Exit

```

The user enters '2' at the prompt:

```

Please Enter your choice: 1

```

The application then prompts for a username and password:

```

Enter username: bhavisha
Enter password: Admin@123

```

It asks for a security question and answer:

```

Enter security question: What is your favorite color?
Enter answer: Blue

```

Finally, it confirms the user was created successfully:

```

Yay.. User created successfully...

```

After a short delay, the menu reappears:

```

1. Create User
2. Login
3. Exit

```

The user then enters '2' again at the prompt:

```

Please Enter your choice: 2

```

The application is waiting for the username input:

```

Enter username: |

```

Figure 20: User Login screen.

- The application checks if the entered username exists, otherwise it will show the message of “Invalid Username!”. Since the username exists, the login process continues, and will happen same for password, security question and answer. If the answer is correct, the login process is considered successful, and a login success message is

displayed.

The screenshot shows a terminal window titled "Run Application". The application's menu bar includes "Run", "File", "Edit", "View", "Help", and a "RunApplication" icon. Below the menu is a toolbar with icons for run, stop, and refresh. The main area displays the following text:

```
Wrong security question...
-----
1. Create User
2. Login
3. Exit
-----
Please Enter your choice: 2
Enter username: bhavisha
Enter password: Admin@123
Enter security question: What is your favorite color?
Enter answer: Blue
Login successful...
```

Figure 21: User login completion

If the username is not found it will show the message of “Username not found!”

The screenshot shows a terminal window titled "Run Application". The application's menu bar includes "Run", "File", "Edit", "View", "Help", and a "RunApplication" icon. Below the menu is a toolbar with icons for run, stop, and refresh. The main area displays the following text:

```
/Library/Java/JavaVirtualMachines/jdk-17.0.5.jdk/Contents/Home/bin/java -javaagent:/Ap
-----
1. Create User
2. Login
3. Exit
-----
Please Enter your choice: 2
Enter username: er
Username not found!
```

Figure 22: Username mismatch

If the password is wrong, then it will show the message “Wrong password...”

```
-----  
1. Create User  
2. Login  
3. Exit  
-----  
Please Enter your choice: 2  
Enter username: bhoza  
Enter password: as  
Wrong password...|  
-----  
1. Create User  
2. Login  
3. Exit  
-----  
Please Enter your choice:
```

Figure 23: Password mismatch

If the security question/answer mismatches, it will show the error message as “Wrong answer.”

```
-----  
Please Enter your choice: 2  
Enter username: bhoza  
Enter password: Admin@123  
Enter security question: home country?  
Enter answer: canada  
Wrong answer...  
-----  
1. Create User  
2. Login  
3. Exit  
-----  
Please Enter your choice: |
```

Figure 24: Security question/answer mismatch

6. Implementation of Queries (DDL & DML):

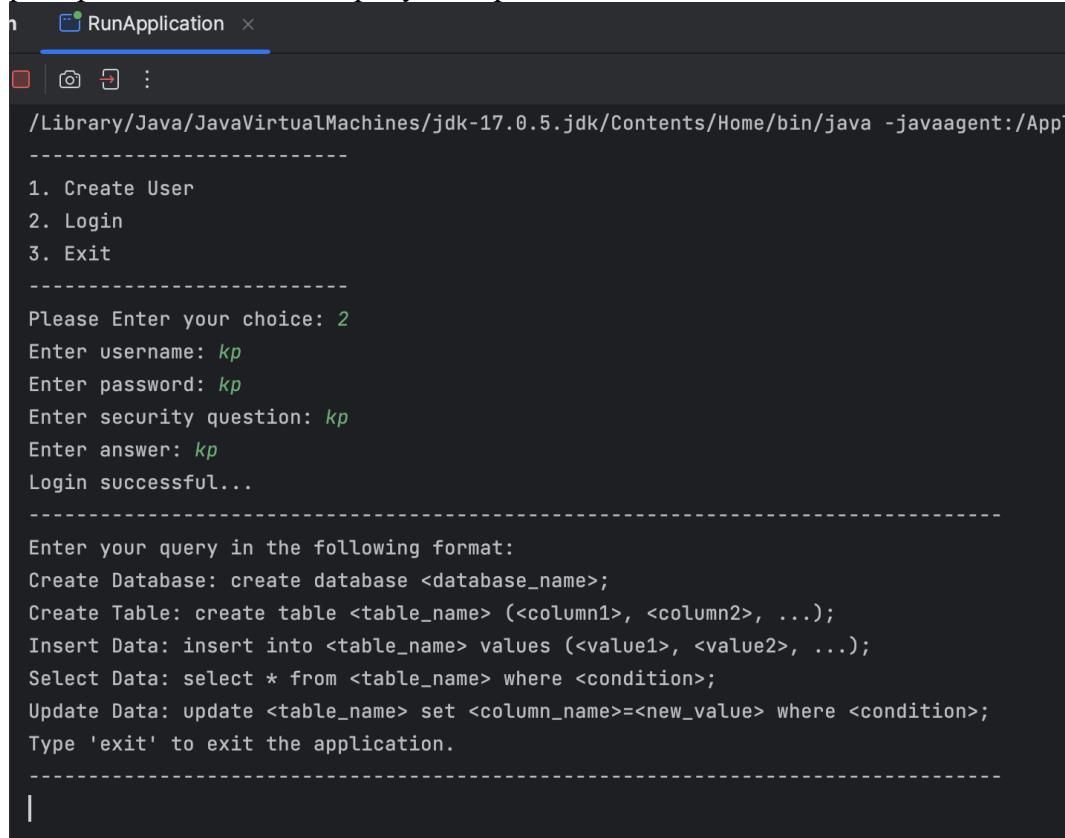
The application also implements various SQL queries such as CREATE, SELECT, INSERT, UPDATE, and DELETE on any number of tables. Separate methods have been created for each query.

The application parses queries using **regular expressions (regex)**, providing users with a powerful and flexible way to query their database. The application's regex engine is highly efficient and can easily handle complex questions.

The application supports a diverse set of regex patterns, allowing users to query the database in a flexible and efficient manner. Users can, for example, search for records based on specific keywords or retrieve data from specific columns. This allows users to find the information quickly and efficiently they require. The concept of regex and checking if the queries are rightly written or not, have used the regex101 site which highlights the syntax which is written correctly [5].

Working flow of queries implementation (CREATE, SELECT, INSERT, UPDATE, and DELETE):

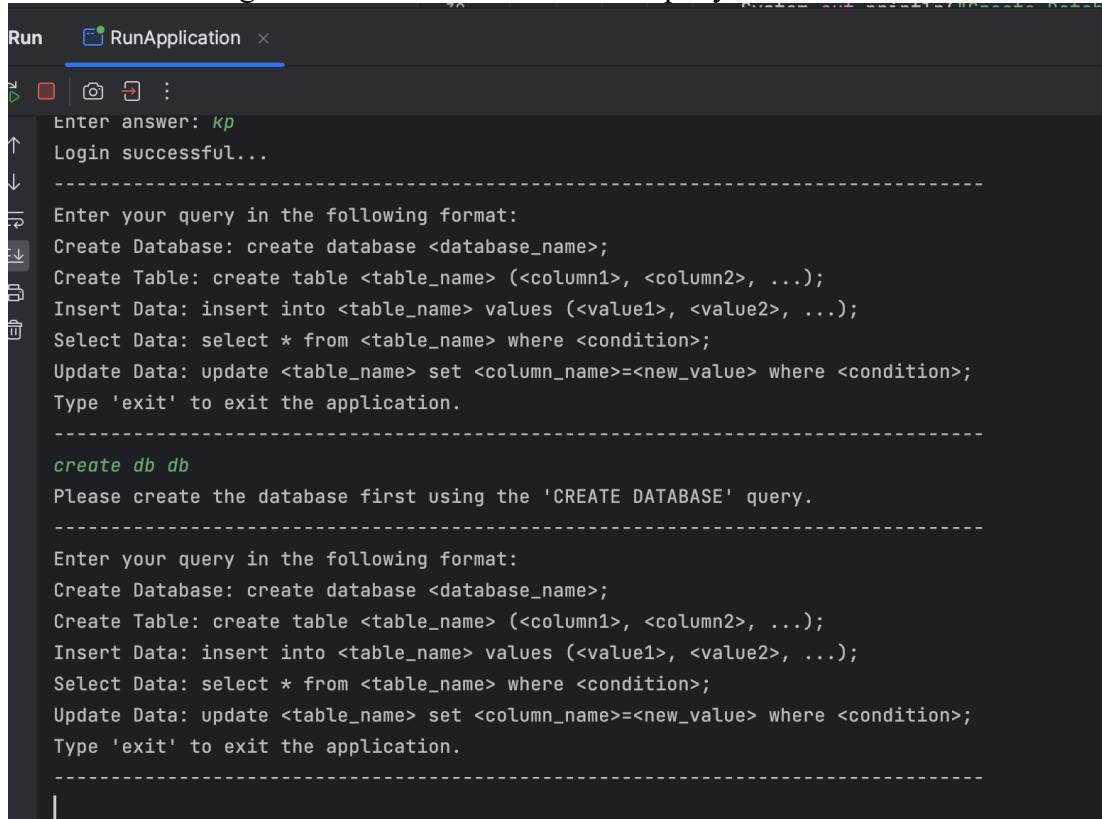
- The application starts by executing the main method in the RunApplication class, which displays the menu options for the user authentication. Once the user is logged in, it will prompt the user to enter a query in a specific format.



```
RunApplication ×
-----
/Library/Java/JavaVirtualMachines/jdk-17.0.5.jdk/Contents/Home/bin/java -javaagent:/Applicat
-----
1. Create User
2. Login
3. Exit
-----
Please Enter your choice: 2
Enter username: kp
Enter password: kp
Enter security question: kp
Enter answer: kp
Login successful...
-----
Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.
|
```

Figure 25: Query insertion menu after login completion

- If the query is not in the given format, it will show the error message “Please create the database first using the ‘CREATE DATABASE’ query.”



The screenshot shows a terminal window titled "Run Application". The application has a menu bar with "Run" and "RunApplication". The main area displays the following text:

```

Run RunApplication ×

Enter answer: kp
↑ Login successful...
↓

Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

-----
create db db
Please create the database first using the 'CREATE DATABASE' query.

-----
Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

|
```

Figure 26: Error message for invalid query insertion

- Let's say the user wants to create a database and enters the query “create database my_dmwaA2_db;”. The application checks if the query starts with create database (case-insensitive). Since it matches, it continues processing and, a success message is displayed: “Database created: my_dmwaA2_db.”

Please create the database first using the 'CREATE DATABASE' query.

Enter your query in the following format:

Create Database: create database <database_name>;

Create Table: create table <table_name> (<column1>, <column2>, ...);

Insert Data: insert into <table_name> values (<value1>, <value2>, ...);

Select Data: select * from <table_name> where <condition>;

Update Data: update <table_name> set <column_name>=<new_value> where <condition>;

Type 'exit' to exit the application.

```
create database my_dmwaA2_db
```

Database created: my_dmwaA2_db

Database created successfully!

Enter your query in the following format:

Create Database: create database <database_name>;

Create Table: create table <table_name> (<column1>, <column2>, ...);

Insert Data: insert into <table_name> values (<value1>, <value2>, ...);

Select Data: select * from <table_name> where <condition>;

Update Data: update <table_name> set <column_name>=<new_value> where <condition>;

Type 'exit' to exit the application.

Figure 27: Successful Database creation

- If the database name is not null (indicating a valid query), the method proceeds to save the database name to a text file.

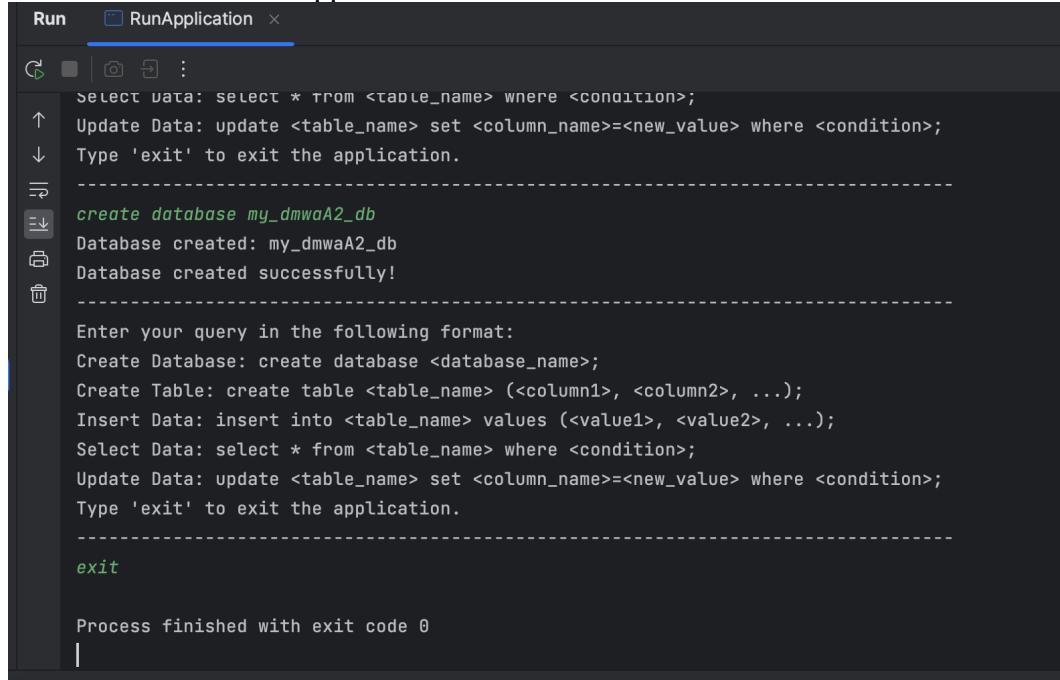
The screenshot shows the IntelliJ IDEA interface with the following details:

- Project View:** The project structure is displayed on the left. It includes a folder named "CSCI5408_A2" containing ".idea" and "logs" subfolders. Inside "logs", several files are listed: "create-database.txt" (selected), "create-table_data.txt", "insert-table_data.txt", "select-table_data.txt", "update-table_data.txt", and "user_details.txt". Below "logs" is a "src" folder containing "main" and "java" subfolders, with "authentication" also present.
- Run Tab:** The "Run" tab is active, showing the configuration for "RunApplication".
- Output Window:** The bottom window displays the application's output:

```
type EXIT to EXIT the application.  
-----  
create database my_dmwaA2_db  
Database created: my_dmwaA2_db  
Database created successfully!
```

Figure 28: Create Database saved in text file.

- After processing the “create database” query, the application continues to display the menu options and wait for the next user input. If the user wants to exit, they can enter “exit” to terminate the application.



```

Run Application x
G | : 
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

create database my_dmwaA2_db
Database created: my_dmwaA2_db
Database created successfully!

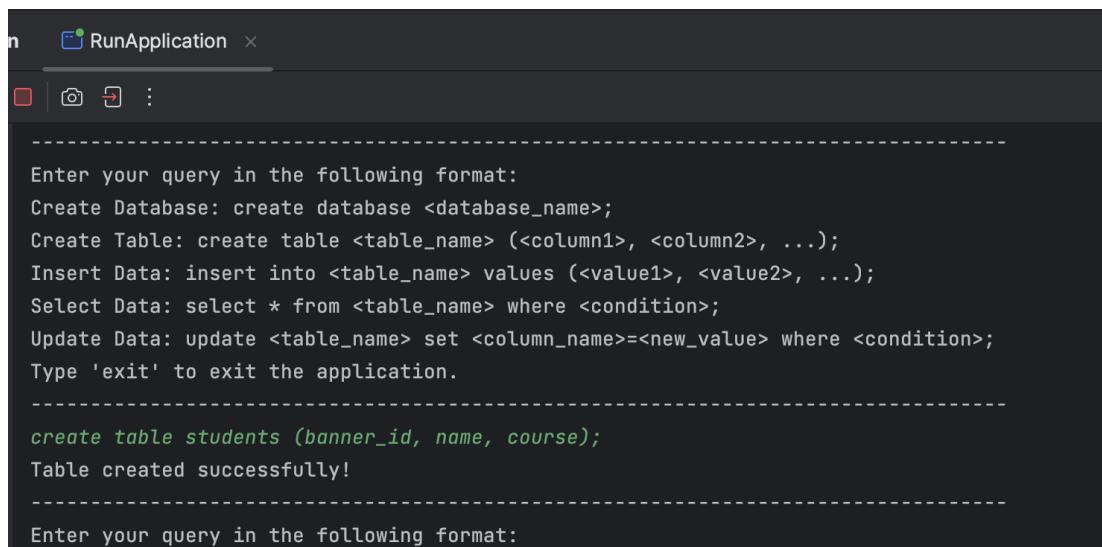
Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

exit

Process finished with exit code 0
|
```

Figure 29: Exit to terminate the application.

- Now let's say the user wants to create a table and enters the query “create table students (banner_id, name, course);”. The application checks if the query starts with “create table” (case-insensitive). Since it matches, it continues processing. Inside the CreateTable.createTable method, the query is parsed and validated using regular expressions (regex). The regex pattern “create\s+table\s+(\w+)\s+\((.+)\);” is used to extract the table name and the column definitions. Once the write operation is successful, a success message is displayed: “Table created successfully!”



```

n Run Application x
n | : 
-----
Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

create table students (banner_id, name, course);
Table created successfully!

-----
Enter your query in the following format:

```

Figure 30: Successful Student table creation

- If the query matches the pattern and the table name and column definitions are successfully extracted, the method proceeds to store the table information in a custom file “create-table_data.txt”.

The screenshot shows a Java application interface with the following components:

- Project View:** Shows the project structure under "src/main/java". The "CreateTable" class is currently selected.
- Code Editor:** Displays the content of `RunApplication.java`, which contains code to create tables for employee, hotel, customer, students, and banner_id.
- Run Configuration:** Shows a configuration for "RunApplication".
- Terminal:** Displays the application's command-line interface with instructions and examples for creating databases, tables, inserting data, selecting data, and updating data. It also shows the creation of a "students" table and the message "Table created successfully!".

Figure 31: Create table saved in text file.

- After processing the “create table” query, the application continues to display the menu options and waits for the next user input. Let's say the user wants to insert values into a students table and enters the query “insert into students values (B00935827, Bhavisha_Oza, MACS);”. The application checks if the query starts with “insert into” (case-insensitive). Since it matches, it continues processing. Inside the InsertTable.insertTable method, the query is parsed and validated using regular expressions (regex). The regex pattern "insert\s+into\s+(\w+)\s+values\s*\((.+)\)\s*;\s*" is used to extract the table name and the values to be inserted. Once the write operation is successful, a success message is displayed: “Data inserted successfully!”

```

Run  RunApplication x

Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

insert into students values (B00935827, Bhavisha_Oza, MACS);
Data inserted successfully!

Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

```

Figure 32: Successful data insertion in Student table.

- If the query matches the pattern and the table name and values are successfully extracted, the method proceeds to store the inserted values in a custom file “insert-table_data.txt”.

The screenshot shows an IDE interface with a Project tree on the left and a Run tab at the top. In the Project tree, under the 'logs' folder, the 'insert-table_data.txt' file is selected. The content of this file is displayed in the main editor area: "B00935827, Bhavisha_Oza, MACS".

In the Run tab, the terminal window shows the same successful insertion message as in Figure 32.

Figure 33: Insert table data saved in text file.

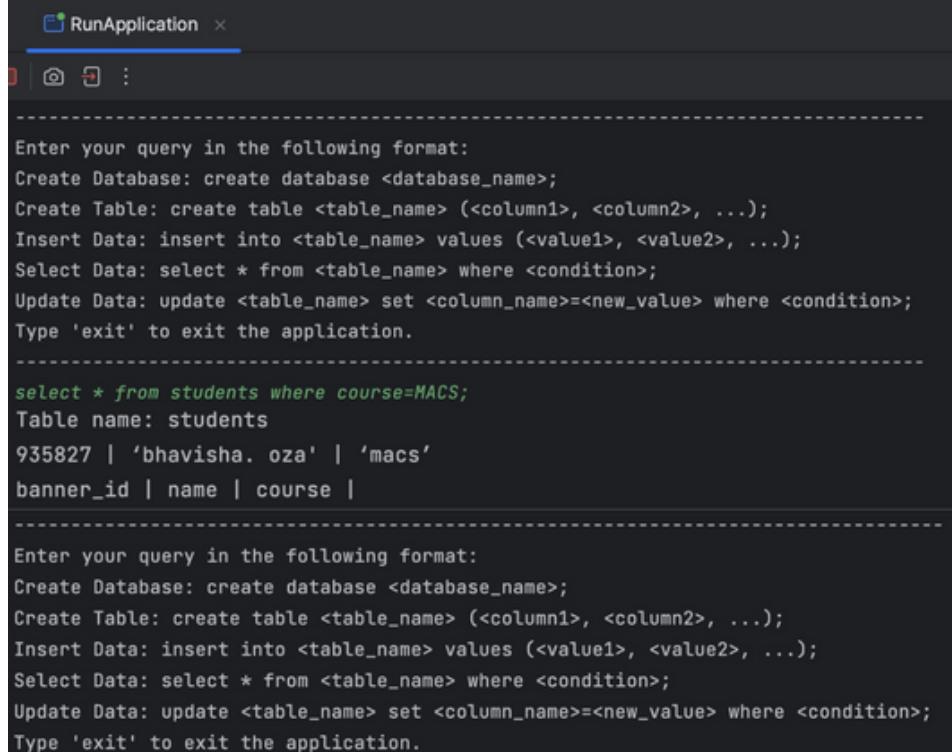
- After processing the “insert table” query, the application continues to display the menu options and waits for the next user input. Let's say the user wants to select values into a students table and enters the query “select * from students where banner_id = 1;”. The application checks if the query starts with "select" (case-insensitive). Since it matches, it

continues processing. Inside the `SelectTable.selectTable` method, the query is parsed and validated using regular expressions (regex). The regex pattern "`select\s+([a-zA-Z_,]+)\s+from\s+([a-zA-Z_]+)(?:\s+where\s+([a-zA-Z\d_]+\s*=\s*\d+));?`" is used to extract the columns, table name, and condition.

It iterates through the lines of the file and checks if the table name matches the requested table. If found, it splits the line using the `TABLE_DELIMITER` constant and extracts the table columns and rows.

Once a condition is provided, it evaluates the condition by comparing the column value with the given condition. If the condition is met, it either displays the entire row or selectively displays the requested columns based on the user's query.

If the query matches the pattern and the columns, table name, and condition are successfully extracted, the method proceeds to retrieve and display the table information.



```
RunApplication x
-----
Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

select * from students where course=MACS;
Table name: students
935827 | 'bhavisha. oza' | 'macs'
banner_id | name | course |
-----
Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.
```

Figure 34: Select query for the condition course = MACS.

- After processing the table data, the application continues to display the menu options and waits for the next user input. Let's say the user wants to update data in a table and enters the query "update students set name=Kairavi where course=MACS;". The application checks if the query starts with "update" (case-insensitive). Since it matches, it continues processing.

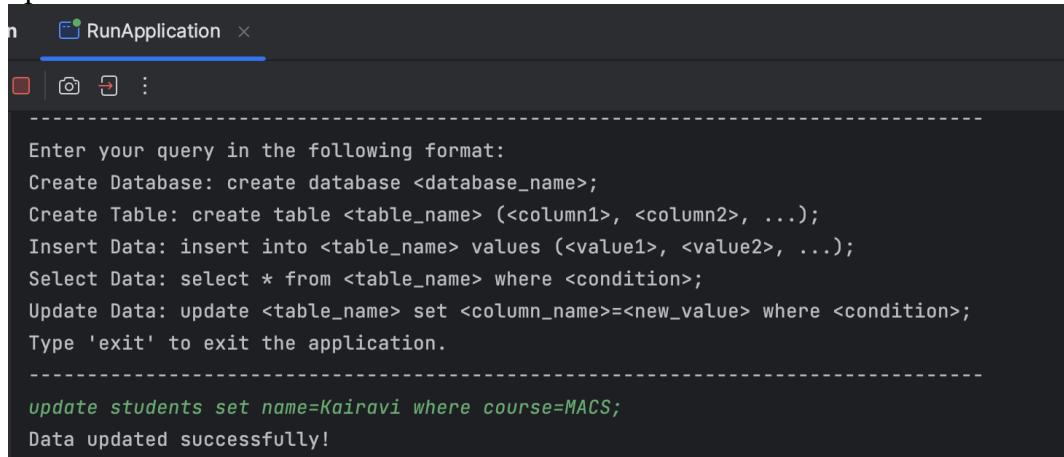
Inside the `UpdateTable.updateTable` method, the query is parsed and validated using regular expressions (regex). The regex pattern

"`update\s+(\w+)\s+set\s+(\w+)\s*=\s*(\w+)\s+where\s+(\w+)\s*=\s*(\w+)\s*`;" is used to extract the table name, set clause, and where clause.

Once the query matches the pattern and the table name, set clause, and where clause are successfully extracted, the method proceeds to update the data.

It checks if the row matches the condition specified in the where clause. If the condition is met, it updates the values based on the set clause.

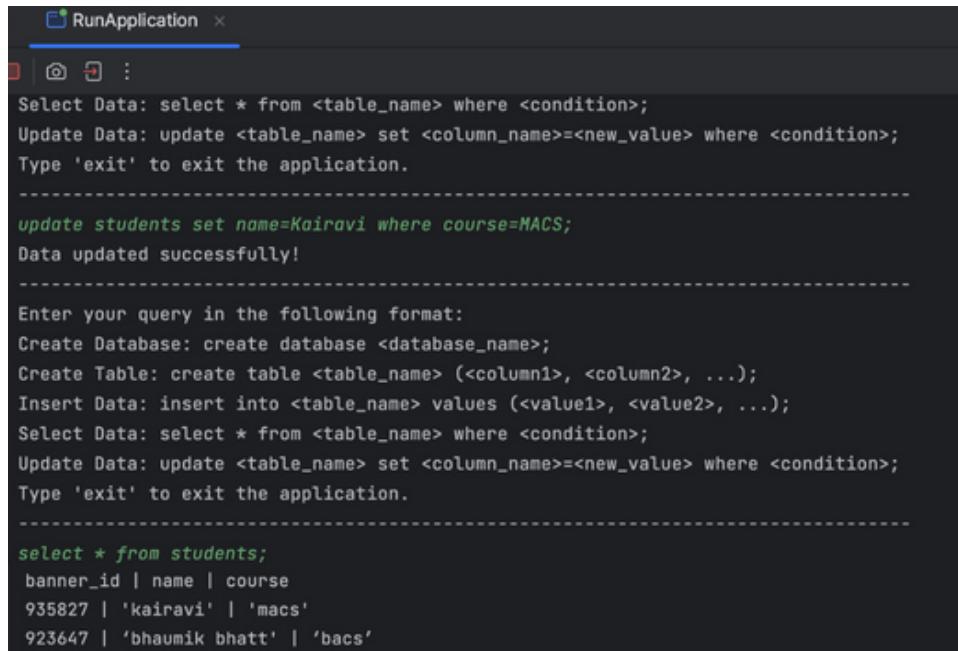
The application displays the message "Data updated successfully!" to indicate that the update was successful.



```
RunApplication x
-----
Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

-----
update students set name=Kairavi where course=MACS;
Data updated successfully!
```

Figure 35: Update query for the condition course = MACS.



```
RunApplication x
-----
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

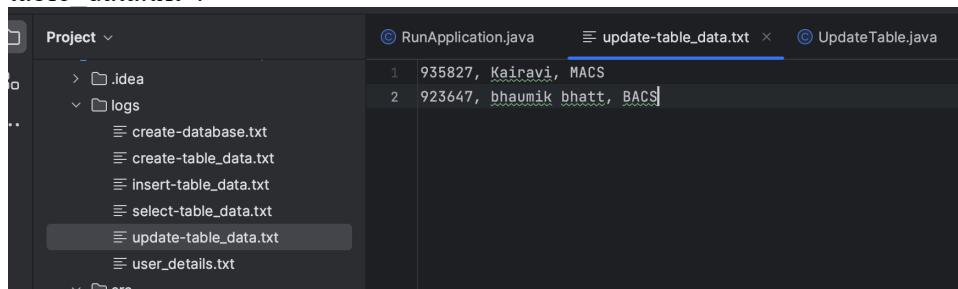
-----
update students set name=Kairavi where course=MACS;
Data updated successfully!

-----
Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

-----
select * from students;
banner_id | name | course
935827 | 'kairavi' | 'macs'
923647 | 'bhaumik bhatt' | 'bacs'
```

Figure 36: Select query for the updated value check name = Kairavi.

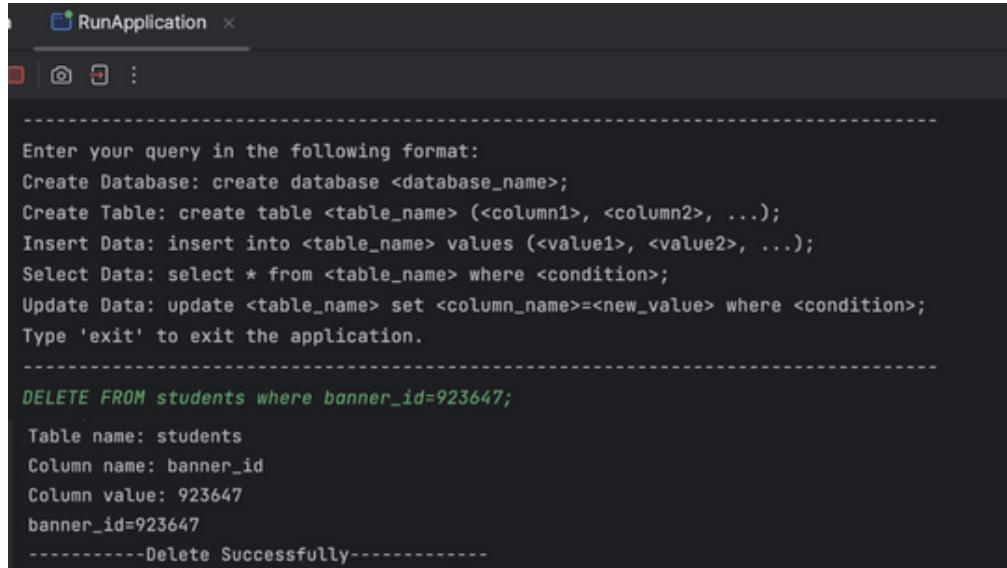
- If the query matches the pattern and the table name and values are successfully extracted, the method proceeds to update the inserted values in a custom file “update-table_data.txt”.



File	Content
update-table_data.txt	935827, Kairavi, MACS 923647, bhaumik bhatt, BACS

Figure 37: Update table data saved in text file.

- The application continues to display the menu options and waits for the next user input. Let's say the user wants to delete rows from a table and enters the query "DELETE FROM students where banner_id=923647;". The application checks if the query starts with "delete from" (case-insensitive). Since it matches, it continues processing.
- Inside the DeleteTable.deleteTable method, the query is parsed and validated using regular expressions (regex). The regex pattern "DELETE FROM ([a-zA-Z0-9_]+) WHERE (.+)" is used to extract the table name and the WHERE clause. If the query matches the pattern and the table name and WHERE clause is successfully extracted, the method proceeds to delete the rows. If the file replacement is successful, it displays the message "Data deleted successfully!" to indicate that the deletion was successful.



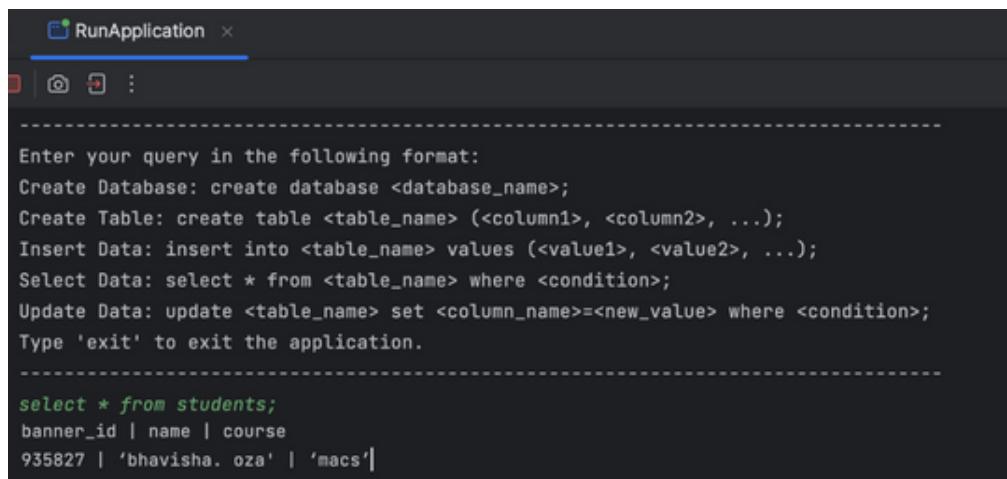
```

RunApplication x
-----[REDACTED]-----
Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

-----[REDACTED]-----
DELETE FROM students where banner_id=923647;
Table name: students
Column name: banner_id
Column value: 923647
banner_id=923647
-----Delete Successfully-----

```

Figure 38: Delete query for the condition banner_id = 923647.



```

RunApplication x
-----[REDACTED]-----
Enter your query in the following format:
Create Database: create database <database_name>;
Create Table: create table <table_name> (<column1>, <column2>, ...);
Insert Data: insert into <table_name> values (<value1>, <value2>, ...);
Select Data: select * from <table_name> where <condition>;
Update Data: update <table_name> set <column_name>=<new_value> where <condition>;
Type 'exit' to exit the application.

-----[REDACTED]-----
select * from students;
banner_id | name | course
935827 | 'bhavisha. oza' | 'macs'

```

Figure 39: Select query for the deleted value banner_id = 923647.

7. Implementation of Transaction:

The implemented code introduces a single transaction handling logic that follows the ACID (Atomicity, Consistency, Isolation, Durability) properties. The system identifies a transaction based on user input, such as "Begin Transaction", "End Transaction", etc.

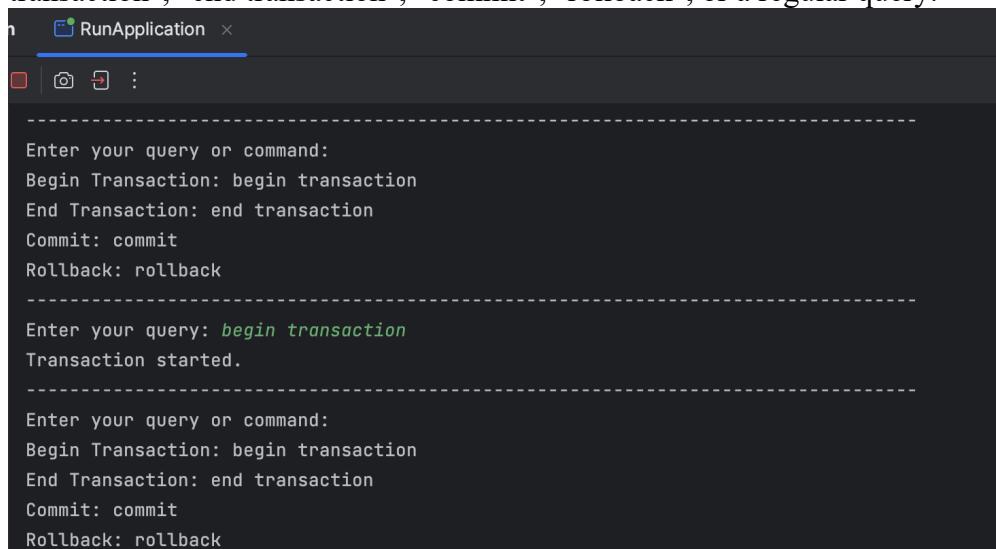
To ensure the ACID properties, the processed queries are not immediately written to the custom-made database text file. Instead, they are stored in an intermediate data structure, such as Lists. On the other hand, if the user inputs "Rollback", the data structure is emptied, and no changes are made to the text file.

This approach allows for the execution of multiple queries within a single transaction, ensuring that the changes are consistent and durable. By separating the execution from the actual updates to the database file, the code provides a mechanism to handle transactions and maintain data integrity.

Working flow of Transaction:

- The user is prompted to enter a query in a specific format. If the user enters a query that starts a transaction ("begin transaction"), the transaction handler's handleTransaction method is called. The transaction handler displays a transaction menu and waits for the user to enter a query or command.

The user can enter one of the following commands within the transaction: "begin transaction", "end transaction", "commit", "rollback", or a regular query.



The screenshot shows a terminal window titled "RunApplication". The terminal prompt is "Enter your query or command:". Below the prompt, there is a list of transaction-related commands: "Begin Transaction: begin transaction", "End Transaction: end transaction", "Commit: commit", and "Rollback: rollback". A dashed line separates this list from the user input area. The user has entered the command "begin transaction", which is highlighted in green, followed by the text "Transaction started.". Another dashed line separates this from the next set of commands. The user has entered "begin transaction" again, which is also highlighted in green, followed by the text "Transaction started.".

Figure 40: Begin Transaction query.

- If the user enters "begin transaction" when not in a transaction, an error message is displayed.

```
n RunApplication x
Enter your query or command:
Begin Transaction: begin transaction
End Transaction: end transaction
Commit: commit
Rollback: rollback
-----
Enter your query: create table visa_requirements (visa_date, age, payment);
You're not in a transaction. Use 'begin transaction' to start a new transaction.
-----
```

Figure 41: Error message for Begin Transaction when not in a transaction.

- If the user enters "begin transaction" while already in a transaction, an error message is displayed.

```
n RunApplication x
Rollback: rollback
-----
Enter your query: begin transaction
Transaction started.
-----
Enter your query or command:
Begin Transaction: begin transaction
End Transaction: end transaction
Commit: commit
Rollback: rollback
-----
Enter your query: begin transaction
A transaction is already in progress.
-----
Enter your query or command:
Begin Transaction: begin transaction
End Transaction: end transaction
Commit: commit
Rollback: rollback
```

Figure 42: Error message for Begin Transaction while already in a transaction.

- Once the user enters “end transaction”, the transaction handler checks if any queries were added to the transaction. If queries were added, it calls the transaction handler's executeQueries method to process and execute the queries.
The executeQueries method iterates over the queries and processes each query. In this example, it simply writes a response for each query to the data file.
If the queries are executed successfully, the transaction is considered committed. If the queries list is empty, the variable exitTransaction is set to true, indicating that the transaction should be exited.

```
Run RunApplication ×
Enter your query or command:
Begin Transaction: begin transaction
End Transaction: end transaction
Commit: commit
Rollback: rollback
-----
Enter your query: create table visa_requirements (visa_date, age, payment);
Query added to transaction.

Enter your query or command:
Begin Transaction: begin transaction
End Transaction: end transaction
Commit: commit
Rollback: rollback
-----
Enter your query: insert into visa_requirements values (13 May 23, 27, CAD 250);
Query added to transaction.

Enter your query or command:
Begin Transaction: begin transaction
End Transaction: end transaction
Commit: commit
Rollback: rollback
-----
Enter your query: end transaction
Queries executed successfully.
```

Figure 43: Transaction completion (Commit)

- If the user enters "rollback" while in a transaction, the transaction handler clears the queries list.

```
Run RunApplication ×
Enter your query or command:
Begin Transaction: begin transaction
End Transaction: end transaction
Commit: commit
Rollback: rollback
-----
Enter your query: insert into visa_requirements values (29 jun 23, 39, INR 7600);
Query added to transaction.

Enter your query or command:
Begin Transaction: begin transaction
End Transaction: end transaction
Commit: commit
Rollback: rollback
-----
Enter your query: rollback
Transaction rolled back.
```

Figure 44: Transaction Rollback.

8. Implementation of ERD*:

The task is to implement an ERD (Entity-Relationship Diagram) generation class that can scan through the data and structure files of a database and generate a console-based representation of the ERD. Primary keys and foreign keys are denoted as "Pk" and "Fk", respectively. The ERD can be displayed as textual output on the screen using symbols like "|" and "-" to represent entity representations and relationships.

I have attempted to generate the ERD by having some custom designed text files. But it was not working correctly so have commented the code into the main method for the same. To accomplish this, the following steps has been taken:

- Created an ERDGenerator class that takes the paths of the data file and structure file as input.
- The generateERD() method is called to generate the Entity-Relationship Diagram (ERD) based on the data and structure files.
- Inside the generateERD() method:
 1. The method readTableColumns() is called to read the table columns from the structure file and store them in a map called tableColumns.
 2. The method readTableData() is called to read the table data from the data file and store it in a map called tableData.
 3. For each table, the entity representation is printed by retrieving the column names, primary keys, and data rows (if available) from the tableColumns and tableData maps. The entity representation is displayed in the console.
 4. The method readRelationships() is called to read the relationships between tables from the structure file and store them in a list called relationships.
 5. The entity representation and relationships are printed in the console. If there are relationships, they are displayed under the "Relationships:" section. If there are no relationships, the message "No relationships found." is displayed.
- The execution of the ERDGenerator class is completed, and the ERD is displayed in the console.

```
Run RunApplication ×
/Library/Java/JavaVirtualMachines/jdk-17.0.5.jdk/Contents/Home/bin/java -javaagent:/Applications/IntelliJ IDEA CE.app/Contents/Lib/idea_rt.jar=57757:/Applications/
Entity-Relationship Diagram
CREATE TABLE products (
Entity: CREATE TABLE products (
| |
| |
CREATE TABLE customers (
Entity: CREATE TABLE customers (
| |
| |
CREATE TABLE order_items (
Entity: CREATE TABLE order_items (
| |
| |
CREATE TABLE orders (
Entity: CREATE TABLE orders (
| |
| |
```

Figure 45: Attempt to create ERD.

Full code can be found in the given repository: <https://git.cs.dal.ca/boza/csci-5408/-tree/main/A2>.

References:

- [1] “Download intelliJ idea – the leading Java and Kotlin IDE,” *JetBrains* [Online]. Available: <https://www.jetbrains.com/idea/download/?section=mac> [Accessed: 01 July 2023].
- [2] “How to Write Doc Comments for the Javadoc Tool,” *Oracle Canada* [Online]. Available: <https://www.oracle.com/ca-en/technical-resources/articles/java/javadoc-tool.html#styleguide> [Accessed: 06 July 2023].
- [3] S. Desai, “All you Need to Know About Solid Principles in Java,” *edureka* [Online]. Available: <https://www.edureka.co/blog/solid-principles-in-java>, 2021. [Accessed: July 08, 2023].
- [4] “MD5 hash in java,” *GeeksforGeeks* [Online]. Available: <https://www.geeksforgeeks.org/md5-hash-in-java/> [Accessed: 05 July 2023].
- [5] “Build, test, and debug regex,” *regex101* [Online]. Available: <https://regex101.com/> [Accessed: 06 July 2023].