JDBC

- JDBC (Java Database Connectivity) is a standard SQL database access interface.
- The JDBC API defines classes to represent constructs such as database connections, SQL statements, result sets, and database metadata.
- JDBC allows a Java program to issue SQL statements and process the results.

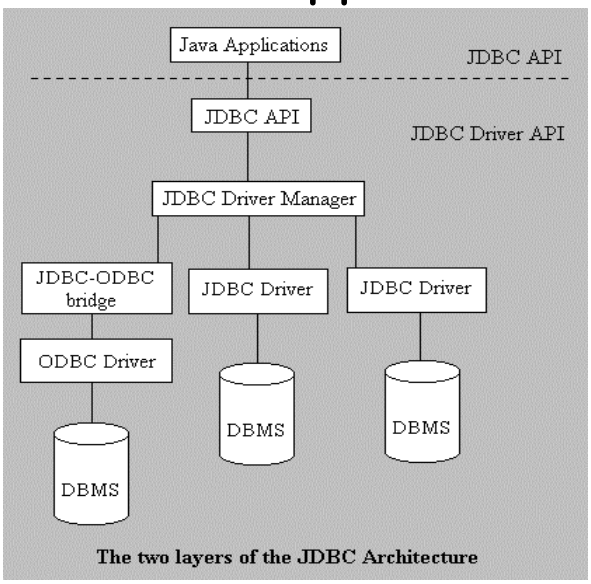
JDBC Goals

- To provide
  - Java programmers with a uniform, simple interface to a wide range of relational databases
  - DB independence. Can replace underlying database with minimal code impact.
  - a common base on which higher level tools and interfaces can be built.

Trivial First Example

- Trivial.java
  - Compile
  - Execute
    - Error!
  - Create an ODBC entry
  - Execute
    - see the result

A JDBC Application



The two layers of the JDBC Architecture

Pieces Continued

- A JDBC application consists of
  - Java client: code implementing the application
  - JDBC API. Provides DB independent abstraction to
    - establish a connection with a database
    - send SQL statements
    - process the results

Pieces Continued

- JDBC Driver
  - Translates API calls to requests made against the specific database.
  - Specific driver for the specific database.
  - Installed on the client. Usually a set of class files placed in the class path.
  - All large databases are now supported.
- Database client software (optional)
  - Establishes communication between DB clients and the DB server.
  - Depending on the DB Manufacturer, you may need to install database client software on the client machine.
  - JDBC Driver may already include this functionality

Pieces Continued

- Database server:
  - The actual database engine
  - Oracle, MSAccess, SQL Server, Postgresql etc.

Alternatives (ODBC)

- **What is ODBC**
  - Microsofts version of JDBC.
  - Many drivers exist for ODBC.
  - Sun provides a JDBC-ODBC driver to allow Java applications connectivity to databases that are only ODBC enabled.

API: Establish Connection

1 ***Class.forName(...)*** make the driver class available

2 ***String url = "jdbc:odbc:supplier-part";***

This is the connect string. The connect string, mentions the driver as well as the database. For the example above, the driver is the `jdbc:odbc` bridge driver. The database is `supplier-part`.

3 ***Connection con=DriverManager.getConnection(url, uID, pw);***

Get a connection (session) with a specific database. Within the context of a Connection, SQL statements are executed and results are returned.

A Connection can be used to obtain information about the DB By default a Connection automatically *commits* changes after each statement.

Typically, setting up a connection is an expennsive operation.

API: Executing Queries

- A query can return many rows, each with many attributes
- Steps are
  1 Send query to the database
  2 Retrieve one row at a time
  3 For each row, retrieve attributes

API: Executing Queries

Example:

```
Statement stmt = con.createStatement();

// Send the query to the DB, get back a ResultSet
ResultSet rs = stmt.executeQuery("SELECT * FROM PART;");

// Go through all rows returned by the query
while(rs.next()){
  // Pull out individual columns from the current row
  int pno=rs.getInt("PNO");
  String pname=rs.getString("PNAME");

  // Print out the values
  System.out.println(pno+"\t"+pname);
}
rs.close();
```


API: Updates

```
Int rowsEffected=
    stmt.executeUpdate(
        "DELETE * FROM ACCOUNTS;");
```

Executes a SQL INSERT, UPDATE or DELETE statement. Returns the number of rows affected.

API: Prepared Statements

- Is a parameterized SQL statement.
- Used to speedup query parsing (statement does not need to be reparsed)
- Used to simplify development (clumsy strings do not have to be created and recreated for each update).

Example:

```
String insert="INSERT INTO ACCOUNT(NAME,AMOUNT)VALUES(?,?);";
PreparedStatement ps =con.prepareStatement(insert);
ps.setString(1,"Charlie"); // Fill in the first ?
ps.setDouble(2,23.45); // Fill in the second ?
rowsEffected=ps.executeUpdate();
ps.setInt(1,"Arnold"); // Fill in the first ?
ps.setInt(2,102.23); // Fill in the second ?
rowsEffected=ps.executeUpdate();
```


Transactions

- A transaction is a collection of DB modifications, which is treated as an atomic DB operation. All take place or none do.
- Transactions are used to make sure that a collection of updates leaves the database in a consistent state (as defined by the application program).
- By default the Connection automatically commits changes after executing each statement. If auto commit has been disabled, the method commit must be called explicitly; otherwise, database changes will not be saved.

API: Transactions

Example:

```
// Change to transactional mode
con.setAutoCommit(false);
// Transaction A begins here
stmt.executeUpdate("DELETE * FROM ACCOUNT...;");// 1
stmt.executeUpdate("INSERT INTO ACCOUNT ...."); // 2
stmt.executeUpdate("INSERT INTO ACCOUNT ...."); // 3
stmt.executeUpdate("INSERT INTO ACCOUNT ...."); // 4
con.commit();
// Commit changes to database
// All of 1,2,3,4 take effect
```


API: Transactions

Example:

```
// Transaction B begins here
stmt.executeUpdate("DELETE * FROM SALES...;"); // 5
stmt.executeUpdate("INSERT INTO SALES ...."); // 6
stmt.executeUpdate("INSERT INTO SALES ...."); // 7
stmt.executeUpdate("INSERT INTO SALES ...."); // 8
con.rollback();
// Rollback to before transaction B began
// None of 5,6,7,8 effects the DB
```

- Example: Transaction.java

Scope of DB Connections

1. **Servlet:** Open/close connection on each servlet invocation
   - Will work, but very slow.
2. **Session:** Keep 1 open connection associated with the session: HttpSession.getParameter("dbCon")
   - Slow
   - Dangerous (multiple concurrent servlets in same session): concurrency problems
   - Awkward (when to close?)
3. **Web App:** Keep 1 open connection for the web application and re-use it
   - Dangerous: Concurrency issues: bottlenecks

Connection Pooling

- The Solution:
  - Maintain a pool of open connections that know how to time themselves out
  - Each servlet calls:

```
DbConnectionPool dbcp =
   getServletContext().getAttribute("dbConPool");
DbConnection con = dbcp.checkoutConnection();
   …
   Statement s = con.createStatement();
   …
dbcp.checkinConnection(con);
```

Connection Pooling

- The DbConnectionPool allocates a new Connection object when asked to do so.
  - It wraps it in a DbConnection object that delegates calls to its enclosed Connection object and returns it to the client.
  - It sets a timeout that will reclaim the Connection for a pool of free connections
    - If client accesses DbConnection after timeout, DbConnection will request a fresh connection from the pool.
- Client returns DbConnection to the pool when done with it.
  - DbConnectionPool does not close the Connection, rather saves it for the next request
- Client may block awaiting a freed connection if some maximum upper limit of open connections is reached.

EJBs

- Enterprise Java Beans
  - Part of Sun J2EE initiative
- Goal:
  - Ease development of Web-oriented, 3-tier, RDBMS-based, applications.
    - Entity bean:
      - Encapsulates a persistent object that is mirrored in an RDBMS
    - Session bean:
      - Encapsulates transactions
- Benefits:
  - Handles all the crap for you (e.g., sessions, connection pooling, …)