Databases... in Python

Storing data (on the server, too)

Luigi De Russis

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Goal

- Making data 'persistent'
  - When application restarts
- Manage big amounts of data
  - Not all in-memory
- Exploit the power of SQL
  - Complex data
  - Complex queries

General Architecture

Python application

DBMS server

Analyzed Databases

MySQL

- Open-source database server (from Oracle)
- Full featured
- Runs as a separate process (may be on a different computer)
- Allows concurrent access
- https://www.mysql.com

MariaDB

- Open-source fork of MySQL server
- Community-driven
- 99% compatible
- In some cases, faster
- On most Linux distributions
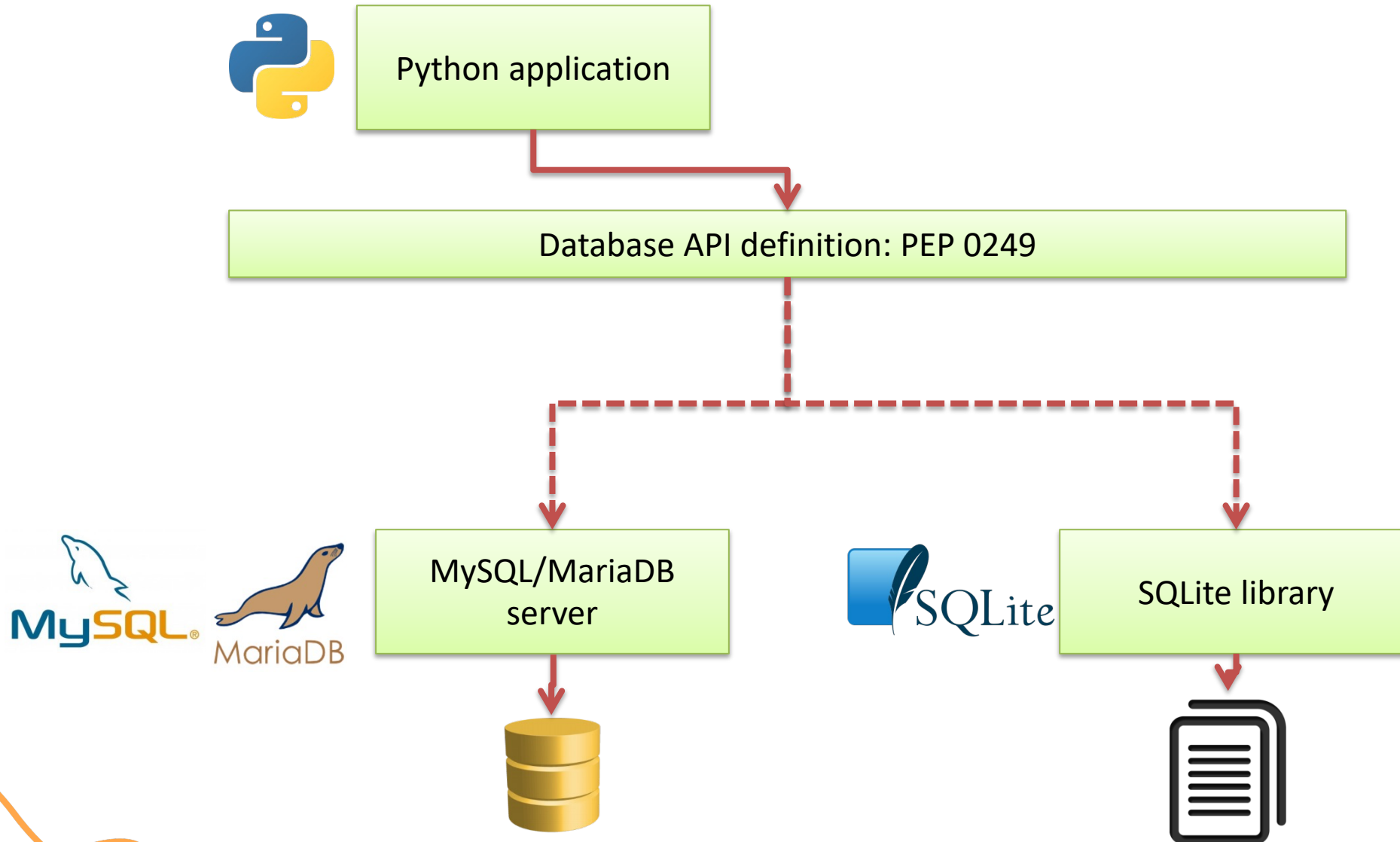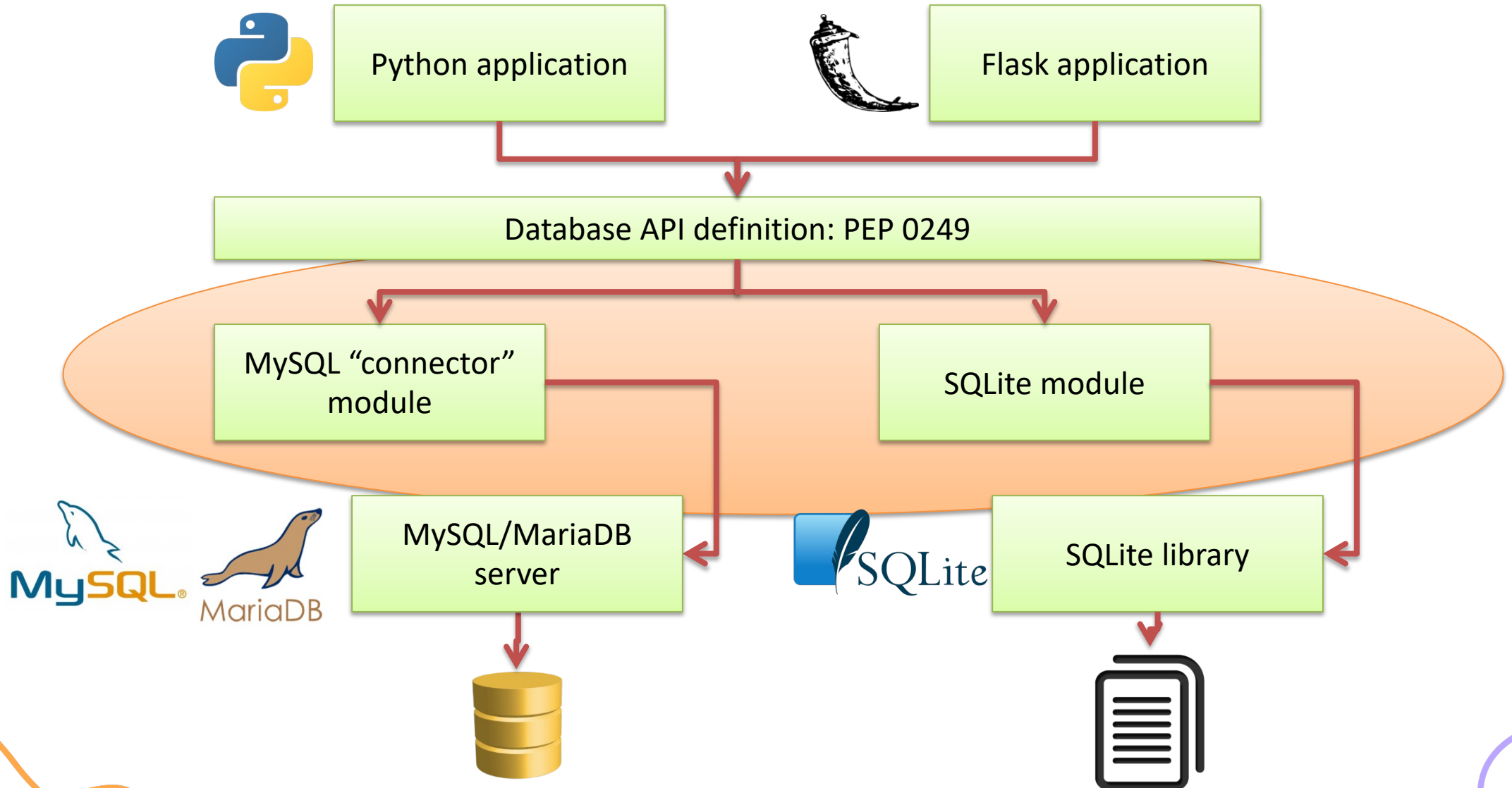- http://mariadb.org/

General Architecture

Analyzed Databases

MySQL / MariaDB

SQLite

- Open-source file-based storage
- Software library integrated in your program (serverless)
- Self-contained
- https://www.sqlite.org/

Python databases

General Architecture

General Architecture

Other Options

- PostgreSQL – more complex, but more complete than MySQL/MariaDB

- Non-relational databases (NoSQL)
  - not considered here

PEP 0249

- Python Database API Specification v2.0
  - https://www.python.org/dev/peps/pep-0249/
- Specifies a standard API that Python modules that are used to access databases should implement
- Does not provide a library nor a module
- Third-party modules may adhere to these specifications

Main Concepts in PEP 249

- Access to database is provided through a **connect** method, that returns a **Connection** object

- For executing queries, you need a **Cursor** object, that can be obtained by the Connection

- A **cursor** may **execute**() a SQL query, with parameters

- A **cursor** may **fetch** the **results** of the query

Minimal Example

1 `sql =` *"SELECT id, original, modified FROM translation"*

2 `conn = mysql.connector.connect(user=`*'root'*`, password=`*''*`,`
`host=`*'localhost'*`, database=`*'funnyecho'*`)`

3 `cursor = conn.cursor()`
`cursor.execute(sql)`

4 `translations = cursor.fetchall()`

5 `cursor.close()`
`conn.close()`

6 `return translations`

Minimal Example

1 `sql = "SELECT id, original, modified FROM translation"`

2 `conn = mysql.connector.connect(user='root', password='', host='localhost', database='funnyecho')`

3 `cursor = conn.cursor()`
`cursor.execute(sql)`

4 `translations = cursor.fetchall`

The **only** step that depends on the type of database

5 `cursor.close()`
`conn.close()`

6 `return translations`

Step 1: Query Definition

- Write a correct SQL statement, stored as a Python string
  - `sql = `*`"SELECT id, original, modified FROM translation"`*
- Variable arguments may be specified with '%s' or '?' placeholders
  - according to the underlying database/library
  - `sql = `*`"INSERT INTO translation (original, modified) VALUES (%s, %s)"`*
  - `sql = `*`"INSERT INTO translation (original, modified) VALUES (?, ?)"`*

Placeholders

- **<u>Never</u>** use string concatenation over SQL statements. N.E.V.E.R. Huge security problems (SQL Injection)

- SQL statement "templates" that include placeholders

- Actual values passed in `.execute()`

- Different libraries use different types of placeholder

Placeholder Syntax

MySQL/MariaDB

- C-like format string

- `...WHERE name=%s`

- Beware: always use %s, even for numeric data – not %d or %f

SQLite

- Question mark

- `...WHERE name=?`

Step 2: Database Connection

- Depending on the library, use the provided 'connect' method
- The method parameters are dependent on the module implementation (non-standard)

  - ```
    conn = mysql.connector.connect(user='root', password='',
    host='localhost', database='funnyecho')
    ```
  - ```
    conn = sqlite3.connect('example.db')
    ```

Step 3: Query Execution

- First, obtain a cursor from the connection
  - `cursor = conn.cursor()`
- Then, execute the query
  - `cursor.execute(sql)`
- Query parameters (%s/? placeholders) are specified as a 'tuple' argument
  - `cursor.execute(sql, (txtbefore, txtafter) )`
  - `cursor.execute(sql, (txtid,) )`
  - Beware: one-element tuples require trailing **,**

Step 4 (SELECT): Result Analysis

- Only if the query was a SELECT

- Use various methods of **cursor**:
  - `cursor.fetchone()`   # next result
  - `cursor.fetchall()`   # all remaining results
  - They return tuples, corresponding to the SELECT'ed columns
  - https://www.python.org/dev/peps/pep-0249/#cursor-methods

Step 4 (UPDATE): Commit the Change

- For INSERT, UPDATE and DELETE there is no result
- The change is not applied immediately to the database, but needs to be "committed"
- `conn.commit()`
  - Will commit all pending executed queries in the connection
- Must be called before `conn.close()`
- DO NOT forget, or you will lose your data

Step 5 (a): Clean Up

- When the cursor is no longer needed
- `cursor.close()`

Step 5 (b): Clean Up

- Do not forget to close the connection, thus freeing up resources on the database server
  - `conn.close()`
- Write the close statement *immediately*, otherwise you will forget it
- Remember not to 'return' the function before cleaning up

Step 6: Use the Results

- Analyze the returned data and do what the application requires for them
- If further queries are needed, go back to step 3
  - re-use the same Connection, creating new Cursors

Using SQLite

- SQLite is a simple file-based storage library

- Since Python 2.5, it is included by default, in the "sqlite3" package
  - https://docs.python.org/3/library/sqlite3.html
  - Developed at https://github.com/ghaering/pysqlite

- The "connection" just means specifying the file name
  - `import sqlite3`
  - `conn = sqlite3.connect('example.db')`

- Remember: placeholder = ?

Alternative SQLite Libraries

- Another Python SQLite Wrapper
  - https://github.com/rogerbinns/apsw/
- More powerful and complete than the built-in library
- It does not follow the PEP 249
  - No interchangeability with other database drivers ☹

Extra, for the curious

USING MYSQL OR MARIADB

Using MySQL

- Pre-requisite: a working installation of the mysql server
  - http://dev.mysql.com/downloads/mysql/
- Pre-requisite: a working installation of the mariadb server
  - https://mariadb.org/download/

MySQL Connectors

Official connector (Oracle)

- Download and install the "MySQL Connector for Python"
  - http://dev.mysql.com/downloads/connector/python/
  - Provides the package "mysql.connector"

Alternative (from pip)

- Pure Python implementation
  - https://github.com/PyMySQL/PyMySQL/
  - pip install PyMySQL
  - Provides the package "pymysql"
- Nearly drop-in replacement
- Easier to install

MySQL Python Connector

- To use: import mysql.connector
- Well-done documentation at
  - http://dev.mysql.com/doc/connector-python/en/index.html
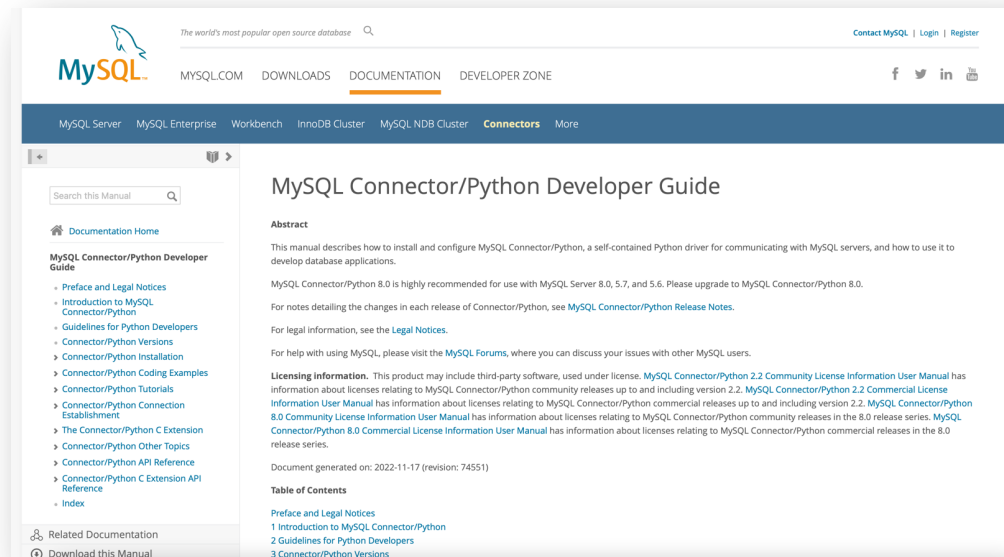
Connecting With mysql (Oracle)

- Basic form
  - `import mysql.connector`
  - `cnx = mysql.connector.connect (`
    - `user='joe',`
    - `password='xxx',`
    - `database='test',`
    - `host='localhost' )`

- Additional parameters
  - http://dev.mysql.com/doc/connector-python/en/connector-python-connectargs.html

Connecting with PyMySQL

- — `import pymysql`
- — `cnx = pymysql.connect ( ... )`
- — `cursor = cnx.cursor()`

- … Same connection parameters

- … Same placeholder (%s)

- … When in doubt, check the Oracle documentation

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