

Web Development using Java, JSP, and Web Services

Relational Databases & JDBC

Today

# Web Development using Java, JSP, and Web Services

## Relational Databases & JDBC

### Lecture #7 2008

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## Terminology

- Database server software referred to as Database Management Systems (DBMS)
- Database schemas describe database structure
- Data ordered in tables, rows and columns
- Tables (relations) provide groupings of data
- Rows (tuples) contain data records
- Columns (attributes) provide field structure

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## Structure

- Keys are used for ids and references
- Data stored in rows (aka records, tuples)
- Data accessed and manipulated via SQL, JDBC etc
- Databases can store vast amounts of data
- Databases also contains simple functions
- Creation of custom functions (stored procedures) supported by most major database systems

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## Motivation

- Allows data storage to be structured after data access patterns
- Data can be indexed and hashed in memory - quick access
- A simple and expressive model that supports logic reasoning (first-order predicate logic)
- Simple and efficient data storage
- Database models support role-based development

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## Database Table

id	username	birthdate	email
1	test1	1970-01-01	test1@jsp.com
2	test2	1970-01-02	test2@jsp.com
3	test3	1970-01-03	test3@jsp.com
4	test4	1970-01-04	test4@jsp.com
5	test5	1970-01-05	test5@jsp.com

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## Transactions

- A way to provide safe concurrent access to databases
- Allows for several operations to be viewed as a single, atomic operation
- If an error occurs, all changes are undone (rollback)

## Structured Query Language (SQL)

- Text-based language used to access databases
- Standardized versions exists (ANSI SQL)
- Most database vendors provide their own dialects
- Select queries are used to ask questions about data
- Insert, update and delete statements are used to manipulate databases
- Create, alter & drop statements are used to create, modify and destroy databases
- Most databases provide functions which can be called using SQL

## SQL Queries

```
SELECT *  
FROM profile  
WHERE profile.id = '123'
```

```
SELECT username, birthdate, email  
FROM profile  
WHERE profile.id = '123'
```

## SQL Queries

```
SELECT COUNT(*)  
FROM profile  
WHERE LEN(profile.email) > 0
```

```
SELECT *  
FROM user, profile  
WHERE user.id = profile.id  
AND LEN(profile.email) > 0  
ORDER BY profile.username  
LIMIT 25
```

<- MySQL dialect

## SQL Updates

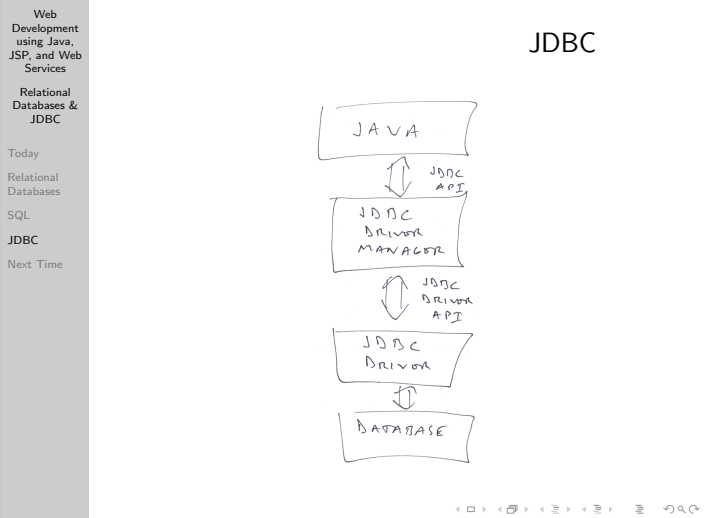
```
INSERT INTO profile (id, username, birthdate, email)  
VALUES (123, 'test1', '1970-01-01', 'test1@jsp.com')
```

```
UPDATE profile SET email = 'test1@jsp.com'  
WHERE id = '123'
```

```
DELETE FROM profile  
WHERE id = '123'
```

## Java Database Connectivity (JDBC)

- Java API for database access
- Constructed around a JDBC Driver Manager
- Database vendors provide JDBC drivers
- Aims to virtualize Java database access
- Switch database without changes in Java code



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## JDBC Data Types

JDBC type	Java type
BIT	boolean
TINYINT	byte
SMALLINT	short
INTEGER	int
BIGINT	long
FLOAT, DOUBLE	double
BINARY, VARBINARY, LONGVARBINARY	byte[]
CHAR, VARCHAR, LONGVARCHAR	String
NUMERIC, DECIMAL	BigDecimal

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## JDBC Data Types

JDBC type	Java type
DATE	java.sql.Date
TIME, TIMESTAMP	java.sql.Timestamp
CLOB	Clob
BLOB	Blob
ARRAY	Array
DISTINCT	mapping underlying type
STRUCT	Struct
REF	Ref
JAVA.OBJECT	underlying Java class

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- ## Using JDBC
- 1 Load driver
  - 2 Create database URL
  - 3 Connect to database
  - 4 Create a statement
  - 5 Execute a query / update
  - 6 Process results
  - 7 Close connection
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- ## JDBC Drivers
- Data buffering
  - Connection pooling
  - Links to stored procedures
  - Driver instantiated via dynamic class loading (required, need only be done once)
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## JDBC Driver Example

```

public static void instantiateDriver (String driver)
    throws ClassNotFoundException
{
    try
    {
        Class.forName(driver).newInstance();
    }
    catch (InstantiationException e)
    {
        throw new ClassNotFoundException(e.getMessage());
    }
    catch (IllegalAccessException e)
    {
        throw new ClassNotFoundException(e.getMessage());
    }
}
  
```

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## JDBC Driver Example

```

static
{
    // Apache Derby
    instantiateDriver("org.apache.derby.jdbc.EmbeddedDriver");

    // MySQL
    instantiateDriver("com.mysql.jdbc.Driver");

    // PostgreSQL
    instantiateDriver("org.postgresql.Driver");
}

```

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## JDBC Database URLs

`jdbc:dbms:[//host:port/]database`

- Provides JDBC database connection information
- Contains host, port, database (optionally username/password)

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## JDBC Database URL Examples

DBMS	URL
Apache Derby	jdbc:derby:database
MySQL	jdbc:mysql://host:3306/database
PostgreSQL	jdbc:postgresql://host:5432/database

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## JDBC Database Connections

- Represents a connection to a database
- May result in an underlying TCP/IP connection
- Connection may be compressed / encrypted
- Costly to create, reuse is recommended

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## JDBC Statement Types

- Statement - simple SQL statement
- PreparedStatement - precompiled SQL statement
- CallableStatement - database stored procedure

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## JDBC Statements

- SQL is constructed and parsed for each request
- Quick and easy
- Should be replaced with prepared statements (when optimizing)

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## JDBC PreparedStatement

- Used to precompile a JDBC statement
- Parameters are added to the statement
- More efficient when queries are repeated

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## JDBC CallableStatements

- Used to call stored procedures in a database
- Parameters are added to call
- Stored procedure executes in the DBMS
- More efficient than prepared statements
- Requires a stored procedure
- Ties the application to a particular DBMS

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## JDBC ResultSets

- Interfaces to statement results
- Can be thought of as table views
- Doesn't actually contain all data returned from queries (requests data as needed)
- Can be used to both read and write data
- Exact behavior of ResultSets depends on statement type

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## JDBC Select

- Retrieves data from the database

```

Connection connection =
    DriverManager.getConnection(url,username,password)
Statement statement =
    connection.createStatement(ResultSet.TYPE_SCROLL_INSENSITIVE,
                               ResultSet.CONCUR_READ_ONLY);
String sql = "SELECT * FROM profile";
ResultSet resultSet = statement.executeQuery(sql);
resultSet.next();
String id = resultSet.getString("id");
String username = resultSet.getString("username");
String birthdate = resultSet.getString("birthdate");
String email = resultSet.getString("email");

```

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## JDBC SQL Insert

- Inserts data into the database
- Data must be manually filtered / escaped

```

Connection connection =
    DriverManager.getConnection(url,username,password)
Statement statement =
    connection.createStatement(ResultSet.TYPE_SCROLL_INSENSITIVE,
                               ResultSet.CONCUR_UPDATABLE);
String sql =
    "INSERT INTO profile (id, username, birthdate, email) " +
    "VALUES (123,'test1','1970-01-01','test1@jsp.com)";
ResultSet resultSet = statement.execute(sql);

```

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## JDBC ResultSet Insert

- Inserts data into the database
- Data is filtered / escaped by JDBC

```

Connection connection =
    DriverManager.getConnection(url,username,password)
Statement statement =
    connection.createStatement(ResultSet.TYPE_SCROLL_INSENSITIVE,
                               ResultSet.CONCUR_UPDATABLE);
String sql = "SELECT * FROM profile";
ResultSet resultSet = statement.executeQuery(sql);
resultSet.moveToInsertRow();
resultSet.updateString("id","123");
resultSet.updateString("username","test1");
resultSet.updateString("birthdate","1970-01-01");
resultSet.updateString("email","test1@jsp.com");
resultSet.insertRow();

```

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## JDBC ResultSet Update

- Updates existing data in the database
- Data is filtered / escaped by JDBC

```
Connection connection =
    DriverManager.getConnection(url,username,password)
Statement statement =
    connection.createStatement(ResultSet.TYPE_SCROLL_INSENSITIVE,
                               ResultSet.CONCUR_UPDATABLE);
String sql = "SELECT * FROM profile WHERE id='123'";
ResultSet resultSet = statement.executeQuery(sql);
resultSet.next();
resultSet.updateString("username","test1");
resultSet.updateString("birthdate","1970-01-01");
resultSet.updateString("email","test1@jsp.com");
resultSet.updateRow();
```

## JDBC Transactions

- `connection.setAutoCommit(false)` (default: true)
- `connection.commit()`
- `connection.rollback()`

## JDBC Transaction Example

```
Connection connection = null;
try
{
    connection = getConnection();
    connection.setAutoCommit(false);
    runSomeQuery();
    runAnotherQuery();
    connection.commit();
}
catch (SQLException e)
{
    connection.rollback();
}
finally
{
    try
    {
        if (connection != null)
            connection.close();
    }
    catch (SQLException e)
    {
    }
}
```

## JDBC MetaData

- Provides information about databases and drivers
- Commonly used to list tables, columns etc
- Comparable to introspection / Java reflection

## Next Time

- Web Security