Advanced Programming

JDBC

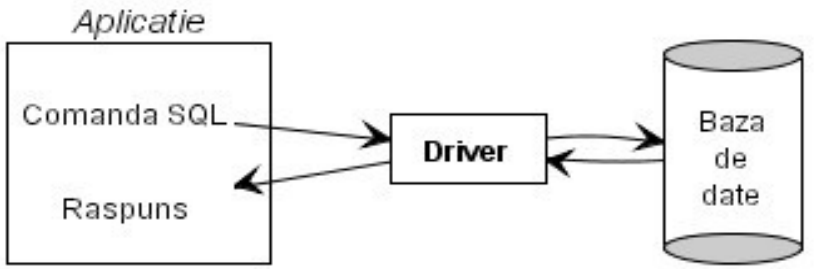
Databases

- **DB** – Collection of *structured* data
- **DBMS** – A Database Management System offers all the “tools” for: *creating*, *accessing*, *updating a db*
- *Efficiency* (indexes, etc.)
- *Consistency* (FK, PK, triggers, etc.)
- *Security* (users, permissions, etc.)

- Models: **relational**, object-oriented, graph, XML, NoSQL, NewSQL, etc.
- Producers: Oracle, Microsoft, Sybase, etc.

Applications That Use a DB

- Create the database: SQL script
- Connect to the database: driver
- Communicate with the database:
  - Execution of SQL commands
    - DDL, DML, DCL
  - Processing results

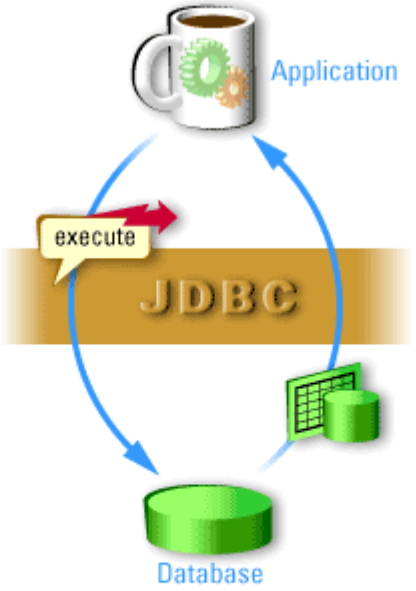


JDBC

- JDBC (Java Database Connectivity) is a Java API that can access any kind of tabular data, especially data stored in a **relational database**.
- Allows the **integration of SQL statements** into a general programming environment by providing library routines which interface with the database.
- **Independent** of the database type
- Based on **adapters (drivers)** between the client and the DBMS
- **java.sql** – the core JDBC API
- javax.sql – Java EE specific

Driver

The interface between the application and the database



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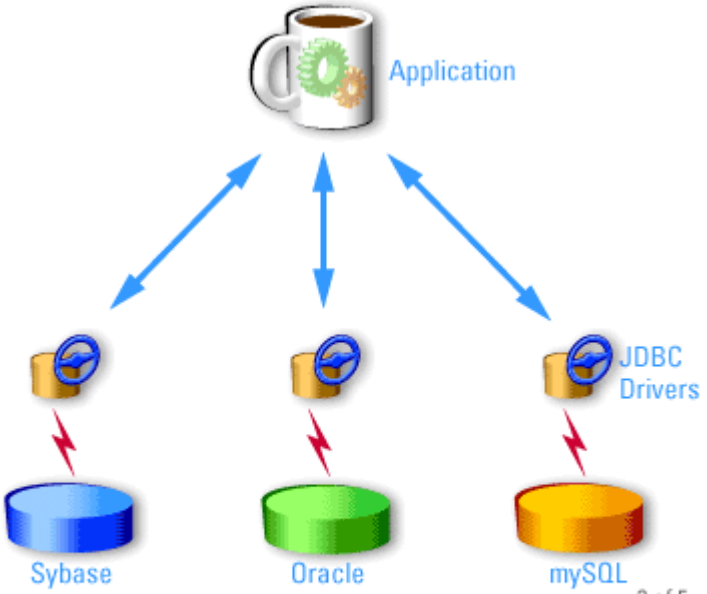
JDBC allows an application to send SQL statements to a database and receive the results.



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JDBC interfaces for specific database engines are implemented by a set of classes called JDBC drivers. Since the JDBC driver handles the low-level connection and translation issues, you can focus on the database application development without worrying about the specifics of each database.

Using a Specific Driver

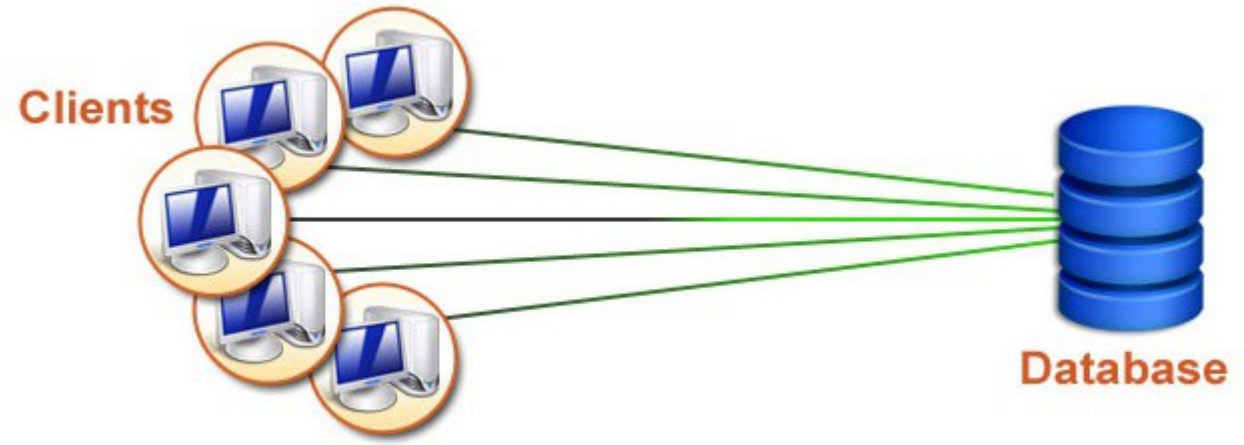
- Identifying the specific database driver
  - for example: *mysql-connector-java.jar*
  - adding the jar to the CLASSPATH
  - identifying the driver class: *com.mysql.jdbc.Driver*
- Loading the driver class
  - `DriverManager.registerDriver(new com.mysql.jdbc.Driver());`
  - `Class.forName("com.mysql.jdbc.Driver").newInstance();`
  - `System.setProperty(`

    `"jdbc.drivers", "com.mysql.jdbc.Driver");`
  - `java -Djdbc.drivers=com.mysql.jdbc.Driver MyApplication`

NOTE: The DataSource interface, new in the JDBC 2.0 API, provides another way to connect to a data source. The use of a DataSource object is the preferred means of connecting to a data source.

Connections

- **Connection (session)** - A context through which the communication with a database takes place.
- SQL statements are executed and results are returned within the context of a connection.
- An application may create multiple connections (to the same database or to different databases).



Locating a Database

JDBC URL

jdbc:sub-protocol:identifier

The sub-protocol identifies the driver type, for instance:

odbc, mysql, oracle, sybase, postgres, etc.

The database identifier is usually specific to a protocol:

jdbc:odbc:test

jdbc:mysql://localhost/test

jdbc:oracle:thin@persistentjava.com:1521:test

jdbc:sybase:test

Connectiong to a Database

A connection is represented by an object of type
java.sql.Connection

```
Connection conn = DriverManager.getConnection(url);
Connection conn = DriverManager.getConnection(
                  url, username, password);
Connection conn = DriverManager.getConnection(
                  url, dbproperties);
```

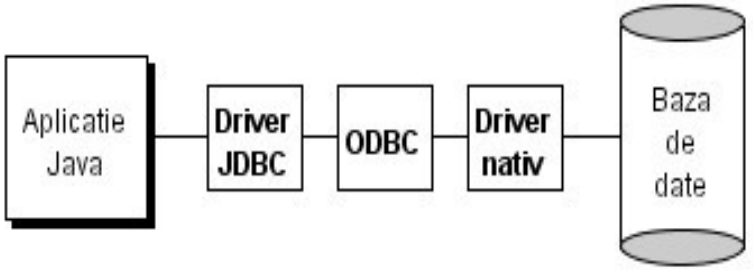
Don't forget to close the connection: `conn.close()`

Example

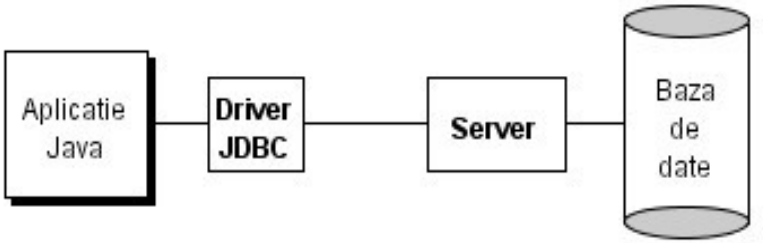
```
String url = "jdbc:mysql://localhost/test" ;

Connection con = null;
try {
  Class.forName("com.mysql.jdbc.Driver");

  Connection con = DriverManager.getConnection(
    url, "myUserName", "mySecretPassword");

} catch(ClassNotFoundException e) {
  System.err.print("ClassNotFoundException: " + e) ;

} catch(SQLException e) {
  System.err.println("SQLException: " + e);

} finally {
  con.close ;
}
```

Driver Types

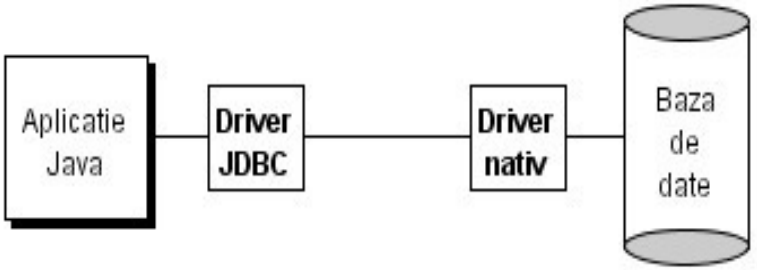
Type 1



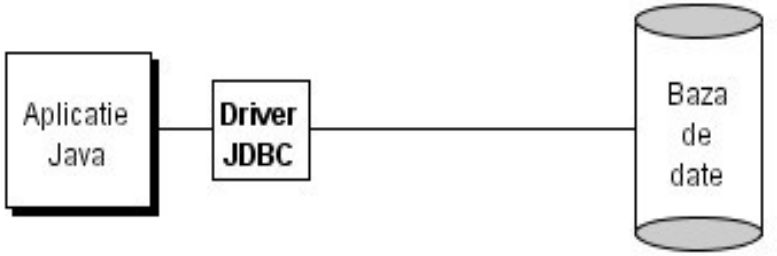
Type 3



Type 2



Type 4



JDBC-ODBC Bridge

- **ODBC**: Open Database Conectivity
- Driver: *sun.jdbc.odbc.JdbcOdbcDriver*
- URL: *jdbc:odbc:identifier*
  - DSN Identifier (Data Source Name)
- Easy to use, "universal" solution to connect to a database
- Not portable, poor execution speed

“The JDBC-ODBC Bridge should be considered a transitional solution. It is not supported by Oracle. Consider using this only if your DBMS does not offer a Java-only JDBC driver.”

Using Connections

- Creating statements for executing SQL commands and returning the results.
  - *Statement, PreparedStatement,*
  - *CallableStatement*
- Getting the metadata: information regarding the database or the results of queries
  - *DatabaseMetaData, ResultSetMetaData*
- Transaction control
  - *commit, rollback*
  - *setAutoCommit*

Statement

The object used for executing a **static** SQL statement and returning the results it produces.

- Creating a *Statement*

```
Connection con = DriverManager.getConnection(url);
Statement stmt = con.createStatement();
```

- Executing a query

```
String sql = "SELECT * FROM persons";
ResultSet rs = stmt.executeQuery(sql);
```

- Executing an update or a delete

```
String sql = "DELETE FROM persons WHERE age < 0";
int nbRowsAffected = stmt.executeUpdate(sql);
sql = "DROP TABLE temp";
stmt.executeUpdate(sql); // Returns 0
```

- Generic SQL statements

```
stmt.execute("any kind of SQL command");
```

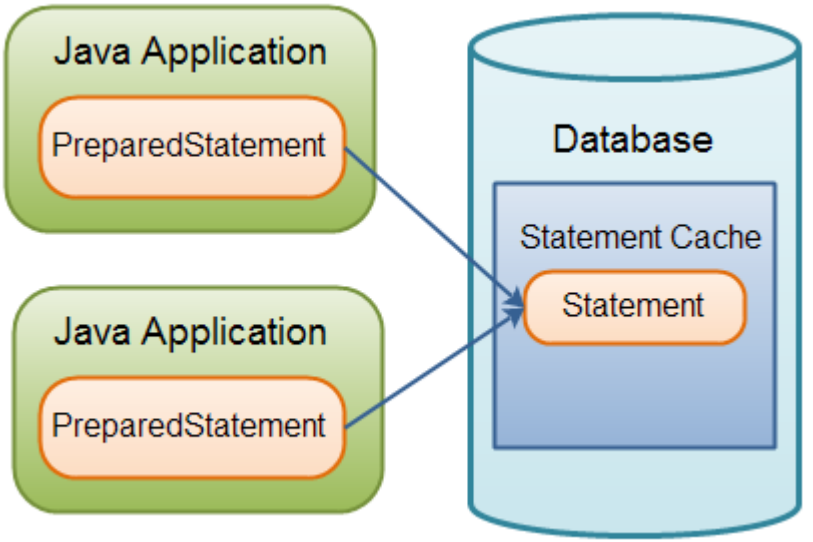
PreparedStatement

An object that represents a precompiled SQL statement.

An SQL statement is precompiled and stored in a *PreparedStatement* object. This object can then be used to efficiently execute this statement multiple times.

→ Batch Commands

```
String sql = "UPDATE persons SET name = ? WHERE id = ?";
Statement pstmt = con.prepareStatement(sql);

pstmt.setString(1, "Ionescu");
pstmt.setInt(2, 100);
pstmt.executeUpdate();

pstmt.setString(1, "Popescu");
pstmt.setInt(2, 200);
pstmt.executeUpdate();
```



JDBC Data Types

java.sql.Types → *defines the constants that are used to identify generic SQL types, called JDBC types.*

Java Data Types – SQL Data Types

setObject - If arbitrary parameter type conversions are required, the method *setObject* should be used with a target SQL type.

```
pstmt.setObject(1, "Ionescu", Types.CHAR);
pstmt.setObject(2, 100, Types.INTEGER); // or simply
pstmt.setObject(2, 100);
```

setNull

```
pstmt.setNull(1, Types.CHAR);
pstmt.setInt(2, null);
```

Handling Large Values

setBinaryStream, setAsciiStream, setCharacterStream

When a very large binary or char value is input to a LONG*Type* parameter, it may be more practical to send it via a stream object. The data will be read from the stream as needed until end-of-file is reached.

```
File file = new File("someFile");

InputStream fin = new FileInputStream(file);

java.sql.PreparedStatement pstmt =

  con.prepareStatement(

    "UPDATE files SET contents = ? " +

    "WHERE name = 'someFile'");

pstmt.setBinaryStream (1, fin);

pstmt.executeUpdate();
```

CallableStatement

The interface used to execute SQL stored procedures.

```
//Crating a CallableStatement
Connection con = DriverManager.getConnection(url);
CallableStatement cstmt = con.prepareCall(
  "{call myStoredProcedure(?, ?)}");

//Setting the IN parameters
cstmt.setString(1, "Ionescu");
cstmt.setInt(2, 100);

//Registering the OUT parameters
cstmt.registerOutParameter(1, java.sql.Types.FLOAT);

//Executing the call and retrieving the results
cstmt.executeQuery();
float result = cstmt.getDouble(1);
```

ResultSet

A *table of data* representing a *database result set*, which is usually generated by executing a statement that queries the database.

```
Statement stmt = con.createStatement();
String sql = "SELECT id, name FROM persons";

ResultSet rs = stmt.executeQuery(sql);
```

id	name
100	Ionescu
200	Popescu

```
while (rs.next()) {
  int cod = rs.getInt("id"); //rs.getInt(1)
  String nume = rs.getString("name");
  System.out.println(id + ", " + name);
}
```

A *ResultSet* object 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 to the next row.

Scrollable and Modifiable Cursors

```
Statement stmt = con.createStatement(
    ResultSet.TYPE_SCROLL_INSENSITIVE,
    ResultSet.CONCUR_UPDATABLE);
String sql = "SELECT id, name FROM persons";
ResultSet rs = stmt.executeQuery(sql);
  // rs will be scrollable,
  // will not show changes made by others
  // and will be updatable
```

Additional Methods

- absolute
- updateRow
- moveToInsertRow
- insertRow
- moveToCurrentRow
- deleteRow

supportsPositionedUpdate/Delete

A default *ResultSet* object is not updatable and has a cursor that moves forward only.

RowSet

Adds support to the JDBC API for the JavaBeans component model

- Extends *ResultSet*
- Conforms to JavaBeans specifications
  - Properties
  - Supports JavaBeans events
- *JdbcRowSet*
- *CachedRowSet* (disconnected)
- *WebRowSet* (XML)
- *JoinRowSet* (offline join)
- *FilteredRowSet* (offline filtering)

Examples

```
JoinRowSet jrs = new JoinRowSetImpl();

ResultSet rs1 = stmt.executeQuery("SELECT * FROM EMPLOYEES");
CachedRowSet empl = new CachedRowSetImpl();
empl.populate(rs1);
empl.setMatchColumn(1);
jrs.addRowSet(empl);

ResultSet rs2 = stmt.executeQuery("SELECT * FROM BONUS_PLAN");
CachedRowSet bonus = new CachedRowSetImpl();
bonus.populate(rs2);
bonus.setMatchColumn(1); // EMP_ID is the first column
jrs.addRowSet(bonus);

FilteredRowSet frs = new FilteredRowSetImpl();
frs.populate(rs1);
Range name = new Range("Ionescu", "Popescu", "EMP_NAME");
frs.setFilter(name); //accepts Predicate objects
frs.next();
```

DatabaseMetaData

Comprehensive information about the database as a whole.

Implemented by driver vendors to let users know the capabilities of a DBMS in combination with the JDBC driver that is used with it → *tables, stored procedures, connection capabilities, supported SQL grammar, etc.*

```
Connection con = DriverManager.getConnection (url);

DatabaseMetaData dbmd = con.getMetaData();

// Get the tables of the database
ResultSet rs = dbmd.getTables (null, null, null, null);
// catalog, schemaPattern, tableNamePattern, types)

while (rs.next ())
  System.out.println(rs.getString ("TABLE_NAME"));
  con . close ();
}
```

ResultSetMetaData

Information about the types and properties of the columns in a *ResultSet* object: the number of columns, their types, their names, etc.

```
ResultSet rs = stmt.executeQuery("SELECT * FROM someTable");

ResultSetMetaData rsmd = rs.getMetaData();

// Find the number of columns in the ResultSety

int n = rsmd.getColumnCount();


// Find the names of the columns

Sring nume[] = new String[n];

for(int i=0; i<n; i++) {

  nume[i] = rsmd.getColumnName(i);

}
```

Transaction Control

- Transaction = An ACID unit of work
- ACID = Atomic, Consistent, Isolated, Durable
- COMMIT, ROLLBACK

```
con.commit();
con.rollback();
```

- Savepoints

```
Savepoint save1 = con.setSavepoint();
…
con.rollback(save1);
```

- Disabling the *AutoCommit* Mode

```
con.setAutoCommit(false);
```

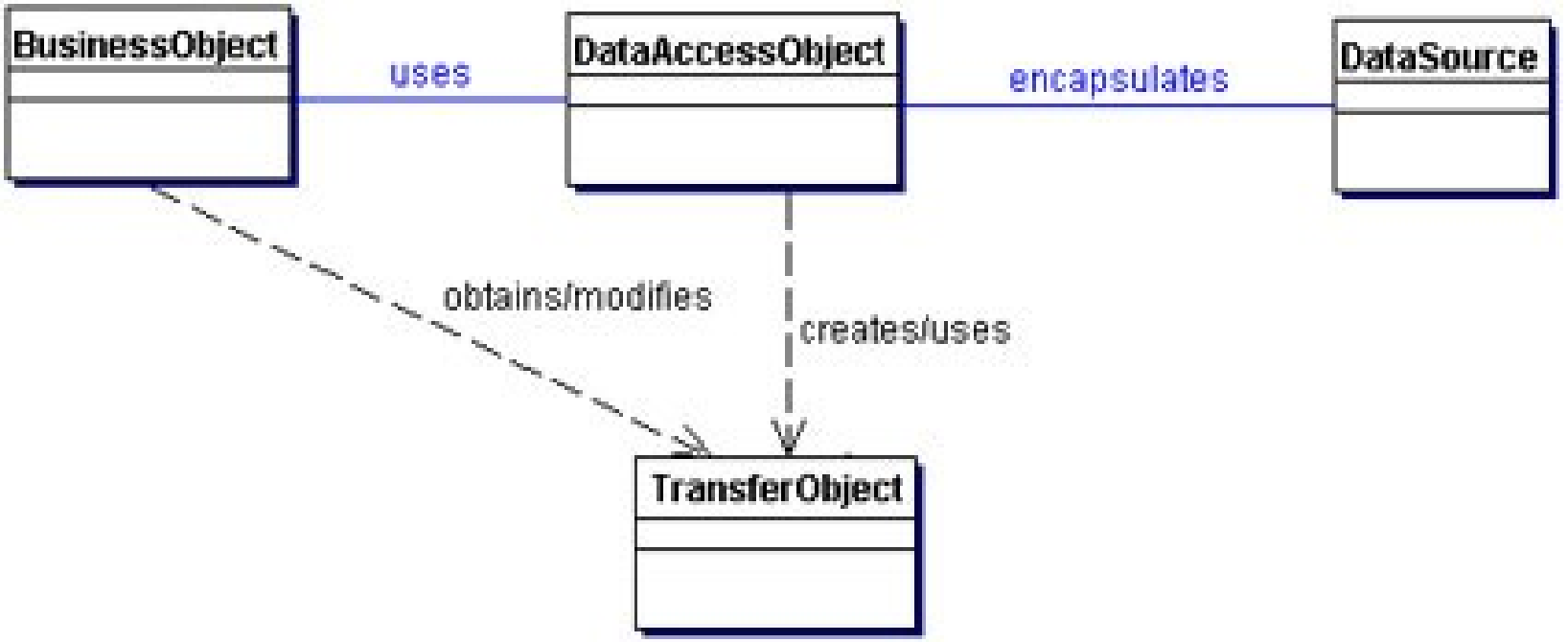
Handling *SQLExceptions*

- *SQLException*

```
public static void printSQLException(SQLException ex) {
  for (Throwable e : ex) {  //SQLException implements Iterable<Throwable>
    //chained exceptions
    if (e instanceof SQLException) {
      SQLException sqlEx = (SQLException)e);
      System.err.println("SQLState  : " + sqlEx.getSQLState());
      System.err.println("Error Code: " + sqlEx.getErrorCode());
      System.err.println("Message   : " + sqlEx.getMessage());
      Throwable t = ex.getCause();
      while(t != null) {
        System.out.println("Cause: " + t);
        t = t.getCause();
      }
    }
  }
}
```

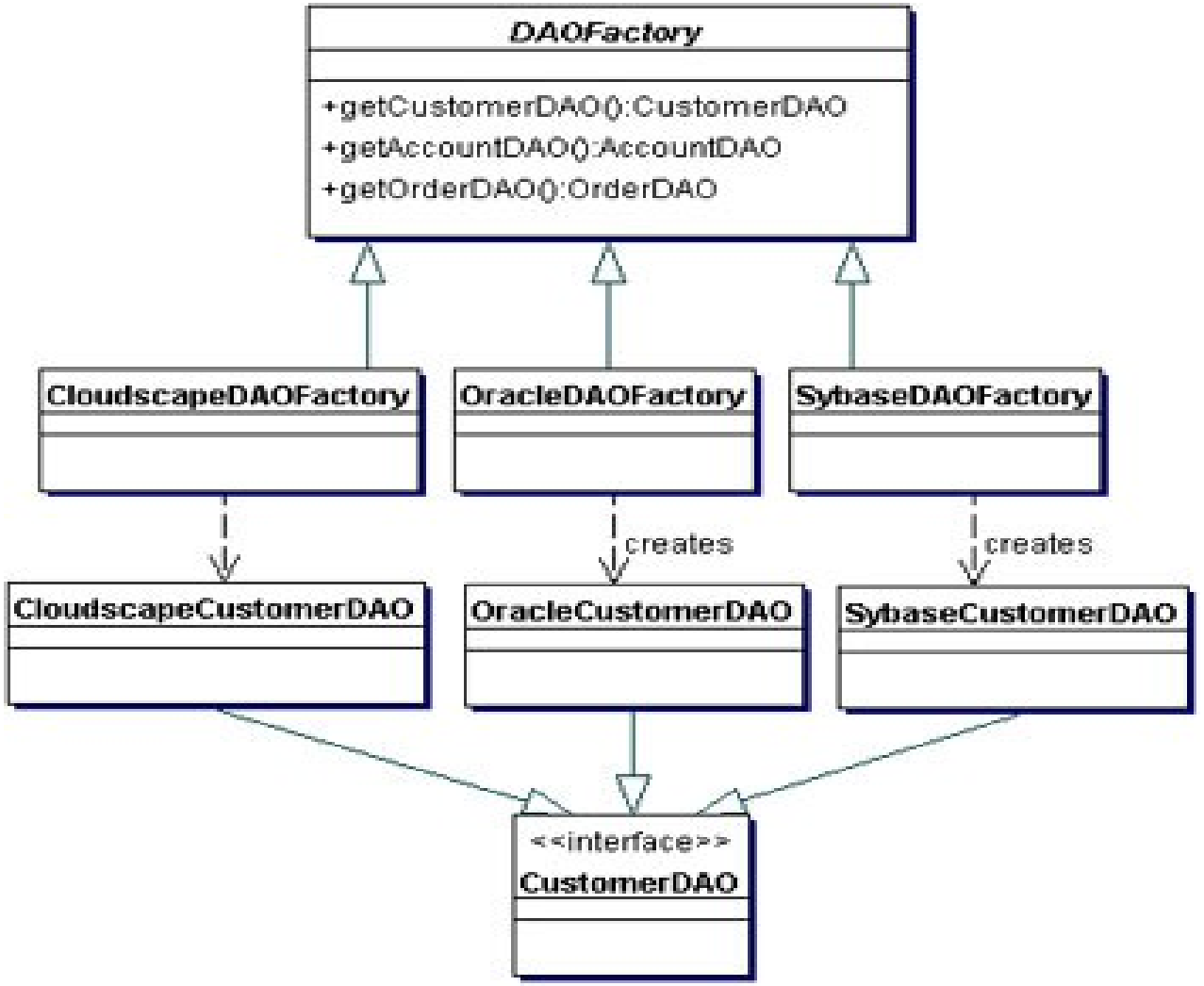
- *SQLWarning* (for example, *DataTruncation*)
  Connection, Statement, ResultSet - getWarnings()

Data Acces Objects (DAO)



- *BusinessObject* – the object that must access the data
- *DataAccessObject* - abstracts and encapsulates all operations related to the data
- *DataSource* - RDBMS, OODBMS, XML, etc.
- *TransferObject* – a representation of the data: entities, beans, etc.

Abstract Factory



Java Tutorial

Trail: JDBC(TM) Database Access

http://docs.oracle.com/javase/tutorial/jdbc/TOC.html