Database-Connection Libraries

CALL-LEVEL INTERFACE

JAVA DATABASE CONNECTIVITY

PHP PEAR/DB

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

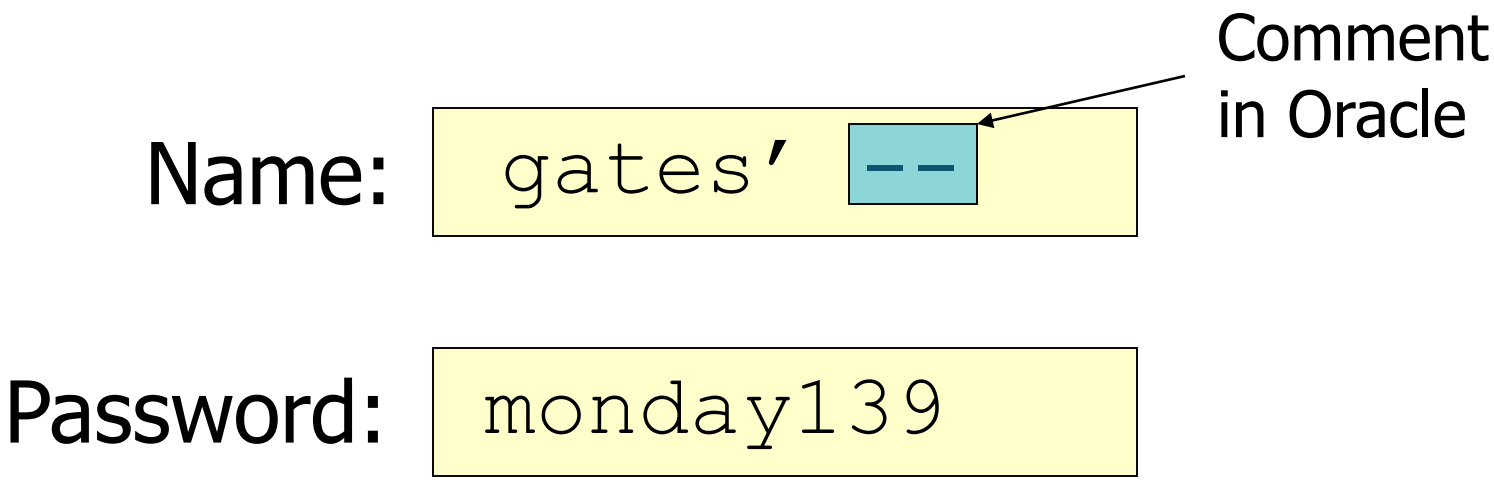
Relation Accounts(name, passwd, acct).

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
```

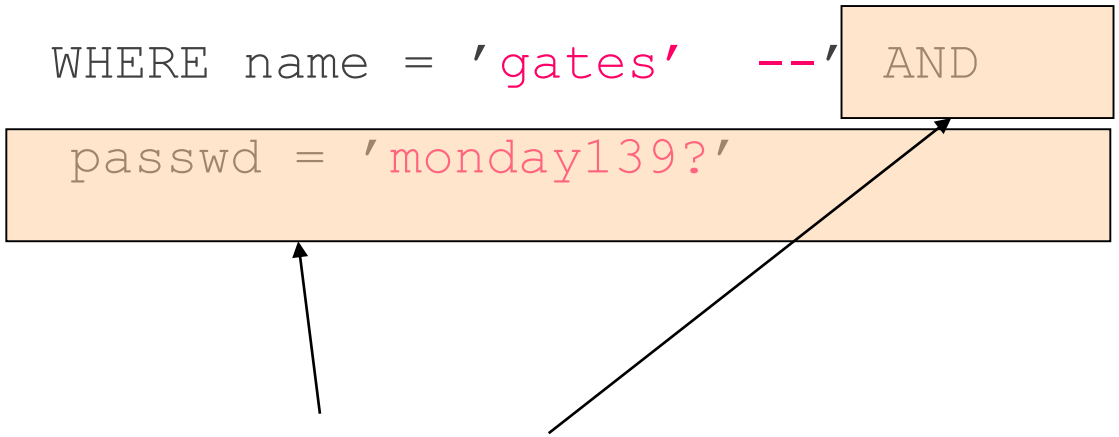
User Types



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.

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.

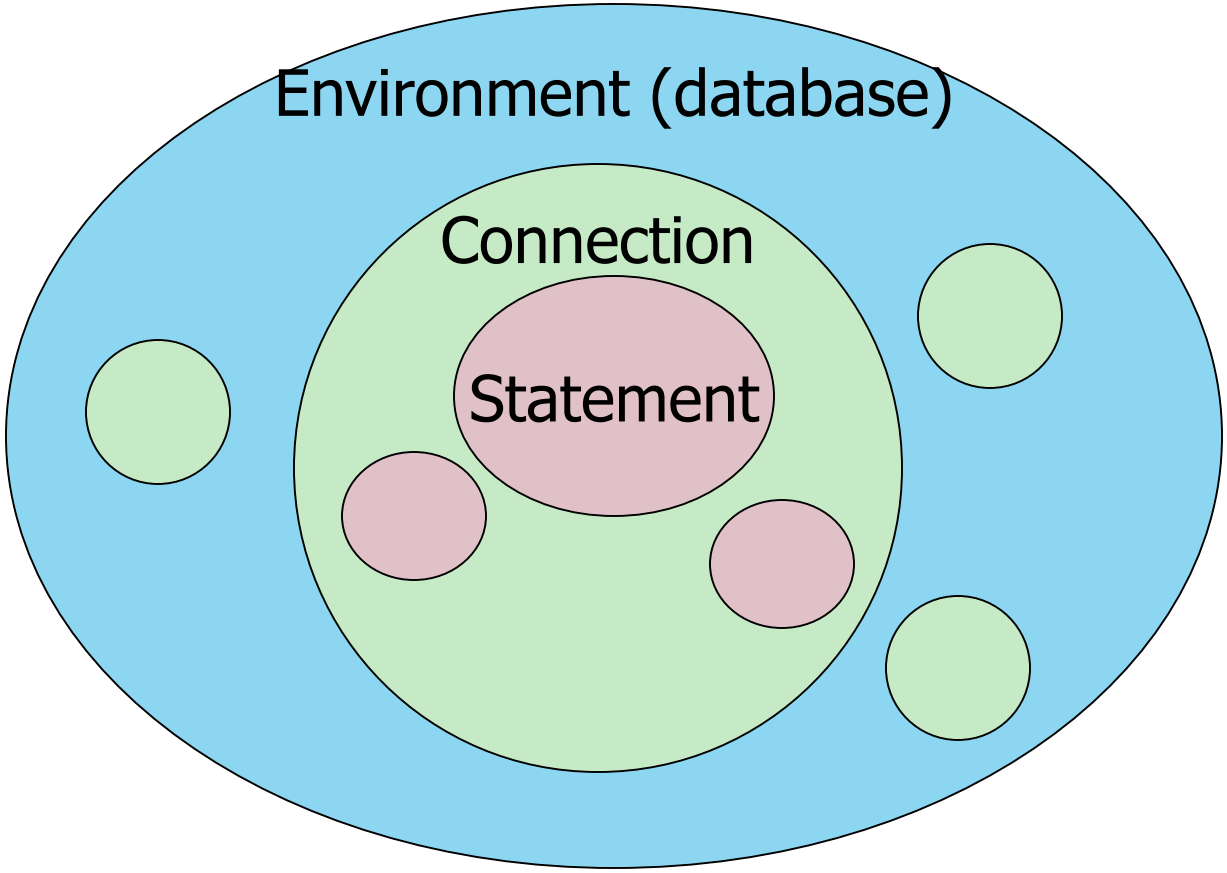
Environments, Connections, Queries

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.

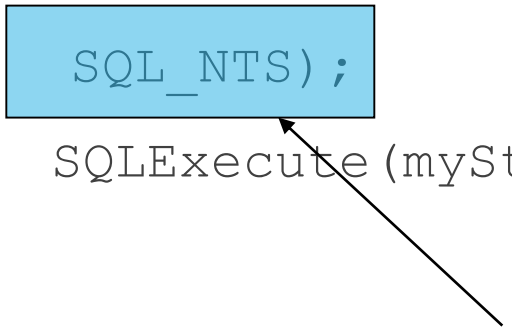
Preparing and Executing

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 */
 }
```

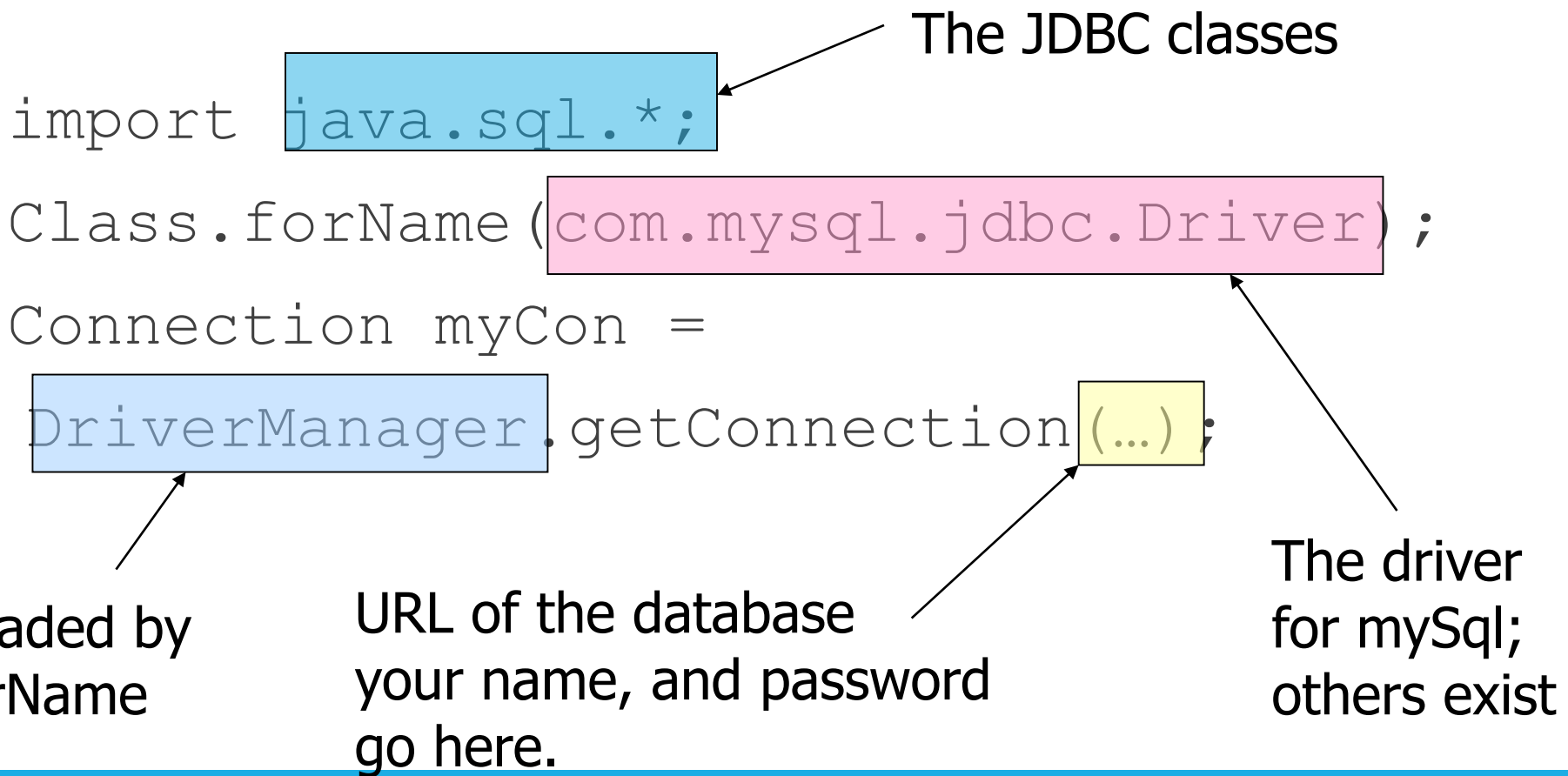
CLI macro representing SQLSTATE = 02000 = "failed to find a tuple."

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()) ;
     ...

}
```

PHP

A language to be used for actions within HTML text.

Indicated by <? PHP code ?>.

DB library exists within *PEAR* (PHP Extension and Application Repository).

- Include with `include(DB.php).`

Variables in PHP

Must begin with $.

OK not to declare a type for a variable.

But you give a variable a value that belongs to a “class,” in which case, methods of that class are available to it.

String Values

PHP solves a very important problem for languages that commonly construct strings as values:

- How do I tell whether a substring needs to be interpreted as a variable and replaced by its value?

PHP solution: Double quotes means replace; single quotes means don't.

Example: Replace or Not?

```
$v = "one hundred dollars";

$sue = 'You owe me $v.';

$joe = "You owe me $v.";
```

Value of $sue is 'You owe me $v', while the value of $joe is 'You owe me one hundred dollars'.

PHP Arrays

Two kinds: *numeric* and *associative*.

Numeric arrays are ordinary, indexed 0,1,…

- Example: $a = array(”Paul”, ”George”, ”John”, ”Ringo”);
  - Then $a[0] is ”Paul”, $a[1] is ”George”, and so on.

Associative Arrays

Elements of an associative array $a are pairs x => y, where *x* is a key string and *y* is any value.

If x => y is an element of $a, then $a[x] is *y*.

Example: Associative Arrays

An environment can be expressed as an associative array, e.g.:

```
$myEnv = array(
"phptype" => "oracle",
"hostspec" => "www.uoit.ca",
"database" => "cs145db",
"username" => "szlichta",
"password" => "notMyPW");
```

Making a Connection

With the DB library imported and the array $myEnv available:

```
$myCon = DB::connect($myEnv);
```

Function connect
in the DB library

Class is Connection
because it is returned
by DB::connect().

Executing SQL Statements

Method query applies to a Connection object.

It takes a string argument and returns a result.

- Could be an error code or the relation returned by a query.

Example: Executing a Query

Find all the bars that sell a beer given by the variable $beer.

```
$beer = 'Bud';
$result = $myCon->query(
  "SELECT bar FROM Sells" .
 „WHERE beer = $beer ;");
```

Concatenation in PHP

Remember this variable is replaced by its value.

Cursors in PHP

The result of a query *is* the tuples returned.

Method fetchRow applies to the result and returns the next tuple, or FALSE if there is none.

Example: Cursors

```
while ($bar =
       $result->fetchRow()) {
 // do something with $bar
}
```

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).