Database-Connection Libraries

CALL-LEVEL INTERFACE

JAVA DATABASE CONNECTIVITY

An Aside: SQL Injection

SQL queries are often constructed by programs.

These queries may take constants from user input.

Careless code can allow rather unexpected queries to be constructed and executed.

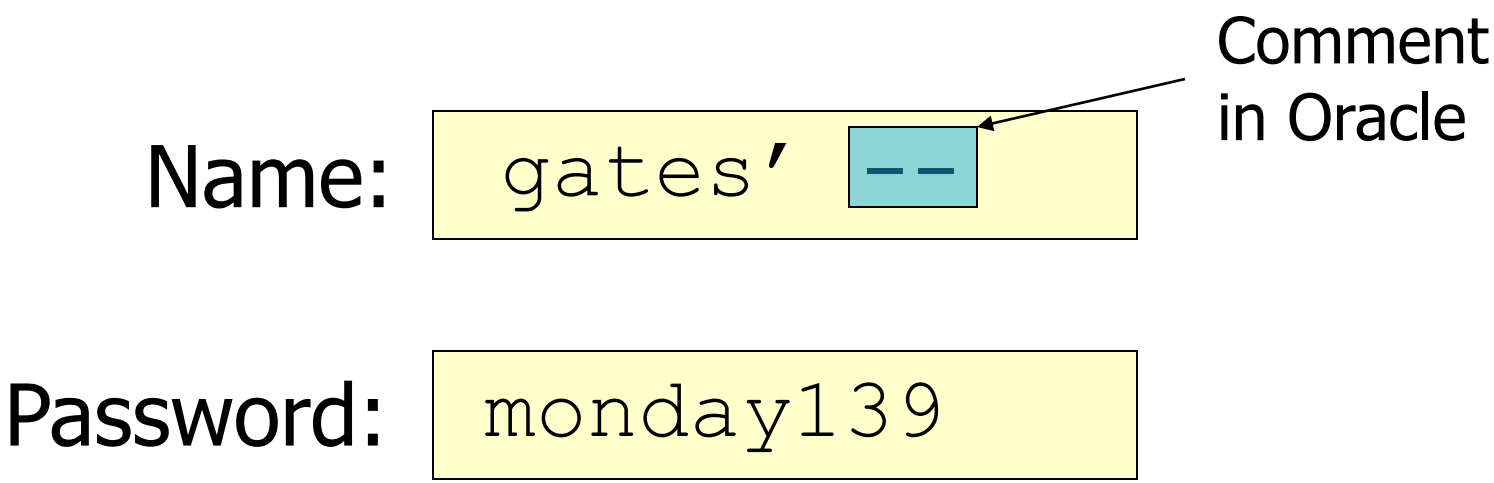
Example: SQL Injection

Relation Accounts(name, passwd, acct).

Web interface: get name and password from user, store in strings *n* and *p*, issue query, display account number.

```
SELECT acct FROM Accounts
WHERE name = :n AND passwd = :p
```

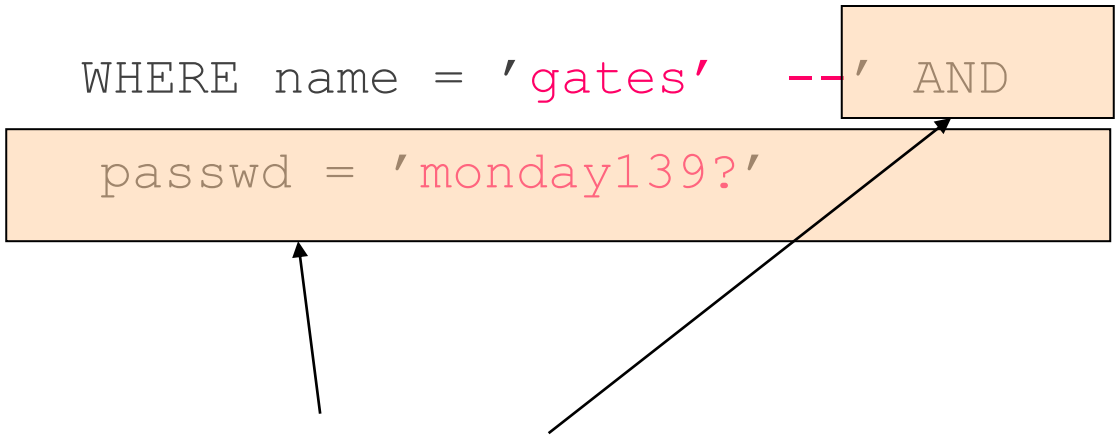
User Types



Your account number is 1234-567

The Query Executed

```
SELECT acct FROM Accounts
WHERE name = 'gates'   --' AND
 passwd = 'monday139?'
```



All treated as a comment

Host/SQL Interfaces Via Libraries

The other approach to connecting databases to conventional languages is to use library calls.

1. C + CLI
2. Java + JDBC
3. PHP + PEAR/DB

Three-Tier Architecture

A common environment for using a database has three tiers of processors:

1. *Web servers* --- talk to the user.
2. *Application servers* --- execute the business logic.
3. *Database servers* --- get what the app servers need from the database.

Layer

Logical separation
How the code is organized

Tier

Physical separation
System infrastructure

Example: Amazon

Database holds the information about products, customers, etc.

Business logic includes things like “what do I do after someone clicks ‘checkout’?”

- Answer: Show the “how will you pay for this?” screen.

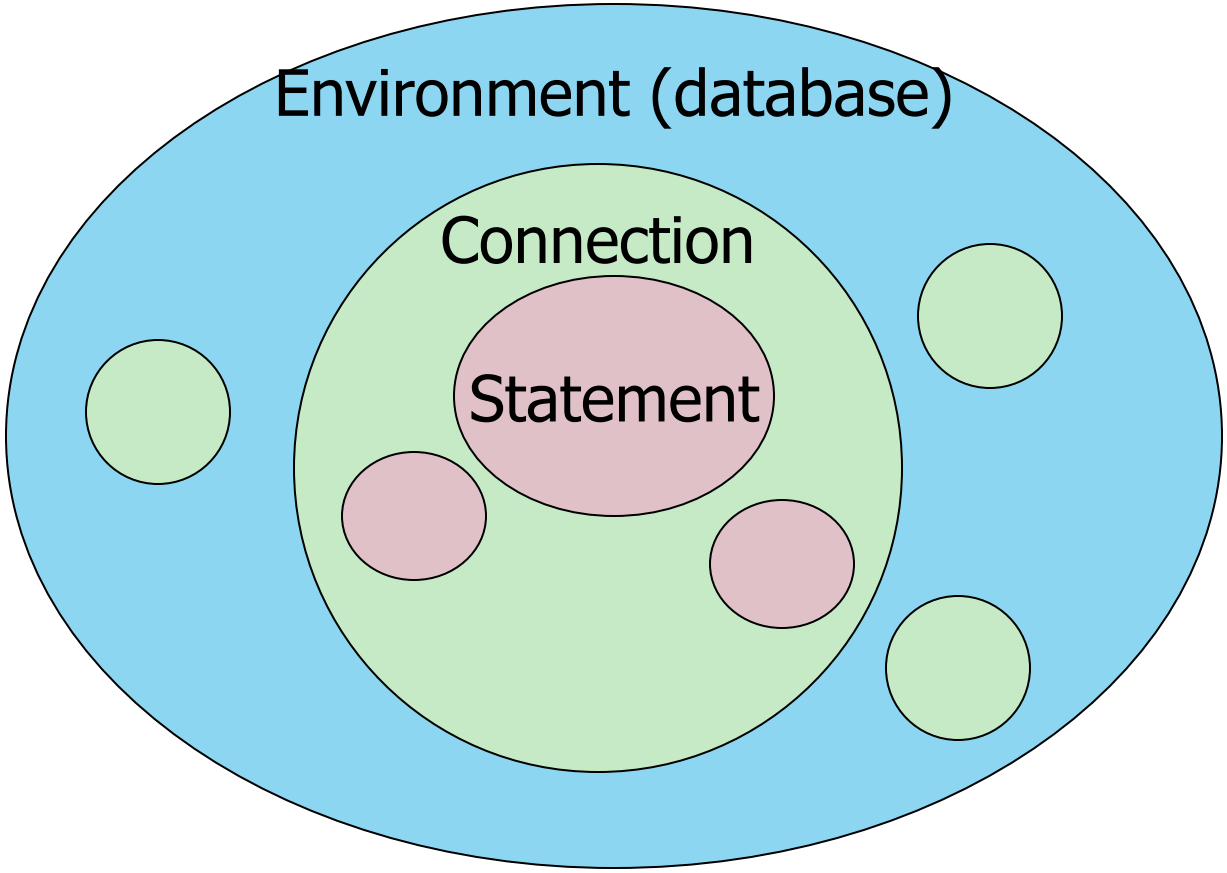
Environments, Connections, Queries

The database is, in many DB-access languages, an *environment*.

Database servers maintain some number of *connections*, so app servers can ask queries or perform modifications.

The app server issues *statements* : queries and modifications, usually.

Diagram to Remember



SQL/CLI

We can use a library of functions.

- The library for C is called SQL/CLI = *Call-Level Interface*.

Data Structures

C connects to the database by structers of the following types:

1. *Environments* : represent the DBMS installation.
2. *Connections* : logins to the database.
3. *Statements* : SQL statements to be passed to a connection.
4. *Descriptions* : records about tuples from a query, or parameters of a statement.

Handles

Function SQLAllocHandle(T,I,O) is used to create these structers, which are called environment, connection, and statement *handles*.

- *T* = type, e.g., SQL_HANDLE_STMT.
- *I* = input handle = struct at next higher level (statement < connection < environment).
- *O* = (address of) output handle.

Example: SQLAllocHandle

```
SQLAllocHandle(SQL_HANDLE_STMT, myCon, &myStat);
```

`myCon` is a previously created connection handle.

`myStat` is the name of the statement handle that will be created.

Preparing and Executing

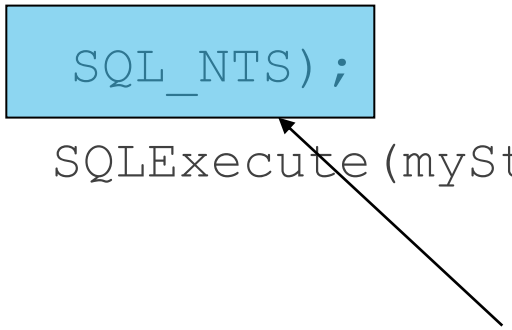
SQLPrepare(H, S, L) causes the string *S*, of length *L*, to be interpreted as a SQL statement;

- the executable statement is placed in statement handle *H*.

SQLExecute(H) causes the SQL statement represented by statement handle *H* to be executed.

Example: Prepare and Execute

```
SQLPrepare(myStat, "SELECT beer, price FROM Sells
 WHERE bar = 'Joe''s Bar'",
  SQL_NTS);
SQLExecute(myStat);
```



This constant says the second argument is a "null-terminated string"; i.e., figure out the length by counting characters.

Direct Execution

If we shall execute a statement *S* only once, we can combine PREPARE and EXECUTE with:

SQLExecuteDirect(H,S,L);

- As before, *H* is a statement handle and *L* is the length of string *S*.

Fetching Tuples

When the SQL statement executed is a query, we need to fetch the tuples of the result.

- A **cursor** is implied by the fact we executed a query; the cursor need not be declared.

SQLFetch(H) gets the next tuple from the result of the statement with handle *H*.

Accessing Query Results

When we fetch a tuple, we need to put the attribute values somewhere.

Each component is bound to a variable by the function SQLBindCol.

- This function has 6 arguments, of which we shall show only 1, 2, and 4:
  - 1 = handle of the query statement.
  - 2 = column number.
  - 4 = address of the variable.

Example: Binding

Suppose we have just done SQLExecute(myStat), where myStat is the handle for query

```
SELECT beer, price FROM Sells
WHERE bar = 'Joe''s Bar'
```

Bind the result to theBeer and thePrice:

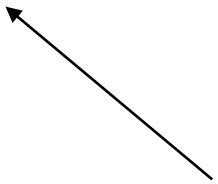
SQLBindCol(myStat, 1, , &theBeer, ,);

SQLBindCol(myStat, 2, , &thePrice, ,);

Example: Fetching

Now, we can fetch all the tuples of the answer by:

```
SQLBindCol(myStat, 1, , &theBeer, , );
SQLBindCol(myStat, 2, , &thePrice, , );
while ( SQLFetch(myStat) != SQL_NO_DATA)
    {
        /* do something with theBeer and
           thePrice */
        SQLBindCol(myStat, 1, , &theBeer, , );
        SQLBindCol(myStat, 2, , &thePrice, , );
    }
```



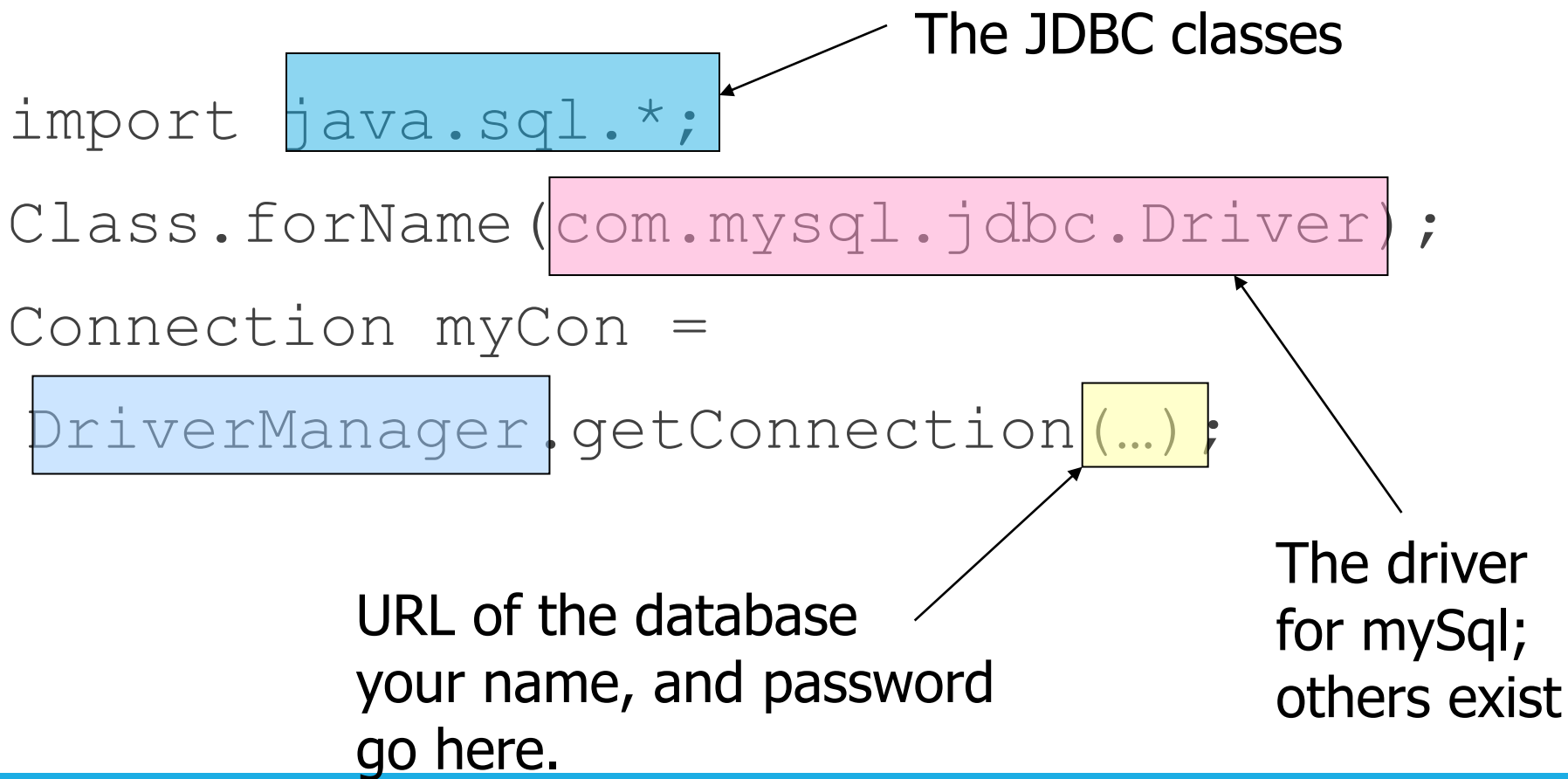
CLI macro representing SQLSTATE = 02000 = "failed to find a tuple."

JDBC

Java Database Connectivity (JDBC) is a library similar to SQL/CLI, but with Java as the host language.

Like CLI, but with a few differences for us to cover.

Making a Connection



Statements

JDBC provides two classes:

1. *Statement* = an object that can accept a string that is a SQL statement and can execute such a string.
2. *PreparedStatement* = an object that has an associated SQL statement ready to execute.

Creating Statements

The Connection class has methods to create Statements and PreparedStatements.

```
Statement stat1 = myCon.createStatement();

PreparedStatement stat2 =

 myCon.createStatement(

        ”SELECT beer, price FROM Sells ” +

        ”WHERE bar = ’Joe’ ’s Bar’ ”

);
```

createStatement with no argument returns a Statement; with one argument it returns a PreparedStatement.

Executing SQL Statements

JDBC distinguishes queries from modifications, which it calls “updates.”

Statement and **PreparedStatement** each have methods executeQuery and executeUpdate.

- For **Statements**: one argument: the query or modification to be executed.
- For **PreparedStatements**: no argument.

Example: Update

stat1 is a **Statement**.

We can use it to insert a tuple as:

```
stat1.executeUpdate(
 ”INSERT INTO Sells ” +
 ”VALUES(’Brass Rail’,’Bud’,3.00)”
);
```

Example: Query

stat2 is a **PreparedStatement** holding the query ”SELECT beer, price FROM Sells WHERE bar = ’Joe’’s Bar’ ”.

executeQuery returns an object of class ResultSet – we’ll examine it later.

The query:

```
ResultSet menu = stat2.executeQuery();
```

Accessing the ResultSet

An object of type *ResultSet* is something like a **cursor**.

Method next() advances the "cursor" to the next tuple.

- The first time next() is applied, it gets the first tuple.
- If there are no more tuples, next() returns the value false.

Accessing Components of Tuples

When a ResultSet is referring to a tuple, we can get the components of that tuple by applying certain methods to the ResultSet.

Method get*X* (*i*), where *X* is some type, and *i* is the component number, returns the value of that component.

- The value must have type *X*.

Example: Accessing Components

menu = ResultSet for query “SELECT beer, price FROM Sells WHERE bar = ’Joe’ ’s Bar’ ”.

Access beer and price from each tuple by:

```
while ( menu.next() ) {
        theBeer = menu.getString(1);
        thePrice = menu.getFloat(2);
       /*something with theBeer and thePrice*/
}
```

Example: Passing Paremeters

```
1) PreparedStatement studiostat =
     myCon.prepareStatement("INSERT INTO
           Studio(name, address) VALUES(?, ?)");

/* get values for variables studioName and
studioAddr from the user */

...

2) studiostat. setString(1, studioName) ;

3) studiostat. setString(2, studioAddr) ;

5) studiostat. ExecuteUpdate();
```

Example: Handling Exceptions

```
try{

...

}catch(SQLException ex){
     System.err.println("SQLException: " +
          ex.getMessage()) ;
     ...

}
```

Actions

Review slides!

Go through code examples „List of Examples” and documentation **:**
http://jdbc.postgresql.org/documentation/93/

Read chapter from the book about SQL libraries (study all the examples).