Introduction to Java Database Connectivity API

CSCE 156 - Introduction to Computer Science II

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Your Database

- CSE hosts your database (MySQL)
- Database name: same as your login
- Changing your password: visit `http://ponca.unl.edu`
- Class database (may be used for examples, assignments): cse156 (password: `cse156student`)
- MySQL commandline usage:
  `mysql -u username -p dbname`
- Command line redirection (careful!):
  `mysql -u username -p dbname < commands.sql`
- `mysqldump` (database backup)

Java Database Connectivity API

Java Database Connectivity (JDBC)

- General API (using interfaces) for Java client code to connect/interact with a database
- Database providers (IBM, Oracle, etc.) provide *drivers*
- Driver: specific implementation of the API for interacting with a particular database
- Support for
  - `Statement`
  - `PreparedStatement`
  - `CallableStatement` (stored procedures)
  - Common Java data types (`Integer, Double, java.sql.Date`)

JDBC: basic step-by-step

1. Load the database JDBC driver
   Note: your particular driver (.jar file) must be in the class or build path of your project
2. Make a connection to the database
3. Formulate your query(ies) & prepare your statement (set parameters)
4. Execute your query
5. If its a `SELECT` query:
   5.1 Get your *result set*
   5.2 Process your results
6. Clean up your resources (close resources, close connection)

JDBC

Reflectively loading a driver

- For portability, applications written toward JDBC API, not a particular driver
- Driver needs to be loaded at run time through reflection
- Could be made configurable or delegated by some controller

```
try {
    Class.forName("com.mysql.jdbc.Driver").newInstance();
} catch (InstantiationException e) {
    ...
} catch (IllegalAccessException e) {
    ...
} catch (ClassNotFoundException e) {
    ...
}
```

JDBC

Connection

Java provides connectivity through `java.sql.Connection`:

```
String url = "jdbc:mysql://cse.unl.edu/database_name";
String username = "cse156student";
Connection conn = null;
try {
  conn = DriverManager.getConnection(url, username, password);
} catch (SQLException sqle) {
  ...
}
```

JDBC

Transactions

- By default, all queries are auto-commit
- To change this, use `conn.setAutoCommit(false)`
- No changes committed until `conn.commit()` is called
- Implicitly: new transaction after each commit
- Able to explicitly rollback using `conn.rollback()`
- Some drivers may also support `conn.setReadOnly(true)`

JDBC

Querying – Prepared Statement

- Always good to use `PreparedStatement`
- Parameters denoted by `?`, indexed by `1..n`
- Can be reused (parameters reset and required)
- Parameters are *safe*!

```
String query = "SELECT ... FROM user WHERE nuid = ?";
PreparedStatement ps = null;
try {
  ps = conn.prepareStatement(query);
  ps.setString(1, "35140602");
} catch (SQLException sqle) {
  ...
}
```

JDBC I

Querying – Result Sets

- `executeQuery()` is for read-only (select statements)
- Select statements return *results*: columns and rows
- Results are encapsulated in a Java `ResultSet` object
- Initially a result set "points" just before the first *row*
- Iterating through a `ResultSet`: `rs.next()`
- Returns a boolean: true if the iteration was successful, false otherwise
- If successful, the "current" result row is now pointed to
- Columns can be referenced by `String` (alias) or index
- Standard getters provide functionality to get-and-cast columns

JDBC II

Querying – Result Sets

```
ResultSet rs = null;
try {
  rs = ps.executeQuery();
  while(rs.next()) {
    Integer nuid = rs.getInt("nuid")
    String firstName = rs.getString("first_name");
  }
} catch (SQLException sqle) {
  ...
}
```

JDBC

Querying – Updates

- *Always* use a prepared statement!
- Same syntax holds for INSERT statements

```
String query = "UPDATE user SET email = ?, last_updated = ? WHERE nuid = ?";
PreparedStatement ps = null;
try {
  ps = conn.prepareStatement(query);
  ps.setString(1, "cmbourke@gmail.com");
  ps.setString(2, "2011-01-01 00:00:01");
  ps.setString(3, "35140602");
  ps.executeUpdate();
} catch (SQLException sqle) {
  ...
}
```

JDBC

Good Practices – Rethrow Exceptions

- Most methods explicitly throw `SQLException`
- Occurs with DB errors or program bugs
- Little can be done either way
- Good to catch, log and rethrow

```
...
} catch (SQLException sqle) {
    System.out.println("SQLException: ");
    sqle.printStackTrace();
    throw new RuntimeException(sqle);
}
```

JDBC

Cleaning Up

- Objects hold onto valuable external resources
- Network traffic (keep alive), limited connection pool, etc.
- Best practice to release resources as soon as they are no longer needed: `close()` method

```
try {
  if(rs != null && !rs.isClosed())
    rs.close();
  if(ps != null && !ps.isClosed())
    ps.close();
  if(conn != null && !conn.isClosed())
    conn.close();
} catch (SQLException e) {
  ...
}
```

JDBC

Full Example Demonstration

Let’s take a look at a full example...

Good Practice Tip 1

ALWAYS use Prepared Statements

When available, in any framework or language, always use prepared statements

- Safer
- Better for batch queries
- Myth: no performance hit
- Protects against *injection attacks*
- Using just one method: more uniform, less of a chance of a mistake
- Unfortunately: some frameworks support *named parameters*, not JDBC

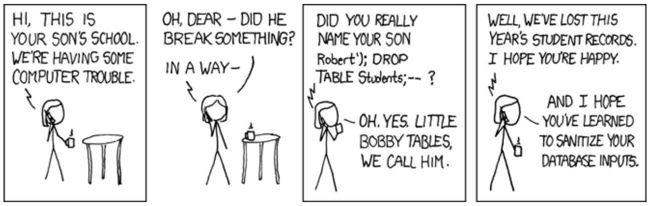
Injection Attack

Example

- Say we pull a string value from a web form (`lastName`)
- Not using a prepared statement:
  `String query = "SELECT primary_email FROM user WHERE last_name = ’"+lastName+"’";`
- Without scrubbing the input, say a user enters:
  `a’;DROP TABLE user;`
- Actual query run:
  `SELECT primary_email FROM user WHERE last = ’a’;DROP TABLE users;`
- Another example: input is `"’ or ’1’=’1"`
- Actual query:
  `SELECT primary_email FROM user WHERE last_name = ’’OR ’1’=’1 ’`

Injection Attack

Example


HI, THIS IS YOUR SON'S SCHOOL. WE'RE HAVING SOME COMPUTER TROUBLE.
OH, DEAR – DID HE BREAK SOMETHING?
IN A WAY–
DID YOU REALLY NAME YOUR SON Robert'); DROP TABLE Students;-- ?
OH. YES. LITTLE BOBBY TABLES, WE CALL HIM.
WELL, WE'VE LOST THIS YEAR'S STUDENT RECORDS. I HOPE YOU'RE HAPPY.
AND I HOPE YOU'VE LEARNED TO SANITIZE YOUR DATABASE INPUTS.

Good Practice Tip 2

Enumerate fields in SELECT statements

- Using `SELECT * ...` grabs all fields even if you don’t use them
- Be intentional about what you want/need, only the minimal set
- Allows the database to optimize, reduces network traffic
- Protects against table changes
- Use aliasing (`first_name AS firstName`) on all fields to reduce affects of changes to field names

Additional Issues

Additional Issues

- Security Issues
  - Where/how should database passwords be stored?
  - Good security policy: *assume* an attacker has your password & take the necessary precautions (secure the server and network)
  - Do not store sensitive data unencrypted
- Efficiency Issues
  - Repeat: **close your resources**
  - Connection Pools
  - Good normalization, design, & practice

Resources

- MySQL 5.1 Reference Manual (`http://dev.mysql.com/doc/refman/5.1/en/index.html`)
- MySQL Community Server (`http://www.mysql.com/downloads/`)
- MySQL Workbench – a MySQL GUI (`http://wb.mysql.com/`)
- Connector/J – MySQL JDBC connector (`http://www.mysql.com/downloads/connector/j/`)
- Stanford's *Introduction to Databases* free online course: `http://db-class.com/`

Exercise

Write basic CRUD methods for the `Employee`/`Person` tables by writing static methods to insert, delete, retrieve and update records in both tables.