Planejamento

- **Aula 6**
  - **Conectividade com Banco de Dados (JDBC)**
  - **Padrão de projeto para acesso a Dados: DAO Design Pattern**
- Aula 7
  - Introdução a Servlets e JSP
- Aula 8
  - Introdução a JSP
  - Prova

Conectividade com Banco de Dados em Java através de JDBC

6.1.1 Introduction

- Database
  - Collection of data
- DBMS
  - Database management system
  - Stores and organizes data
- SQL
  - Relational database
  - Structured Query Language

6.1.1 Introduction (Cont.)

- RDBMS
  - Relational database management system
  - Firebird
    - firebird.sourceforge.net
- JDBC
  - Java Database Connectivity
  - JDBC driver

6.1.2 Relational-Database Model

- Relational database
  - Table
    - Rows, columns
  - Primary key
    - Unique data
- SQL statement
  - Query

6.1.2 Relational-Database Model (Cont.)

	Number	Name	Department	Salary	Location
	23603	Jones	413	1100	New Jersey
	24568	Kerwin	413	2000	New Jersey
Row	34589	Larson	642	1800	Los Angeles
	35761	Myers	611	1400	Orlando
	47132	Neumann	413	9000	New Jersey
	78321	Stephens	611	8500	Orlando
	Primary key		Column		

Fig. 6.1.1 **`Employee`** table sample data.

6.1.2 Relational-Database Model (Cont.)

Department	Location
413	New Jersey
611	Orlando
642	Los Angeles

Fig. 6.1.2 Result of selecting distinct **Department** and **Location** data from the **Employee** table.

6.1.3 Relational Database Overview: The `books` Database

- Sample `books` database
  - Four tables
    - `authors`, `publishers`, `authorISBN` and `titles`
  - Relationships among the tables

6.1.3 Relational Database Overview: The `books` Database (Cont.)

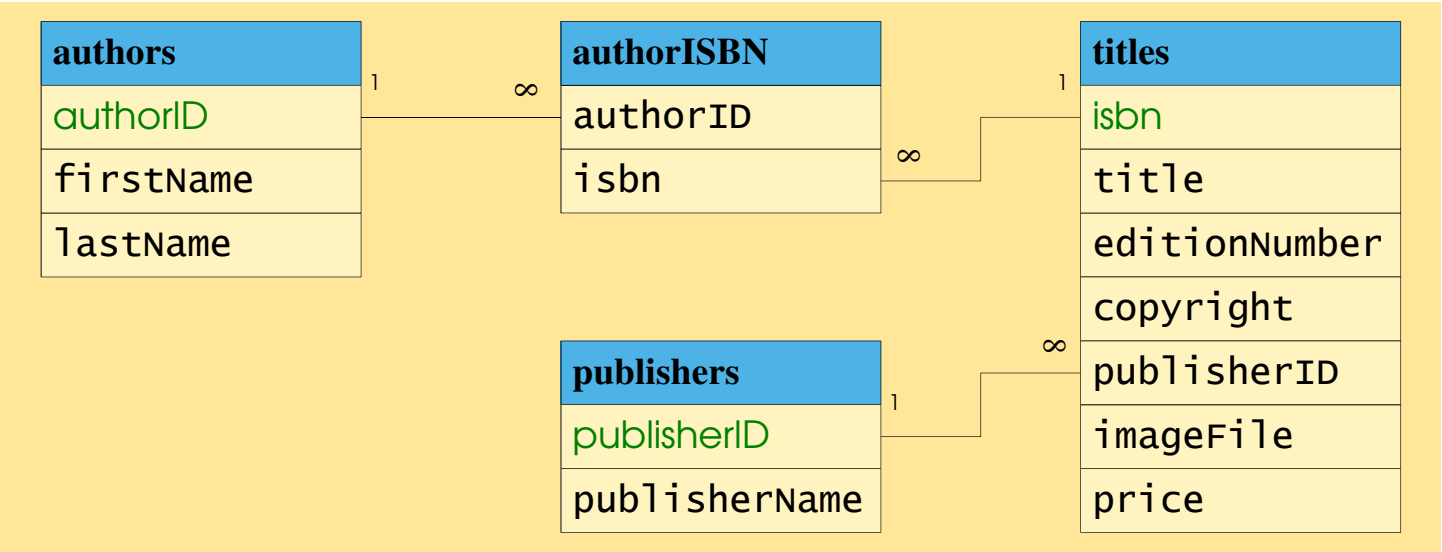


Fig. 6.1.11 Table relationships in **`books`**.

6.1.3 Relational Database Overview: The `books` Database (Cont.)

Column	Description
`authorID`	Author's ID number in the database. In the `books` database, this integer column is defined as *autoincremented*. For each row inserted in this table, the database automatically increments the `authorID` value to ensure that each row has a unique `authorID`. This column represents the table's primary key.
`firstName`	Author's first name (a string).
`lastName`	Author's last name (a string).

Fig. 23.3 `authors` table from `books`.

`authorID`	`firstName`	`lastName`
1	Harvey	Deitel
2	Paul	Deitel
3	Tem	Nieto
4	Sean	Santry

Fig. 23.4 Sample data from the `authors` table.

6.1.3 Relational Database Overview: The `books` Database (Cont.)

Column	Description
`publisherID`	The publisher's ID number in the database. This autoincremented integer is the table's primary key.
`publisherName`	The name of the publisher (a string).

Fig. 23.5 `publishers` table from `books`.

`publisherID`	`publisherName`
1	Prentice Hall
2	Prentice Hall PTG

Fig. 6.1.6 Data from the `publishers` table.

6.1.3 Relational Database Overview: The `books` Database (Cont.)

Column	Description
`isbn`	ISBN of the book (a string). The table's primary key.
`title`	Title of the book (a string).
`editionNumber`	Edition number of the book (an integer).
`copyright`	Copyright year of the book (a string).
`publisherID`	Publisher's ID number (an integer). A foreign key to the `publishers` table.
`imageFile`	Name of the file containing the book's cover image (a string).
`price`	Suggested retail price of the book (a real number). [*Note:* The prices shown in this book are for example purposes only.]

Fig. 23.7 `titles` table from `books`.

6.1.3 Relational Database Overview: The `books` Database (Cont.)

isbn	title	edition-Number	copy-right	publish-erID	imageFile	price
0130895725	C How to Program	3	2001	1	chtp3.jpg	74.95
0130384747	C++ How to Program	4	2002	1	cpphtp4.jpg	74.95
0130461342	Java Web Services for Experienced Programmers	1	2002	1	jwsfep1.jpg	54.95
0131016210	Java How to Program	5	2003	1	jhtp5.jpg	74.95
0130852473	The Complete Java 2 Training Course	5	2002	2	javactc5.jpg	109.95
0130895601	Advanced Java 2 Platform How to Program	1	2002	1	advjhtp1.jpg	74.95

Fig. 23.8 Sample data from the `titles` table of books.

6.1.3 Relational Database Overview: The `books` Database (Cont.)

Column	Description
`authorID`	The author's ID number, a foreign key to the `authors` table.
`isbn`	The ISBN for a book, a foreign key to the `titles` table..

Fig. 23.9 `authorISBN` table from `books`.

`authorID`	`isbn`	`authorID`	`isbn`
1	0130895725	2	0139163050
2	0130895725	3	0130829293
2	0132261197	3	0130284173
2	0130895717	3	0130284181
2	0135289106	4	0130895601

Fig. 6.1.10 Sample data from the `authorISBN` table of `books`.

6.1.4 SQL

- SQL overview
- SQL keywords

SQL keyword	Description
`SELECT`	Retrieves data from one or more tables.
`FROM`	Tables involved in the query. Required in every `SELECT`.
`WHERE`	Criteria for selection that determine the rows to be retrieved, deleted or updated.
`GROUP BY`	Criteria for grouping rows.
`ORDER BY`	Criteria for ordering rows.
`INNER JOIN`	Merge rows from multiple tables.
`INSERT`	Insert rows into a specified table.
`UPDATE`	Update rows in a specified table.
`DELETE`	Delete rows from a specified table.

Fig. 6.1.12 SQL query keywords.

6.1.4.1 Basic SELECT Query

- Simplest form of a SELECT query
  - **SELECT** * **FROM** *tableName*
    - **SELECT** * **FROM** **authors**
- Select specific fields from a table
  - **SELECT** **authorID**, **lastName** **FROM** **authors**

authorID	lastName
1	Deitel
2	Deitel
3	Nieto
4	Santry

Fig. 6.1.13 Sample `authorID` and `lastName` data from the `authors` table.

6.1.4.2 `WHERE` Clause

- specify the selection criteria
  - **`SELECT`** *columnName1*, *columnName2*, … **`FROM`** *tableName* **`WHERE`** *criteria*
    - **`SELECT`** title, editionNumber, copyright

      `FROM` titles

      `WHERE` copyright > 2000
- **`WHERE`** clause condition operators
  - <, >, <=, >=, =, <>
  - **`LIKE`**
    - wildcard characters `%` and `_`

6.1.4.2 WHERE Clause (Cont.)

title	editionNumber	copyright
C How to Program	3	2001
C++ How to Program	4	2002
The Complete C++ Training Course	4	2002
Internet and World Wide Web How to Program	2	2002
Java How to Program	5	2003
XML How to Program	1	2001
Perl How to Program	1	2001
Advanced Java 2 Platform How to Program	1	2002

Fig. 23.14 Sampling of titles with copyrights after 2000 from table `titles`.

6.1.4.2 WHERE Clause (Cont.)

- **SELECT** authorID, firstName, lastName

  FROM authors

  WHERE lastName **LIKE** 'D%'

authorID	firstName	lastName
1	Harvey	Deitel
2	Paul	Deitel

Fig. 6.1.15 Authors whose last name starts with `D` from the `authors` table.

6.1.4.2 WHERE Clause (Cont.)

- **SELECT** authorID, firstName, lastName

  FROM authors

  WHERE lastName **LIKE** '_i%'

authorID	firstName	lastName
3	Tem	Nieto

Fig. 6.1.16 The only author from the `authors` table whose last name contains `i` as the second letter.

6.1.4.3 ORDER BY Clause

- Optional **ORDER BY** clause
  - **SELECT** *columnName1*, *columnName2*, … **FROM** *tableName* **ORDER BY** *column* **ASC**
  - **SELECT** *columnName1*, *columnName2*, … **FROM** *tableName* **ORDER BY** *column* **DESC**
- **ORDER BY** multiple fields
  - **ORDER BY** *column1 sortingOrder*, *column2 sortingOrder*, …
- Combine the **WHERE** and **ORDER BY** clauses

6.1.4.3 ORDER BY Clause (Cont.)

- **SELECT** authorID, firstName, lastName

  FROM authors

  ORDER BY lastName **ASC**

authorID	firstName	lastName
2	Paul	Deitel
1	Harvey	Deitel
3	Tem	Nieto
4	Sean	Santry

Fig. 6.1.17 Sample data from table `authors` in ascending order by `lastName`.

6.1.4.3 ORDER BY Clause (Cont.)

- **SELECT** authorID, firstName, lastName

  FROM authors

  ORDER BY lastName **DESC**

authorID	firstName	lastName
4	Sean	Santry
3	Tem	Nieto
2	Paul	Deitel
1	Harvey	Deitel

Fig. 6.1.18 Sample data from table `authors` in descending order by `lastName`.

6.1.4.3 ORDER BY Clause (Cont.)

- **SELECT** authorID, firstName, lastName

  FROM authors

  ORDER BY lastName, firstName

authorID	firstName	lastName
1	Harvey	Deitel
2	Paul	Deitel
3	Tem	Nieto
4	Sean	Santry

Fig. 6.1.19 Sample author data from table `authors` in ascending order by `lastName` and by `firstName`.

6.1.4.3 ORDER BY Clause (Cont.)

- **SELECT** isbn, title, editionNumber, copyright, price
  FROM titles **WHERE** title **LIKE** '%How to Program'
  ORDER BY title **ASC**

isbn	title	edition-Number	copy-right	price
0130895601	Advanced Java 2 Platform How to Program	1	2002	74.95
0130895725	C How to Program	3	2001	74.95
0130384747	C++ How to Program	4	2002	74.95
0130308978	Internet and World Wide Web How to Program	2	2002	74.95
0130284181	Perl How to Program	1	2001	74.95
0134569555	Visual Basic 6 How to Program	1	1999	74.95
0130284173	XML How to Program	1	2001	74.95
013028419x	e-Business and e-Commerce How to Program	1	2001	74.95

Fig. 6.1.20 Sampling of books from table `titles` whose titles end with `How to Program` in ascending order by `title`.

6.1.4.4 Merging Data from Multiple Tables: Joining

- Split related data into separate tables
- Join the tables
  - Merge data from multiple tables into a single view
  - INNER JOIN
    - **SELECT** *columnName1*, *columnName2*, …
      FROM *table1*
      INNER JOIN *table2*
        ON *table1.columnName* = *table2.column2Name*
    - **SELECT** firstName, lastName, isbn
      FROM authors, authorISBN
      INNER JOIN authorISBN
        ON authors.authorID = authorISBN.authorID
      ORDER BY lastName, firstName

6.1.4.4 Merging Data from Multiple Tables: Joining (Cont.)

firstName	lastName	isbn	firstName	lastName	isbn
Harvey	Deitel	0130895601	Paul	Deitel	0130895717
Harvey	Deitel	0130284181	Paul	Deitel	0132261197
Harvey	Deitel	0134569555	Paul	Deitel	0130895725
Harvey	Deitel	0139163050	Paul	Deitel	0130829293
Harvey	Deitel	0135289106	Paul	Deitel	0134569555
Harvey	Deitel	0130895717	Paul	Deitel	0130829277
Harvey	Deitel	0130284173	Tem	Nieto	0130161438
Harvey	Deitel	0130829293	Tem	Nieto	013028419x
Paul	Deitel	0130852473	Sean	Santry	0130895601

Fig. 23.21 Sampling of authors and ISBNs for the books they have written in ascending order by `lastName` and `firstName`.

6.1.4.5 INSERT Statement

- Insert a row into a table
  - **INSERT INTO** *tableName* (*columnName1*, … , *columnNameN*)

    VALUES (*value1*, … , *valueN*)
    - **INSERT INTO** authors (firstName, lastName)

      VALUES ('Sue', 'Smith')

authorID	firstName	lastName
1	Harvey	Deitel
2	Paul	Deitel
3	Tem	Nieto
4	Sean	Santry
5	Sue	Smith

Fig. 6.1.22 Sample data from table `Authors` after an `INSERT` operation.

6.1.4.6 UPDATE Statement

- Modify data in a table
  - **UPDATE** *tableName*

    SET *columnName1* = *value1*, … , *columnNameN* = *valueN*

    WHERE *criteria*

    - **UPDATE** authors

      SET lastName = 'Jones'

      WHERE lastName = 'Smith' **AND** firstName = 'Sue'

authorID	firstName	lastName
1	Harvey	Deitel
2	Paul	Deitel
3	Tem	Nieto
4	Sean	Santry
5	Sue	Jones

Fig. 6.1.23 Sample data from table `authors` after an `UPDATE` operation.

6.1.4.7 DELETE Statement

- Remove data from a table
  - **DELETE FROM** *tableName* **WHERE** *criteria*
    - **DELETE FROM** authors

      WHERE lastName = 'Jones' **AND** firstName = 'Sue'

authorID	firstName	lastName
1	Harvey	Deitel
2	Paul	Deitel
3	Tem	Nieto
4	Sean	Santry

Fig. 6.1.24 Sample data from table `authors` after a `DELETE` operation.

6.1.5 Creating Database books in Firebird

- FireBird
  - **Banco de Dados open source, baseado no Borland Interbase**
- **Driver nativo JDBC 4**

  - `createDatabase books.sql`

Fig. 6.1.25 Executing Cloudscape from a command prompt in Windows 2000.

Tabela Authors

```
CREATE TABLE AUTHORS (
AUTHORID VARCHAR(40) NOT NULL,
FIRSTNAME VARCHAR(40),
LASTNAME  VARCHAR(40) );

insert into authors values ('1','Harvey','Deitel');
insert into authors values ('2','Paul','Deitel');
insert into authors values ('3','Tem','Nieto');
insert into authors values ('4','Sean','Santry');
```

6.1.6 Modificando Databases com JDBC

- Connect to a database
- Query the database
- Display the results of the query

6.1.6.1 Connecting to and Querying a Database

- DisplayAuthors
  - Retrieves the entire **`authors`** table
  - Displays the data in a **`JTextArea`**

Um Programa bastante simples

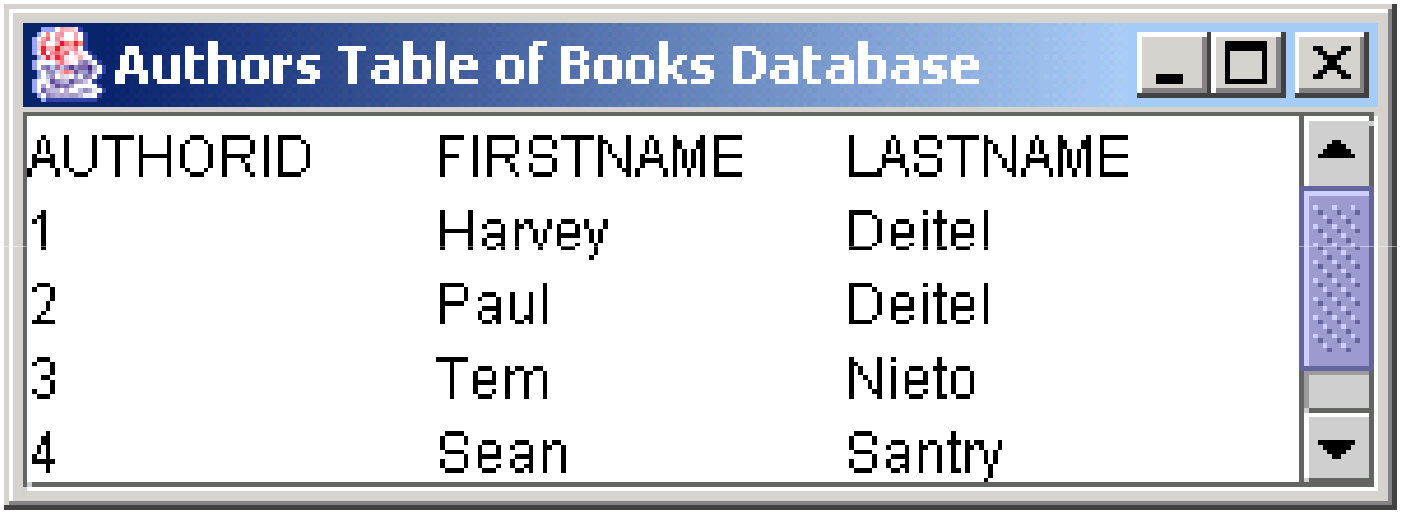
- FirstJDBCProgram.java

```
public class FirstJDBCProgram
{
            // JDBC driver name and database URL
   static final String JDBC_DRIVER = "org.firebirdsql.jdbc.FBDriver";
   static final String host="126.0.0.1";
   static final String path="c:\\stefanini\\books.fdb";
   static final String DATABASE_URL = "jdbc:firebirdsql:"+host+"/3050:"+path;

public static void main(String args[])
{


System.out.println("#testando acesso a banco de dado Firebird\n\n");
Connection conn = null;
String teste = "SELECT * FROM authors;";
try
{
Class.forName(JDBC_DRIVER);
conn = DriverManager.getConnection(DATABASE_URL, "SYSDBA", "masterkey");
System.out.println("Conexão aberta com sucesso!");
Statement stm = conn.createStatement();
ResultSet rs = stm.executeQuery(teste);
while (rs.next())
{
String linha = rs.getString("first_name");
System.out.println("Autor:" +linha);
}

System.out.println("select realizado\n");
} ……
```

Exercício

- Faça um programa que escreva a lista de autores com nome e sobrenome

Authors Database



```
1  // Fig. 6.1.26: DisplayAuthors.java
2  // Displaying the contents of the authors table.
3
4  import java.awt.*;
5  import java.sql.*;
6  import java.util.*;
7  import javax.swing.*;
8
9  public class DisplayAuthors extends JFrame {
10
11    // JDBC driver name and database URL
12    static final String JDBC_DRIVER = "com.ibm.db2j.jdbc.DB2jDriver";
13    static final String DATABASE_URL = "jdbc:db2j:books";
14
15    // declare Connection and Statement for accessing
16    // and querying database
17    private Connection connection;
18    private Statement statement;
19
20    // constructor connects to database, queries database, processes
21    // results and displays results in window
22    public DisplayAuthors()
23    {
24       super( "Authors Table of Books Database" );
25
```

Imports package `java.sql`, which contains classes and interfaces for the JDBC API.

```
26          // connect to database books and query database
27          try {
28
29             // specify location of database on filesystem
30             System.setProperty( "db2j.system.home", "C:/Cloudscape_5.0" );
31
32             // load database driver class
33             Class.forName( JDBC_DRIVER );
34
35             // establish connection to dat
36             connection = DriverManager.getConnection( DA
37
38             // create Statement for querying database
39             statement = connection.createStatement();
40
41             // query database
42             ResultSet resultSet =
43                statement.executeQuery( "SELECT * FROM authors" );
44
45             // process query results
46             StringBuffer results = new StringBuffer();
47             ResultSetMetaData metaData = resultSet.getMetaData();
48             int numberOfColumns = metaData.getColumnCount();
49
```

Specify location of database

Loads the class definition for the database driv

Invokes `Connection` method `createStatement` to obtain an object that implements interface `Statement`.

ze a
rence
on.

Use the `Statement` object's `executeQuery` method to execute a query

Obtains the metadata

Uses `ResultSetMetaData` method `getColumnCount` to retrieve the number of columns in the `ResultSet`.

```
50          for ( int i = 1; i <= numberOfColumns; i++ )
51             results.append( metaData.getColumnName( i ) + "\t" );
52
53          results.append( "\n" );
54
55          while ( resultSet.next() ) {
56
57             for ( int i = 1; i <= numberOfColumns; i++ )
58                results.append( resultSet.getObject( i ) + "\t" );
59
60             results.append( "\n" );
61          }
62
63          // set up GUI and display window
64          JTextArea textArea = new JTextArea( results.toString() );
65          Container container = getContentPane();
66
67          container.add( new JScrollPane( textArea ) );
68
69          setSize( 300, 100 );  // set window size
70          setVisible( true );   // display window
71
72       }  // end try
73
```

Append the column names to the `StringBuffer results`.

Append the data in each `ResultSet` row to the `StringBuffer results`.

Create the GUI that displays the `StringBuffer results`, set the size of the application window and show the application window.

```
74          // detect problems interacting with the database
75          catch ( SQLException sqlException ) {
76             JOptionPane.showMessageDialog( null, sqlException.getMessage(),
77                "Database Error", JOptionPane.ERROR_MESSAGE );
78
79             System.exit( 1 );
80          }
81
82          // detect problems loading database driver
83          catch ( ClassNotFoundException classNotFound ) {
84             JOptionPane.showMessageDialog( null, classNotFound.getMessage(),
85                "Driver Not Found", JOptionPane.ERROR_MESSAGE );
86
87             System.exit( 1 );
88          }
89
90          // ensure statement and connection are closed properly
91          finally {
92
93             try {
94                statement.close();
95                connection.close();
96             }
97
```

Close the `Statement` and the database `Connection`.

```
98            // handle exceptions closing statement and connection
99            catch ( SQLException sqlException ) {
100              JOptionPane.showMessageDialog( null,
101                 sqlException.getMessage(), "Database Error",
102                 JOptionPane.ERROR_MESSAGE );
103
104              System.exit( 1 );
105           }
106        }
107
108     }  // end DisplayAuthors constructor
109
110     // launch the application
111     public static void main( String args[] )
112     {
113        DisplayAuthors window = new DisplayAuthors();
114        window.setDefaultCloseOperation( JFrame.EXIT_ON_CLOSE );
115     }
116
117  }  // end class DisplayAuthors
```

Exercícios

- Altere o programa para que este apresente a lista de livros (isbn, título, número da edição, preço) disponíveis no banco de dados

- Inclua à direita do preço o nome da Editora (publisher)

6.1.6.1 Connecting to and Querying a JDBC Data Source (Cont.)

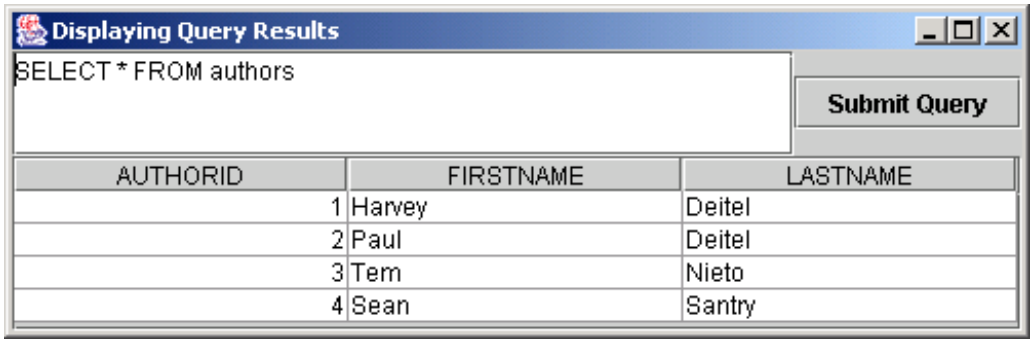
Type	Description
1	The *JDBC-to-ODBC bridge driver* connects Java programs to Microsoft ODBC (Open Database Connectivity) data sources. The Java 2 Software Development Kit from Sun Microsystems, Inc. includes the JDBC-to-ODBC bridge driver (`sun.jdbc.odbc.JdbcOdbcDriver`). This driver typically requires the ODBC driver to be installed on the client computer and normally requires configuration of the ODBC data source. The bridge driver was introduced primarily for development purposes and should not be used for production applications.
2	*Native-API, partly Java drivers* enable JDBC programs to use database-specific APIs (normally written in C or C++) that allow client programs to access databases via the Java Native Interface. This driver type translates JDBC into database-specific code. Type 2 drivers were introduced for reasons similar to the Type 1 ODBC bridge driver.
3	*JDBC-Net pure Java drivers* take JDBC requests and translate them into a network protocol that is not database specific. These requests are sent to a server, which translates the database requests into a database-specific protocol.
4	*Native-protocol pure Java drivers* convert JDBC requests to database-specific network protocols, so that Java programs can connect directly to a database.

Fig. 23.26 JDBC driver types.

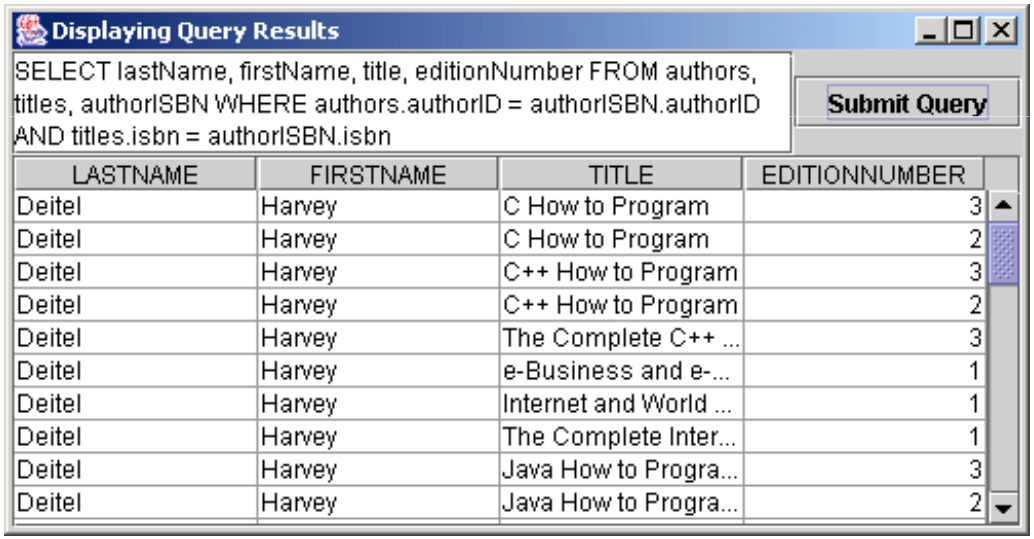
6.1.6.2 Querying the `books` Database

- Allow the user to enter any query into the program
- Display the results of a query in a JTable

6.1.6.2 Querying the `books` Database (Cont.)



AUTHORID	FIRSTNAME	LASTNAME
1	Harvey	Deitel
2	Paul	Deitel
3	Tem	Nieto
4	Sean	Santry



LASTNAME	FIRSTNAME	TITLE	EDITIONNUMBER
Deitel	Harvey	C How to Program	3
Deitel	Harvey	C How to Program	2
Deitel	Harvey	C++ How to Program	3
Deitel	Harvey	C++ How to Program	2
Deitel	Harvey	The Complete C++ ...	3
Deitel	Harvey	e-Business and e-...	1
Deitel	Harvey	Internet and World ...	1
Deitel	Harvey	The Complete Inter...	1
Deitel	Harvey	Java How to Progra...	3
Deitel	Harvey	Java How to Progra...	2

```
1  // Fig. 6.1.27: ResultSetTableModel.java
2  // A TableModel that supplies ResultSet data to a JTable.
3
4  import java.sql.*;
5  import java.util.*;
6  import javax.swing.table.*;
7
8  // ResultSet rows and columns are counted from 1 and JTable
9  // rows and columns are counted from 0. When processing
10 // ResultSet rows or columns for use in a JTable, it is
11 // necessary to add 1 to the row or column number to manipulate
12 // the appropriate ResultSet column (i.e., JTable column 0 is
13 // ResultSet column 1 and JTable row 0 is ResultSet row 1).
14 public class ResultSetTableModel extends AbstractTableModel {
15    private Connection connection;
16    private Statement statement;
17    private ResultSet resultSet;
18    private ResultSetMetaData metaData;
19    private int numberOfRows;
20
21    // keep track of database connection status
22    private boolean connectedToDatabase = false;
23
```

```
24     // initialize resultSet and obtain its meta data object;
25     // determine number of rows
26     public ResultSetTableModel( String driver, String url,
27        String query ) throws SQLException, ClassNotFoundException
28     {
29        // load database driver class
30        Class.forName( driver );
31
32        // connect to database
33        connection = DriverManager.getConnection( url );
34
35        // create Statement to query database
36        statement = connection.createStatement(
37           ResultSet.TYPE_SCROLL_INSENSITIVE,
38           ResultSet.CONCUR_READ_ONLY );
39
40        // update database connection status
41        connectedToDatabase = true;
42
43        // set query and execute it
44        setQuery( query );
45     }
46
```

Establishes a `connection` to the database.

Invokes `Connection` method `createStatement` to create a `Statement` object.

Invokes `ResultSetTableModel` method `setQuery` to perform the default query.

```
47       // get class that represents column type
48       public Class getColumnClass( int column ) throws IllegalStateException
49       {
50          // ensure database connection is available
51          if ( !connectedToDatabase )
52             throw new IllegalStateException( "Not Connected to Database" );
53
54          // determine Java class of column
55          try {
56             String className = metaData.getColumnClassName( column + 1 );
57
58             // return Class object that represents
59             return Class.forName( className );
60          }
61
62          // catch SQLExceptions and ClassNotFoundExceptions
63          catch ( Exception exception ) {
64             exception.printStackTrace();
65          }
66
67          // if problems occur ab        be Object
68          return Object.class;
69       }
70
```

Obtains the fully qualified class name for the specified column.

Loads the class definition for the class and returns the corresponding `Class` object.

Returns the default type.

```
71       // get number of columns in ResultSet
72       public int getColumnCount() throws IllegalStateException
73       {
74          // ensure database connection is available
75          if ( !connectedToDatabase )
76             throw new IllegalStateException( "Not Connected to Database" );
77
78          // determine number of columns
79          try {
80             return metaData.getColumnCount();
81          }
82
83          // catch SQLExceptions and print error message
84          catch ( SQLException sqlException ) {
85             sqlException.printStackTrace();
86          }
87
88          // if problems occur above, return 0 for number of columns
89          return 0;
90       }
91
92       // get name of a particular column in ResultSet
93       public String getColumnName( int column ) throws IllegalStateException
94       {
95          // ensure database connection is available
96          if ( !connectedToDatabase )
97             throw new IllegalStateException( "Not Connected to Database" );
```

Obtains the number of columns in the `ResultSet`.

```
98
99          // determine column name
100         try {
101            return metaData.getColumnName( column + 1 );
102         }
103
104         // catch SQLExceptions and print error message
105         catch ( SQLException sqlException ) {
106            sqlException.printStackTrace();
107         }
108
109         // if problems, return empty string for column name
110         return "";
111      }
112
113      // return number of rows in ResultSet
114      public int getRowCount() throws IllegalStateException
115      {
116         // ensure database connection is available
117         if ( !connectedToDatabase )
118            throw new IllegalStateException( "Not Connected to Database" );
119
120         return numberOfRows;
121      }
122
```

Obtains the column name from the `ResultSet`.

```
123     // obtain value in particular row and column
124     public Object getValueAt( int row, int column )
125        throws IllegalStateException
126     {
127        // ensure database connection is available
128        if ( !connectedToDatabase )
129           throw new IllegalStateException( "Not Connected to Database" );
130
131        // obtain a value at specified ResultSet row and column
132        try {
133           resultSet.absolute( row + 1 );
134
135           return resultSet.getObject( column + 1 );
136        }
137
138        // catch SQLExceptions and print error message
139        catch ( SQLException sqlException ) {
140           sqlException.printStackTrace();
141        }
142
143        // if problems, return empty string object
144        return "";
145     }
146
```

Uses `ResultSet` method `absolute` to position the `ResultSet` cursor at a specific row.

Uses `ResultSet` method `getObject` to obtain the `Object` in a specific column of the current row.

```
147    // set new database query string
148    public void setQuery( String query )
149       throws SQLException, IllegalStateException
150    {
151       // ensure database connection is available
152       if ( !connectedToDatabase )
153          throw new IllegalStateException( "Not Connected to Database" );
154
155       // specify query and execute it
156       resultSet = statement.executeQuery( query );
157
158       // obtain meta data for ResultSet
159       metaData = resultSet.getMetaData();
160
161       // determine number of rows in Re
162       resultSet.last();
163       numberOfRows = resultSet.getRow()
164
165       // notify JTable that model has c
166       fireTableStructureChanged();
167    }
168
```

Executes the query to obtain a new `ResultSet`.

Uses `ResultSet` method `last`

Uses `ResultSet` method `getRow` to obtain the row number for the

Invokes method `fireTableStructureChanged` to notify any `JTable` using this `ResultSetTableModel` object as its model that the structure of the model has changed.

```
169    // close Statement and Connection
170    public void disconnectFromDatabase()
171    {
172       // close Statement and Connection
173       try {
174          statement.close();
175          connection.close();
176       }
177
178       // catch SQLExceptions and print error message
179       catch ( SQLException sqlException ) {
180          sqlException.printStackTrace();
181       }
182
183       // update database connection status
184       finally {
185          connectedToDatabase = false;
186       }
187    }
188
189 }  // end class ResultSetTableModel
```

Close the `Statement` and `Connection` if a `ResultSetTableModel` object is garbage collected.

6.1.6.2 Querying the `books` Database (Cont.)

ResultSet static type constant	Description
`TYPE_FORWARD_ONLY`	
	Specifies that a `ResultSet`'s cursor can move only in the forward direction (i.e., from the first row to the last row in the `ResultSet`).
`TYPE_SCROLL_INSENSITIVE`	
	Specifies that a `ResultSet`'s cursor can scroll in either direction and that the changes made to the `ResultSet` during `ResultSet` processing are not reflected in the `ResultSet` unless the program queries the database again.
`TYPE_SCROLL_SENSITIVE`	
	Specifies that a `ResultSet`'s cursor can scroll in either direction and that the changes made to the `ResultSet` during `ResultSet` processing are reflected immediately in the `ResultSet`.

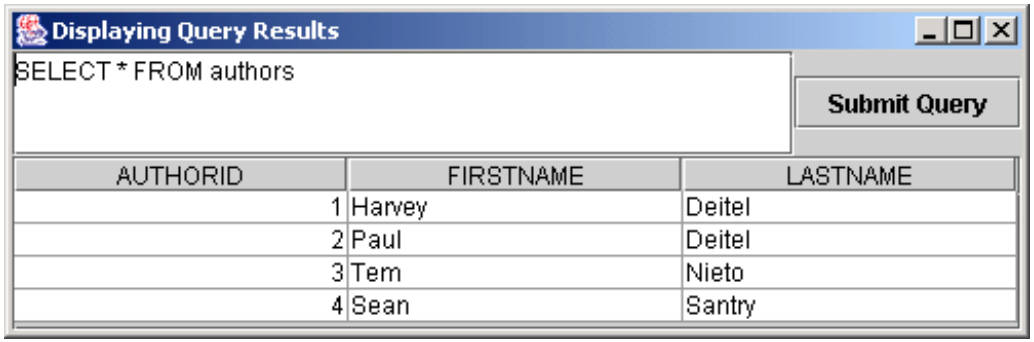
Fig. 23.28 `ResultSet` constants for specifying `ResultSet` type.

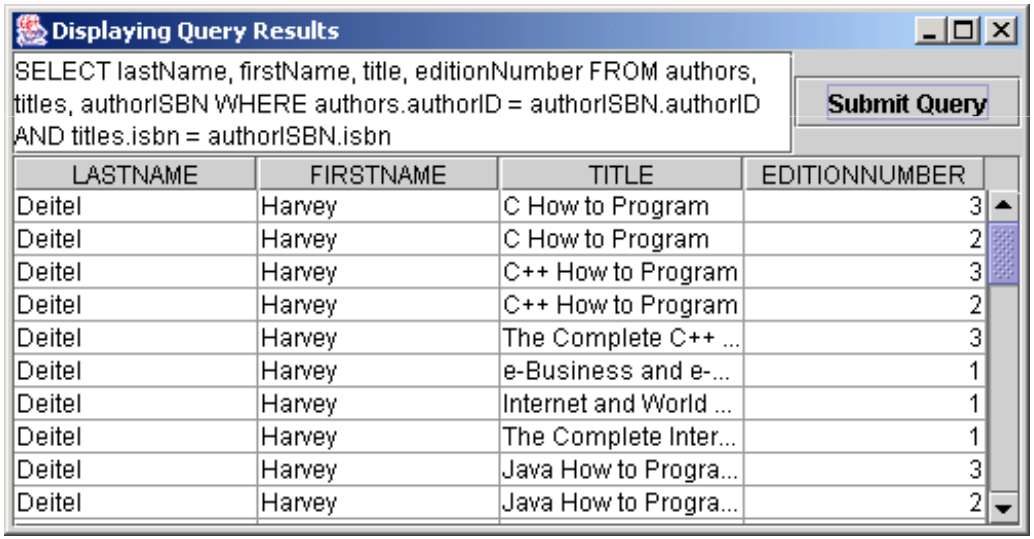
6.1.6.2 Querying the `books` Database (Cont.)

`ResultSet static` concurrency constant	Description
`CONCUR_READ_ONLY`	Specifies that a `ResultSet` cannot be updated (i.e., changes to the `ResultSet` contents cannot be reflected in the database with `ResultSet`'s *update* methods).
`CONCUR_UPDATABLE`	Specifies that a `ResultSet` can be updated (i.e., changes to the `ResultSet` contents can be reflected in the database with `ResultSet`'s *update* methods).

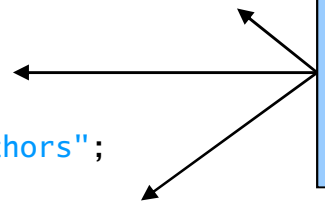
Fig. 23.29 `ResultSet` constants for specifying result properties.

6.1.6.2 Querying the `books` Database (Cont.)





```
1  // Fig. 6.1.30: DisplayQueryResults.java
2  // Display the contents of the Authors table in the
3  // Books database.
4
5  import java.awt.*;
6  import java.awt.event.*;
7  import java.sql.*;
8  import java.util.*;
9  import javax.swing.*;
10 import javax.swing.table.*;
11
12 public class DisplayQueryResults extends JFrame {
13
14    // JDBC driver and database URL
15    static final String JDBC_DRIVER = "com.ibm.db2j.jdbc.DB2jDriver";
16    static final String DATABASE_URL = "jdbc:db2j:books";
17
18    // default query selects all rows from authors table
19    static final String DEFAULT_QUERY = "SELECT * FROM authors";
20
21    private ResultSetTableModel tableModel;
22    private JTextArea queryArea;
23
24       // create ResultSetTableModel and GUI
25       public DisplayQueryResults()
26       {
27          super( "Displaying Query Results" );
```



Define the database driver class name, database URL and default query.

```
28
29          // create ResultSetTableModel and display database table
30          try {
31
32             // specify location of database on filesystem
33             System.setProperty( "db2j.system.home", "C:/Cloudscape_5.0" );
34
35             // create TableModel for results of query SELECT * FROM authors
36             tableModel = new ResultSetTableModel( JDBC_DRIVER, DATABASE_
37                DEFAULT_QUERY );
38
39             // set up JTextArea in which user types queries
40             queryArea = new JTextArea( DEFAULT_QUERY, 3, 100 );
41             queryArea.setWrapStyleWord( true );
42             queryArea.setLineWrap( true );
43
44             JScrollPane scrollPane = new JScrollPane( queryArea,
45                ScrollPaneConstants.VERTICAL_SCROLLBAR_AS_NEEDED,
46                ScrollPaneConstants.HORIZONTAL_SCROLLBAR_NEVER );
47
48             // set up JButton for submitting queries
49             JButton submitButton = new JButton( "Submit Query" );
50
51             // create Box to manage placement of queryArea and
52             // submitButton in GUI
53             Box box = Box.createHorizontalBox();
54             box.add( scrollPane );
55             box.add( submitButton );
56
```

Create `TableModel` for results of query `SELECT * FROM authors`

```
57          // create JTable delegate for tableModel
58          JTable resultTable = new JTable( tableModel );
59
60          // place GUI components on content pane
61          Container c = getContentPane();
62          c.add( box, BorderLayout.NORTH );
63          c.add( new JScrollPane( resultTable ), BorderLayout.CENTER );
64
65          // create event listener for submitBu
66          submitButton.addActionListener(
67
68             new ActionListener() {
69
70                // pass query to table model
71                public void actionPerformed( ActionEvent event )
72                {
73                   // perform a new query
74                   try {
75                      tableModel.setQuery( queryArea.getText() );
76                   }
77
78                   // catch SQLExceptions when performing
79                   catch ( SQLException sqlException ) {
80                      JOptionPane.showMessageDialog( null,
81                         sqlException.getMessage(), "Database error",
82                         JOptionPane.ERROR_MESSAGE );
83
```

Create `JTable` delegate for `tableModel`

Register an event handler for the `submitButton` that the user clicks to submit a query to the database.

Invokes `ResultSetTableModel` method `setQuery` to execute the new query.

```
84                          // try to recover from invalid user query
85                          // by executing default query
86                          try {
87                             tableModel.setQuery( DEFAULT_QUERY );
88                             queryArea.setText( DEFAULT_QUERY );
89                          }
90
91                          // catch SQLException when performing default query
92                          catch ( SQLException sqlException2 ) {
93                             JOptionPane.showMessageDialog( null,
94                                sqlException2.getMessage(), "Database error",
95                                JOptionPane.ERROR_MESSAGE );
96
97                             // ensure database connection is closed
98                             tableModel.disconnectFromDatabase();
99
100                            System.exit( 1 );   // terminate application
101
102                         }  // end inner catch
103
104                      } // end outer catch
105
106                   }  // end actionPerformed
107
108                }  // end ActionListener inner class
109
110             ); // end call to addActionListener
111
```

```
112            // set window size and display window
113            setSize( 500, 250 );
114            setVisible( true );
115
116         }  // end try
117
118         // catch ClassNotFoundException thrown by
119         // ResultSetTableModel if database driver not found
120         catch ( ClassNotFoundException classNotFound ) {
121            JOptionPane.showMessageDialog( null,
122               "Cloudscape driver not found", "Driver not found",
123               JOptionPane.ERROR_MESSAGE );
124
125            System.exit( 1 );   // terminate application
126         } // end catch
127
128         // catch SQLException thrown by ResultSetTableModel
129         // if problems occur while setting up database
130         // connection and querying database
131         catch ( SQLException sqlException ) {
132            JOptionPane.showMessageDialog( null, sqlException.getMessage(),
133               "Database error", JOptionPane.ERROR_MESSAGE );
134
135            // ensure database connection is closed
136            tableModel.disconnectFromDatabase();
137
138            System.exit( 1 );   // terminate application
139         }
140
```

```
141         // dispose of window when user quits application (this overrides
142         // the default of HIDE_ON_CLOSE)
143         setDefaultCloseOperation( DISPOSE_ON_CLOSE );
144
145         // ensure database connection is closed when user quits application
146         addWindowListener(
147
148            new WindowAdapter() {
149
150               // disconnect from database and exit when window has closed
151               public void windowClosed( WindowEvent event )
152               {
153                  tableModel.disconnectFromDatabase();
154                  System.exit( 0 );
155               }
156            }
157         );
158
159      }  // end DisplayQueryResults constructor
160
161      // execute application
162      public static void main( String args[] )
163      {
164         new DisplayQueryResults();
165      }
166
167   }  // end class DisplayQueryResults
```

Exercícios

- Altere o programa para que este execute inicialmente a consulta a tabela de livros (titles)
- Elabore e execute uma query SQL sobre o banco de dados books envolvendo pelo menos três tabelas
- Crie um botão chamado “Execute Update” que realiza operações de atualização no programa DisplayQueryResults: insert/update
  - Insira um nome autor
  - Atualize o preço do livro Core Java para 60.00

Data Access Object

- **Context**
  - Access to data varies depending on the source of the data. Access to persistent storage, such as to a database, varies greatly depending on the type of storage (relational databases, object-oriented databases, flat files, and so forth) and the vendor implementation.

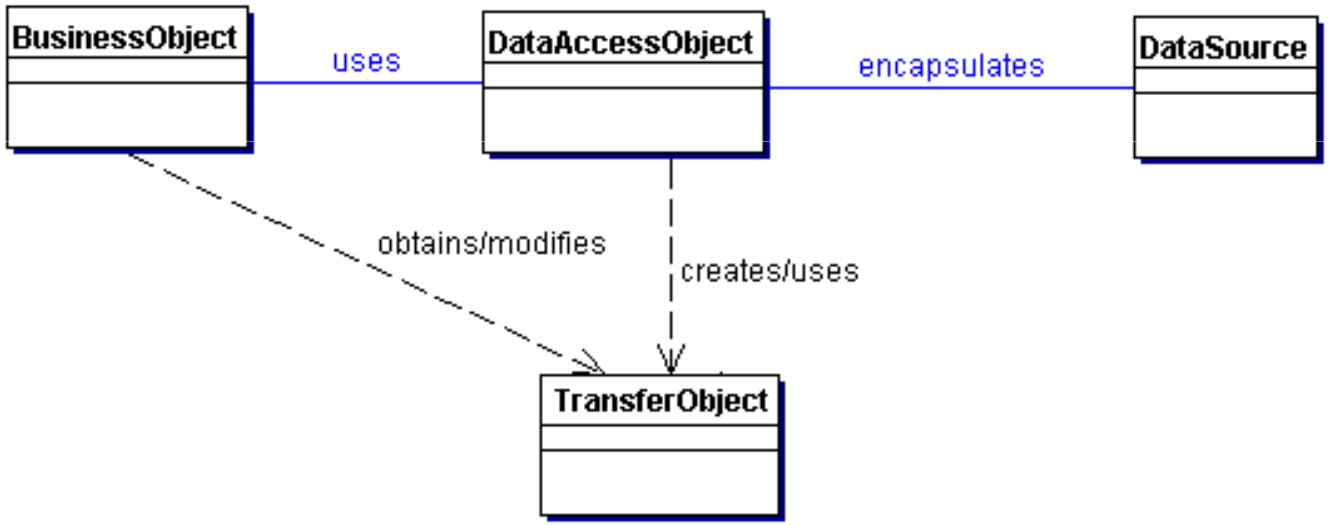
- **Problem**
  - Code that depends on specific features of data resources ties together business logic with data access logic. This makes it difficult to replace or modify an application's data resources.

Solution: DAO

- **Use a Data Access Object (DAO) to abstract and encapsulate all access to the data source. The DAO manages the connection with the data source to obtain and store data.**
  - Each DAO implementation deals with the access mechanism required to work with the data source.
    - The data source could be a persistent store like an RDBMS, an external service like a B2B exchange, a repository like an LDAP database, or a business service accessed via CORBA Internet Inter-ORB Protocol (IIOP) or low-level sockets.
  - The DAO completely hides the data source implementation details from its clients.
    - The business component that relies on the DAO uses the simpler interface exposed by the DAO for its clients.
    - Because the interface exposed by the DAO to clients does not change when the underlying data source implementation changes, this pattern **allows the DAO to adapt to different storage schemes without affecting its clients** or business components.
  - Essentially, the **DAO acts as an adapter** between the component and the data source.

DAO: Data Access Object

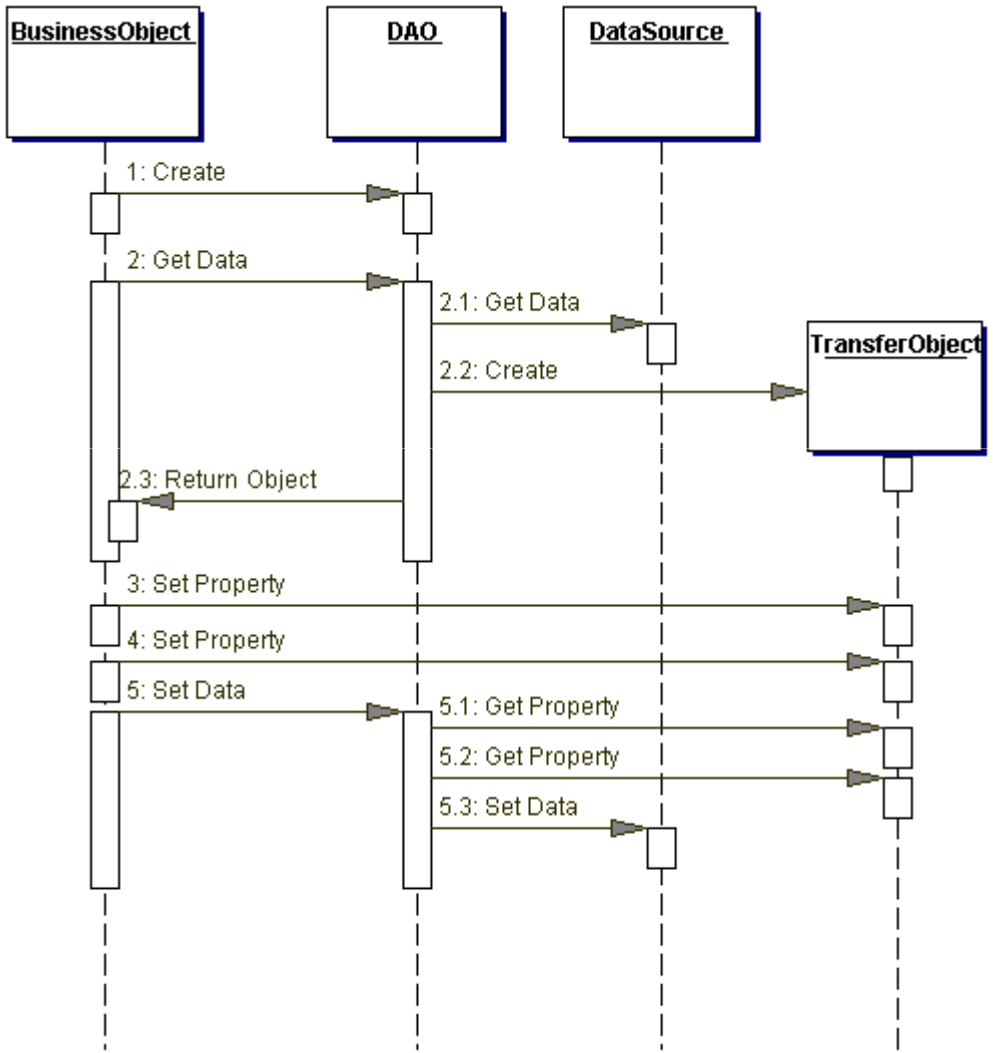
- Estrutura



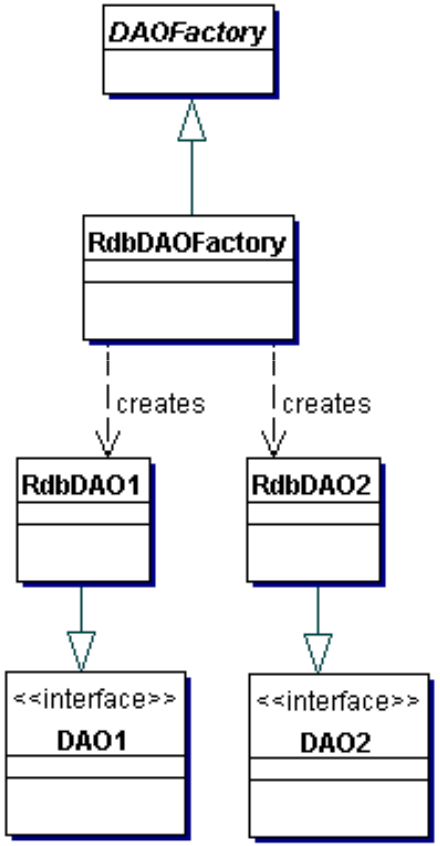
Componentes

- **BusinessObject**
  - The BusinessObject represents the data client. It is the object that requires access to the data source to obtain and store data. A BusinessObject may be implemented as a session bean, entity bean, or some other Java object, in addition to a servlet or helper bean that accesses the data source.
- **DataAccessObject**
  - The DataAccessObject is the primary object of this pattern. The DataAccessObject abstracts the underlying data access implementation for the BusinessObject to enable transparent access to the data source. The BusinessObject also delegates data load and store operations to the DataAccessObject.
- **DataSource**
  - This represents a data source implementation. A data source could be a database such as an RDBMS, OODBMS, XML repository, flat file system, and so forth. A data source can also be another system (legacy/mainframe), service (B2B service or credit card bureau), or some kind of repository (LDAP).
- **TransferObject**
  - This represents a Transfer Object used as a data carrier. The DataAccessObject may use a Transfer Object to return data to the client. The DataAccessObject may also receive the data from the client in a Transfer Object to update the data in the data source.

Diagrama de Seqüência - DAO



DAO e Factory

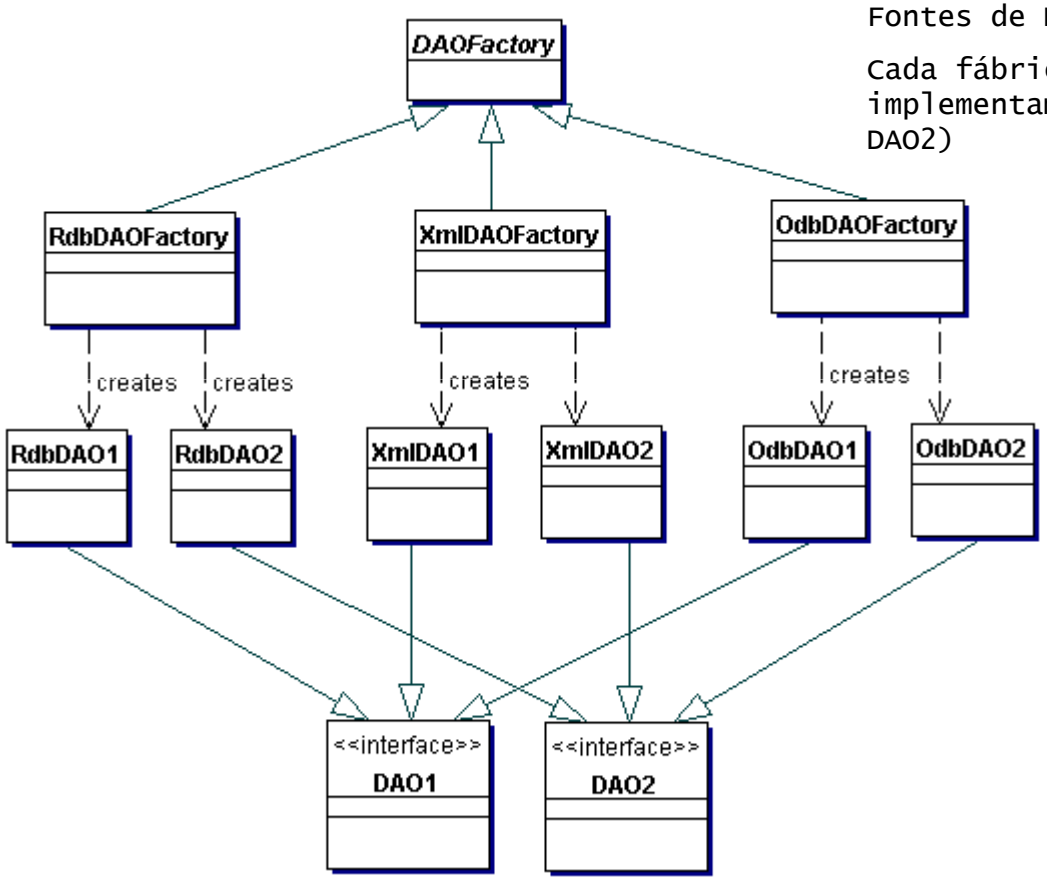


Exemplo:

Um DAOFactory é herdado por uma fábrica específica para um banco de dados Relacional(RdbDAOFactory).

Esta fábrica cria as várias instâncias que implementam as interfaces necessárias (DAO1 e DAO2)

Múltiplas implementações de DAOFactory



Exemplo:

Um DAOFactory é herdado por várias classes que implementam mecanismos acessos a diferentes Fontes de Dados (Rdb, XML e Odb)

Cada fábrica cria as várias instâncias que implementam as interfaces necessárias (DAO1 e DAO2)

Exemplo: DAO

- Problema: Alterar o DisplayAuthors para funcionar através de um DAO

1. Criar Inteface AuthorsDAO
2. Criar Transfer Object para transferir dados sem acoplar os objetos. AuthorTO e AuthorsTO
3. Alterar o cliente para utilizar o DAO
4. Implementar interface AuthorsDAO para fazer acesso usando o Firebird: AuthorsDAOImpl

```
//Interface DAO

package DAO;

public interface AuthorDAO {
   public AuthorsTO getAuthors();
}
```

AuthorsDAO.java

```
package DAO;

public class AuthorTO {
  private int id;
  private String firstName;
  private String lastName;

  public AuthorTO(int id,String first,  String last) {
            firstName = first;
            this.id = id;
            lastName = last;
}
public String toString() {
              return id+"\t"+ firstName+"\t"+lastName;
  }
public String getFirstName() {
            return firstName;
}
public void setFirstName(String firstName) {
            this.firstName = firstName;
}
public int getId() {
            return id;
}
public void setId(int id) {
            this.id = id;
}
public String getLastName() {
            return lastName;
}
public void setLastName(String lastName) {
            this.lastName = lastName;
}

}
```

AuthorTO.java

```
package DAO;
import java.util.Iterator;
import java.util.Vector;


public class AuthorsTO  extends Vector<AuthorTO> {

           public String toString () {
                      StringBuffer str=new StringBuffer();
                      str.append("AUTHORID  FIRSTNAME  LASTNAME\n");
                      for (Iterator iter = this.iterator(); iter.hasNext();) {
                                 AuthorTO element = (AuthorTO) iter.next();
                                 str.append(element);
                                 str.append("\n");
                      }
                      return str.toString();
           }
}
```

AuthorsTO.java

```
package DAO;

import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.ResultSet;
import java.sql.SQLException;
import java.sql.Statement;

import javax.swing.JOptionPane;

public class AuthorDAOImpl implements AuthorDAO {
                // JDBC driver name and database URL
                static final String JDBC_DRIVER = "org.firebirdsql.jdbc.FBDriver";
                static final String host="126.0.0.1";
                static final String path="c:\\eclipse\\stefanini\\Aula7\\books.fdb";
                static final String DATABASE_URL = "jdbc:firebirdsql:"+host+"/3050:"+path;

// declare Connection and Statement for accessing
// and querying database
private Connection connection;
private Statement statement;

             public AuthorsTO getAuthors() {
                    // connect to database books and query database
                    try {
           // load database driver class
                       Class.forName( JDBC_DRIVER );

                       // establish connection to database
                       connection = DriverManager.getConnection( DATABASE_URL , "SYSDBA",
"masterkey");

                       // create Statement for querying database
                       statement = connection.createStatement();

                       // query database
                       ResultSet resultSet =
                          statement.executeQuery( "SELECT * FROM authors;" );
```

AuthorDAOImpl.java

AuthorDAOImpl.java

```
                    // process query results
                    AuthorsTO authors=new AuthorsTO();

                    //resultSet=statement.executeQuery( "SELECT * FROM authors" );
                    while ( resultSet.next() ) {
                         int id=resultSet.getInt(1);
                         String firstName=resultSet.getString(2);
                         String lastName=resultSet.getString(3);
                         authors.add(new AuthorTO(id,firstName,lastName));
                    }
                   return authors;
                 }
                 // detect problems interacting with the database
                 catch ( SQLException sqlException ) {
                    JOptionPane.showMessageDialog( null, sqlException.getMessage(),
                       "Database Error", JOptionPane.ERROR_MESSAGE );

                    System.exit( 1 );
                 }
                 // detect problems loading database driver
                 catch ( ClassNotFoundException classNotFound ) {
                    JOptionPane.showMessageDialog( null, classNotFound.getMessage(),
                       "Driver Not Found", JOptionPane.ERROR_MESSAGE );

                    System.exit( 1 );
                 }
                 // ensure statement and connection are closed properly
                 finally {
                    try {
                       statement.close();
                       connection.close();
                    }
                    // handle exceptions closing statement and connection
                    catch ( SQLException sqlException ) {
                       JOptionPane.showMessageDialog( null,
                          sqlException.getMessage(), "Database Error",
                          JOptionPane.ERROR_MESSAGE );

                       System.exit( 1 );
                    }         }

              return null;
              }
}
```

AuthorView.java

```
            package Solucoes;

//           Displaying the contents of the authors table.
            import java.awt.*;
            import java.sql.*;
            import java.util.*;
            import javax.swing.*;

            public class AuthorsView extends JFrame {


               // constructor connects to database, queries database, processes
               // results and displays results in window
               public AuthorsView()
               {
                  super( "Authors Table of Books Database" );
                     DAOFactory fac=DAOFactory.getDAOFactory(DAOFactory.FIREBIRD);
                     AuthorDAO authors=fac.getAuthorDAO();
                     AuthorsTO authorsTO=authors.getAuthors();
                     // set up GUI and display window
                     JTextArea textArea = new JTextArea( authorsTO.toString() );
                     Container container = getContentPane();

                     container.add( new JScrollPane( textArea ) );

                     setSize( 300, 100 );  // set window size
                     setVisible( true );   // display window



               }  // end DisplayAuthors constructor

               // launch the application
               public static void main( String args[] )
               {
                  AuthorsView window = new AuthorsView();
                  window.setDefaultCloseOperation( JFrame.EXIT_ON_CLOSE );
               }

}  // end class
```

Vantagens e Desvantagens

- Desvantagens
  - Tinha 1 classe agora tenho: 3 classes e 1 interface
- Vantagens
  - Desacoplamento entre o cliente e o acesso ao banco de dados
  - Apenas 1 classe é dependente do banco de dados
  - Facilita o reuso
    - Outras classes que desejarem acessar dados dos autores podem fazê-lo criando uma intância do DAO
  - Facilita a portabilidade
    - Portar o programa para outro banco de dados (SQL Server, Oracle, etc.) envolve a criação de apenas 1 classe que implemente AuthorDAO e instanciar a implementação correta (pode-se usar o DP Factory, para facilitar esta instanciação)

Exercício

- Crie uma classe abstrata DAOFactory com o método estático getDAOFactory(int ds). Onde ds é um indicador de Fonte de Data Source (ds). Quando ds=1 deve-se retornar uma FireBirdDAOFactory. Retorne nulo em outros casos.

- DAOFactory deve especificar o método abstrato getAuthorDAO que retorna um AuthorDAO

- Crie uma classe FireBirdDAOFactory que herde DAOFactory e implemente o método getAuthorsDAO e retorne um AuthorsDAOImpl

- Quais as vantagens/desvantagens de criar factory neste caso?

DAOFactory

```
 // Abstract class DAO Factory
public abstract class DAOFactory {
// List of DAO types supported by the factory
public static final   int FIREBIRD = 1;
public static final int ORACLE = 2;
public static final int SYBASE = 3; ...
// There will be a method for each DAO that can be
// created. The concrete factories will have to
// implement these methods.
public abstract CustomerDAO getAuthorsDAO();

public static DAOFactory getDAOFactory( int ds) {
switch (whichFactory) {
   case FIREBIRD: return new FireBirdDAOFactory();
   case ORACLE : return new OracleDAOFactory();
   case SYBASE : return new SybaseDAOFactory();
   ...
   default : return null;
 }
}
}
```

FireBirdDAOFactory

```
// Firebird concrete DAO Factory implementation

public class FireBirdDAOFactory extends DAOFactory {

 AuthorDAO getAuthorDAO() {
   // AuthorDAOImpl implements AuthorDAO
      return new AuthorDAOImpl();
 }

}
```

Authors

```
 package DAO;

//          Displaying the contents of the authors table.
            import java.awt.*;
            import java.sql.*;
            import java.util.*;
            import javax.swing.*;

            public class Authors extends JFrame {


               // constructor connects to database, queries database, processes
               // results and displays results in window
               public Authors()
               {
                  super( "Authors Table of Books Database" );
                  DAOFactory fac=DAOFactory.getDAOFactory(DAOFactory.FIREBIRD);
                  AuthorDAO authors=fac.getAuthorDAO();
                  AuthorsTO authorsTO=authors.getAuthors();
                  // set up GUI and display window
                  JTextArea textArea = new JTextArea( authorsTO.toString() );
                  Container container = getContentPane();
.....
.....
.....
.....
.....
.....
```

6.1.7 Referências sobre JDBC

- Sun Microsystems JDBC home page
  - Java.sun.com/products/jdbc
- SQL materials
  - www.sql.org
- Home page do Banco de Dados Firebird
  - http://firebird.sourceforge.net/
- Referências sobre DAO Design Pattern
  - http://java.sun.com/blueprints/patterns/DAO.html