CHAPTER

35

Advanced Java Database Programming

Objectives

- To create a universal SQL client for accessing local or remote database (§35.2).
- To execute SQL statements in a batch mode (§35.3).
- To process updatable and scrollable result sets (§35.4).
- To simplify Java database programming using `RowSet` (§35.5).
- To store and retrieve images in JDBC (§35.6).

35.1 Introduction

This chapter introduces advanced features for Java database programming.

Chapter 34 introduced JDBC's basic features. This chapter covers its advanced features. You will learn how to develop a universal SQL client for accessing any local or remote relational database, learn how to execute statements in a batch mode to improve performance, learn scrollable result sets and how to update a database through result sets, learn how to use `RowSet` to simplify database access, and learn how to store and retrieve images.

35.2 A Universal SQL Client

This section develops a universal SQL client for connecting and accessing any SQL database.

In Chapter 34, you used various drivers to connect to the database, created statements for executing SQL statements, and processed the results from SQL queries. This section presents a universal SQL client that enables you to connect to any relational database and execute SQL commands interactively, as shown in Figure 35.1. The client can connect to any JDBC data source and can submit SQL SELECT commands and non-SELECT commands for execution. The execution result is displayed for the SELECT queries, and the execution status is displayed for the non-SELECT commands. Listing 35.1 gives the program.

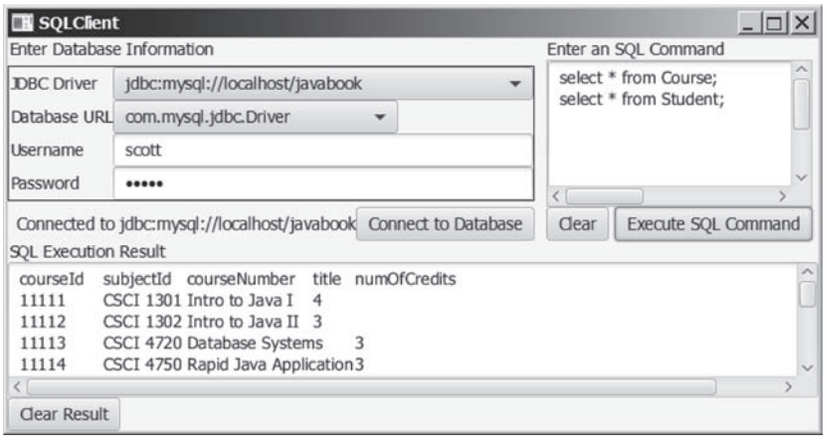


FIGURE 35.1 You can connect to any JDBC data source and execute SQL commands interactively.

LISTING 35.1 SQLClient.java

```
1  import java.sql.*;
2  import javafx.application.Application;
3  import javafx.collections.FXCollections;
4  import javafx.geometry.Pos;
5  import javafx.scene.Scene;
6  import javafx.scene.control.Button;
7  import javafx.scene.control.ComboBox;
8  import javafx.scene.control.Label;
9  import javafx.scene.control.PasswordField;
10 import javafx.scene.control.ScrollPane;
11 import javafx.scene.control.TextArea;
12 import javafx.scene.control.TextField;
13 import javafx.scene.layout.BorderPane;
14 import javafx.scene.layout.GridPane;
15 import javafx.scene.layout.HBox;
16 import javafx.scene.layout.VBox;
```

```
17  import javafx.stage.Stage;
18
19  public class SQLClient extends Application {
20    // Connection to the database
21    private Connection connection;
22
23    // Statement to execute SQL commands
24    private Statement statement;
25
26    // Text area to enter SQL commands
27    private TextArea tasqlCommand = new TextArea();
28
29    // Text area to display results from SQL commands
30    private TextArea taSQLResult = new TextArea();
31
32    // DBC info for a database connection
33    private TextField tfUsername = new TextField();
34    private PasswordField pfPassword = new PasswordField();
35    private ComboBox<String> cboURL = new ComboBox<>();
36    private ComboBox<String> cboDriver = new ComboBox<>();
37
38    private Button btExecuteSQL = new Button("Execute SQL Command");
39    private Button btClearSQLCommand = new Button("Clear");
40    private Button btConnectDB = new Button("Connect to Database");
41    private Button btClearSQLResult = new Button("Clear Result");
42    private Label lblConnectionStatus
43      = new Label("No connection now");
44
45    @Override // Override the start method in the Application class
46    public void start(Stage primaryStage) {
47      cboURL.getItems().addAll(FXCollections.observableArrayList(
48        "jdbc:mysql://localhost/javabook",
49        "jdbc:mysql://liang.armstrong.edu/javabook",
50        "jdbc:odbc:exampleMDBDataSource",
51        "jdbc:oracle:thin:@liang.armstrong.edu:1521:orcl"));
52      cboURL.getSelectionModel().selectFirst();
53
54      cboDriver.getItems().addAll(FXCollections.observableArrayList(
55       "com.mysql.jdbc.Driver", "sun.jdbc.odbc.dbcOdbcDriver",
56       "oracle.jdbc.driver.OracleDriver"));
57      cboDriver.getSelectionModel().selectFirst();
58
59      // Create UI for connecting to the database
60      GridPane gridPane = new GridPane();
61      gridPane.add(cboURL, 1, 0);
62      gridPane.add(cboDriver, 1, 1);
63      gridPane.add(tfUsername, 1, 2);
64      gridPane.add(pfPassword, 1, 3);
65      gridPane.add(new Label("JDBC Driver"), 0, 0);
66      gridPane.add(new Label("Database URL"), 0, 1);
67      gridPane.add(new Label("Username"), 0, 2);
68      gridPane.add(new Label("Password"), 0, 3);
69
70      HBox hBoxConnection = new HBox();
71      hBoxConnection.getChildren().addAll(
72        lblConnectionStatus, btConnectDB);
73      hBoxConnection.setAlignment(Pos.CENTER_RIGHT);
74
75      VBox vBoxConnection = new VBox(5);
76      vBoxConnection.getChildren().addAll(
77        new Label("Enter Database Information"),
```

```
78        gridPane, hBoxConnection);
79
80      gridPane.setStyle("-fx-border-color: black;");
81
82      HBox hBoxSQLCommand = new HBox(5);
83      hBoxSQLCommand.getChildren().addAll(
84        btClearSQLCommand, btExecuteSQL);
85      hBoxSQLCommand.setAlignment(Pos.CENTER_RIGHT);
86
87      BorderPane borderPaneSqlCommand = new BorderPane();
88      borderPaneSqlCommand.setTop(
89        new Label("Enter an SQL Command"));
90      borderPaneSqlCommand.setCenter(
91        new ScrollPane(tasqlCommand));
92      borderPaneSqlCommand.setBottom(
93        hBoxSQLCommand);
94
95      HBox hBoxConnectionCommand = new HBox(10);
96      hBoxConnectionCommand.getChildren().addAll(
97        vBoxConnection, borderPaneSqlCommand);
98
99      BorderPane borderPaneExecutionResult = new BorderPane();
100     borderPaneExecutionResult.setTop(
101       new Label("SQL Execution Result"));
102     borderPaneExecutionResult.setCenter(taSQLResult);
103     borderPaneExecutionResult.setBottom(btClearSQLResult);
104
105     BorderPane borderPane = new BorderPane();
106     borderPane.setTop(hBoxConnectionCommand);
107     borderPane.setCenter(borderPaneExecutionResult);
108
109     // Create a scene and place it in the stage
110     Scene scene = new Scene(borderPane, 670, 400);
111     primaryStage.setTitle("SQLClient"); // Set the stage title
112     primaryStage.setScene(scene); // Place the scene in the stage
113     primaryStage.show(); // Display the stage
114
115     btConnectDB.setOnAction(e -> connectToDB());
116     btExecuteSQL.setOnAction(e -> executeSQL());
117     btClearSQLCommand.setOnAction(e -> tasqlCommand.setText(null));
118     btClearSQLResult.setOnAction(e -> taSQLResult.setText(null));
119   }
120
121   /** Connect to DB */
122   private void connectToDB() {
123     // Get database information from the user input
124     String driver = cboDriver
125       .getSelectionModel().getSelectedItem();
126     String url = cboURL.getSelectionModel().getSelectedItem();
127     String username = tfUsername.getText().trim();
128     String password = pfPassword.getText().trim();
129
130     // Connection to the database
131     try {
132       Class.forName(driver);
133       connection = DriverManager.getConnection(
134         url, username, password);
135       lblConnectionStatus.setText("Connected to " + url);
136     }
137     catch (java.lang.Exception ex) {
138       ex.printStackTrace();
```

```
139       }
140     }
141
142     /** Execute SQL commands */
143     private void executeSQL() {
144       if (connection == null) {
145         taSQLResult.setText("Please connect to a database first");
146         return;
147       }
148       else {
149         String sqlCommands = tasqlCommand.getText().trim();
150         String[] commands = sqlCommands.replace('\n', ' ').split(";");
151
152         for (String aCommand: commands) {
153           if (aCommand.trim().toUpperCase().startsWith("SELECT")) {
154             processSQLSelect(aCommand);
155           }
156           else {
157             processSQLNonSelect(aCommand);
158           }
159         }
160       }
161     }
162
163     /** Execute SQL SELECT commands */
164     private void processSQLSelect(String sqlCommand) {
165       try {
166         // Get a new statement for the current connection
167         statement = connection.createStatement();
168
169         // Execute a SELECT SQL command
170         ResultSet resultSet = statement.executeQuery(sqlCommand);
171
172         // Find the number of columns in the result set
173         int columnCount = resultSet.getMetaData().getColumnCount();
174         String row = "";
175
176         // Display column names
177         for (int i = 1; i <= columnCount; i++) {
178           row += resultSet.getMetaData().getColumnName(i) + "\t";
179         }
180
181         taSQLResult.appendText(row + '\n');
182
183         while (resultSet.next()) {
184           // Reset row to empty
185           row = "";
186
187           for (int i = 1; i <= columnCount; i++) {
188             // A non-String column is converted to a string
189             row += resultSet.getString(i) + "\t";
190           }
191
192           taSQLResult.appendText(row + '\n');
193         }
194       }
195       catch (SQLException ex) {
196         taSQLResult.setText(ex.toString());
197       }
198     }
199
```

```
200    /** Execute SQL DDL, and modification commands */
201    private void processSQLNonSelect(String sqlCommand) {
202      try {
203        // Get a new statement for the current connection
204        statement = connection.createStatement();
205
206        // Execute a non-SELECT SQL command
207        statement.executeUpdate(sqlCommand);
208
209        taSQLResult.setText("SQL command executed");
210      }
211      catch (SQLException ex) {
212        taSQLResult.setText(ex.toString());
213      }
214    }
215  }
```

The user selects or enters the JDBC driver, database URL, username, and password, and clicks the *Connect to Database* button to connect to the specified database using the `connectToDB()` method (lines 122–140).

When the user clicks the *Execute SQL Command* button, the `executeSQL()` method is invoked (lines 143–161) to get the SQL commands from the text area (`jtaSQLCommand`) and extract each command separated by a semicolon (;). It then determines whether the command is a SELECT query or a DDL or data modification statement (lines 153–158). If the command is a SELECT query, the `processSQLSelect` method is invoked (lines 164–198). This method uses the `executeQuery` method (line 170) to obtain the query result. The result is displayed in the text area `jtaSQLResult` (line 181). If the command is a non-SELECT query, the `processSQLNonSelect()` method is invoked (lines 201–214). This method uses the `executeUpdate` method (line 207) to execute the SQL command.

The `getMetaData` method (lines 173, 178) in the `ResultSet` interface is used to obtain an instance of `ResultSetMetaData`. The `getColumnCount` method (line 173) returns the number of columns in the result set, and the `getColumnName(i)` method (line 178) returns the column name for the *i*th column.

35.3 Batch Processing

You can send a batch of SQL statements to the database for execution at once to improve efficiency.

In all the preceding examples, SQL commands are submitted to the database for execution one at a time. This is inefficient for processing a large number of updates. For example, suppose you wanted to insert a thousand rows into a table. Submitting one INSERT command at a time would take nearly a thousand times longer than submitting all the INSERT commands in a batch at once. To improve performance, JDBC introduced the batch update for processing nonselect SQL commands. A batch update consists of a sequence of nonselect SQL commands. These commands are collected in a batch and submitted to the database all together.

To use the batch update, you add nonselect commands to a batch using the `addBatch` method in the `Statement` interface. After all the SQL commands are added to the batch, use the `executeBatch` method to submit the batch to the database for execution.

For example, the following code adds a create table command, adds two insert statements in a batch, and executes the batch:

```
Statement statement = connection.createStatement();

// Add SQL commands to the batch
statement.addBatch("create table T (C1 integer, C2 varchar(15))");
```

```
statement.addBatch("insert into T values (100, 'Smith')");
statement.addBatch("insert into T values (200, 'Jones')");

// Execute the batch
int count[] = statement.executeBatch();
```

The `executeBatch()` method returns an array of counts, each of which counts the number of rows affected by the SQL command. The first count returns 0 because it is a DDL command. The other counts return 1 because only one row is affected.

Note

To find out whether a driver supports batch updates, invoke `supportsBatchUpdates()` on a `DatabaseMetaData` instance. If the driver supports batch updates, it will return `true`. The JDBC drivers for MySQL, Access, and Oracle all support batch updates.

To demonstrate batch processing, consider writing a program that gets data from a text file and copies the data from the text file to a table, as shown in Figure 35.2. The text file consists of lines that each corresponds to a row in the table. The fields in a row are separated by commas. The string values in a row are enclosed in single quotes. You can view the text file by clicking the *View File* button and copy the text to the table by clicking the *Copy* button. The table must already be defined in the database. Figure 35.2 shows the text file `table.txt` copied to table `Person`. `Person` is created using the following statement:

```
create table Person (
  firstName varchar(20),
  mi char(1),
  lastName varchar(20)
)
```

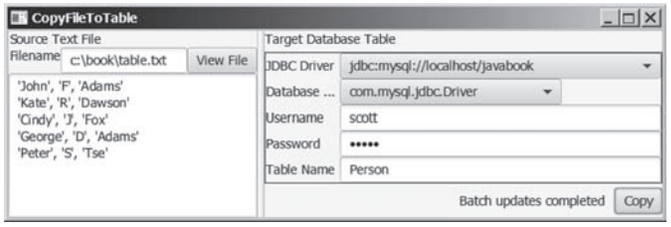


FIGURE 35.2 The `CopyFileToTable` utility copies text files to database tables.

Listing 35.2 gives the solution to the problem.

LISTING 35.2 CopyFileToTable.java

```
1  import java.io.File;
2  import java.io.FileNotFoundException;
3  import java.io.IOException;
4  import java.sql.*;
5  import java.util.Scanner;
6  import javafx.application.Application;
7  import javafx.collections.FXCollections;
8  import javafx.geometry.Pos;
9  import javafx.scene.Scene;
10 import javafx.scene.control.Button;
11 import javafx.scene.control.ComboBox;
12 import javafx.scene.control.Label;
13 import javafx.scene.control.PasswordField;
14 import javafx.scene.control.SplitPane;
```

```
15  import javafx.scene.control.TextArea;
16  import javafx.scene.control.TextField;
17  import javafx.scene.layout.BorderPane;
18  import javafx.scene.layout.GridPane;
19  import javafx.scene.layout.HBox;
20  import javafx.scene.layout.VBox;
21  import javafx.stage.Stage;
22
23  public class CopyFileToTable extends Application {
24    // Text file info
25    private TextField tfFilename = new TextField();
26    private TextArea taFile = new TextArea();
27
28    // JDBC and table info
29    private ComboBox<String> cboURL = new ComboBox<>();
30    private ComboBox<String> cboDriver = new ComboBox<>();
31    private TextField tfUsername = new TextField();
32    private PasswordField pfPassword = new PasswordField();
33    private TextField tfTableName = new TextField();
34
35    private Button btViewFile = new Button("View File");
36    private Button btCopy = new Button("Copy");
37    private Label lblStatus = new Label();
38
39    @Override // Override the start method in the Application class
40    public void start(Stage primaryStage) {
41      cboURL.getItems().addAll(FXCollections.observableArrayList(
42        "jdbc:mysql://localhost/javabook",
43        "jdbc:mysql://liang.armstrong.edu/javabook",
44        "jdbc:odbc:exampleMDBDataSource",
45        "jdbc:oracle:thin:@liang.armstrong.edu:1521:orcl"));
46      cboURL.getSelectionModel().selectFirst();
47
48      cboDriver.getItems().addAll(FXCollections.observableArrayList(
49        "com.mysql.jdbc.Driver", "sun.jdbc.odbc.dbcOdbcDriver",
50        "oracle.jdbc.driver.OracleDriver"));
51      cboDriver.getSelectionModel().selectFirst();
52
53      // Create UI for connecting to the database
54      GridPane gridPane = new GridPane();
55      gridPane.add(new Label("JDBC Driver"), 0, 0);
56      gridPane.add(new Label("Database URL"), 0, 1);
57      gridPane.add(new Label("Username"), 0, 2);
58      gridPane.add(new Label("Password"), 0, 3);
59      gridPane.add(new Label("Table Name"), 0, 4);
60      gridPane.add(cboURL, 1, 0);
61      gridPane.add(cboDriver, 1, 1);
62      gridPane.add(tfUsername, 1, 2);
63      gridPane.add(pfPassword, 1, 3);
64      gridPane.add(tfTableName, 1, 4);
65
66      HBox hBoxConnection = new HBox(10);
67      hBoxConnection.getChildren().addAll(lblStatus, btCopy);
68      hBoxConnection.setAlignment(Pos.CENTER_RIGHT);
69
70      VBox vBoxConnection = new VBox(5);
71      vBoxConnection.getChildren().addAll(
72        new Label("Target Database Table"),
73        gridPane, hBoxConnection);
74
75      gridPane.setStyle("-fx-border-color: black;");
```

```
76
77      BorderPane borderPaneFileName = new BorderPane();
78      borderPaneFileName.setLeft(new Label("Filename"));
79      borderPaneFileName.setCenter(tfFilename);
80      borderPaneFileName.setRight(btViewFile);
81
82      BorderPane borderPaneFileContent = new BorderPane();
83      borderPaneFileContent.setTop(borderPaneFileName);
84      borderPaneFileContent.setCenter(taFile);
85
86      BorderPane borderPaneFileSource = new BorderPane();
87      borderPaneFileSource.setTop(new Label("Source Text File"));
88      borderPaneFileSource.setCenter(borderPaneFileContent);
89
90      SplitPane sp = new SplitPane();
91      sp.getItems().addAll(borderPaneFileSource, vBoxConnection);
92
93      // Create a scene and place it in the stage
94      Scene scene = new Scene(sp, 680, 230);
95      primaryStage.setTitle("CopyFileToTable"); // Set the stage title
96      primaryStage.setScene(scene); // Place the scene in the stage
97      primaryStage.show(); // Display the stage
98
99      btViewFile.setOnAction(e -> showFile());
100     btCopy.setOnAction(e -> {
101       try {
102         copyFile();
103       }
104       catch (Exception ex) {
105         lblStatus.setText(ex.toString());
106       }
107     });
108   }
109
110   /** Display the file in the text area */
111   private void showFile() {
112     Scanner input = null;
113     try {
114       // Use a Scanner to read text from the file
115       input = new Scanner(new File(tfFilename.getText().trim()));
116
117       // Read a line and append the line to the text area
118       while (input.hasNext())
119         taFile.appendText(input.nextLine() + '\n');
120     }
121     catch (FileNotFoundException ex) {
122       System.out.println("File not found: " + tfFilename.getText());
123     }
124     catch (IOException ex) {
125       ex.printStackTrace();
126     }
127     finally {
128       if (input != null) input.close();
129     }
130   }
131
132   private void copyFile() throws Exception {
133     // Load the JDBC driver
134     Class.forName(cboDriver.getSelectionModel()
135       .getSelectedItem().trim());
136     System.out.println("Driver loaded");
```

```
137
138       // Establish a connection
139       Connection conn = DriverManager.getConnection(
140         cboURL.getSelectionModel().getSelectedItem().trim(),
141         tfUsername.getText().trim(),
142         String.valueOf(pfPassword.getText()).trim());
143       System.out.println("Database connected");
144
145       // Read each line from the text file and insert it to the table
146       insertRows(conn);
147     }
148
149     private void insertRows(Connection connection) {
150       // Build the SQL INSERT statement
151       String sqlInsert = "insert into " + tfTableName.getText()
152         + " values (";
153
154       // Use a Scanner to read text from the file
155       Scanner input = null;
156
157       // Get file name from the text field
158       String filename = tfFilename.getText().trim();
159
160       try {
161         // Create a scanner
162         input = new Scanner(new File(filename));
163
164         // Create a statement
165         Statement statement = connection.createStatement();
166
167         System.out.println("Driver major version? " +
168           connection.getMetaData().getDriverMajorVersion());
169
170         // Determine if batchUpdatesSupported is supported
171         boolean batchUpdatesSupported = false;
172
173         try {
174           if (connection.getMetaData().supportsBatchUpdates()) {
175             batchUpdatesSupported = true;
176             System.out.println("batch updates supported");
177           }
178           else {
179             System.out.println("The driver " +
180               "does not support batch updates");
181           }
182         }
183         catch (UnsupportedOperationException ex) {
184           System.out.println("The operation is not supported");
185         }
186
187         // Determine if the driver is capable of batch updates
188         if (batchUpdatesSupported) {
189           // Read a line and add the insert table command to the batch
190           while (input.hasNext()) {
191             statement.addBatch(sqlInsert + input.nextLine() + ")");
192           }
193
194           statement.executeBatch();
195
196           lblStatus.setText("Batch updates completed");
197         }
```

```
198         else {
199           // Read a line and execute insert table command
200           while (input.hasNext()) {
201             statement.executeUpdate(sqlInsert + input.nextLine() + ")");
202           }
203
204           lblStatus.setText("Single row update completed");
205         }
206       }
207       catch (SQLException ex) {
208         System.out.println(ex);
209       }
210       catch (FileNotFoundException ex) {
211         System.out.println("File not found: " + filename);
212       }
213       finally {
214         if (input != null) input.close();
215       }
216     }
217   }
```

The `insertRows` method (lines 149–216) uses the batch updates to submit SQL INSERT commands to the database for execution, if the driver supports batch updates. Lines 174–181 check whether the driver supports batch updates. If the driver does not support the operation, an `UnsupportedOperationException` exception will be thrown (line 183) when the `supportsBatchUpdates()` method is invoked.

The tables must already be created in the database. The file format and contents must match the database table specification. Otherwise, the SQL INSERT command will fail.

In Exercise 35.1, you will write a program to insert a thousand records to a database and compare the performance with and without batch updates.

35.3.1 What is batch processing in JDBC? What are the benefits of using batch processing?

35.3.2 How do you add an SQL statement to a batch? How do you execute a batch?

35.3.3 Can you execute a SELECT statement in a batch?

35.3.4 How do you know whether a JDBC driver supports batch updates?

35.4 Scrollable and Updatable Result Set

You can use scrollable and updatable result set to move the cursor anywhere in the result set to perform insertion, deletion, and update.

The result sets used in the preceding examples are read sequentially. A result set maintains a cursor pointing to its current row of data. Initially the cursor is positioned before the first row. The `next()` method moves the cursor forward to the next row. This is known as *sequential forward reading*.

A more powerful way of accessing database is to use a scrollable and updatable result, which enables you to scroll the rows both forward and backward and move the cursor to a desired location using the `first`, `last`, `next`, `previous`, `absolute`, or `relative` method. Additionally, you can insert, delete, or update a row in the result set and have the changes automatically reflected in the database.

To obtain a scrollable or updatable result set, you must first create a statement with an appropriate type and concurrency mode. For a static statement, use

```
Statement statement = connection.createStatement
  (int resultSetType, int resultSetConcurrency);
```

For a prepared statement, use

```
PreparedStatement statement = connection.prepareStatement
  (String sql, int resultSetType, int resultSetConcurrency);
```

The possible values of `resultSetType` are the constants defined in the `ResultSet`:

- `TYPE_FORWARD_ONLY`: The result set is accessed forward sequentially.
- `TYPE_SCROLL_INSENSITIVE`: The result set is scrollable, but not sensitive to changes in the database.
- `TYPE_SCROLL_SENSITIVE`: The result set is scrollable and sensitive to changes made by others. Use this type if you want the result set to be scrollable and updatable.

The possible values of `resultSetConcurrency` are the constants defined in the `ResultSet`:

- `CONCUR_READ_ONLY`: The result set cannot be used to update the database.
- `CONCUR_UPDATABLE`: The result set can be used to update the database.

For example, if you want the result set to be scrollable and updatable, you can create a statement, as follows:

```
Statement statement = connection.createStatement
  (ResultSet.TYPE_SCROLL_SENSITIVE, ResultSet.CONCUR_UPDATABLE)
```

You use the `executeQuery` method in a `Statement` object to execute an SQL query that returns a result set as follows:

```
ResultSet resultSet = statement.executeQuery(query);
```

You can now use the methods `first()`, `next()`, `previous()`, and `last()` to move the cursor to the first row, next row, previous row, and last row. The `absolute(int row)` method moves the cursor to the specified row; and the `getXxx(int columnIndex)` or `getXxx(String columnName)` method is used to retrieve the value of a specified field at the current row. The methods `insertRow()`, `deleteRow()`, and `updateRow()` can also be used to insert, delete, and update the current row. Before applying `insertRow` or `updateRow`, you need to use the method `updateXxx(int columnIndex, Xxx value)` or `update(String columnName, Xxx value)` to write a new value to the field at the current row. The `cancelRowUpdates()` method cancels the updates made to a row. The `close()` method closes the result set and releases its resource. The `wasNull()` method returns true if the last column read had a value of SQL NULL.

Listing 35.3 gives an example that demonstrates how to create a scrollable and updatable result set. The program creates a result set for the `StateCapital` table. The `StateCapital` table is defined as follows:

```
create table StateCapital (
  state varchar(40),
  capital varchar(40)
);
```

LISTING 35.3 ScrollUpdateResultSet.java

```
1  import java.sql.*;
2
3  public class ScrollUpdateResultSet {
4    public static void main(String[] args)
5        throws SQLException, ClassNotFoundException {
```

```
6       // Load the JDBC driver
7       Class.forName("oracle.jdbc.driver.OracleDriver");
8       System.out.println("Driver loaded");
9
10      // Connect to a database
11      Connection connection = DriverManager.getConnection
12        ("jdbc:oracle:thin:@liang.armstrong.edu:1521:orcl",
13         "scott", "tiger");
14      connection.setAutoCommit(true);
15      System.out.println("Database connected");
16
17      // Get a new statement for the current connection
18      Statement statement = connection.createStatement(
19        ResultSet.TYPE_SCROLL_SENSITIVE, ResultSet.CONCUR_UPDATABLE);
20
21      // Get ResultSet
22      ResultSet resultSet = statement.executeQuery
23        ("select state, capital from StateCapital");
24
25      System.out.println("Before update ");
26      displayResultSet(resultSet);
27
28      // Update the second row
29      resultSet.absolute(2); // Move cursor to the second row
30      resultSet.updateString("state", "New S"); // Update the column
31      resultSet.updateString("capital", "New C"); // Update the column
32      resultSet.updateRow(); // Update the row in the data source
33
34      // Insert after the last row
35      resultSet.last();
36      resultSet.moveToInsertRow(); // Move cursor to the insert row
37      resultSet.updateString("state", "Florida");
38      resultSet.updateString("capital", "Tallahassee");
39      resultSet.insertRow(); // Insert the row
40      resultSet.moveToCurrentRow(); // Move the cursor to the current row
41
42      // Delete fourth row
43      resultSet.absolute(4); // Move cursor to the 5th row
44      resultSet.deleteRow(); // Delete the second row
45
46      System.out.println("After update ");
47      resultSet = statement.executeQuery
48        ("select state, capital from StateCapital");
49      displayResultSet(resultSet);
50
51      // Close the connection
52      resultSet.close();
53    }
54
55    private static void displayResultSet(ResultSet resultSet)
56        throws SQLException {
57      ResultSetMetaData rsMetaData = resultSet.getMetaData();
58      resultSet.beforeFirst();
59      while (resultSet.next()) {
60        for (int i = 1; i <= rsMetaData.getColumnCount(); i++)
61          System.out.printf("%-12s\t", resultSet.getObject(i));
62        System.out.println();
63      }
64    }
65  }
```

```
Driver loaded
Database connected

Before update
Indiana         Indianapolis
Illinois        Springfield
California      Sacramento
Georgia         Atlanta
Texas           Austin

After update
Indiana         Indianapolis
New S           New C
California      Sacramento
Texas           Austin
Florida         Tallahassee
```

The code in lines 18–19 creates a `Statement` for producing scrollable and updatable result sets.

The program moves the cursor to the second row in the result set (line 29), updates two columns in this row (lines 30–31), and invokes the `updateRow()` method to update the row in the underlying database (line 32).

An updatable `ResultSet` object has a special row associated with it that serves as a staging area for building a row to be inserted. This special row is called the *insert row*. To insert a row, first invoke the `moveToInsertRow()` method to move the cursor to the insert row (line 36), then update the columns using the `updateXxx` method (lines 37–38), and finally insert the row using the `insertRow()` method (line 39). Invoking `moveToCurrentRow()` moves the cursor to the current inserted row (lines 40).

The program moves to the fourth row and invokes the `deleteRow()` method to delete the row from the database (lines 43–44).

Note

Not all current drivers support scrollable and updatable result sets. The example is tested using Oracle ojdbc6 driver. You can use `supportsResultSetType(int type)` and `supportsResultSetConcurrency(int type, int concurrency)` in the `DatabaseMetaData` interface to find out which result type and currency modes are supported by the JDBC driver. But even if a driver supports the scrollable and updatable result set, a result set for a complex query might not be able to perform an update. For example, the result set for a query that involves several tables is likely not to support update operations.

Note

The program may not work due to an issue in the Oracle JDBC driver if lines 22–23 are replaced by

```
ResultSet resultSet = statement.executeQuery
  ("select * from StateCapital");
```

35.4.1 What is a scrollable result set? What is an updatable result set?

35.4.2 How do you create a scrollable and updatable `ResultSet`?

35.4.3 How do you know whether a JDBC driver supports a scrollable and updatable `ResultSet`?

35.5 RowSet, JdbcRowSet, and CachedRowSet

The RowSet interface can be used to simplify database programming.

The `RowSet` interface extends `java.sql.ResultSet` with additional capabilities that allow a `RowSet` instance to be configured to connect to a JDBC url, username, and password, set an SQL command, execute the command, and retrieve the execution result. In essence, it combines `Connection`, `Statement`, and `ResultSet` into one interface.

Note

Not all JDBC drivers support `RowSet`. Currently, the JDBC-ODBC driver does not support all features of `RowSet`.

35.5.1 RowSet Basics

There are two types of `RowSet` objects: connected and disconnected. A *connected* `RowSet` object makes a connection with a data source and maintains that connection throughout its life cycle. A disconnected `RowSet` object makes a connection with a data source, executes a query to get data from the data source, and then closes the connection. A *disconnected* rowset may make changes to its data while it is disconnected and then send the changes back to the original source of the data, but it must reestablish a connection to do so.

There are several versions of `RowSet`. Two frequently used are `JdbcRowSet` and `CachedRowSet`. Both are subinterfaces of `RowSet`. `JdbcRowSet` is connected, while `CachedRowSet` is disconnected. Also, `JdbcRowSet` is neither serializable nor cloneable, while `CachedRowSet` is both. The database vendors are free to provide concrete implementations for these interfaces. Oracle has provided the reference implementation `JdbcRowSetImpl` for `JdbcRowSet` and `CachedRowSetImpl` for `CachedRowSet`. Figure 35.3 shows the relationship of these components.

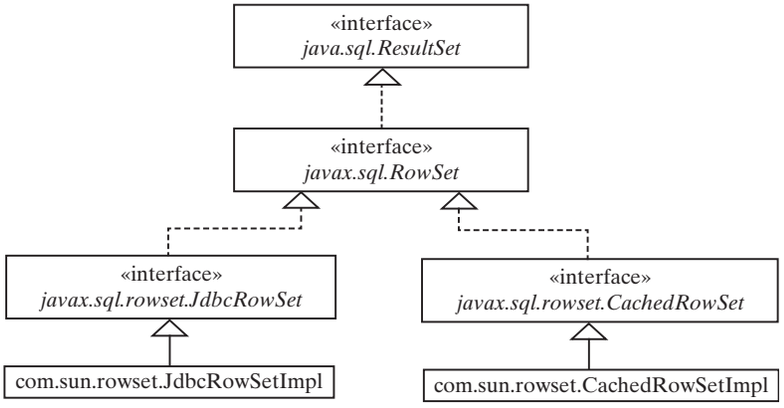


FIGURE 35.3 The `JdbcRowSetImpl` and `CachedRowSetImpl` are concrete implementations of `RowSet`.

The `RowSet` interface contains the JavaBeans properties with getter and setter methods. You can use the setter methods to set a new url, username, password, and command for an SQL statement. Using a `RowSet`, Listing 34.1 can be simplified, as shown in Listing 35.4.

LISTING 35.4 SimpleRowSet.java

```
1  import java.sql.SQLException;
2  import javax.sql.RowSet;
3  import com.sun.rowset.*;
4
```

```
 5  public class SimpleRowSet {
 6    public static void main(String[] args)
 7        throws SQLException, ClassNotFoundException {
 8      // Load the JDBC driver
 9      Class.forName("com.mysql.jdbc.Driver");
10      System.out.println("Driver loaded");
11
12      // Create a row set
13      RowSet rowSet = new JdbcRowSetImpl();
14
15      // Set RowSet properties
16      rowSet.setUrl("jdbc:mysql://localhost/javabook");
17      rowSet.setUsername("scott");
18      rowSet.setPassword("tiger");
19      rowSet.setCommand("select firstName, mi, lastName " +
20        "from Student where lastName = 'Smith'");
21      rowSet.execute();
22
23      // Iterate through the result and print the student names
24      while (rowSet.next())
25        System.out.println(rowSet.getString(1) + "\t" +
26          rowSet.getString(2) + "\t" + rowSet.getString(3));
27
28      // Close the connection
29      rowSet.close();
30    }
31  }
```

Line 13 creates a `RowSet` object using `JdbcRowSetImpl`. The program uses the `RowSet`'s set method to set a URL, username, and password (lines 16–18) and a command for a query statement (line 19). Line 24 executes the command in the `RowSet`. The methods `next()` and `getString(int)` for processing the query result (lines 25–26) are inherited from `ResultSet`.

If you replace `JdbcRowSet` with `CachedRowSet` in line 13, the program will work just fine. Note, the JDBC-ODBC driver supports `JdbcRowSetImpl`, but not `CachedRowSetImpl`.

Tip

Since `RowSet` is a subinterface of `ResultSet`, all the methods in `ResultSet` can be used in `RowSet`. For example, you can obtain `ResultSetMetaData` from a `RowSet` using the `getMetaData()` method.

35.5.2 RowSet for PreparedStatement

The discussion in §34.5, "PreparedStatement," introduced processing parameterized SQL statements using the `PreparedStatement` interface. `RowSet` has the capability to support parameterized SQL statements. The set methods for setting parameter values in `PreparedStatement` are implemented in `RowSet`. You can use these methods to set parameter values for a parameterized SQL command. Listing 35.5 demonstrates how to use a parameterized statement in `RowSet`. Line 19 sets an SQL query statement with two parameters for `lastName` and `mi` in a `RowSet`. Since these two parameters are strings, the `setString` method is used to set actual values in lines 21–22.

LISTING 35.5 RowSetPreparedStatement.java

```
1  import java.sql.*;
2  import javax.sql.RowSet;
3  import com.sun.rowset.*;
4
```

```
5  public class RowSetPreparedStatement {
6    public static void main(String[] args)
7        throws SQLException, ClassNotFoundException {
8      // Load the JDBC driver
9      Class.forName("com.mysql.jdbc.Driver");
10     System.out.println("Driver loaded");
11
12     // Create a row set
13     RowSet rowSet = new JdbcRowSetImpl();
14
15     // Set RowSet properties
16     rowSet.setUrl("jdbc:mysql://localhost/javabook");
17     rowSet.setUsername("scott");
18     rowSet.setPassword("tiger");
19     rowSet.setCommand("select * from Student where lastName = ? " +
20       "and mi = ?");
21     rowSet.setString(1, "Smith");
22     rowSet.setString(2, "R");
23     rowSet.execute();
24
25     ResultSetMetaData rsMetaData = rowSet.getMetaData();
26     for (int i = 1; i <= rsMetaData.getColumnCount(); i++)
27       System.out.printf("%-12s\t", rsMetaData.getColumnName(i));
28     System.out.println();
29
30     // Iterate through the result and print the student names
31     while (rowSet.next()) {
32       for (int i = 1; i <= rsMetaData.getColumnCount(); i++)
33         System.out.printf("%-12s\t", rowSet.getObject(i));
34       System.out.println();
35     }
36
37     // Close the connection
38     rowSet.close();
39   }
40 }
```

35.5.3 Scrolling and Updating RowSet

By default, a `ResultSet` object is neither scrollable nor updatable. However, a `RowSet` object is both. It is easier to scroll and update a database through a `RowSet` than through a `ResultSet`. Listing 35.6 rewrites Listing 35.3 using a `RowSet`. You can use methods such as `absolute(int)` to move the cursor and methods such as `delete()`, `updateRow()`, and `insertRow()` to update the database.

LISTING 35.6 ScrollUpdateRowSet.java

```
1  import java.sql.*;
2  import javax.sql.RowSet;
3  import com.sun.rowset.JdbcRowSetImpl;
4
5  public class ScrollUpdateRowSet {
6    public static void main(String[] args)
7        throws SQLException, ClassNotFoundException {
8      // Load the JDBC driver
9      Class.forName("com.mysql.jdbc.Driver");
10     System.out.println("Driver loaded");
11
```

```
12      // Create a row set
13      RowSet rowSet = new JdbcRowSetImpl();
14
15      // Set RowSet properties
16      rowSet.setUrl("jdbc:mysql://localhost/javabook");
17      rowSet.setUsername("scott");
18      rowSet.setPassword("tiger");
19      rowSet.setCommand("select state, capital from StateCapital");
20      rowSet.execute();
21
22      System.out.println("Before update ");
23      displayRowSet(rowSet);
24
25      // Update the second row
26      rowSet.absolute(2); // Move cursor to the 2nd row
27      rowSet.updateString("state", "New S"); // Update the column
28      rowSet.updateString("capital", "New C"); // Update the column
29      rowSet.updateRow(); // Update the row in the data source
30
31      // Insert after the second row
32      rowSet.last();
33      rowSet.moveToInsertRow(); // Move cursor to the insert row
34      rowSet.updateString("state", "Florida");
35      rowSet.updateString("capital", "Tallahassee");
36      rowSet.insertRow(); // Insert the row
37      rowSet.moveToCurrentRow(); // Move the cursor to the current row
38
39      // Delete fourth row
40      rowSet.absolute(4); // Move cursor to the fifth row
41      rowSet.deleteRow(); // Delete the second row
42
43      System.out.println("After update ");
44      displayRowSet(rowSet);
45
46      // Close the connection
47      rowSet.close();
48    }
49
50    private static void displayRowSet(RowSet rowSet)
51        throws SQLException {
52      ResultSetMetaData rsMetaData = rowSet.getMetaData();
53      rowSet.beforeFirst();
54      while (rowSet.next()) {
55        for (int i = 1; i <= rsMetaData.getColumnCount(); i++)
56          System.out.printf("%-12s\t", rowSet.getObject(i));
57        System.out.println();
58      }
59    }
60  }
```

If you replace `JdbcRowSet` with `CachedRowSet` in line 13, the database is not changed. To make the changes on the `CachedRowSet` effective in the database, you must invoke the `acceptChanges()` method after you make all the changes, as follows:

```
// Write changes back to the database
((com.sun.rowset.CachedRowSetImpl)rowSet).acceptChanges();
```

This method automatically reconnects to the database and writes all the changes back to the database.

35.5.4 RowSetEvent

A `RowSet` object fires a `RowSetEvent` whenever the object's cursor has moved, a row has changed, or the entire row set has changed. This event can be used to synchronize a `RowSet` with the components that rely on the `RowSet`. For example, a visual component that displays the contents of a `RowSet` should be synchronized with the `RowSet`. The `RowSetEvent` can be used to achieve synchronization. The handlers in `RowSetListener` are `cursorMoved(RowSetEvent)`, `rowChanged(RowSetEvent)`, and `cursorSetChanged(RowSetEvent)`.

Listing 35.7 gives an example that demonstrates `RowSetEvent`. A listener for `RowSetEvent` is registered in lines 14–26. When `rowSet.execute()` (line 33) is executed, the entire row set is changed, so the listener's `rowSetChanged` handler is invoked. When `rowSet.last()` (line 35) is executed, the cursor is moved, so the listener's `cursorMoved` handler is invoked. When `rowSet.updateRow()` (line 37) is executed, the row is updated, so the listener's `rowChanged` handler is invoked.

LISTING 35.7 TestRowSetEvent.java

```
1  import java.sql.*;
2  import javax.sql.*;
3  import com.sun.rowset.*;
4
5  public class TestRowSetEvent {
6    public static void main(String[] args)
7        throws SQLException, ClassNotFoundException {
8      // Load the JDBC driver
9      Class.forName("com.mysql.jdbc.Driver");
10     System.out.println("Driver loaded");
11
12     // Create a row set
13     RowSet rowSet = new JdbcRowSetImpl();
14     rowSet.addRowSetListener(new RowSetListener() {
15       public void cursorMoved(RowSetEvent e) {
16         System.out.println("Cursor moved");
17       }
18
19       public void rowChanged(RowSetEvent e) {
20         System.out.println("Row changed");
21       }
22
23       public void rowSetChanged(RowSetEvent e) {
24         System.out.println("row set changed");
25       }
26     });
27
28     // Set RowSet properties
29     rowSet.setUrl("jdbc:mysql://localhost/javabook");
30     rowSet.setUsername("scott");
31     rowSet.setPassword("tiger");
32     rowSet.setCommand("select * from Student");
33     rowSet.execute();
34
35     rowSet.last(); // Cursor moved
36     rowSet.updateString("lastName", "Yao"); // Update column
37     rowSet.updateRow(); // Row updated
38
39     // Close the connection
40     rowSet.close();
41   }
42 }
```

35.5.1 What are the advantages of `RowSet`?

35.5.2 What are `JdbcRowSet` and `CachedRowSet`? What are the differences between them?

35.5.3 How do you create a `JdbcRowSet` and a `CachedRowSet`?

35.5.4 Can you scroll and update a `RowSet`? What method must be invoked to write the changes in a `CachedRowSet` to the database?

35.5.5 Describe the handlers in `RowSetListener`.

35.6 Storing and Retrieving Images in JDBC

You can store and retrieve images using JDBC.

A database can store not only numbers and strings, but also images. SQL3 introduced a new data type called BLOB (*B*inary *L*arge *OB*ject) for storing binary data, which can be used to store images. Another new SQL3 type is CLOB (*C*haracter *L*arge *OB*ject) for storing a large text in the character format. JDBC introduced the interfaces `java.sql.Blob` and `java.sql.Clob` to support mapping for these new SQL types. You can use `getBlob`, `setBinaryStream`, `getClob`, `setBlob`, and `setClob`, to access SQL BLOB and CLOB values in the interfaces `ResultSet` and `PreparedStatement`.

To store an image into a cell in a table, the corresponding column for the cell must be of the BLOB type. For example, the following SQL statement creates a table whose type for the flag column is BLOB:

```
create table Country(name varchar(30), flag blob,
  description varchar(255));
```

In the preceding statement, the `description` column is limited to 255 characters, which is the upper limit for MySQL. For Oracle, the upper limit is 32,672 bytes. For a large character field, you can use the CLOB type for Oracle, which can store up to two GB of characters. MySQL does not support CLOB. However, you can use BLOB to store a long string and convert binary data into characters.

Note

MS Access database does not support the BLOB and CLOB types.

To insert a record with images to a table, define a prepared statement like this one:

```
PreparedStatement pstmt = connection.prepareStatement(
 "insert into Country values(?, ?, ?)");
```

Images are usually stored in files. You may first get an instance of `InputStream` for an image file then use the `setBinaryStream` method to associate the input stream with a cell in the table, as follows:

```
// Store image to the table cell
File file = new File(imageFilename);
InputStream inputImage = new FileInputStream(file);
pstmt.setBinaryStream(2, inputImage, (int)(file.length()));
```

To retrieve an image from a table, use the `getBlob` method, as shown below:

```
// Store image to the table cell
Blob blob = rs.getBlob(1);
ImageIcon imageIcon = new ImageIcon(
  blob.getBytes(1, (int)blob.length()));
```

Listing 35.8 gives a program that demonstrates how to store and retrieve images in JDBC. The program first creates the `Country` table and stores data to it. Then the program retrieves

the country names from the table and adds them to a combo box. When the user selects a name from the combo box, the country's flag and description are displayed, as shown in Figure 35.4.

FIGURE 35.4 The program enables you to retrieve data, including images, from a table and displays them.

LISTING 35.8 StoreAndRetrieveImage.java

```
1  import java.sql.*;
2  import java.io.*;
3  import javafx.application.Application;
4  import javafx.scene.Scene;
5  import javafx.scene.control.ComboBox;
6  import javafx.scene.control.Label;
7  import javafx.scene.image.Image;
8  import javafx.scene.image.ImageView;
9  import javafx.scene.layout.BorderPane;
10 import javafx.stage.Stage;
11
12 public class StoreAndRetrieveImage extends Application {
13   // Connection to the database
14   private Connection connection;
15
16   // Statement for static SQL statements
17   private Statement stmt;
18
19   // Prepared statement
20   private PreparedStatement pstmt = null;
21   private DescriptionPane descriptionPane
22     = new DescriptionPane();
23
24   private ComboBox<String> cboCountry = new ComboBox<>();
25
26   @Override // Override the start method in the Application class
27   public void start(Stage primaryStage) {
28     try {
29       connectDB(); // Connect to DB
30       storeDataToTable(); //Store data to the table (including image)
31       fillDataInComboBox(); // Fill in combo box
32       retrieveFlagInfo(cboCountry.getSelectionModel().getSelectedItem());
33     }
34     catch (Exception ex) {
35       ex.printStackTrace();
36     }
37
38     BorderPane paneForComboBox = new BorderPane();
39     paneForComboBox.setLeft(new Label("Select a country: "));
40     paneForComboBox.setCenter(cboCountry);
41     cboCountry.setPrefWidth(400);
42     BorderPane pane = new BorderPane();
```

```
43      pane.setTop(paneForComboBox);
44      pane.setCenter(descriptionPane);
45
46      Scene scene = new Scene(pane, 350, 150);
47      primaryStage.setTitle("StoreAndRetrieveImage");
48      primaryStage.setScene(scene); // Place the scene in the stage
49      primaryStage.show(); // Display the stage
50
51      cboCountry.setOnAction(e ->
52        retrieveFlagInfo(cboCountry.getValue()));
53    }
54
55    private void connectDB() throws Exception {
56      // Load the driver
57      Class.forName("com.mysql.jdbc.Driver");
58      System.out.println("Driver loaded");
59
60      // Establish connection
61      connection = DriverManager.getConnection
62        ("jdbc:mysql://localhost/javabook", "scott", "tiger");
63      System.out.println("Database connected");
64
65      // Create a statement for static SQL
66      stmt = connection.createStatement();
67
68      // Create a prepared statement to retrieve flag and description
69      pstmt = connection.prepareStatement("select flag, description " +
70        "from Country where name = ?");
71    }
72
73    private void storeDataToTable() {
74      String[] countries = {"Canada", "UK", "USA", "Germany",
75        "Indian", "China"};
76
77     String[] imageFilenames = {"image/ca.gif", "image/uk.gif",
78        "image/us.gif", "image/germany.gif", "image/india.gif",
79        "image/china.gif"};
80
81     String[] descriptions = {"A text to describe Canadian " +
82        "flag is omitted", "British flag ...", "American flag ...",
83        "German flag ...", "Indian flag ...", "Chinese flag ..."};
84
85      try {
86        // Create a prepared statement to insert records
87        PreparedStatement pstmt = connection.prepareStatement(
88          "insert into Country values(?, ?, ?)");
89
90        // Store all predefined records
91        for (int i = 0; i < countries.length; i++) {
92          pstmt.setString(1, countries[i]);
93
94          // Store image to the table cell
95          java.net.URL url =
96            this.getClass().getResource(imageFilenames[i]);
97          InputStream inputImage = url.openStream();
98          pstmt.setBinaryStream(2, inputImage,
99            (int)(inputImage.available()));
100
101         pstmt.setString(3, descriptions[i]);
102         pstmt.executeUpdate();
```

```
103         }
104
105         System.out.println("Table Country populated");
106       }
107       catch (Exception ex) {
108         ex.printStackTrace();
109       }
110     }
111
112     private void fillDataInComboBox()  throws Exception {
113       ResultSet rs = stmt.executeQuery("select name from Country");
114       while (rs.next()) {
115         cboCountry.getItems().add(rs.getString(1));
116       }
117       cboCountry.getSelectionModel().selectFirst();
118     }
119
120     private void retrieveFlagInfo(String name) {
121       try {
122         pstmt.setString(1, name);
123         ResultSet rs = pstmt.executeQuery();
124         if (rs.next()) {
125           Blob blob = rs.getBlob(1);
126           ByteArrayInputStream in = new ByteArrayInputStream
127             (blob.getBytes(1, (int)blob.length()));
128           Image image = new Image(in);
129           ImageView imageView = new ImageView(image);
130           descriptionPane.setImageView(imageView);
131           descriptionPane.setTitle(name);
132           String description = rs.getString(2);
133           descriptionPane.setDescription(description);
134         }
135       }
136       catch (Exception ex) {
137         System.err.println(ex);
138       }
139     }
140   }
```

`DescriptionPane` (line 21) is a component for displaying a country (name, flag, and description). This component was presented in Listing 16.6, DescriptionPane.java.

The `storeDataToTable` method (lines 73–110) populates the table with data. The `fillDataInComboBox` method (lines 112–118) retrieves the country names and adds them to the combo box. The `retrieveFlagInfo(name)` method (lines 120–139) retrieves the flag and description for the specified country name.

35.6.1 How do you store images into a database?

35.6.2 How do you retrieve images from a database?

35.6.3 Does Oracle support the SQL3 BLOB type and CLOB type? What about MySQL and Access?

Key Terms

BLOB type 35-20
CLOB type 35-20
batch mode 35-2
cached row set 35-15
row set 35-15
scrollable result set 35-2
updatable result set 35-11

Chapter Summary

1. This chapter developed a universal SQL client that can be used to access any local or remote relational database.

2. You can use the `addBatch(SQLString)` method to add SQL statements to a statement for batch processing.

3. You can create a statement to specify that the result set be scrollable and updatable. By default, the result set is neither of these.

4. The `RowSet` can be used to simplify Java database programming. A `RowSet` object is scrollable and updatable. A `RowSet` can fire a `RowSetEvent`.

5. You can store and retrieve image data in JDBC using the SQL BLOB type.

Quiz

Answer the quiz for this chapter online at the book Companion Website.

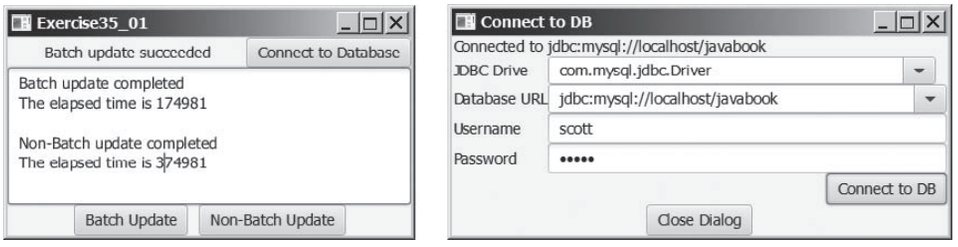
MyProgrammingLab™

Programming Exercises

35.1 (*Batch update*) Write a program that inserts a thousand records to a database, and compare the performance with and without batch updates, as shown in Figure 35.5a. Suppose the table is defined as follows:

```
create table Temp(num1 double, num2 double, num3 double)
```

Use the `Math.random()` method to generate random numbers for each record. Create a dialog box that contains `DBConnectionPanel`, discussed in Exercise 34.3. Use this dialog box to connect to the database. When you click the *Connect to Database* button in Figure 35.5a, the dialog box in Figure 35.5b is displayed.



(a) (b)

Figure 35.5 The program demonstrates the performance improvements that result from using batch updates.

35.2 (*Scrollable result set*) Write a program that uses the buttons *First*, *Next*, *Prior*, *Last*, *Insert*, *Delete*, and *Update*, and modify a single record in the `Address` table, as shown in Figure 35.6.

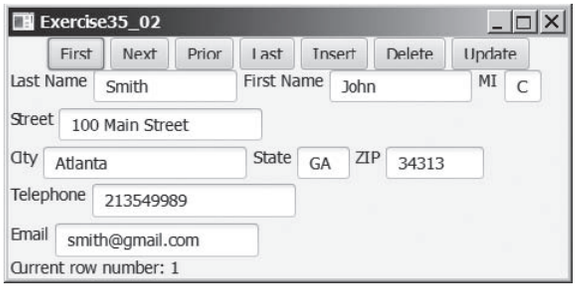
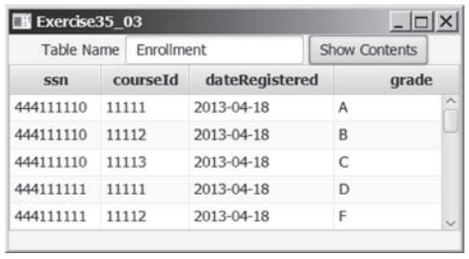


FIGURE 35.6 You can use the buttons to display and modify a single record in the `Address` table.

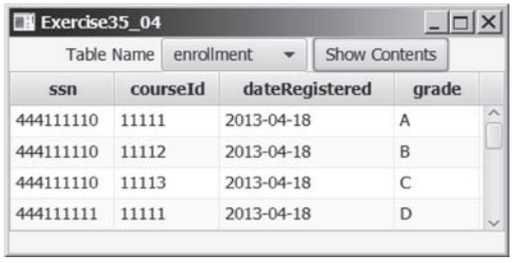
The `Address` table is defined as follows:

```
create table Address (
  firstname varchar(25),
  mi char(1),
  lastname varchar(25),
  street varchar(40),
  city varchar(20),
  state varchar(2),
  zip varchar(5),
  telephone varchar(10),
  email varchar(30),
  primary key (firstname, mi, lastname)
);
```

***35.3** (*Display table contents*) Write a program that displays the content for a given table. As shown in Figure 35.7a, you enter a table and click the *Show Contents* button to display the table contents in a table view.



(a)



(b)

FIGURE 35.7 (a) Enter a table name to display the table contents. (b) Select a table name from the combo box to display its contents.

***35.4** (*Find tables and showing their contents*) Write a program that fills in table names in a combo box, as shown in Figure 35.7b. You can select a table from the combo box to display its contents in a table view.

**35.5 (*Revise SQLClient.java*) Rewrite Listing 35.1, SQLClient.java, to display the query result in a `TableView`, as shown in Figure 35.8.

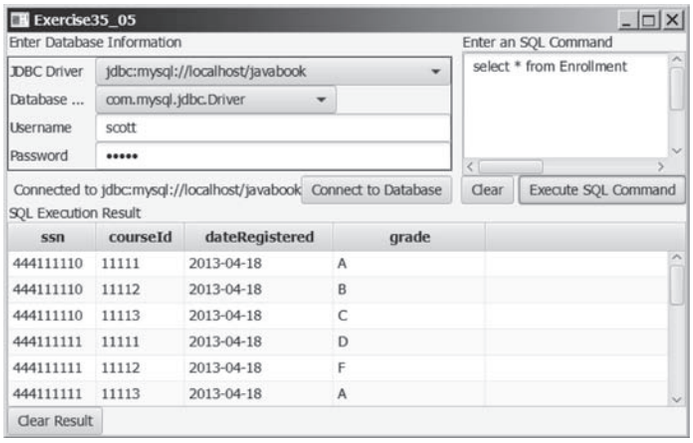


FIGURE 35.8 The query result is displayed in a `TableView`.

*35.5 (*Populate Salary table)* Rewrite Programming Exercise 34.8 using a batch mode to improve performance.