Server-side Web Programming

Lecture 14:
Efficient and Safe Database Access on Web Servers

Synchronized Database Access

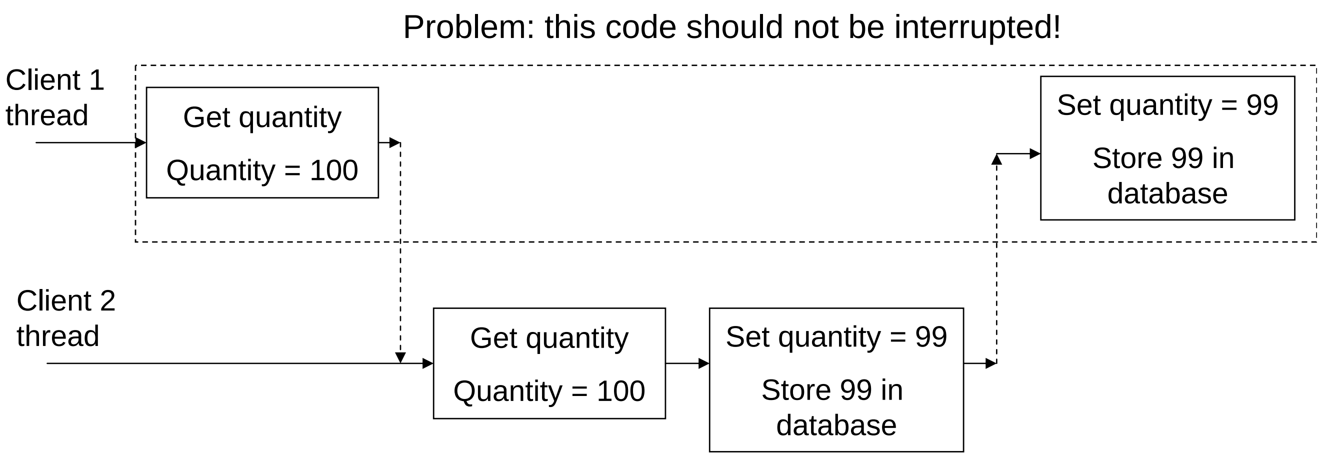
- Many database updates can occur "simultaneously" on busy sites
- Can interfere with one another
- Example: Quantity update after purchase
  - Query for previous quantity
  - Subtract 1
  - Update database with new quantity

```
try {
  statement = connection.createStatement();
  // Execute query to get current quantity
  books = statement.executeQuery("SELECT * FROM inventory WHERE productCode = '"+
                                 productCode+"'");
  books.next();
  int quantity = books.getInt("quantity");
  quantity = quantity - 1; // Decrement quantity
  // Set value to new quantity
  statement.executeUpdate("UPDATE inventory SET quantity = "+quantity+
                          " WHERE productCode = '"+productCode+"'");
  }
```

Synchronized Database Access

- Java runs separate clients as “parallel” <u>threads</u> which execute “simultaneously”
  - Processor <u>swaps back and forth</u> between threads
- Problem if following sequence occurs:
  - Current quantity = 100
  - Client 1 code to get current quantity executes (value = 100)
  - *Processor swaps to client 2 thread*
  - Client 2 code to get current quantity (value <u>still</u> = 100)
  - Client 2 code sets new quantity to 99 and stores in database
  - *Processor swaps back to client 1 thread*
  - **Client 1 code <u>also</u> sets new quantity to 99 and stores in database!**

Synchronized Database Access

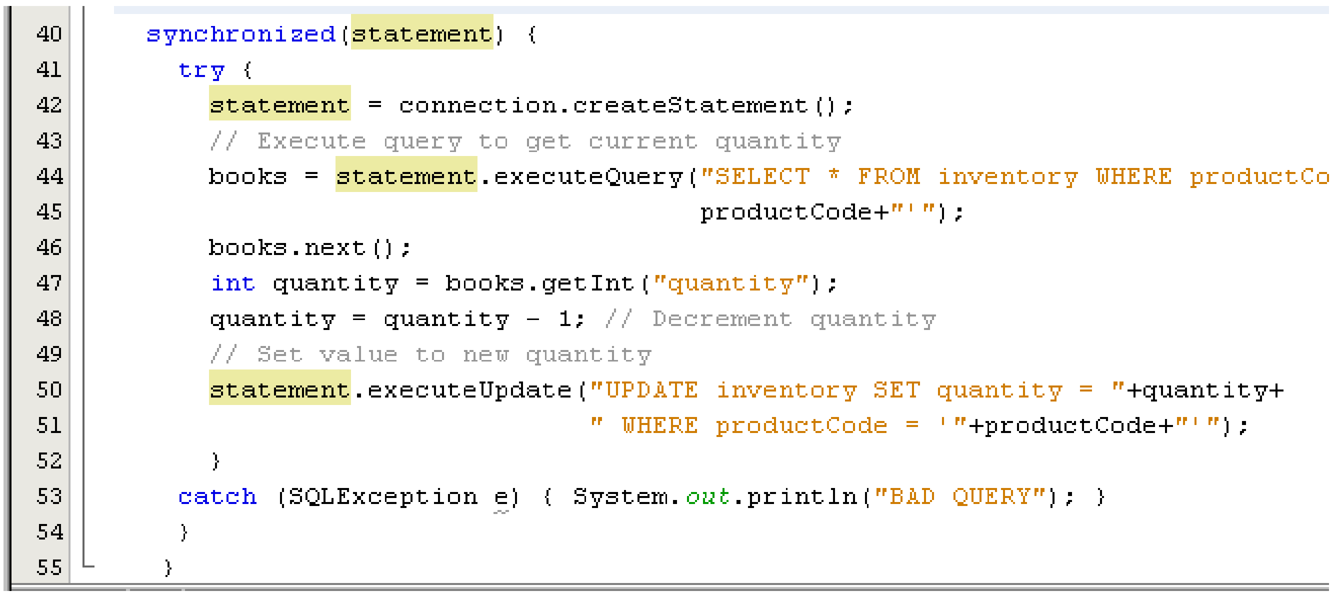


Synchronized Database Access

- Can declare sections of code to be synchronized
  - Only one thread may execute it at a time
  - Another thread cannot start the code until the first has finished it
- Syntax: **`synchronized(`*`object`*`) { `*`code`*` }`**

Only one thread at a time should be able to execute this code on this object

Synchronized Database Access



```
synchronized(statement) {
  try {
    statement = connection.createStatement();
    // Execute query to get current quantity
    books = statement.executeQuery("SELECT * FROM inventory WHERE productCo
                                   productCode+"'");
    books.next();
    int quantity = books.getInt("quantity");
    quantity = quantity - 1; // Decrement quantity
    // Set value to new quantity
    statement.executeUpdate("UPDATE inventory SET quantity = "+quantity+
                            " WHERE productCode = '"+productCode+"'");
    }
  catch (SQLException e) { System.out.println("BAD QUERY"); }
  }
 }
```

Efficiency in Database Access

- Database access most time consuming part of most e-commerce transactions
- Most costly parts:
  - Creating new connections to database
  - Creating new statements using those connections
- Idea:
  Do as much as possible in advance
  - Prepared statements
  - Connection pooling

Prepared Statements

- Executing a statement takes time for database server
  - Parses SQL statement and looks for syntax errors
  - Determines optimal way to execute statement
    - Particularly for statements involving loading multiple tables
- Most database statements are similar in form
- Example: Adding books to database
  - Thousands of statements executed
  - All statements of form:

```
"SELECT * FROM books WHERE productCode = ____“
"INSERT INTO books (productCode, title, price)
             VALUES (_____, _____, ______)"
```

Prepared Statements

- Tell database server about basic form of statements in advance
  - Database server can do all work for that type of statement once
- "Fill in blanks" for actual values when actually execute statement
  - Hard work already done

- Syntax:
  - Define **`PreparedStatement`** object instead of **`Statement`**

```
PreparedStatement check = null;
PreparedStatement insert = null;
```

Prepared Statements

- Define prepared statement using **`connection.prepareStatement`**
- Place '**?**' where actual values will be inserted

```
check = connection.prepareStatement("SELECT * FROM
                         books WHERE productCode = ?");

insert = connection.prepareStatement("INSERT INTO
                    books (productCode, title, price)
                    VALUES (?, ?, ?)");
```

Prepared Statements

- Use set*<u>Type</u>* (*<u>index</u>*, *<u>value</u>*) to insert values into the statement

Type of field (like get method in ResultSet)

Which ‘**?**’ to insert the value into

```
productCode = request.getParameter("productCode");
title = request.getParameter("title");
price = Double.parseDouble(request.getParameter("price"));
```

```
check.setString(1, productCode);
```

Insert productCode into first (and only) ‘**?**’ in check

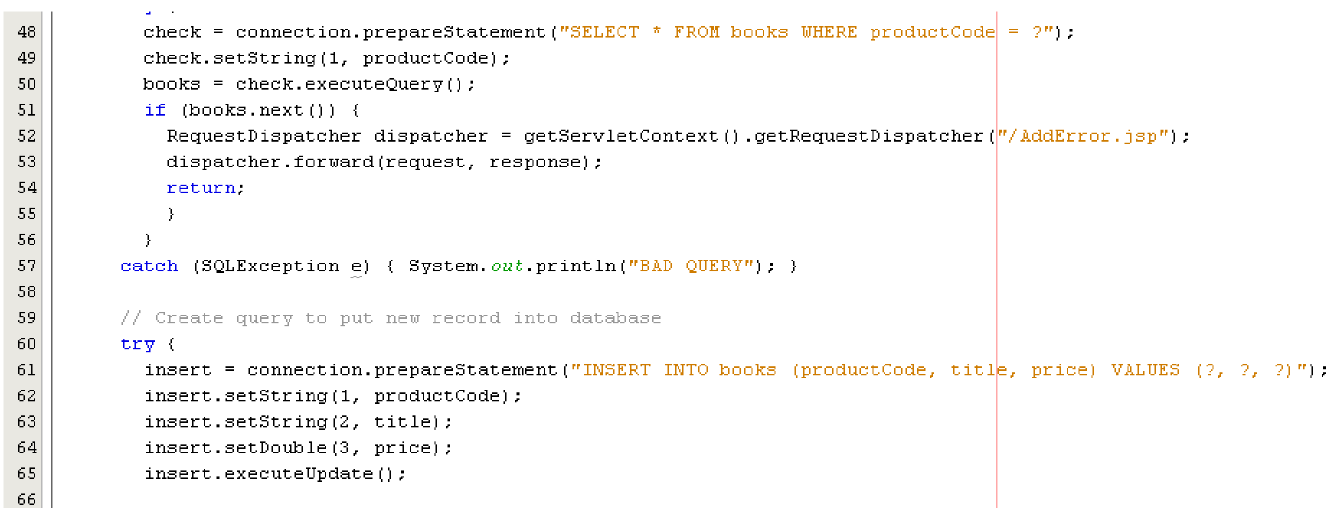
```
insert.setString(1, productCode);
insert.setString(2, title);
insert.setDouble(3, price);
```

Insert productCode, title, and price into first, second, and third ‘**?**’s respectively in insert

Note that price is inserted as <u>double</u>

Prepared Statements

- Execute statements as before
  – No parameters for SQL, since form already set



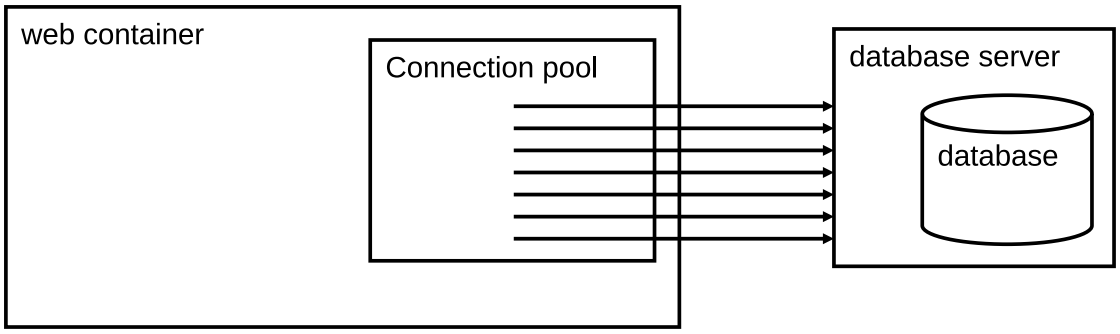
```
    check = connection.prepareStatement("SELECT * FROM books WHERE productCode = ?");
    check.setString(1, productCode);
    books = check.executeQuery();
    if (books.next()) {
      RequestDispatcher dispatcher = getServletContext().getRequestDispatcher("/AddError.jsp");
      dispatcher.forward(request, response);
      return;
      }
    }
  catch (SQLException e) { System.out.println("BAD QUERY"); }

  // Create query to put new record into database
  try {
    insert = connection.prepareStatement("INSERT INTO books (productCode, title, price) VALUES (?, ?, ?)");
    insert.setString(1, productCode);
    insert.setString(2, title);
    insert.setDouble(3, price);
    insert.executeUpdate();
```

Connection Pooling

- Every time client sends request, new connection to database created
  - May be many current connections (one per thread)
  - Most time consuming part of process

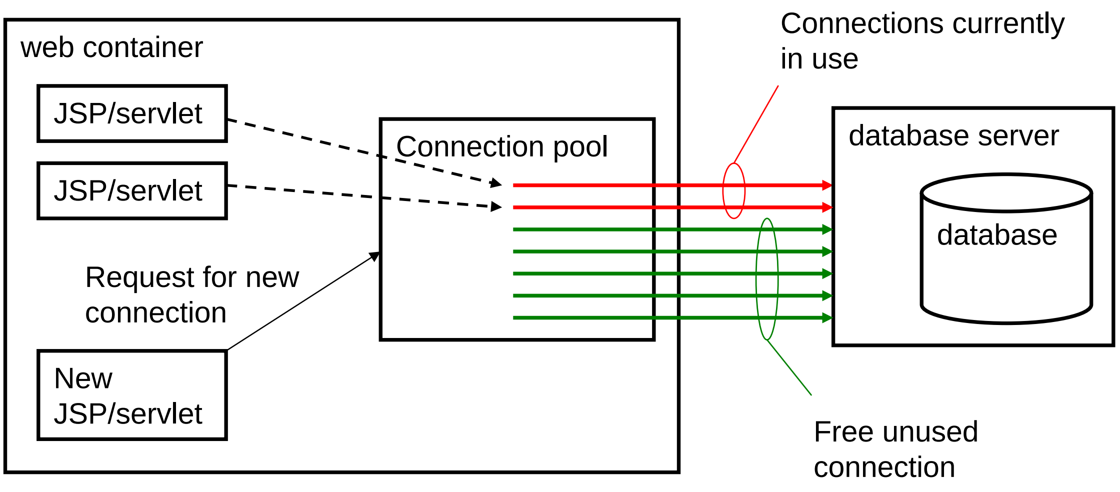
Solution:

- Create pool of connections in advance
  - No overhead when actual requests made later by clients



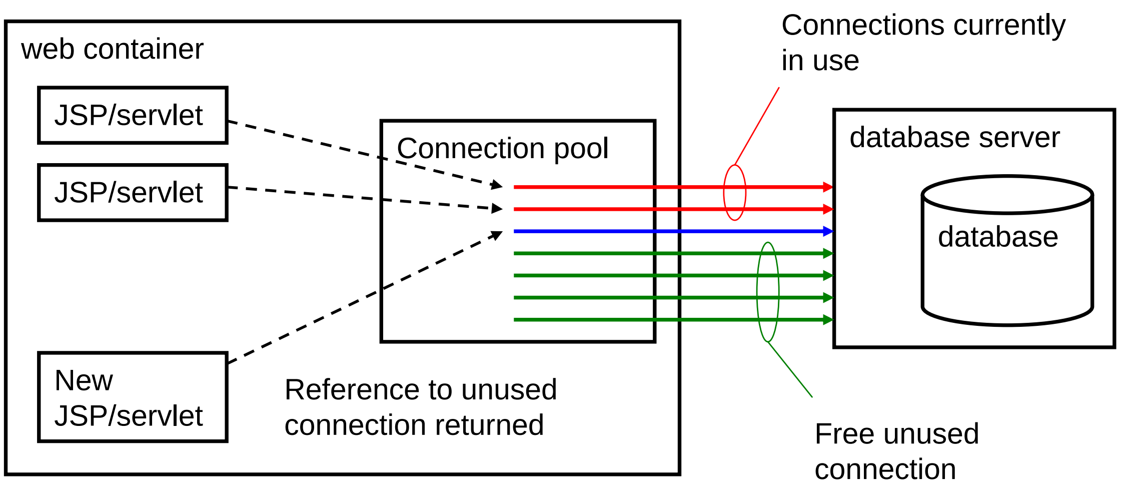
Connection Pooling

- When connection requested:
  - Get unused connection from pool



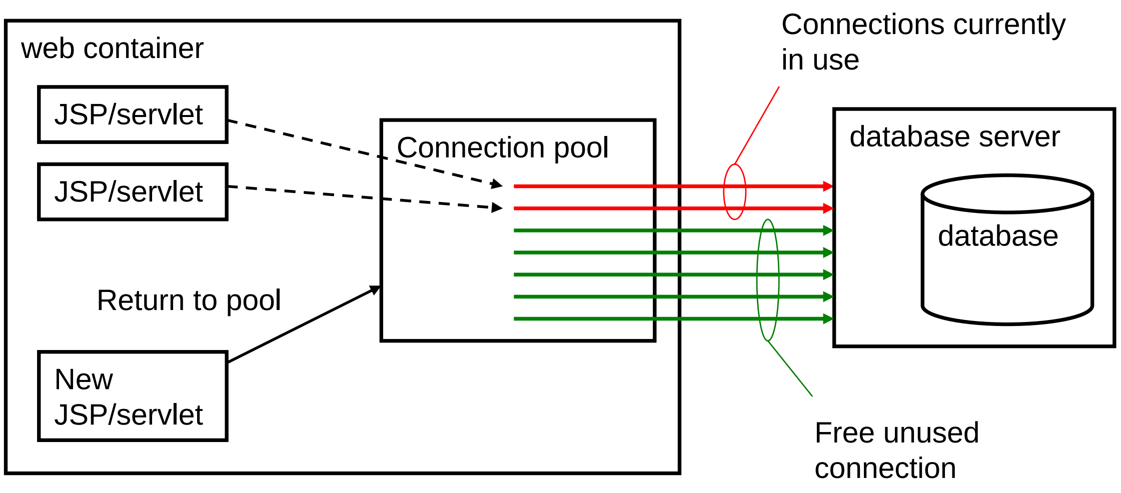
Connection Pooling

- When connection requested:
  - Connection used by servlet/JSP



Connection Pooling

- When finished, JSP/servlet <u>returns</u> the connection back to the pool
  - Now free for use by another



Connection Pooling

- Unlike prepared statement, no built in Java methods/classes
  - Write your own
    - **`http://java.sun.com/developer/onlineTraining/Programming/JDCBook/conpool.html`**
  - Third party classes
    - **`dbConnectionBroker`**, etc.
  - Build components directly into **`web.xml/context.xml`** files
    - Page 466 of text
    - Not well supported by Tomcat

Connection Pooling

- Usually static object
  - Automatically constructs connections first time **`getConnection`** called
- Usually provide following methods:
  - **`ConnectionPool.getInstance()`**
  - **`freeConnection()`**
- Example:

```
Connection connection = ConnectionPool.getInstance();

// Code that creates statement, executes queries, etc.

connection.freeConnection();
```

Connection Pooling

- Required parameters:
  - Driver name
    - **`"com.mysql.jdbc.Driver“`**
  - Url, name, and password
    - **`"jdbc:mysql://localhost/bookstore", “root", “sesame"`**
  - Number of initial connections to create
    - Usually a few hundred to a few thousand
  - <u>Timeout</u> for idle connections
    - Time after which idle connections are returned to pool automatically
    - Important to prevent pool running out!

Necessary so connection pool can connect to database