Database Applications Cont.: JDBC and Java Access to DBMS MySQLdb and Python Access to MySQL

University of California, Berkeley

School of Information

IS 257: Database Management

Announcements

- Questions?
- Assignment 2b Due Today
- Assignment 3 (Coming Soon)
  - Next Week: NoSQL

Lecture Outline

- Review:
  - PHP
- Java and JDBC
- SQLite3 (and Python)
- MySQL and Python

Lecture Outline

- Review:
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What is PHP?

- PHP is an acronym for "PHP: Hypertext Preprocessor"
- PHP is a widely-used, open source scripting language
- PHP scripts are executed on the server
- PHP is free to download and use

What is a PHP File?

- PHP files can contain text, HTML, CSS, JavaScript, and PHP code
- PHP code are executed on the server, and the result is returned to the browser as plain HTML
- PHP files have extension ".php"

What can PHP do?

- PHP can generate dynamic page content
- PHP can create, open, read, write, delete, and close files on the server
- PHP can collect form data
- PHP can send and receive cookies
- PHP can add, delete, modify data in your database
- PHP can be used to control user-access
- PHP can encrypt data

Why PHP?

- PHP runs on various platforms (Windows, Linux, Unix, Mac OS X, etc.)
- PHP is compatible with almost all servers used today (Apache, IIS, etc.)
- PHP supports a wide range of databases
- PHP is free. Download it from the official PHP resource: www.php.net
- PHP is easy to learn and runs efficiently on the server side

PHP Hello World

```
<!DOCTYPE html>
<html>
<body>

<h1>My first PHP page</h1>

<?php
echo "Hello World!";
?>

</body>
</html>
```

PHP Combined with MySQL

- DBMS interface appears as a set of functions:

```
<HTML><BODY>
<?php
mysql_connect(“localhost”, “usename”, “password”);
mysql_select_db(“mydb”);
$result = mysql_query(“SELECT * FROM employees”);
 while ($r = mysql_fetch_array($result,MYSQL_ASSOC)) {

            printf("<center><H2>%s",$r[”LAST_NAME"]);

printf(”, %s</H2></center> ",$r[”FIRST_NAME"]);

}
?></BODY></HTML>
```

Mysqli – an enhanced interface

```
include 'msqlini.php';
$mysqli = new mysqli($host,$user,$pw,$dbname);
if ($mysqli->connect_error) {
   echo "Failed to connect to MySQL: (" . $mysqli->connect_errno . ") " .
            $mysqli->connect_error;}
$cust_id = $_GET["cust_id"];
$cust_id = mysql_real_escape_string($cust_id);

/* start first prepared statement */
$stmt = $mysqli->stmt_init();
if ($stmt->prepare("SELECT * FROM DIVECUST where Customer_No= ? ")) {
  if (!$stmt->bind_param("i", $cid)) {
    echo "Binding parameters failed: (" . $stmt->errno . ") " . $stmt->error;
  }
  $cid = $cust_id;
  if (!$stmt->execute()) {
      echo "Execute failed: (" . $stmt->errno . ") " . $stmt->error;
  }
  $stmt->bind_result($custid,$name,$street,$city,$state,$zip,$country,$phone,
$contact);
```

Connecting to returned values

```
if ($stmt->prepare("SELECT * FROM DIVECUST where Customer_No= ? ")) {

  if (!$stmt->bind_param("i", $cid)) {
    echo "Binding parameters failed: (" . $stmt->errno . ") " . $stmt->error;
  }
  $cid = $cust_id;

  if (!$stmt->execute()) {
       echo "Execute failed: (" . $stmt->errno . ") " . $stmt->error;
  }
  $stmt->bind_result($custid,$name,$street,$city,$state,$zip,$country,$phone,
$contact);

  while ($stmt->fetch()) {
    echo "<br>Customer ID: $custid";
    echo "<br>Name: <font size=+1><b>$name</b></font>";
    echo "<br>Street: $street";
    echo "<br>City: $city";
    echo "<br>State: $state";
    echo "<br>ZIP: $zip";
    echo "<br>Country: $country";
    echo "<br>Phone: $phone";
    echo "<br>Date of first contact: $contact";
  }
  $stmt->close();
}
```

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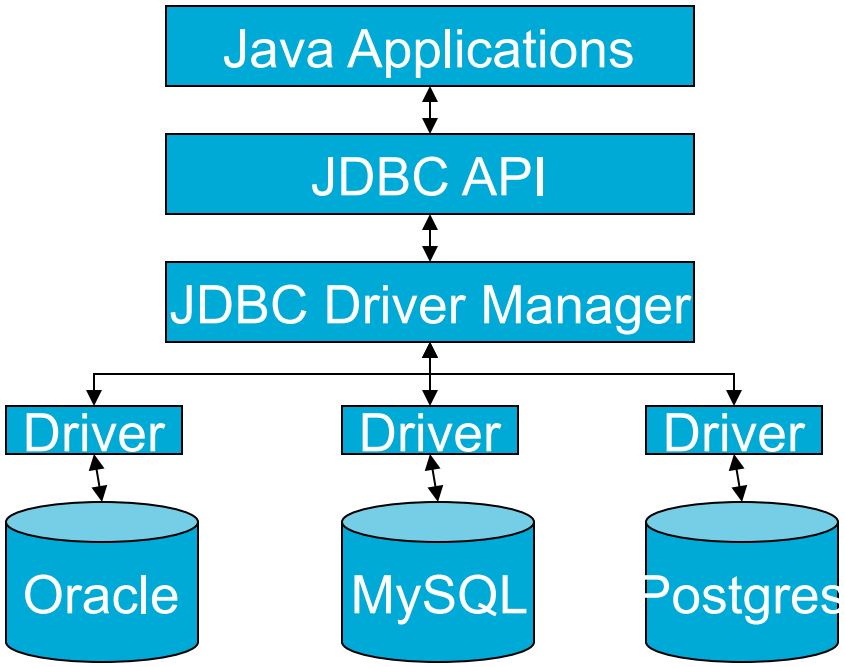
Java and JDBC

- Java was probably the high-level language used in most instruction and development in recent years.
- One of the earliest “enterprise” additions to Java was JDBC
- JDBC is an API that provides a mid-level access to DBMS from Java applications
- Intended to be an open cross-platform standard for database access in Java
- Similar in intent to Microsoft’s ODBC

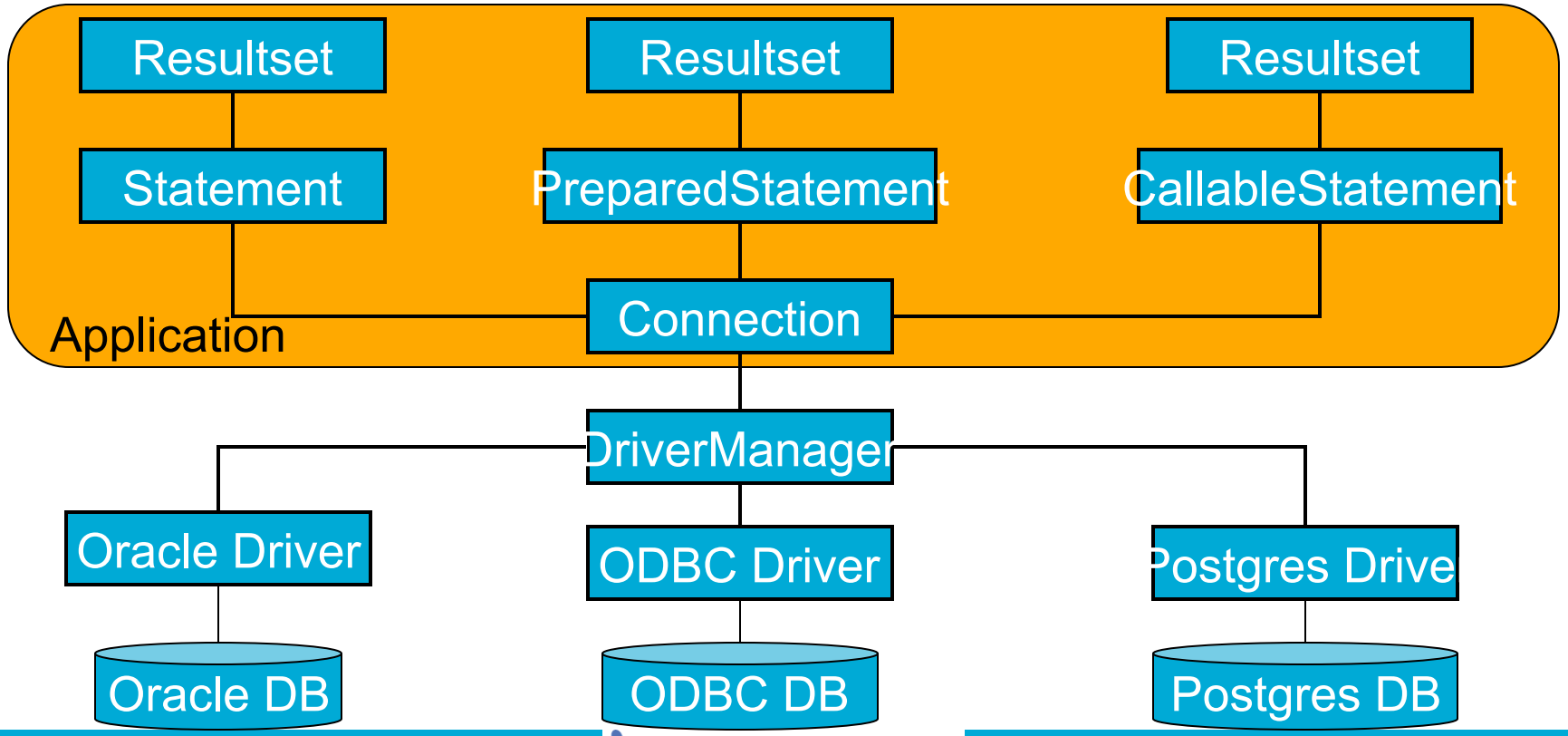
JDBC Architecture

- The goal of JDBC is to be a generic SQL database access framework that works for any database system with no changes to the interface code



JDBC

- Provides a standard set of interfaces for any DBMS with a JDBC driver – using SQL to specify the databases operations.



JDBC Simple Java Implementation

```
import java.sql.*;

public class JDBCTestMysqlHarbinger {

    public static void main(java.lang.String[] args) {
            try {
                // this is where the driver is loaded
                Class.forName("com.mysql.jdbc.Driver").newInstance();

            }
            catch (InstantiationException i) {
                System.out.println("Unable to load driver Class");
                return;
            }
            catch (ClassNotFoundException e) {
                System.out.println("Unable to load driver Class");
                return;
            }
            catch (IllegalAccessException e) {
```

JDBC Simple Java Impl.

```
        try {
//All DB accees is within the try/catch block...
Connection con = DriverManager.getConnection("jdbc:mysql://localhost
                                /ray?user=ray&password=XXXXXXX");
// Do an SQL statement...
Statement stmt = con.createStatement();
ResultSet rs = stmt.executeQuery("SELECT name FROM DIVECUST");
```

JDBC Simple Java Impl.

```
    // show the Results...
    while(rs.next()) {

            System.out.println(rs.getString("Name"));
            System.out.println("");
    }

    // Release the db resources...
    rs.close();
    stmt.close();
    con.close();
}
catch (SQLException se) {
    // inform user of errors...
     System.out.println("SQL Exception: " + se.getMessage());
            se.printStackTrace(System.out);
}
```

JDBC

- Once a connection has been made you can create three different types of statement objects
- Statement
  - The basic SQL statement as in the example
- PreparedStatement
  - A pre-compiled SQL statement
- CallableStatement
  - Permits access to stored procedures in the Database

JDBC Resultset methods

- Next() to loop through rows in the resultset
- To access the attributes of each row you need to know its type, or you can use the generic “getObject()” which wraps the attribute as an object

JDBC "GetXXX()" methods

SQL data type	Java Type	GetXXX()
CHAR	String	getString()
VARCHAR	String	getString()
LONGVARCHAR	String	getString()
NUMERIC	Java.math. BigDecimal	GetBigDecimal()
DECIMAL	Java.math. BigDecimal	GetBigDecimal()
BIT	Boolean	getBoolean()
TINYINT	Byte	getByte()

JDBC GetXXX() Methods

SQL data type	Java Type	GetXXX()
SMALLINT	Integer (short)	getShort()
INTEGER	Integer	getInt()
BIGINT	Long	getLong()
REAL	Float	getFloat()
FLOAT	Double	getDouble()
DOUBLE	Double	getDouble()
BINARY	Byte[]	getBytes()
VARBINARY	Byte[]	getBytes()
LONGVARBINARY	Byte[]	getBytes()

JDBC GetXXX() Methods

SQL data type	Java Type	GetXXX()
DATE	java.sql.Date	getDate()
TIME	java.sql.Time	getTime()
TIMESTAMP	Java.sql.Timestamp	getTimeStamp()

Large Object Handling

- Large binary data can be read from a resultset as streams using:
  - getAsciiStream()
  - getBinaryStream()
  - getUnicodeStream()

```
ResultSet rs = stmt.executeQuery("SELECT IMAGE FROM PICTURES WHERE
                                        PID = 1223"));
if (rs.next()) {
        BufferedInputStream gifData = new BufferedInputSteam(
                                                rs.getBinaryStream("IMAGE"));
        byte[] buf = new byte[4*1024]; // 4K buffer
        int len;
        while ((len = gifData.read(buf,0,buf.length)) != -1) {
                out.write(buf, 0, len);
        }
}
```

JDBC Metadata

- There are also methods to access the metadata associated with a resultSet
  - ResultSetMetaData rsmd = rs.getMetaData();
- Metadata methods include…
  - getColumnCount();
  - getColumnLabel(col);
  - getColumnTypeName(col)

JDBC access to other DBMS

- The basic JDBC interface is the same, the only differences are in how the drivers are loaded…

```
public class JDBCTestMysql {
    public static void main(java.lang.String[] args) {
            try {
                // this is where the driver is loaded
                //Class.forName("com.mysql.jdbc.Driver").newInstance();
                DriverManager.registerDriver(new OracleDriver());
            }
            catch (InstantiationException i) {
                System.out.println("Unable to load driver Class");
                return;
            }
            catch (ClassNotFoundException e) {
                System.out.println("Unable to load driver Class"); …
```

JDBC for MySQL

```
try {
   //All DB access is within the try/catch block...
   // make a connection to MySQL on Dream
   Connection con = DriverManager.getConnection("jdbc:oracle:thin:
            @dream.sims.berkeley.edu:1521:dev","ray", "XXXXXX");
  //Connection con = DriverManager.getConnection(
  // "jdbc:mysql://localhost/MyDatabase?user=MyLogin&password=MySQLPW");
  // Do an SQL statement…
       Statement stmt = con.createStatement();
       ResultSet rs = stmt.executeQuery("SELECT NAME FROM DIVECUST");
```

- Otherwise everything is the same as in the MySQL example
- For connecting to the machine you are running the program on, you can use “localhost” instead of the machine name

Demo – JDBC for MySQL

- Demo of JDBC code on Harbinger
- Code will be available on class web site

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Python and MySQL

- Python has a standard for database interfaces called the Python DB-API. Most Python database interfaces adhere to this standard.
- You can choose the right database for your application. Python Database API supports a wide range of database servers including MySQL, PostgreSQL, Microsoft SQL Server, Oracle, Sybase, etc.

SQLite3

- We have already mentioned the SQLite3 interface, which is an example of the DB-API
- Today we will look at it in a bit more detail, and see how an embedded DBMS might be used in your applications

SQLite3

- Light-weight implementation of a relational DBMS (~340Kb)
  - Includes most of the features of full DBMS
  - Intended to be embedded in programs
- Available on iSchool servers and for other machines as open source
- Used as the data manager in iPhone apps and Firefox (among many others)
- Databases are stored as files in the OS

SQLite3 Data types

- SQLite uses a more generic dynamic type system. In SQLite, the datatype of a value is associated with the value itself, not with its container
- Types are:
  - **NULL**: The value is a NULL value.
  - **INTEGER**: The value is a signed integer, stored in 1, 2, 3, 4, 6, or 8 bytes depending on the magnitude of the value
  - **REAL**: The value is a floating point value, stored as an 8-byte IEEE floating point number.
  - **TEXT**. The value is a text string, stored using the database encoding (UTF-8, UTF-16BE or UTF-16LE). (default max 1,000,000,000 chars)
  - **BLOB**. The value is a blob of data, stored exactly as it was input.

SQLite3 Command line

```
[dhcp137:~] ray% sqlite3 test.db
SQLite version 3.6.22
Enter ".help" for instructions
Enter SQL statements terminated with a ";"
sqlite> .tables
sqlite> create table stuff (id int, name varchar(30),address varchar(50));
sqlite> .tables
stuff
sqlite> insert into stuff values (1,'Jane Smith',"123 east st.");
sqlite> select * from stuff;
1|Jane Smith|123 east st.
sqlite> insert into stuff values (2, 'Bob Jones', '234 west st.');
sqlite> insert into stuff values (3, 'John Smith', '567 North st.');
sqlite> update stuff set address = "546 North st." where id = 1;
sqlite> select * from stuff;
1|Jane Smith|546 North st.
2|Bob Jones|234 west st.
3|John Smith|567 North st.
```

Wildcard searching

```
sqlite> select * from stuff where name like '%Smith%';
1|Jane Smith|546 North st.
3|John Smith|567 North st.
sqlite> select * from stuff where name like 'J%Smith%';
1|Jane Smith|546 North st.
3|John Smith|567 North st.
sqlite> select * from stuff where name like 'Ja%Smith%';
1|Jane Smith|546 North st.
sqlite> select * from stuff where name like 'Jones';
sqlite> select * from stuff where name like '%Jones';
2|Bob Jones|234 west st.
sqlite> select name from stuff
   ...> ;
Jane Smith
Bob Jones
John Smith
sqlite>
```

Create backups

```
sqlite> .dump
PRAGMA foreign_keys=OFF;
BEGIN TRANSACTION;
CREATE TABLE stuff (id int, name varchar(30),address varchar(50));
INSERT INTO "stuff" VALUES(1,'Jane Smith','546 North st.');
INSERT INTO "stuff" VALUES(2,'Bob Jones','234 west st.');
INSERT INTO "stuff" VALUES(3,'John Smith','567 North st.');
COMMIT;
sqlite> .schema
CREATE TABLE stuff (id int, name varchar(30),address varchar(50));
```

Creating Tables from Tables

```
sqlite> create table names as select name, id from stuff;
sqlite> .schema
CREATE TABLE names(name TEXT,id INT);
CREATE TABLE stuff (id int, name varchar(30),address varchar(50));
sqlite> select * from names;
Jane Smith|1
Bob Jones|2
John Smith|3
sqlite> create table names2 as select name as xx, id as key from stuff;
sqlite> .schema
CREATE TABLE names(name TEXT,id INT);
CREATE TABLE names2(xx TEXT,"key" INT);
CREATE TABLE stuff (id int, name varchar(30),address varchar(50));
sqlite> drop table names2;
sqlite> .schema
CREATE TABLE names(name TEXT,id INT);
CREATE TABLE stuff (id int, name varchar(30),address varchar(50));
```

Using SQLite3 from Python

- SQLite is available as a loadable python library
  - You can use any SQL commands to create, add data, search, update and delete

SQLite3 from Python

```
[dhcp137:~] ray% python
Python 2.5.1 (r251:54869, Apr 18 2007, 22:08:04)
[GCC 4.0.1 (Apple Computer, Inc. build 5367)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> import sqlite3
>>> sqlite3.version
'2.3.2'
>>> sqlite3.sqlite_version
'3.3.14'
>>>
```

SQLite3 from Python

```
[dhcp137:~] ray% python
Python 2.5.1 (r251:54869, Apr 18 2007, 22:08:04)
[GCC 4.0.1 (Apple Computer, Inc. build 5367)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> import sqlite3 as lite
>>> import sys
>>> con = None
>>> try:
...     con = lite.connect('newtest.db')
...     cur = con.cursor()
...     cur.execute('SELECT SQLITE_VERSION()')
...     data = cur.fetchone()
...     print "SQLite version: %s" % data
... except lite.Error, e:
...     print "Error %s:" % e.args[0]
...     sys.exit(1)
... finally:
...     if con:
...             con.close()
...
<sqlite3.Cursor object at 0x46eb90>
SQLite version: 3.3.14
>>>
```

SQLite3 from Python

```
#!/usr/bin/python2.7
# -*- coding: utf-8 -*-
import sqlite3 as lite
import sys
# our data is defined as a tuple of tuples…
cars = (
        (1, 'Audi', 52642),
        (2, 'Mercedes', 57127),
        (3, 'Skoda', 9000),
        (4, 'Volvo', 29000),
        (5, 'Bentley', 350000),
        (6, 'Hummer', 41400),
        (7, 'Volkswagen', 21600)
)
con = lite.connect('newtest.db')
with con:
        cur = con.cursor()
        cur.execute("DROP TABLE IF EXISTS Cars")
        cur.execute("CREATE TABLE Cars(Id INT, Name TEXT, Price INT)")
        cur.executemany("INSERT INTO Cars VALUES(?, ?, ?)", cars)
```

Another Example

```
#!/bin/env python
# -*- coding: utf-8 -*-
import sqlite3 as lite
import sys

con = lite.connect(':memory:')

with con:
        cur = con.cursor()
        cur.execute("CREATE TABLE Friends(Id INTEGER PRIMARY KEY,
                        Name TEXT);")
        cur.execute("INSERT INTO Friends(Name) VALUES ('Tom');")
        cur.execute("INSERT INTO Friends(Name) VALUES ('Rebecca');")
        cur.execute("INSERT INTO Friends(Name) VALUES ('Jim');")
        cur.execute("INSERT INTO Friends(Name) VALUES ('Robert');")

        lid = cur.lastrowid
        print "The last Id of the inserted row is %d" % lid
```

Retrieving Data

```
#!/bin/env python
# -*- coding: utf-8 -*-

import sqlite3 as lite
import sys

#connect to the cars database…
con = lite.connect('newtest.db')

with con:
        cur = con.cursor()
        cur.execute("SELECT * FROM Cars")
        rows = cur.fetchall()
        for row in rows:
                print row
```

```
ray% python2.7 retrnewtest.py
(1, u'Audi', 52642)
(2, u'Mercedes', 57127)
(3, u'Skoda', 9000)
(4, u'Volvo', 29000)
(5, u'Bentley', 350000)
(6, u'Hummer', 41400)
(7, u'Volkswagen', 21600)
(8, u'Citroen', 21000)
ray%
```

Updating data

```
cur.execute("UPDATE Cars set Price = 450000 where Name = 'Bentley'")

cur.execute("SELECT * FROM Cars")
rows = cur.fetchall()
for row in rows:
        print row
```

```
(1, u'Audi', 52642)
(2, u'Mercedes', 57127)
(3, u'Skoda', 9000)
(4, u'Volvo', 29000)
(5, u'Bentley', 450000)
(6, u'Hummer', 41400)
(7, u'Volkswagen', 21600)
(8, u'Citroen', 21000)
ray%
```

Add another row…

```
[dhcp137:~] ray% python2.7
Python 2.7.2 (default, Oct 11 2012, 20:14:37)
[GCC 4.2.1 Compatible Apple Clang 4.0 …
>>> import sqlite3 as lite
>>> import sys
>>>
>>> con = lite.connect('newtest.db')
>>>
>>> with con:
...     cur = con.cursor()
...     cur.execute("INSERT INTO Cars VALUES(8,'Citroen',21000)")
...
<sqlite3.Cursor object at 0x107fafc00>
>>>
```

From the SQLite3 command line

```
[dhcp137:~] ray% sqlite3 newtest.db
SQLite version 3.6.22
Enter ".help" for instructions
Enter SQL statements terminated with a ";"
sqlite> select * from cars;
1|Audi|52642
2|Mercedes|57127
3|Skoda|9000
4|Volvo|29000
5|Bentley|350000
6|Hummer|41400
7|Volkswagen|21600
8|Citroen|21000
sqlite>
```

INSERT more data…

```
sqlite> select * from cars;
1|Audi|52642
2|Mercedes|57127
3|Skoda|9000
4|Volvo|29000
5|Bentley|450000
6|Hummer|41400
7|Volkswagen|21600
8|Citroen|21000
10|Audi|51000
11|Mercedes|55000
12|Mercedes|56300
13|Volvo|31500
14|Volvo|31000
15|Audi|52000
17|Hummer|42400
16|Hummer|42400
```

Use Aggregates to summarize data

```
#!/usr/bin/python2.7
# -*- coding: utf-8 -*-
import sqlite3 as lite
import sys

con = lite.connect('newtest.db')
with con:
        cur = con.cursor()
        cur.execute("SELECT Name, AVG(Price)
                                FROM Cars GROUP BY Name")
        rows = cur.fetchall()
        for row in rows:
                print row
```

```
ray% python2.7 aggnewtest.py
(u'Audi', 51880.666666666664)
(u'Bentley', 450000.0)
(u'Citroen', 21000.0)
(u'Hummer', 42066.666666666664)
(u'Mercedes', 56142.333333333336)
(u'Skoda', 9000.0)
(u'Volkswagen', 21600.0)
(u'Volvo', 30500.0)
```

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MySQLdb

- MySQLdb is a DB-API for MySQL
- The basic setup is fairly simple…
  - Pip install MySQL-python
  - Conda install mysql-python
- Or, if on harbinger it is already installed
- To use the interface…

MySQLdb

```
#!/usr/bin/python

import MySQLdb

# Open database connection
db = MySQLdb.connect("ischool.berkeley.edu","ray",”YOURPW","ray" )

# prepare a cursor object using cursor() method
cursor = db.cursor()

# execute SQL query using execute() method.
cursor.execute("SELECT VERSION()")

# Fetch a single row using fetchone() method.
data = cursor.fetchone()

print "Database version : %s " % data

# disconnect from server
db.close()
```

MySQLdb

```
#!/usr/bin/python
import MySQLdb
…
cursor = db.cursor()
# Make a string of SQL commands…
sql = "SELECT * FROM DIVECUST"

try:
   # Execute the SQL command in a try/except in case of failure
   cursor.execute(sql)
   # Fetch all the rows in a list of lists.
   results = cursor.fetchall()
   for row in results:
      custno = row[0]
      custname = row[1]
      street = row[2]
      city = row[3]
      state = row[4]
      zip = row[5]
      country = row[6]
      # Now print fetched result
      print "%s : %s, %s, %s, %s %s" % \
            (custname, street, city, state, zip, country)
except:
   print "Error: unable to fetch data”

# disconnect from server
db.close()
```

Can run any SQL…

```
#!/usr/bin/python
import MySQLdb
# Open database connection
db = MySQLdb.connect("localhost","testuser","test123","TESTDB" )

# prepare a cursor object using cursor() method
cursor = db.cursor()

# Drop table if it already exist using execute() method.
cursor.execute("DROP TABLE IF EXISTS EMPLOYEE")

# Create table as per requirement
sql = """CREATE TABLE EMPLOYEE (
         FIRST_NAME  CHAR(20) NOT NULL,
         LAST_NAME  CHAR(20),
         AGE INT,
         SEX CHAR(1),
         INCOME FLOAT )"""
cursor.execute(sql)

# disconnect from server
db.close()
```

MySQLdb

```
#!/usr/bin/python

import MySQLdb

# Open database connection
db = MySQLdb.connect("localhost","testuser","test123","TESTDB" )

# prepare a cursor object using cursor() method
cursor = db.cursor()

# Prepare SQL query to INSERT a record into the database.
sql = """INSERT INTO EMPLOYEE(FIRST_NAME,
        LAST_NAME, AGE, SEX, INCOME)
        VALUES ('Mac', 'Mohan', 20, 'M', 2000)"""
try:
   # Execute the SQL command
   cursor.execute(sql)
   # Commit your changes in the database
   db.commit()
except:
   # Rollback in case there is any error
   db.rollback()

# disconnect from server
db.close()
```

MySQLdb

```
#!/usr/bin/python

import MySQLdb

# Open database connection
db = MySQLdb.connect("localhost","testuser","test123","TESTDB" )

# prepare a cursor object using cursor() method
cursor = db.cursor()

# Prepare SQL query to UPDATE required records
sql = "UPDATE EMPLOYEE SET AGE = AGE + 1
                    WHERE SEX = '%c'" % ('M')
try:
   # Execute the SQL command
   cursor.execute(sql)
   # Commit your changes in the database
   db.commit()
except:
   # Rollback in case there is any error
   db.rollback()

# disconnect from server
db.close()
```