JDBC

Objectives

- Learn (a little) about relational database concepts
- Learn (a little) about SQL
- Learn to use the Java database API
  - JDBC

SQL and Relational Databases

SQL Primer

- Two types of commands
  - Data Definition
    - Create Table
    - Drop Table
  - Data Manipulation
    - Select
    - Insert
    - Update
    - Delete

RDB Concepts

- Tables
  - A defined set of columns
  - Having zero or more rows of data
- Primary-Key
  - Those attributes whose values uniquely identify one row from all others
- Foreign-Key
  - Those columns in one table which hold the primary-key from another table
  - Define relationships between rows in different tables

RDB Concepts

- Index
  - A structure providing rapid access to the rows of a table based on the values of its ‘indexed’ columns
  - Applied to the columns which are frequently used to identify the rows of interest
  - Always created for columns in primary-key

Constraints

- Constraints
  - Constrain the values that may be placed in a table
    - PRIMARY KEY
      - Prohibits duplicate values in this column(s) and disallows NULL
    - UNIQUE KEY
      - Prohibits duplicate values in this column(s)
    - FOREIGN KEY
      - Identifies the column(s) migrated as a foreign key and the table migrated from
      - Allows optional specification of a delete rule

The Java Database API: JDBC

JDBC

- Not an acronym
  - Misinterpreted to be Java Database Connectivity
- A set of classes defined in the `java.sql` and `javax.sql` packages
  - Provides a standard mechanism for accessing relational databases that support Structured Query Language (SQL).
  - Provides support for ODBC through a JDBC-ODBC bridge.
  - Other JDBC drivers are preferred

JDBC Driver Types

- Type 1
  - JDBC-ODBC Bridge Technology
- Type 2
  - JNI drivers for C/C++ connection libraries
- Type 3
  - Socket-level Middleware Translator
- Type 4
  - Pure Java-DBMS driver

Type 1 Drivers

- JDBC-ODBC Bridge
  - Translates call into ODBC and redirects to the DBMS’s ODBC driver
  - ODBC must exist on every client
  - Slow – due to translation

Type 2 Drivers

- Native API
  - Java driver makes JNI calls on the DBMS API (usually written in C or C++)
  - Requires client-side code libraries
  - Provided by DBMS vendor
  - Can crash JVMs
  - Fast

Type 3 Drivers

- Middleware Pure Java Driver
  - Process:
    1. JDBC driver translates JDBC calls into a DBMS-independent protocol
    2. Communicates over a socket with a middleware server that translates into native API DBMS calls
  - Single driver provides access to multiple DBMSs
  - No client code need be installed

Type 4 Drivers

- Pure Java Drivers
  - Driver talks directly to the DBMS using Java sockets
  - No Middleware layer needed
  - No client code need be installed

Establishing a Connection

- Connecting to a JDBC Data Source requires:
  - Loading the JDBC driver class
  - Connecting to the data source
  - Specify database as a URL
    - A database URL has the form: jdbc:*subprotocol*:*subname*

Loading Drivers

- Three approaches:
  1. Using DataSource class and JNDI
     - Preferred method
  2. Identify driver classes using system properties
     - When naming service isn’t available
  3. Load driver class explicitly
     - For quick and dirty development
     - Least desirable

Using JNDI

- Configure DataSource in JNDI, then
  - Uses JNDI and **javax.sql.DataSource**

```
Connection conn = null;
InitialContext ctx = new InitialContext();
DataSource ds = (DataSource)ctx.lookup( "jdbc/"+"mySrc" );
try
{
    conn = ds.getConnection();
}
catch( SQLException ex )
{
    ...
```

Using Properties

- Set **jdbc.drivers** property

  -Djdbc.drivers=com.mysql.jdbc.Driver

```
Connection conn = null;
String db = "jdbc:mysql://localhost/EmployeeDB";
String user = "student";
String pass = "student";
try
{
   conn = DriverManager.getConnection( db, user, pass );
}
catch( SQLException ex )
{
   ...
```

Using Explicit Driver

- Load the driver manually

```
Connection conn = null;
String db = "jdbc:mysql://localhost/EmployeeDB";
String driverClassName = "com.mysql.jdbc.Driver";
String user = "student";
String pass = "student";
try
{
     Class.forName( driverClassName );
     conn = DriverManager.getConnection( db, user, pass );
}
catch( Exception ex )
{
   ...
```

Using the Connection

- The **Connection** class provides methods for:
  - Creating statements for execution
  - Controlling the behavior of the connection.
- Virtually all JDBC methods throw **SQLException**

Connection Methods

```
Statement createStatement()

PreparedStatement prepareStatement(String sql)

CallableStatement prepareCall( String sql )

void setAutoCommit( boolean autoCommit )

boolean getAutoCommit()

void commit()

void rollback()

void close()
```

Statement

- Once the statement is created it may be used to execute SQL.

```
ResultSet executeQuery( String sql )
int executeUpdate( String sql )
```

Batch Processing

- Allows processing of multiple statements in one request
  - New in JDBC 2.0

```
void addBatch( String sql )
Void clearBatch()
int[] executeBatch()
```

Executing a Query

```
Connection conn = null;
String db = "jdbc:mysql://localhost/EmployeeDB";
String driverClassName = "com.mysql.jdbc.Driver";
String username = "student";
String password = ”student";
Class.forName( driverClassName );
conn = DriverManager.getConnection( db, user, pass );


Statement stmt = conn.createStatement();
String query = "SELECT employee_name, salary"
             + "  FROM employee"
             + " ORDER BY employee_name";
ResultSet rs = stmt.executeQuery( query );
```

ResultSet

- Provides a mechanism for accessing the results of a query. Provides methods for:
  - Moving through the resultant records.
  - Getting the values out the records.
  - Closing the **ResultSet**.

```
boolean next()
void close()
ResultSetMetaData getMetaData()
```

ResultSetMetadata

- Provides a wide variety of methods for obtaining information about the **ResultSet**, the following are just a few.

```
int getColumnCount()
String getColumnName(int column)
int getColumnType( int column )
boolean wasNull()
```

Getting Values

- Get methods are provided for obtaining values from a record, all the “standard” SQL types are supported.
- Each method:
  - Accepts a single argument
    - Column index (indexes are 1-based, not 0-based)

    -or-

    - Column name
  - Returns the appropriate Java type

SQL-Java Type Mapping

- Methods for retrieving SQL types

SQL Type	Java Type	Method	2.0
ARRAY	**Array**	**getArray**	**x**
BIGINT	**long**	**getLong**	
BINARY	**byte[]**	**getBytes**	
BIT	**boolean**	**getBoolean**	
BLOB	**java.sql.Blob**	**getBlob**	**x**
CHAR	**String**	**getString**	
CLOB	**java.sql.Clob**	**getClob**	**x**
DATE	**java.sql.Date**	**getDate**	
DECIMAL	**java.math.BigDecimal**	**getBigDecimal**	
DOUBLE	**double**	**getDouble**	
FLOAT	**double**	**getDouble**	
INTEGER	**int**	**getInt**	

SQL-Java Type Mapping

SQL Type	Java Type	Method	2.
LONGVARBINARY	**java.io.InputStream**	**getBinaryStream**	0
LONGVARCHAR	**java.io.InputStream**	**getAsciiStream** **getUnicodeStream**	
NUMERIC	**java.math.BigDecimal**	**getBigDecimal**	
REAL	**float**	**getFloat**	
REF	**java.sql.Ref**	**getRef**	**x**
STRUCT	**java.sql.Struct**	**getObject**	**x**
SMALLINT	**short**	**getShort**	
TIME	**java.sql.Time**	**getTime**	
TIMESTAMP	**java.sql.Timestamp**	**getTimestamp**	
TINYINT	**byte**	**getByte**	
VARBINARY	**byte[]**	**getBytes**	
VARCHAR	**String**	**getString**	
<user-defined>	**Object (optional map)**	**getObject**	**x**

Using ResultSet

```
Connection conn = null;
String db = "jdbc:mysql://localhost/EmployeeDB";
String driverClassName = ″com.mysql.jdbc.Driver";

String username = "student";
String password = "student";
Class.forName( driverClassName );
conn = DriverManager.getConnection( db, user, pass );
Statement stmt = conn.createStatement();
String query = "SELECT employee_name, salary"
             + "  FROM employee"
             + " ORDER BY employee_name";
ResultSet rs = stmt.executeQuery( query );

while( rs.next() )
{
   System.out.print( rs.getString("employee_name") );
   System.out.print( rs.getInt("salary") );
}
```

Scrollable ResultSet

- New in JDBC 2.0
  - Scrolling forward and backward
  - Absolute positioning
  - Direct insert of a row
  - Direct update of a row
  - Statement specifies type of **ResultSet** to create

Types of ResultSet

- Scroll type
  - TYPE_FORWARD_ONLY
    - Cursor may move only forward
  - TYPE_SCROLL_INSENSITIVE
    - NOT sensitive to changes made by others
  - TYPE_SCROLL_SENSITIVE
    - Sensitive to changes made by others
- Concurrency
  - CONCUR_READ_ONLY
    - May NOT be updated
  - CONCUR_UPDATABLE
    - May be updated

ResultSet Operations

- Provides a mechanism for accessing the results of a query. Provides methods for:
  - Navigating the resultant records
    - Locating cursor
    - Moving cursor
  - Determining where the cursor is
  - Modifying resultant records
    - Inserting (a special row is provided)
    - Updating
    - Deleting

Navigation Operations

```
boolean previous()
boolean first()
boolean last()
void absolute( int position )
void relative( int rows )
int getRow()
boolean isFirst()
boolean isLast()
boolean isBeforeFirst()
boolean isAfterLast()
```

Modification Operations

```
void moveToInsertRow()
void insertRow()
void updateRow()
int getRow()
void refreshRow()
void updateXxx( String colName, xxx value )
void deleteRow()
```

Obtaining Scrollable ResultSet

```
Connection conn = null;
String db = "jdbc:mysql://localhost/EmployeeDB";
String driverClassName = ″com.mysql.jdbc.Driver";
String username = "student";
String password = "student";
Class.forName( driverClassName );
conn = DriverManager.getConnection( db, user, pass );

Statement stmt;
stmt = conn.createStatement( ResultSet.TYPE_SCROLL_SENSITIVE,
                             ResultSet.CONCUR_UPDATABLE );
String query = "SELECT employee_name, salary"
             + "  FROM employee"
             + " ORDER BY employee_name";
ResultSet rs = stmt.executeQuery( query );
```

Updating via ResultSet

```
...
conn = DriverManager.getConnection( db, user, pass );

String query = "SELECT employee_id, salary"
             + "  FROM employee"
             + " WHERE employee_name = 'Barney Rubble'" );
Statement stmt;
stmt = conn.createStatement( ResultSet.TYPE_SCROLL_SENSITIVE,
                             ResultSet.CONCUR_ UPDATABLE );
rs = stmt.executeQuery( query );
rs.updateInt("salary", 55000 );
rs.updateRow();
...
```

Inserting via ResultSet

```
byte[] thePassword;
...
conn = DriverManager.getConnection( db, user, pass );

String query = "SELECT employee_id, employee_name, salary"
             + "  FROM employee" );
Statement stmt;
stmt = conn.createStatement( ResultSet.TYPE_SCROLL_SENSITIVE,
                             ResultSet.CONCUR_READ_ONLY );
rs.moveToInsertRow();
rs.updateString("employee_name", 'Bambam Rubble' );
rs.updateInt("salary", 25000 );
rs.insertRow();
...
```

Precompiled SQL

- Provides superior performance for queries which are executed repeatedly.
- Queries contain parameter markers to allow parameter replacement for each execution.

Parameter Markers

- Methods are provided for performing parameter substitution.
- Each of the set methods accepts:
  - A first argument that is the parameter index
    - Parameter indexes are 1-based, not 0-based
  - A second argument of the appropriate type
  - Third argument for length on stream methods

Parameter Replacement Methods

- Set of methods for setting parameters

```
setXxx( int paramIndex, xxx value )
```

SQL Type	Java Type	Method	2.0
ARRAY	**Array**	**setArray**	**x**
BIGINT	**long**	**setLong**	
BINARY	**byte[]**	**setBytes**	
BIT	**boolean**	**setBoolean**	
BLOB	**java.sql.Blob**	**setBlob**	**x**
CLOB	**java.sql.Clob**	**setClob**	**x**
DATE	**java.sql.Date**	**setDate**	
DECIMAL	**Object**	**setObject (scale)**	
DOUBLE	**double**	**setDouble**	
FLOAT	**double**	**setFloat**	
INTEGER	**int**	**setInt**	

Parameter Replacement Methods

SQL Type	Java Type	Method	2.0
LONGVARBINARY	java.io.InputStream	setBinaryStream	
LONGVARCHAR	java.io.InputStream	setAsciiStream setUnicodeStream setCharacterStream	
NUMERIC	Java.math.BigDecimal	setBigDecimal	
REF	java.sql.Ref	setRef	x
SMALLINT	short	setShort	
TIME	java.sql.Time	setTime	
TIMESTAMP	java.sql.Timestamp	setTimestamp	
TINYINT	byte	setByte	
VARBINARY	byte[]	setBytes	
VARCHAR	String	setString	
<user-defined>	Object (optional map)	setObject	x

Using Parameter Markers

```
String query = "SELECT employee_name, salary"
             + " FROM employee"
             + " WHERE employee_name = ?";

PreparedStatement ps = con.prepareStatement( query );
.
.
.
ps.setString( 1, "Barney Rubble" );
ResultSet rs = ps.executeQuery();
```

Auto Fields

- Fields automatically populated by the database
  - Typically integer
  - Commonly used to provide unique index
  - Database must provide a means of determining the value of the last generated value
    - Varies by database

      ```
      SELECT LAST_INSERT_ID
      ```

Example

< Review Source Code >

EmployeeDb.java

SQL Backup Slides

Create

- Creates a new table

```
CREATE TABLE table_name
(column_def,... [, constraint_def,...])
```

- Column definition

```
column datatype [[NOT] NULL] [AUTO_INCREMENT]
[PRIMARY KEY]
```

- Constraint definition

```
[CONSTRAINT name]
UNIQUE (column,...) |
PRIMARY KEY (column,...) |
FOREIGN KEY(column,...) REFERENCES ref_tab(column,...)
```

Create Examples

```
CREATE TABLE employee
(employee_id INTEGER AUTO_INCREMENT,
 employee_name VARCHAR(30),
 salary INTEGER NOT NULL,
PRIMARY KEY (employee_id),
UNIQUE KEY(employee_name))
```

```
CREATE TABLE dependent_type
(relationship VARCHAR(10) PRIMARY KEY)
```

```
CREATE TABLE dependent
(employee_id INTEGER NOT NULL,
 dependent_name VARCHAR(30) NOT NULL,
 relationship VARCHAR(10) NOT NULL,
 PRIMARY KEY(employee_id,dependent_name),
 FOREIGN KEY(employee_id) REFERENCES employee(employee_id),
 FOREIGN KEY(relationship) REFERENCES
dependent_type(relationship))
```

Create Index

- Creates an index on a set of columns in a table

```
CREATE [UNIQUE] INDEX index_name
     ON table_name (column,...)
```

Select

- Select a set of information which meets some criteria

```
SELECT [DISTINCT] columns|*
  FROM tables
[WHERE criteria]
[ORDER BY column_list]
[UNION [ALL] select_statement]
```

```
SELECT employee_name, salary
  FROM employee
 WHERE salary > 50000
 ORDER BY salary, employee_name
```

Logical Operators

=	Equal to
>	Greater than
>=	Greater than equal to
<	Less than
<=	Less than equal to
<>	Not equal to
AND	Both conditions are true
OR	Either condition is true
NOT	Returns the opposite condition

SQL Operators

IN(*list*)	Match any of a list of values
LIKE	Match character pattern % represents zero or more characters _ represents any single character
NULL	The null value

Union

- Combines results of two queries
  - Queries must have same number of columns
  - Columns must be of same type
  - Order results of UNION not individual queries

```
SELECT employee_name
  FROM employee
 UNION
SELECT dependent_name
  FROM dependent
 ORDER BY 1
```

Join

- Combine columns from multiple tables
  - Construct a joined row from rows in each table, matching on a column(s) value
  - Use table aliases or table names to specify unique column names

Join Examples

```
SELECT employee_name, dependent_name
  FROM employee, dependent
 WHERE employee.employee_id = dependent.employee_id
 ORDER BY employee_name, dependent_name
```

```
SELECT e.employee_name, d.dependent_name
  FROM employee e, dependent d
 WHERE e.employee_id = d.employee_id
 ORDER BY e.employee_name, d.dependent_name
```

Subquery

- Uses the results of one query as part of another query

```
SELECT employee_name, salary
  FROM employee
 WHERE salary > (SELECT e.salary
                   FROM employee e
                  WHERE e.employee_name
                                    = 'Barney Rubble')
```

Column Functions

- Summarize the contents of an entire column
  - SUM()
  - AVG()
  - MIN()
  - MAX()
  - COUNT() and COUNT(*)

```
SELECT SUM(salary),AVG(salary),MAX(salary),MIN(salary)
  FROM employee
```

Insert

- Adds new rows into a table

```
INSERT INTO table [(column [, column2 ])]
     VALUES (value [, value])|select_statement
```

```
INSERT INTO employee
  VALUES (‘Fred Flintstone’, 55000 )
```

```
INSERT INTO employee ( employee_name, salary )
  VALUES (‘Barney Ruble’, 45000 )
```

Update

- Modifies existing rows

```
UPDATE table
   SET column = value [, column = value]
[WHERE condition]
```

Update Examples

```
UPDATE employee
   SET salary = 50000
 WHERE (employee_id = 1)
```

```
UPDATE employee
   SET salary = 50000
 WHERE employee_id IN (SELECT DISTINCT employee_id
                         FROM employee e
                         WHERE e.employee_name
                                    = 'Barney Rubble')
```

Delete

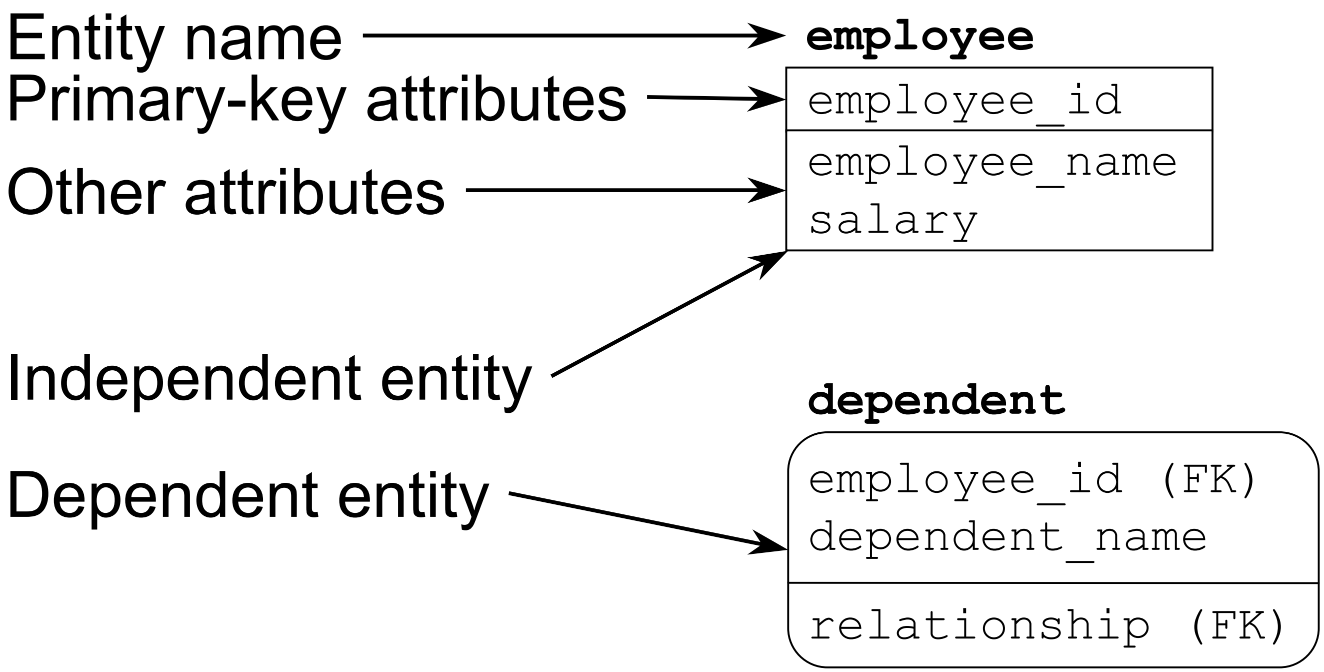
- Remove existing rows

```
DELETE FROM table
[WHERE condition]
```

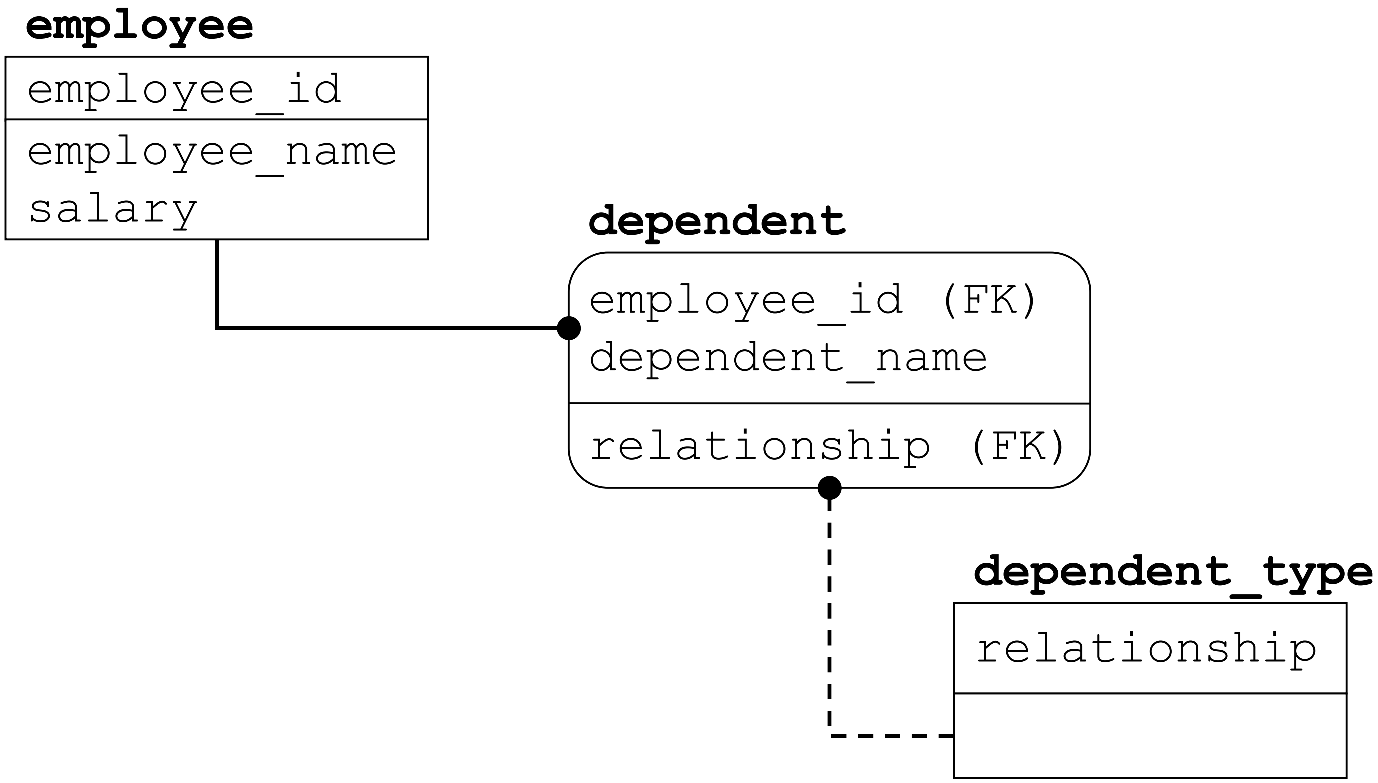
```
DELETE FROM employee
WHERE (employee_id = 0)
```

```
DELETE FROM employee
WHERE employee_id IN (SELECT DISTINCT employee_id
                      FROM employee e
                      WHERE e.employee_name
                            = 'Fred Flintstone')
```

IDEF1X Entity Notation



Example Schema


employee
employee_id
employee_name
salary
dependent
employee_id (FK)
dependent_name
relationship (FK)
dependent_type
relationship