Database Applications (1)

Han-fen Hu

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Outline

- Introduction to Database Management Systems (DBMS)
- Java and DBMS
- Getting a Database Connection
- SQL Statements
- Statements and Prepared Statements
- Inserting, Updating and Deleting Rows

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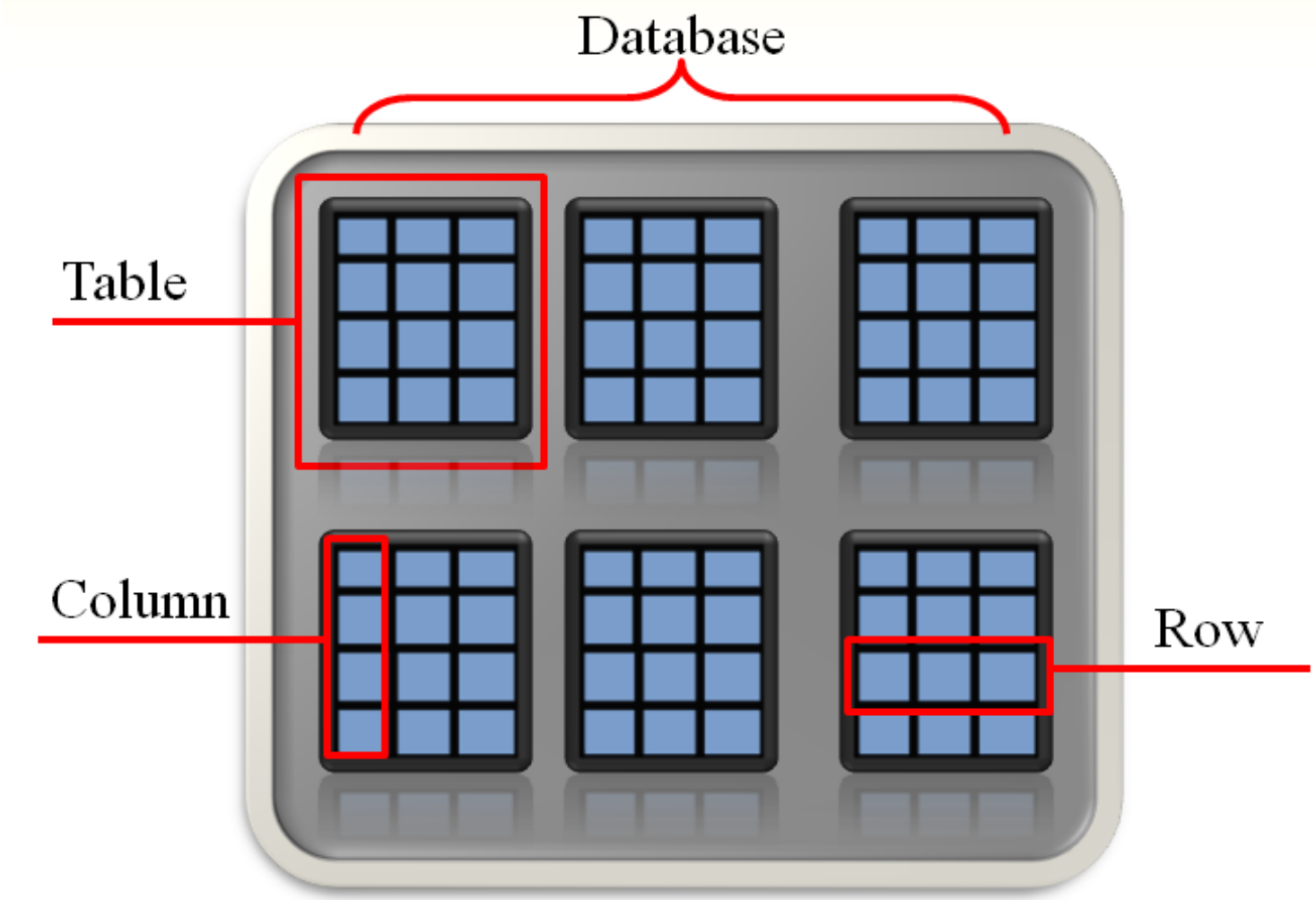
Database Management Systems (1)

- Storing data in traditional text or binary files has its limits
  - well suited for applications that store only a small amount of data
  - not practical for applications that must store a large amount of data
  - simple operations become cumbersome and inefficient as data increases

Database Management Systems (2)

- A database management system stores data in a database
- A relational database is organized into one or more tables
- Each table holds a collection of related data, organized into rows and columns
  - A row is a complete set of information about a single item, divided into columns
  - Each column is an individual piece of information about the item

Concept of Database



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Example: Coffee table

Each row contains data for a single item.

Description	ProdNum	Price
Bolivian Dark	14-001	8.95
Bolivian Medium	14-002	8.95
Brazilian Dark	15-001	7.95
Brazilian Medium	15-002	7.95
Brazilian Decaf	15-003	8.55
Central American Dark	16-001	9.95
Central American Medium	16-002	9.95
Sumatra Dark	17-001	7.95
Sumatra Decaf	17-002	8.95
Sumatra Medium	17-003	7.95
Sumatra Organic Dark	17-004	11.95
Kona Medium	18-001	18.45
Kona Dark	18-002	18.45
French Roast Dark	19-001	9.65
Galapagos Medium	20-001	6.85
Guatemalan Dark	21-001	9.95
Guatemalan Decaf	21-002	10.45
Guatemalan Medium	21-003	9.95

`Description` Column

`ProdNum` Column

`Price` Column

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Database Management Systems (3)

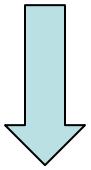
- A primary key is a field (or a set of fields) that contain(s) a unique identifier for each record
  - A primary key can be a single column
  - Or multiple columns together as the key
- Primary key values must be unique
  - Student ID
  - Semester+Year+ClassNumber

Database Management Systems (4)

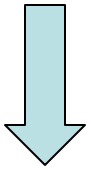
- A *database management system (DBMS)* is software that is specifically designed to work with large amounts of data in an efficient and organized manner
  - Data is stored using the database management system
  - Applications written in Java or other languages communicate with the DBMS rather than manipulate the data directly
  - DBMS carries out instructions and sends the results back to the application

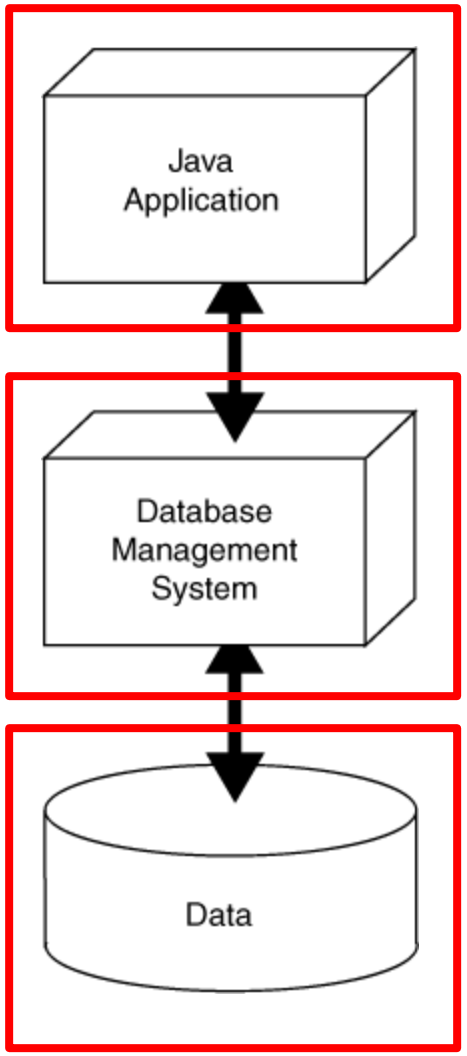
Java Applications Interact with a DBMS

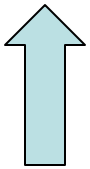
The Application sends a command to the DBMS



The DBMS executes the command on the Data







The DBMS sends the result back to the Application

The Application displays the result to the user

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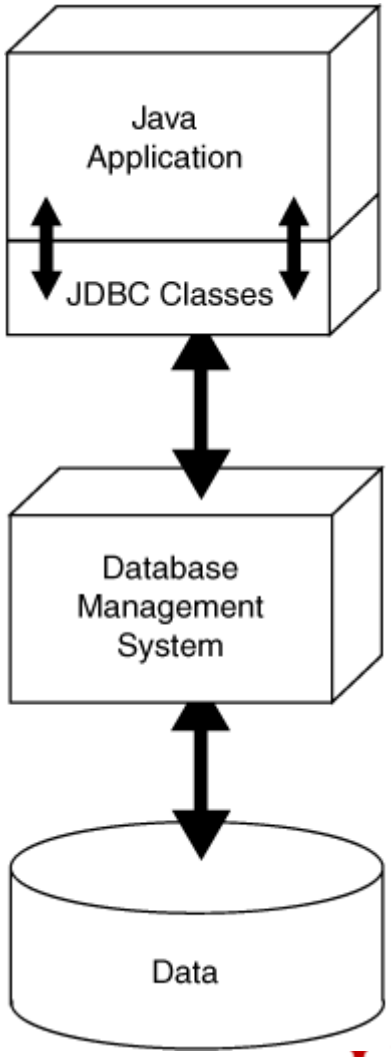
JDBC Provides Connectivity to the DBMS

- JDBC stands for *Java database connectivity*
- It is the technology that makes communication possible between the Java application and DBMS
- The Java API contains numerous JDBC classes that allow your Java applications to interact with a DBMS



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JDBC (1)

- To use JDBC to work with a database you will need a DBMS
  - Java DB
  - Oracle
  - Microsoft SQL Server
  - MySQL

JDBC (2)

- Java comes with a standard set of JDBC classes
  - **`java.sql`** and **`javax.sql`**
- Using JDBC in a Java application requires the following steps
  1. Get a connection to the database
  2. Pass a string containing an SQL statement to the DBMS
  3. If the SQL statement has results to send back, they will be sent back as a result set
  4. When finished working with the database, close the connection

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Getting a Database Connection (1)

- The static **`DriverManager.getConnection`** method is used to get a connection to the database
  - General format of the simplest version:

```
DriverManager.getConnection(DatabaseURL);
```

  - General format if a user name and a password are required:

```
DriverManager.getConnection(DatabaseURL,
                            Username,
                            Password);
```

    - ***`Username`*** is a string containing a valid username
    - ***`Password`*** is a string containing a password
    - ***`DatabaseURL`*** lists the protocol used to access the database

Getting a Database Connection (2)

- ***DatabaseURL*** is a string known as a *database URL*
  - URL stands for uniform resource locator
- A simple database URL has the following general format:

  protocol:subprotocol:databaseName

  - ***protocol*** is the database protocol
    - value is **jdbc** when using JDBC
  - **subprotocol** varies depending on the type of DBMS
    - value is **mysql** when using MySQL
  - **databaseName** is the name of the database, include the URL and port number
- Using MySQL, the URL for the **CoffeeDB** database is:

```
jdbc:mysql://localhost:3306/coffeeShopData
```

Getting a Database Connection (3)

- Using Microsoft SQL Seiver, the URL for the **`CoffeeDB`** database is:

```
jdbc:sqlserver://localhost:1433;databaseName=
CoffeeShopData
```

Getting a Database Connection (4)

- The **`DriverManager.getConnection`** method
  - Searches for and loads a compatible JDBC driver for the database specified by the URL
  - Returns a reference to a **`Connection`** object
    - Should be saved in a variable, so it can be used later
  - Throws an **`SQLException`** if it fails to load a compatible JDBC driver

```
Final String DB_URL ="jdbc:mysql://localhost:3306/coffeeDB";
Connection conn = DriverManager.getConnection(DB_URL);
```

Lab (1)

- CreateDB.java
- TestConnection.java

SQL (1)

- SQL stands for structured query language
  - A standard language for working with database management systems
- Statements or queries are strings passed from the application to the DBMS using API method calls
  - Consists of several key words, used to construct statements known as queries
  - Serve as instructions for the DBMS to carry out operations on its data

SQL (2)

- The **`SELECT`** statement is used to retrieve the rows in a table

  `SELECT` ***`Columns`*** **`FROM`** ***`Table`***

  - *Columns* is one or more column names
  - *Table* is a table name

SQL (3)

- Example 1

```
SELECT Description FROM Coffee
```

- Example 2:

```
SELECT Description, Price FROM Coffee
```

  - Multiple column names are separated with a comma

- Example 3:

```
SELECT * FROM Coffee
```

  - The * character can be used to retrieve all columns in the table

Passing an SQL Statement to the DBMS

- You must get a reference to a **`Statement`** object before you can issue SQL statements to the DBMS
  - A **`Statement`** object has an **`executeQuery`** method that returns a reference to a **`ResultSet`** object
  - A **`ResultSet`** object contains the results of the query

- Example:

```
Connection conn =
DriverManager.getConnection(DB_URL,USER_NAME,PASSWORD);
Statement stmt = conn.createStatement();
String sql = "SELECT Description FROM Coffee";
ResultSet result = stmt.executeQuery(sql);
```

Getting a Row from the `ResultSet` Object (1)

- A **`ResultSet`** object has an internal *cursor*
  - Points to a specific row in the **`ResultSet`**
  - The row to which it points is the *current row*
  - Initially positioned just before the first row
  - Can be moved from row to row to examine all rows

Initially the cursor is positioned just before the first row in the `ResultSet`.

Cursor →

Row 1	Sumatra Organic Dark	17-004	11.95
Row 2	Kona Medium	18-001	18.45
Row 3	Kona Dark	18-002	18.45
Row 4	Guatemalan Decaf	21-002	10.45

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Getting a Row from the `ResultSet` Object (2)

- A **`ResultSet`** object's **`next`** method moves the cursor to the next row in the **`ResultSet`**

```
result.next();
```

  - moves to first row in a newly created **`ResultSet`**
  - moves to the next row each time it is called

After the `ResultSet` object's `next` method is called the first time, the cursor is positioned at the first row.

Cursor →	Row 1	Sumatra Organic Dark	17-004	11.95
	Row 2	Kona Medium	18-001	18.45
	Row 3	Kona Dark	18-002	18.45
	Row 4	Guatemalan Decaf	21-002	10.45

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Getting a Row from the **`ResultSet`** Object (3)

- A **`ResultSet`** object's **`next`** method returns a Boolean value
  - **`true`** if successfully moved to the next row
  - **`false`** if there are no more rows
- A **`while`** loop can be used to move through all the rows of a newly created **`ResultSet`**

```
while (result.next()){
   // Process the current row.
}
```

Getting Columns in a `ResultSet` Object

- You use one of the **`ResultSet`** object's "get" methods to retrieve the contents of a specific column in the current row.

```
System.out.println(result.getString("Description"));
System.out.println(result.getString("ProdNum"));
System.out.println(result.getDouble("Price"));
```

Lab (2)

- TestConnection.java
  - We can add some SELECT statement to query data

Inserting Rows (1)

- In SQL, the INSERT statement inserts a row into a table

```
INSERT INTO TableName VALUES (Value1, Value2, ...)
```

  - TableName is the name of the database table
  - Value1, Value2, ... is a list of column values

- Example:

```
INSERT INTO Coffee
VALUES ('Honduran Dark', '22-001', 8.65)
```

  - Strings are enclosed in single quotes
  - Values appear in the same order as the columns in the table
  - Inserts a new row with the following column values:

```
Description: Honduran Dark
ProdNum: 22-001
Price: 8.65
```

Inserting Rows (2)

- If column order is uncertain, the following general format can be used

```
INSERT INTO TableName
   (ColumnName1, ColumnName2, ...)
VALUES
   (Value1, Value2, ...)
```

  - ColumnName1, ColumnName2, ... is a list of column names
  - Value1, Value2, ... is a list of corresponding column values

- Example:

```
INSERT INTO Coffee
   (ProdNum, Price, Description)
VALUES
   ('22-001', 8.65, 'Honduran Dark')
```

Inserting Rows (3)

- To issue an **`INSERT`** statement, you must get a reference to a **`Statement`** object
  - The **`Statement`** object has an **`executeUpdate`** method
  - Accepts a string containing the **`SQL INSERT`** statement as an argument
  - Returns an **`int`** value for the number of rows inserted

Inserting Rows: Example

```
String sqlStatement = "INSERT INTO Coffee " +
                      "(ProdNum, Price, Description)" +
                      " VALUES " +
                      "('22-001', 8.65, 'Honduran Dark')";

int rows = stmt.executeUpdate(sqlStatement);
```

- rows should contain the value 1, indicating that one row was inserted

Inserting Rows (4)

- We can also use prepared statement for insertion
  - A parameterized query in which placeholders used for parameters and the parameter values supplied at execution time.

Inserting Rows: Example

```
String sqlStatement =
"Insert into Coffee (ProdNum, Description, Price) values (?,?,?)";

PreparedStatement prepStmt = conn.prepareStatement(sqlStatement);

prepStmt.setString(1, prodNum);
prepStmt.setString(2, description);
prepStmt.setDouble(3, price);

int row = prepStmt.executeUpdate();

// prodNum, description, and price are variables with values to be
inserted.
```

Lab (3)

- CoffeeInserter.java
  - The program would allow the user to input the description, product number, and price.
  - Then the program connects to the database, sets up the prepared statement object, and executes the SQL statement.

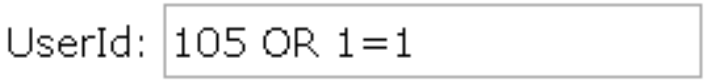
Statement vs. Prepared Statement

- Statement
  - Executing static, simple SQL statements
  - Not accepting input parameters
  - Prone to security issue
- PreparedStatement
  - Executing SQL statements dynamically, with conditions
  - Accepting input parameters
  - More secured

SQL Injection

- Based on 1=1 is Always True
- Example
  - If your code used to validate username/password looked like this

```
sqlStatement = "SELECT * FROM Users WHERE UserId = " +
userIdTextField.getText();
```



  - When the user enters the SQL statement will look like this

```
SELECT * FROM Users WHERE UserId = 105 OR 1=1;
```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Use SQL Parameters for Protection

- Example

```
sqlStatement = "SELECT * FROM Users WHERE
UserId = ?";

PreparedStatement prepStmt =
conn.prepareStatement(sqlStatement);

prepStmt.setString(1, userIdTextField.getText());

prepStmt.executeQuery();
```

Lab (4)

- CustomerFinder.java
  - Use a prepared statement in a query.

Updating an Existing Row

- In SQL, the **UPDATE** statement changes the contents of an existing row in a table

```
UPDATE Table
    SET Column = Value
    WHERE Criteria
```

  - ***Table*** is a table name
  - ***Column*** is a column name
  - ***Value*** is the value to store in the column
  - ***Criteria*** is a conditional expression

- Example:

```
UPDATE Coffee
   SET Price = 9.95
   WHERE Description = 'Galapagos Organic Medium'
```

Updating More Than One Row

- It is possible to update more than one row
- Example:

```
UPDATE Coffee
   SET Price = 12.95
   WHERE Price >= 9.95
```

  - Updates the price of all rows where the current product price is no less than 9.95

- Warning!

```
UPDATE Coffee
   SET Price = 4.95
```

  - Because this statement does not have a **WHERE** clause, it will change the price for every row

Updating Rows with JDBC (1)

- To issue an **`UPDATE`** statement, you must get a reference to a **`Statement`** object
  - The **`Statement`** object has an **`executeUpdate`** method
  - Accepts a string containing the SQL **`UPDATE`** statement as an argument
  - Returns an **`int`** value for the number of rows affected
- Example:

```
String sqlStatement = "UPDATE Coffee " +
                      "SET Price = 9.95" +
                      " WHERE " +
                      "Description = 'Brazilian Decaf'";
int rows = stmt.executeUpdate(sqlStatement);
```

  - **`rows`** indicates the number of rows that were changed

Updating Rows with JDBC (2)

- Similarly, we can use a prepared statement to execute an update statement

```
String sqlStatement = "UPDATE Coffee SET Price = ? WHERE ProdNum = ?";

PreparedStatement prepStmt = conn.prepareStatement(sqlStatement);

prepStmt.setDouble(1, price);
prepStmt.setString(2, prodNum);

int rows = prepStmt.executeUpdate();
```

Lab (5)

- CoffeePriceUpdater.java
  - The program finds a specific product and update its price.
  - It first calls findProduct () to determine whether the record exists. If yes, ask the user to input a new price, and then class updatePrice() to update the price.

Deleting Rows (1)

- In SQL, the **DELETE** statement deletes one or more rows in a table

  DELETE FROM *Table* WHERE *Criteria*

  - **Table** is the table name
  - **Criteria** is a conditional expression

- Example 1:

```
DELETE FROM Coffee WHERE ProdNum = '20-001'
```

  - Deletes a single row in the Coffee table where the product number is 20-001

Deleting Rows (2)

- Warning!

```
DELETE FROM Coffee
```

  - Because this statement does not have a WHERE clause, it will delete every row in the Coffee table

Deleting Rows with JDBC (1)

- To issue a **`DELETE`** statement, you must get a reference to a **`Statement`** object
  - The **`Statement`** object has an **`executeUpdate`** method
  - Accepts a string containing the SQL **`DELETE`** statement as an argument
  - Returns an **`int`** value for the number of rows that were deleted
- Example:

```
String sqlStatement = "DELETE FROM Coffee " +
      "WHERE ProdNum = '20-001'";
int rows = stmt.executeUpdate(sqlStatement);
```

  - **`rows`** indicates the number of rows that were deleted

Deleting Rows with JDBC (1)

- With prepared statement

```
String sqlStatement = "DELETE FROM Coffee WHERE ProdNum = ?";

PreparedStatement prepStmt = conn.prepareStatement(sqlStatement);

prepStmt.setString(1, prodNum);


int rows = prepStmt.executeUpdate();
```

Lab (6)

- CoffeeDeletion.java
  - This program is very similar to CoffeePriceUpdater.java.
  - After calling findProduct() to determine whether the record exists, ask the user whether he/she wants to remove the record. If yes, call deleteCoffee() to remove the record.