Database Access with JDBC

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Overview

- Overview of JDBC technology
- JDBC drivers
- Seven basic steps in using JDBC
- Retrieving data from a ResultSet
- Using prepared and callable statements
- Handling SQL exceptions
- Submitting multiple statements as a transaction

JDBC Introduction

- **JDBC provides a standard library for accessing relational databases**
  - API standardizes
    - Way to establish connection to database
    - Approach to initiating queries
    - Method to create stored (parameterized) queries
    - The data structure of query result (table)
      - Determining the number of columns
      - Looking up metadata, etc.
  - API does not standardize SQL syntax
    - JDBC is not embedded SQL
  - JDBC classes are in the java.sql package
- **Note: JDBC is not officially an acronym; unofficially, "Java DataBase Connectivity" is commonly used**

On-line Resources

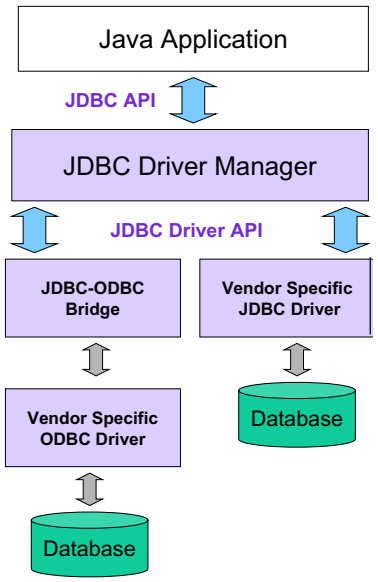
- **Sun's JDBC Site**
  - http://java.sun.com/products/jdbc/
- **JDBC Tutorial**
  - http://java.sun.com/docs/books/tutorial/jdbc/
- **List of Available JDBC Drivers**
  - http://industry.java.sun.com/products/jdbc/drivers/
- **API for java.sql**
  - http://java.sun.com/j2se/1.4/docs/api/java/sql/package-summary.html

Oracle On-line Resources

- **JDBC Road Map**
  - http://technet.oracle.com/tech/java/jroadmap/index2.htm?Info&jdbc/listing.htm
- **SQLJ & JDBC Basic Samples**
  - http://technet.oracle.com/tech/java/sqlj_jdbc/index2.htm?Code&files/basic/basic.htm
- **JDBC Drivers**
  - http://technet.oracle.com/software/tech/java/sqlj_jdbc/htdocs/listing.htm
  - Requires free registration
- **Certification**
  - http://technet.oracle.com/training/certification/

JDBC Drivers

- **JDBC consists of two parts:**
  - JDBC API, a purely Java-based API
  - JDBC Driver Manager,which communicates with vendor-specific drivers that perform the real communication with the database.
    - Point: translation to vendor format is performed on the client
      - No changes needed to server
      - Driver (translator) needed on client



JDBC Data Types

JDBC Type	Java Type
BIT	boolean
TINYINT	byte
SMALLINT	short
INTEGER	int
BIGINT	long
REAL	float
FLOAT DOUBLE	double
BINARY VARBINARY LONGVARBINARY	byte[]
CHAR VARCHAR LONGVARCHAR	String

JDBC Type	Java Type
NUMERIC DECIMAL	BigDecimal
DATE	java.sql.Date
TIME TIMESTAMP	java.sql.Timestamp
CLOB	Clob*
BLOB	Blob*
ARRAY	Array*
DISTINCT	mapping of underlying type
STRUCT	Struct*
REF	Ref*
JAVA_OBJECT	underlying Java class

*SQL3 data type supported in JDBC 2.0

Seven Basic Steps in Using JDBC

1. Load the driver
2. Define the Connection URL
3. Establish the Connection
4. Create a Statement object
5. Execute a query
6. Process the results
7. Close the connection

JDBC: Details of Process

1. **Load the driver**

```
try {
  Class.forName("connect.microsoft.MicrosoftDriver");
  Class.forName("oracle.jdbc.driver.OracleDriver");
} catch { ClassNotFoundException cnfe) {
  System.out.println("Error loading driver: " cnfe);
}
```

2. **Define the Connection URL**

```
String host = "dbhost.yourcompany.com";
String dbName = "someName";
int port = 1234;
String oracleURL = "jdbc:oracle:thin:@" + host +
                   ":" + port + ":" + dbName;
String sybaseURL = "jdbc:sybase:Tds:" + host  +
                   ":" + port + ":" +
                   "?SERVICENAME=" + dbName;
```


JDBC: Details of Process (Continued)

3. **Establish the Connection**

```
String username = "jay_debesee";
String password = "secret";
Connection connection =
    DriverManager.getConnection(oracleURL,
                                username,
                                password);
```

- **Optionally, look up information about the database**

```
DatabaseMetaData dbMetaData =
  connection.getMetaData();
String productName =
  dbMetaData.getDatabaseProductName();
System.out.println("Database: " + productName);
String productVersion =
  dbMetaData.getDatabaseProductVersion();
System.out.println("Version: " + productVersion);
```

JDBC: Details of Process (Continued)

4. Create a Statement

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

5. Execute a Query

```
String query =
  "SELECT col1, col2, col3 FROM sometable";
ResultSet resultSet =
  statement.executeQuery(query);
```

- To modify the database, use `executeUpdate`, supplying a string that uses `UPDATE`, `INSERT`, or `DELETE`
- Use `setQueryTimeout` to specify a maximum delay to wait for results

JDBC: Details of Process (Continued)

6. Process the Result

```
while(resultSet.next()) {
  System.out.println(resultSet.getString(1) + " " +
                     resultSet.getString(2) + " " +
                     resultSet.getString(3));
}
```

- First column has index 1, not 0
- `ResultSet` provides various `getXxx` methods that take a colu index *or column name* and returns the data
- You can also access result meta data (column names, etc.)

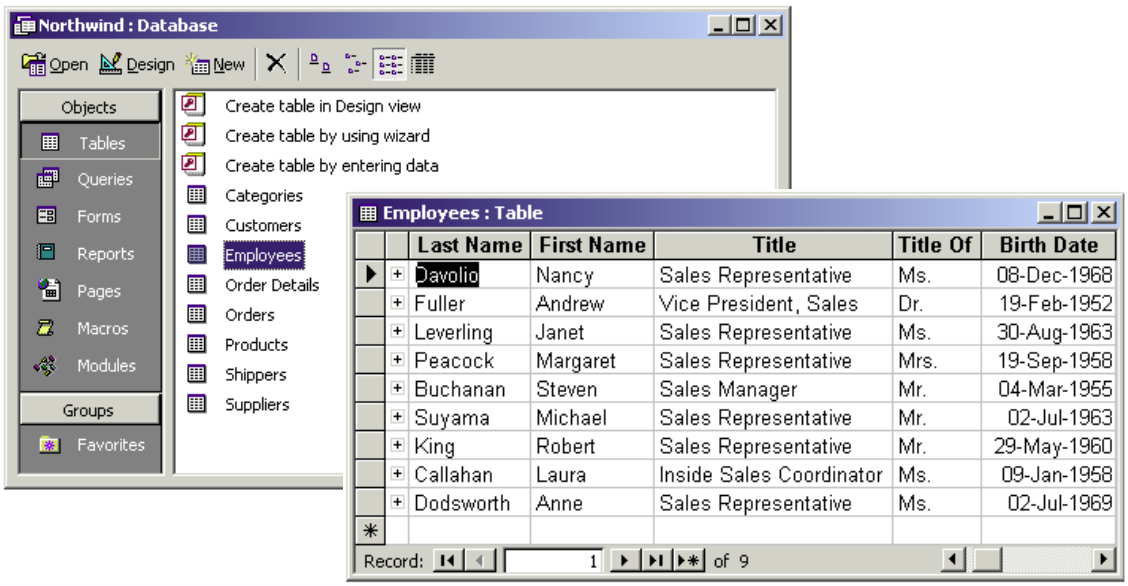
7. Close the Connection

```
connection.close();
```

- Since opening a connection is expensive, postpone this step if additional database operations are expected

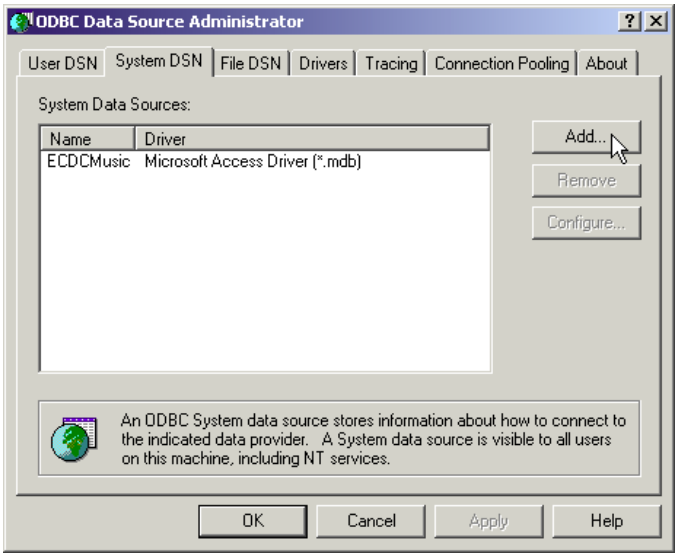
The Microsoft Access Northwind Database

- **Database that comes preinstalled with Microsoft Office**



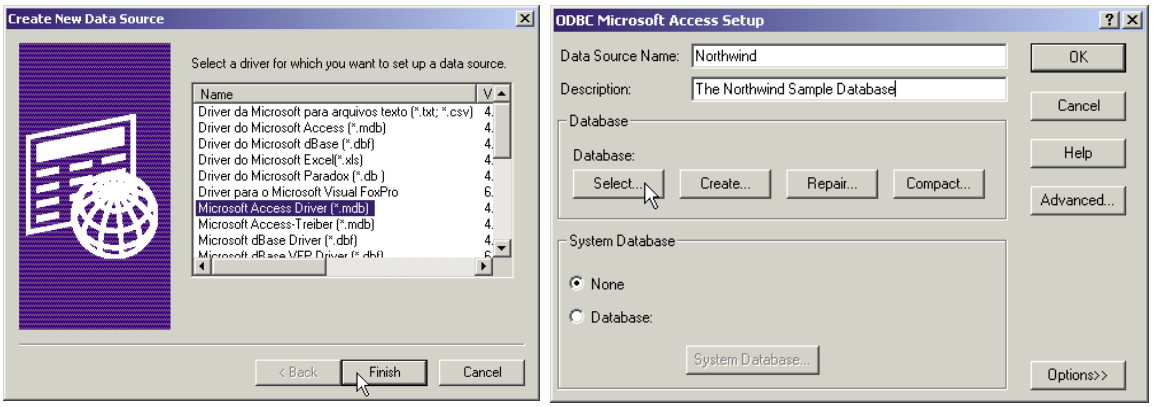
Using Microsoft Access via ODBC

- **Click Start, Settings, Control Panel, Administrative Tools, Data Sources, System DSN, and select Add**



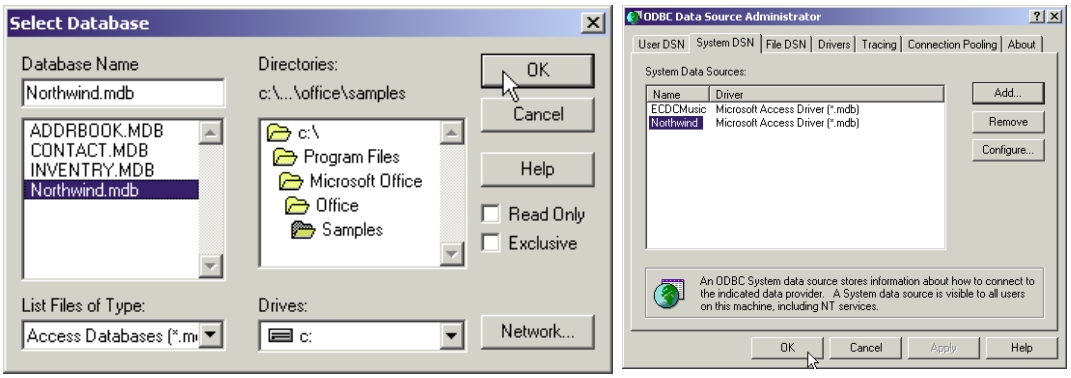
Using Microsoft Access via ODBC (Continued)

- **Select Microsoft Access Driver, Finish, type a name under Data Source Name, and hit Select**



Using Microsoft Access via ODBC (Continued)

- **Navigate to the Samples directory of MS Office, select Northwind.mdb, hit OK, then hit OK in following two windows**



Using Microsoft Access via ODBC (Continued)

- **Use sun.jdbc.odbc.JdbcOdbcDriver as the class name of the JDBC driver.**
  - Class.forName("sun.jdbc.odbc.JdbcOdbcDriver");
- **Use "jdbc:odbc:Northwind" as the database address, and use empty strings for the username and password.**
  - Connection connection = DriverManager.getConnection("jdbc:odbc:Northwind", "","");

Simple Standalone Northwind Test

```
package coreservlets;

import java.sql.*;

public class NorthwindTest {
  public static void main(String[] args) {
    String driver =
      "sun.jdbc.odbc.JdbcOdbcDriver";
    String url = "jdbc:odbc:Northwind";
    String username = "";
    String password = "";
    showEmployeeTable(driver, url,
                      username, password);
  }
```

Simple Standalone Northwind Test (Continued)

```
  public static void showEmployeeTable(String driver,
                                       String url,
                                       String username,
                                       String password) {
  try {
    // Load database driver if not already loaded.
    Class.forName(driver);
    // Establish network connection to database.
    Connection connection =
      DriverManager.getConnection(url,
                                  username, password);
    System.out.println("Employees\n" +
                       "=========");
    Statement statement = connection.createStatement();
    String query =
      "SELECT firstname, lastname FROM employees";
    // Send query to database and store results.
    ResultSet resultSet = statement.executeQuery(query);
```


Simple Standalone Northwind Test (Continued)

```
    // Print results.
    while(resultSet.next()) {
      // First name
      System.out.print(resultSet.getString(1) + " ");
      // Last name
      System.out.println(resultSet.getString(2));
    }
  } catch(ClassNotFoundException cnfe) {
    System.err.println("Error loading driver: " + cnfe);
  } catch(SQLException sqle) {
    System.err.println("Error connecting: " + sqle);
  }
 }
}
```

Simple Standalone Northwind Test: Results

```
Prompt> java coreservlets.NorthwindTest

Employees
=========
Nancy Davolio
Andrew Fuller
Janet Leverling
Margaret Peacock
Steven Buchanan
Michael Suyama
Robert King
Laura Callahan
Anne Dodsworth
```


Using MetaData

- **System-wide data**
  - connection.getMetaData().getDatabaseProductName()
  - connection.getMetaData().getDatabaseProductVersion()
- **Table-specific data**
  - resultSet.getMetaData().getColumnCount()
    - When using the result, remember that the index starts at 1, not 0
  - resultSet.getMetaData().getColumnName()

Using MetaData: Example

```
public class NorthwindServlet extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    response.setContentType("text/html");
    PrintWriter out = response.getWriter();
    … out.println(docType + …);
    String driver = "sun.jdbc.odbc.JdbcOdbcDriver";
    String url = "jdbc:odbc:Northwind";
    String username = "";
    String password = "";
    String tableName = request.getParameter("tableName");
    if ((tableName == null) || (tableName.equals(""))) {
      tableName = "employees";
    }
    showTable(driver, url, username, password,
              tableName, out);
    out.println("</CENTER></BODY></HTML>");
  }
```

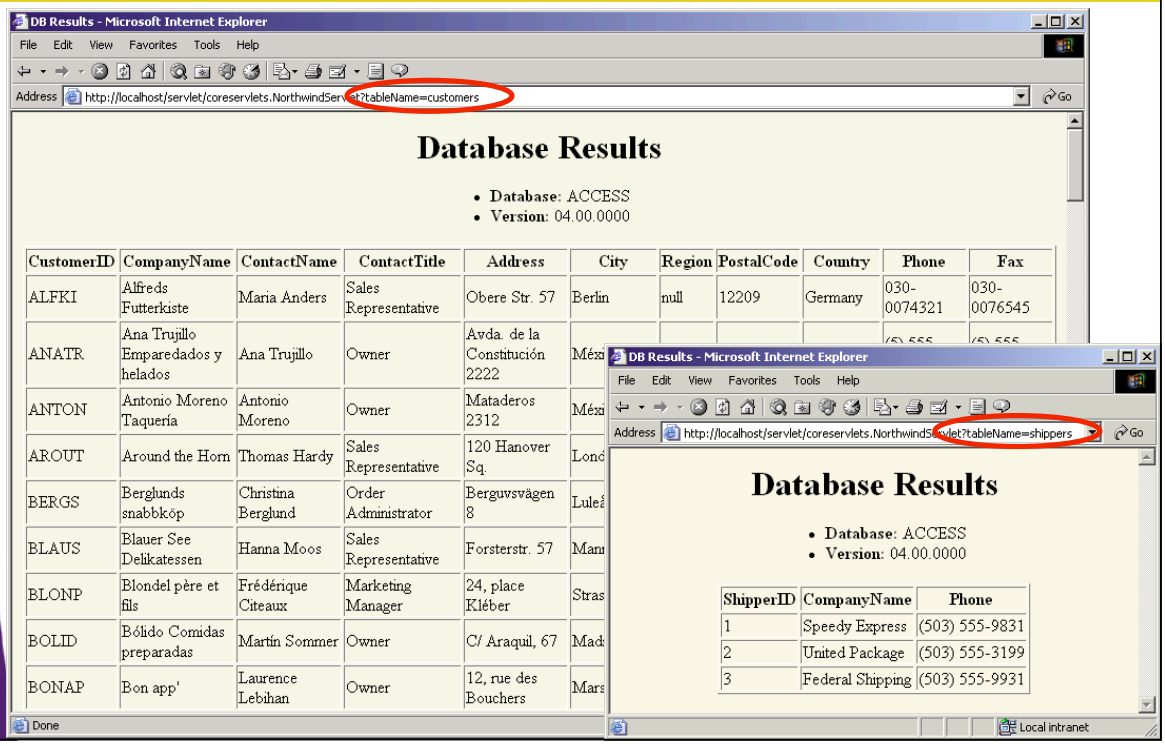

Using MetaData: Example (Continued)

```
  private void showTable(String driver,
                         String url,
                         String username,
                         String password,
                         String tableName,
                         PrintWriter out) {
    try {
      Class.forName(driver);
      Connection connection =
        DriverManager.getConnection(url, username, password);
      DatabaseMetaData dbMetaData = connection.getMetaData();
      out.println("<UL>");
      String productName =
        dbMetaData.getDatabaseProductName();
      out.println("  <LI><B>Database:</B> " +
                  productName);
      String productVersion =
        dbMetaData.getDatabaseProductVersion();
      out.println("  <LI><B>Version:</B> " +
                  productVersion +
                  "\n</UL>");
```

Using MetaData: Example (Continued)

```
Statement statement = connection.createStatement();
String query =
  "SELECT * FROM " + tableName;
ResultSet resultSet = statement.executeQuery(query);
out.println("<TABLE BORDER=1>");
ResultSetMetaData resultsMetaData =
  resultSet.getMetaData();
int columnCount = resultsMetaData.getColumnCount();
out.println("<TR>");
for(int i=1; i<columnCount+1; i++) {
  out.print("<TH>" + resultsMetaData.getColumnName(i));
}
out.println();
while(resultSet.next()) {
  out.println("<TR>");
  for(int i=1; i<columnCount+1; i++) {
    out.print("<TD>" + resultSet.getString(i));
  }
  out.println();
}
out.println("</TABLE>");
```


Using MetaData: Results



Using Statement

- **Overview**
  - Through the `Statement` object, SQL statements are sent to the database.
  - Three types of statement objects are available:
    - **`Statement`**
      - For executing a simple SQL statement
    - **`PreparedStatement`**
      - For executing a precompiled SQL statement passing in parameters
    - **`CallableStatement`**
      - For executing a database stored procedure

Useful Statement Methods

- **executeQuery**
  - Executes the SQL query and returns the data in a table (ResultSet)
  - The resulting table may be empty but never null

```
ResultSet results =
  statement.executeQuery("SELECT a, b FROM table");
```

- **executeUpdate**
  - Used to execute for INSERT, UPDATE, or DELETE SQL statements
  - The return is the number of rows that were affected in the database
  - Supports Data Definition Language (DDL) statements CREATE TABLE, DROP TABLE and ALTER TABLE

```
int rows =
  statement.executeUpdate("DELETE FROM EMPLOYEES" +
                          "WHERE STATUS=0");
```

Useful Statement Methods (Continued)

- **execute**
  - Generic method for executing stored procedures and prepared statements
  - Rarely used (for multiple return result sets)
  - The statement execution may or may not return a ResultSet (use statement.getResultSet). If the return value is true, two or more result sets were produced
- **getMaxRows/setMaxRows**
  - Determines the maximum number of rows a `ResultSet` may contain
  - Unless explicitly set, the number of rows is unlimited (return value of 0)
- **getQueryTimeout/setQueryTimeout**
  - Specifies the amount of a time a driver will wait for a STATEMENT to complete before throwing a `SQLException`

Prepared Statements (Precompiled Queries)

- **Idea**
  - If you are going to execute similar SQL statements multiple times, using "prepared" (parameterized) statements can be more efficient
  - Create a statement in standard form that is sent to the database for compilation before actually being used
  - Each time you use it, you simply replace some of the marked parameters using the `setXxx` methods
- **As PreparedStatement inherits from Statement the corresponding execute methods have no parameters**
  - execute()
  - executeQuery()
  - executeUpdate()

Prepared Statement, Example

```
Connection connection =
  DriverManager.getConnection(url, user,
  password);
PreparedStatement statement =
  connection.prepareStatement("UPDATE employees "+
                              "SET salary = ? " +
                              "WHERE id = ?");
int[] newSalaries = getSalaries();
int[] employeeIDs = getIDs();
for(int i=0; i<employeeIDs.length; i++) {
  statement.setInt(1, newSalaries[i]);
  statement.setInt(2, employeeIDs[i]);
  statement.executeUpdate();
}
```


Useful Prepared Statement Methods

- **set*Xxx***
  - Sets the indicated parameter (?) in the SQL statement to the value
- **clearParameters**
  - Clears all set parameter values in the statement
- **Handling Servlet Data**
  - Query data obtained from a user through an HTML form may have SQL or special characters that may require escape sequences
  - To handle the special characters, pass the string to the `PreparedStatement` `setString` method which will automatically escape the string as necessary

Transactions

- **Idea**
  - By default, after each SQL statement is executed the changes are automatically committed to the database
  - Turn auto-commit off to group two or more statements together into a transaction

```
connection.setAutoCommit(false)
```

  - Call commit to permanently record the changes to the database after executing a group of statements
  - Call rollback if an error occurs

Transactions: Example

```
Connection connection =
  DriverManager.getConnection(url, username, passwd);
connection.setAutoCommit(false);
try {
  statement.executeUpdate(...);
  statement.executeUpdate(...);

  connection.commit();
} catch (Exception e) {
  try {
    connection.rollback();
  } catch (SQLException sqle) {
    // report problem
  }
} finally {
  try {
   connection.close();
  } catch (SQLException sqle) { }
}
```

Useful Connection Methods (for Transactions)

- **getAutoCommit/setAutoCommit**
  - By default, a connection is set to auto-commit
  - Retrieves or sets the auto-commit mode
- **commit**
  - Force all changes since the last call to commit to become permanent
  - Any database locks currently held by this `Connection` object are released
- **rollback**
  - Drops all changes since the previous call to commit
  - Releases any database locks held by this `Connection` object

More JDBC Options

- **Stored procedures**
- **Changing buffer size**
- **Connection pooling**
- **JSP Standard Tag Library (JSTL) – custom tags to hide JDBC details**

Summary

- **You use the same Java syntax with all databases**
  - Translation to native format is done on the client via a JDBC driver
  - Standardized Java syntax does not equate to standardized SQL syntax
- **Steps in using JDBC**
  1. Load the driver
  2. Define the Connection URL
  3. Establish the Connection
  4. Create a Statement object
  5. Execute a query
  6. Process the results
  7. Close the connection

Questions?