Database Programming

1. Databases
   - a library manager
   - relational design of databases
   - query, commit, rollback
2. MySQL
   - an open source database
   - running MySQL: database creation
   - entering, modifying, and querying
3. MySQLdb: MySQL with Python

MCS 275 Lecture 24
Programming Tools and File Management
Jan Verschelde, 7 March 2016

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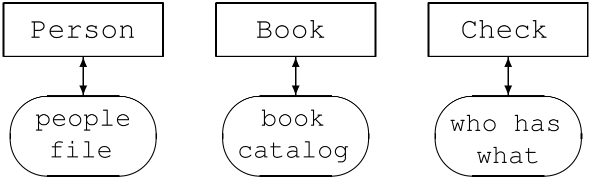
File Oriented Information Systems

a library manager

Consider the management of a library, using files:

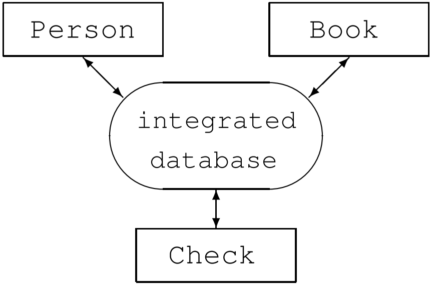


The information system consists of 3 files:

1. records of people (librarians and patrons);
2. data catalog of books in the library;
3. who has checked out what books.

Database Information Systems

A database is a collection of data organized and managed by a specific software system: the *Database Management System* (DBMS).



To design databases we consider the *relational model*.

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The Relational Model

some terminology

A *relation* is a table with a fixed number of columns.

The columns are called *attributes*, taking values belonging to a *domain* (similar to types).
The rows are called *tuples*.

The *schema of a relation* describes the structure of the relation. A *subschema* describes only that portion of the database relevant for the user.
For example: a librarian can see which books any patron has checked out, whereas the view of a patron is limited.

The *instance of a relation* is the set of tuples of the relation present at the database at any given moment.

Schema of our Library Database

In our library database, we have three relations: `Person`, `Book`, and `Check`.

Attributes of `Person` are identification number (id), name, (email) address, and status (librarian or patron).

Attributes of `Book` are identification number, author, title, and availability status (in or out).

`Check` relates identification numbers of people to the identification numbers of books checked out. The two attributes in `Check` are person_id and book_id.

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Structured Query Language (SQL)

Structured Query Language (SQL) is a standard supported on all relational databases.

Suppose we want to see the titles of all books checked out by a person with identification number equal to `nb`.

A query in SQL could then be formulated as

```
SELECT title
FROM BOOK, CHECK
WHERE CHECK.person_id = nb
  AND CHECK.book_id = BOOK.id
```

The result of this query is a new table,
with one attribute: title.

Maintaining Database Integrity

commit and rollback

For large, multiuser, and distributed databases (such as banking), losing data can be very costly.

To ensure database integrity, the information to perform the updated is backed up, stored in a log file.

The Commit/Rollback protocol regulates the update of a database in two stages:

commit	At the commit point, all data to perform the update in the database has been stored in the log. In case of malfunction during the update, the data is retrieved from the log.
rollback	If problem should arise during the actual update, the update can be made undone, using the information from the log.

SQL is 4GL

structured query language

Classification of programming languages:

1. native machine code for the CPU
2. assembler language
3. high level programming languages:
   Ada, C/C++, Fortran, Java, Python, etc...
4. languages closer to being like a human language
   $\rightarrow$ SQL statements read like sentences.

SQL is fourth generation language (4GL).

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MySQL & MySQLdb

`MySQL` is an open source database,
developed by the company `MySQL AB`.
In February 2008, Sun Microsystems acquired `MySQL AB` and the expertise of the GPL software for $1 billion.
In January 2010, Oracle acquired Sun for $7.38 billion.

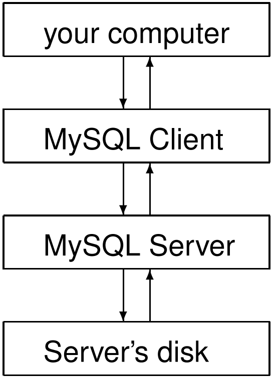
`MySQL` can be downloaded for free from
`http://www.mysql.com/downloads`.
Following the instructions, install `MySQL` first.

`MySQLdb` is an interface to connect Python to `MySQL`.

An alternative to `MySQLdb` is `pymysql`.

The Flow of Data

client/server computing



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Starting and Stopping the Daemon – as root

It may be that MySQL is started at boot time.

Otherwise:

```
$ sudo mysqld_safe

Starting mysqld daemon with databases
from /usr/local/mysql/data
```

Shutting the MySQL server down:

```
$ sudo mysqladmin shutdown

STOPPING server from pid file
/usr/local/mysql/data/ambiorix.local.pid
080304 21:33:10  mysqld ended
```

Running MySQL – creating and deleting databases

The command `mysqladmin` is used in `MySQL` for server administration.

We need to use it to create first a database.

On a Mac OS X, at the prompt `$`:

```
$ sudo mysqladmin create Book
```

We have created a database with name `Book`.

To delete the database `Book`:

```
$ sudo mysqladmin drop Book
```

MySQL to create the Table Book

```
$ sudo mysqladmin create Library

$ sudo mysql
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 4
Server version: 5.0.45 MySQL Community Server (GPL)

Type 'help;' or '\h' for help. Type '\c' to clear the buffe

mysql> use Library;
Database changed
mysql> create table Book
    -> (id INT, title CHAR(80), available SMALLINT);
Query OK, 0 rows affected (0.00 sec)
```

We created a table `Book` with attributes
(1) `id` of domain `INT`; (2) `title` of domain `CHAR`,
80 wide; and (3) `available` of domain `SMALLINT`.

The Tables Person and Checked

```
mysql> create table Person
    -> (id INT, name CHAR(20), status SMALLINT);
Query OK, 0 rows affected (0.00 sec)

mysql> create table Checked
    -> (idbook INT, idname INT);
Query OK, 0 rows affected (0.00 sec)

mysql> show tables;
+-------------------+
| Tables_in_library |
+-------------------+
| Book              |
| Checked           |
| Person            |
+-------------------+
3 rows in set (0.01 sec)
```

Database Programming

Entering Data

```
mysql> explain Book;
+-----------+--------------+------+-----+---------+-------+
| Field     | Type         | Null | Key | Default | Extra |
+-----------+--------------+------+-----+---------+-------+
| id        | int(11)      | YES  |     | NULL    |       |
| title     | char(80)     | YES  |     | NULL    |       |
| available | smallint(6)  | YES  |     | NULL    |       |
+-----------+--------------+------+-----+---------+-------+
mysql> insert into Book values
    -> (1,"The Art & Craft of Computing",1);
mysql> insert into Book values
    -> (2,"Making Use of Python",1);
mysql> select * from Book;
+------+------------------------------+-----------+
| id   | title                        | available |
+------+------------------------------+-----------+
|    1 | The Art & Craft of Computing |         1 |
|    2 | Making Use of Python         |         1 |
+------+------------------------------+-----------+
```

Inserting Records in Person

```
mysql> explain Person;
+--------+--------------+------+-----+---------+-------+
| Field  | Type         | Null | Key | Default | Extra |
+--------+--------------+------+-----+---------+-------+
| id     | int(11)      | YES  |     | NULL    |       |
| name   | char(20)     | YES  |     | NULL    |       |
| status | smallint(6)  | YES  |     | NULL    |       |
+--------+--------------+------+-----+---------+-------+
mysql> insert into Person values
    -> (1,"Rashi Gupta",1);
mysql> insert into Person values
    -> (2,"Guido van Rossum",0);
mysql> select * from Person;
+------+-------------------+--------+
| id   | name              | status |
+------+-------------------+--------+
|    1 | Rashi Gupta       |      1 |
|    2 | Guido van Rossum  |      0 |
+------+-------------------+--------+
```

Inserting Records in Checked

```
mysql> explain Checked;
+--------+----------+------+-----+---------+-------+
| Field  | Type     | Null | Key | Default | Extra |
+--------+----------+------+-----+---------+-------+
| idbook | int(11)  | YES  |     | NULL    |       |
| idname | int(11)  | YES  |     | NULL    |       |
+--------+----------+------+-----+---------+-------+

mysql> insert into Checked values (1,2);
mysql> select * from Checked;
+--------+--------+
| idbook | idname |
+--------+--------+
|      1 |      2 |
+--------+--------+
```

Modifying Records in Book

The book with id = 1 is no longer available:

```
mysql> update Book set available=0 where id = 1;
Query OK, 1 row affected (0.00 sec)
Rows matched: 1  Changed: 1  Warnings: 0
mysql> select * from Book;
+------+-----------------------------+-----------+
| id   | title                       | available |
+------+-----------------------------+-----------+
|    1 | The Art & Craft of Computing |         0 |
|    2 | Making Use of Python        |         1 |
+------+-----------------------------+-----------+
```

A more involved Query

Let us select the tiles of all books
Guido van Rossum has checked out:

```
mysql> select title
    -> from Book, Person, Checked
    -> where Person.name = "Guido van Rossum"
    ->   and Checked.idname = Person.id
    ->   and Checked.idbook = Book.id;

+-------------------------------+
| title                         |
+-------------------------------+
| The Art & Craft of Computing |
+-------------------------------+

mysql> exit;
Bye
```

Using MySQLdb in Python

`MySQLdb` is an interface to use `MySQL`
from within a Python session.
At the command prompt `$`:

```
$ sudo 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 i
>>> import MySQLdb
>>> L = MySQLdb.connect(db="Library")
>>> c = L.cursor()
```

Observe:

- with connect(), we identify the database `Library`;
- L.cursor() returns a new object to represent a database cursor used to manage all operations.

an alternative: pymysql

For Python 3.5, `pymysql` works just as well:

```
$ python
Python 3.5.0 (v3.5.0:374f501f4567, Sep 12 2015, 11:00:
[GCC 4.2.1 (Apple Inc. build 5666) (dot 3)] on darwin
Type "help", "copyright", "credits" or "license" for m
>>> import pymysql
>>> L = pymysql.connect(db="Library")
>>> c = L.cursor()
>>> c.execute("show tables")
1
>>> c.fetchone()
('Book',)
>>> c.execute("select * from Book")
1
>>> c.fetchall()
((1, 'primer on scientific programming', 1),)
```

Retrieving Information – using execute and fetchone

With a cursor `c`, we pass MySQL commands
as string argument to the `c.execute()` method:

```
>>> c.execute("show tables")
3L
```

The `3L` indicates there are 3 lines of output.
To retrieve the output line by line, we use `fetchone`:

```
>>> c.fetchone()
('Book',)
>>> c.fetchone()
('Checked',)
>>> c.fetchone()
('Person',)
>>> c.fetchone()
```

All Results at Once

With `fetchall()` we obtain all results at once.

```
>>> c.execute("select * from Book")
2L
>>> c.fetchall()
((1L, 'The Art & Craft of Computing', 0),\
 (2L, 'Making Use of Python', 1))
```

A more involved query:

```
>>> s = "select title " + \
... " from Book, Person, Checked" + \
... " where Person.Name = \"Guido van Rossum\"" + \
... "   and Checked.idname = Person.id" + \
... "   and Checked.idbook = Book.id"
>>> r = c.execute(s)
>>> c.fetchall()
(('The Art & Craft of Computing',),)
```

Summary + Assignments

We started chapter 11 in *Making Use of Python*;
see also §9.1,2 in *Computer Science, an overview*,
visit `http://www.mysqltutorial.org/`.

Assignments:

1. Design a simple relational database to manage bank accounts, and to perform financial transactions.
2. Download and install `MySQL` and `MySQLdb`, or `pymysql`.
3. Write a Python function that takes on input the name of a person and returns the query to select all titles of the books that person has checked out.
4. Use `MySQL` and `MySQLdb` (or `pymysql`) to extend the `login_form` with a database that stores user names and passwords, used to grant or deny access.