Databases in Python

MySQL, SQLite

Accessing persistent storage (Relational databases) from Python code

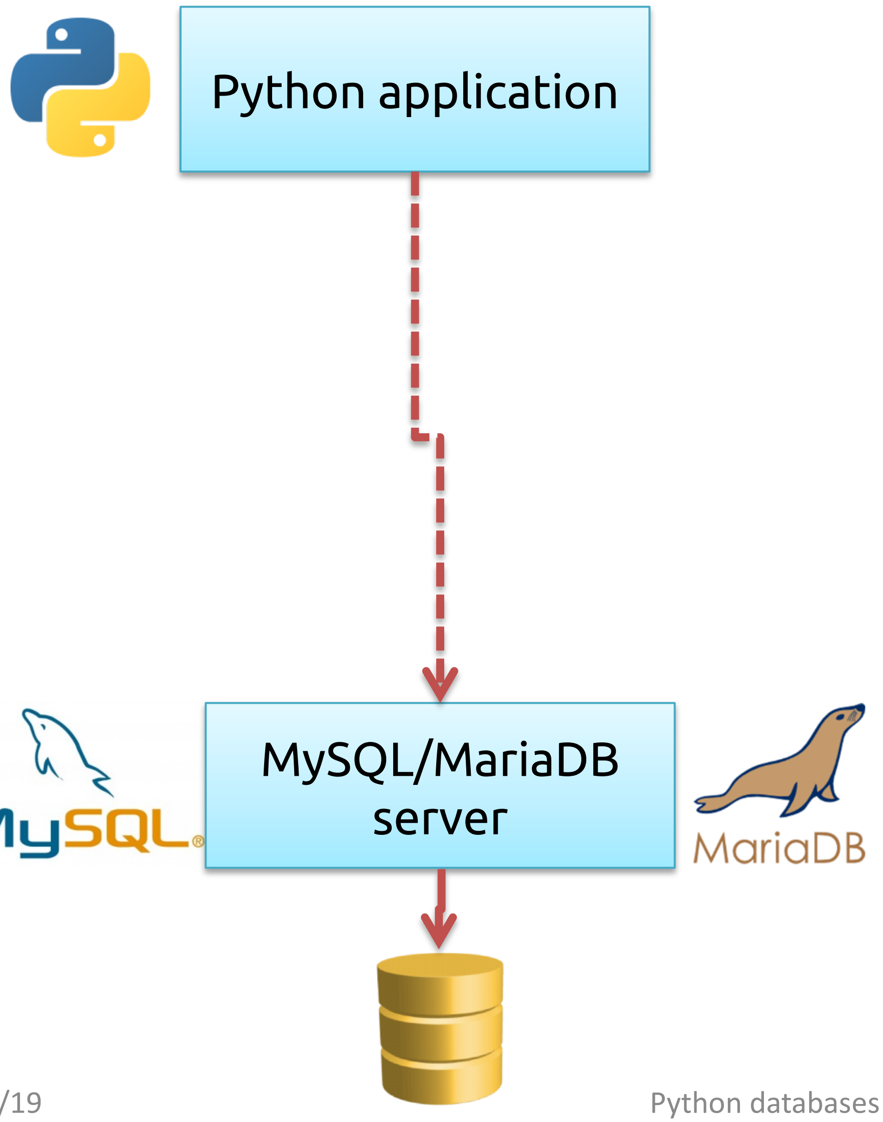
POLITECNICO
DI TORINO

e-Lite

Goal

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

General Architecture



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
- http://dev.mysql.com

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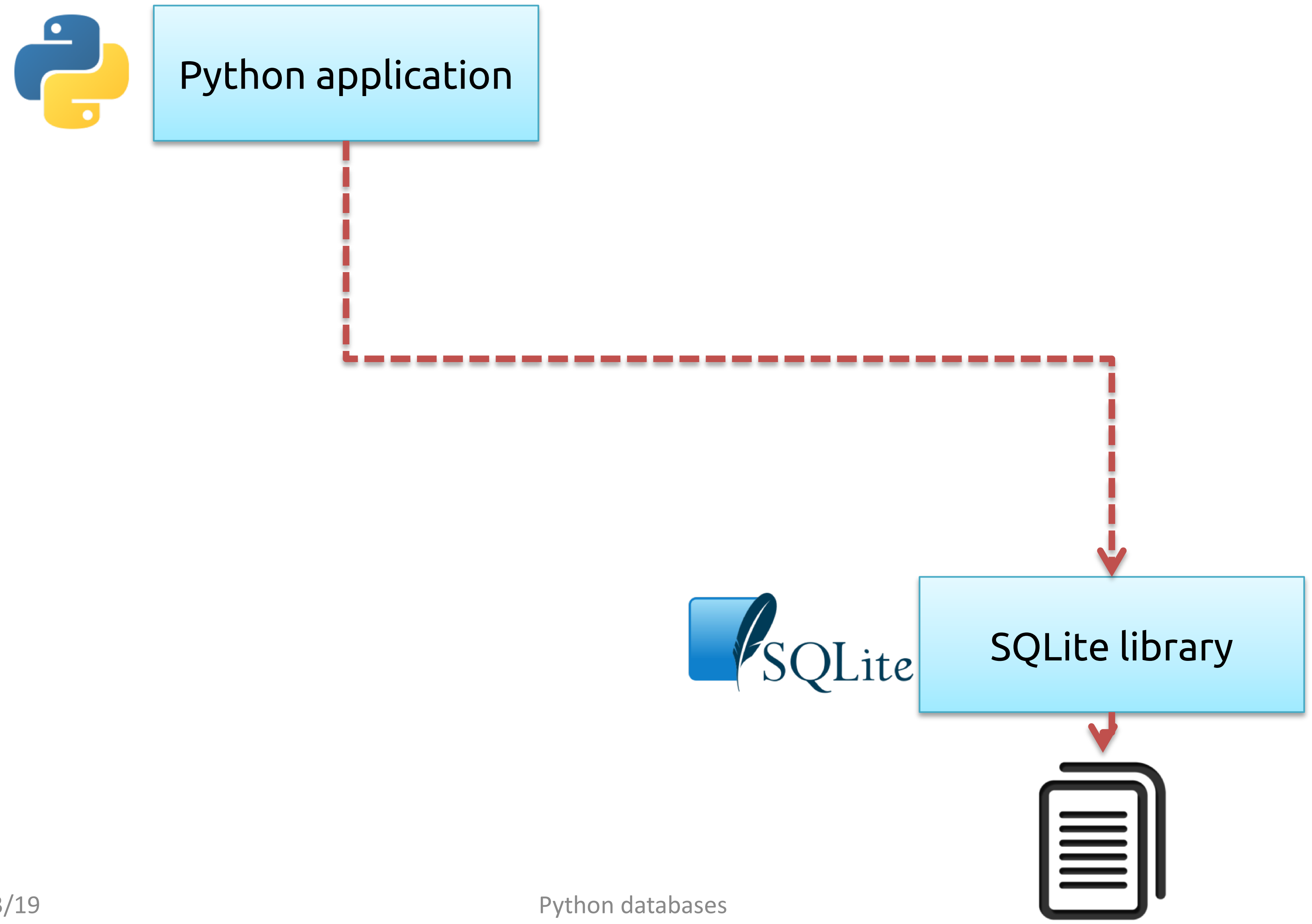
MariaDB

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

General Architecture



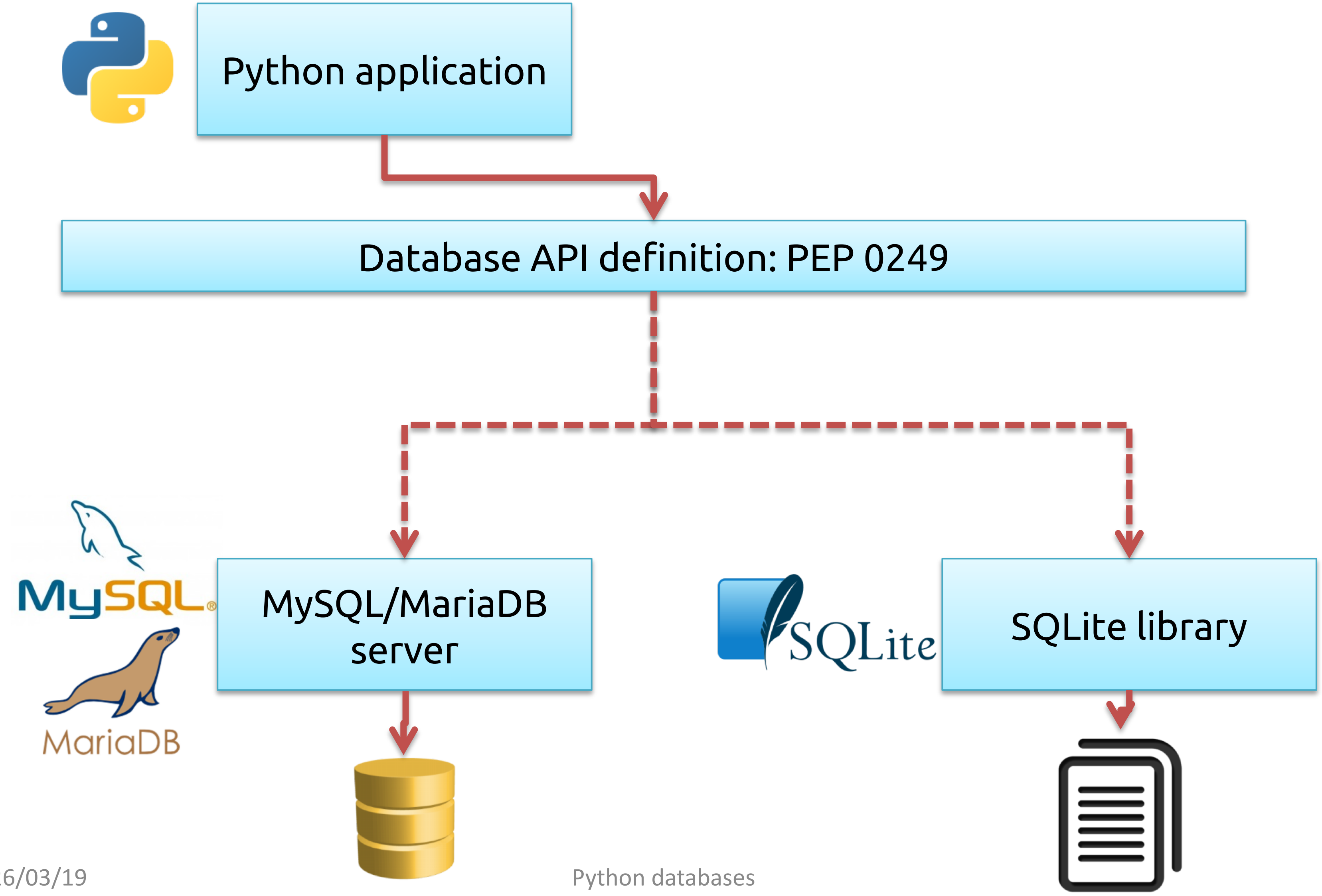
Analyzed databases

MySQL / MariaDB

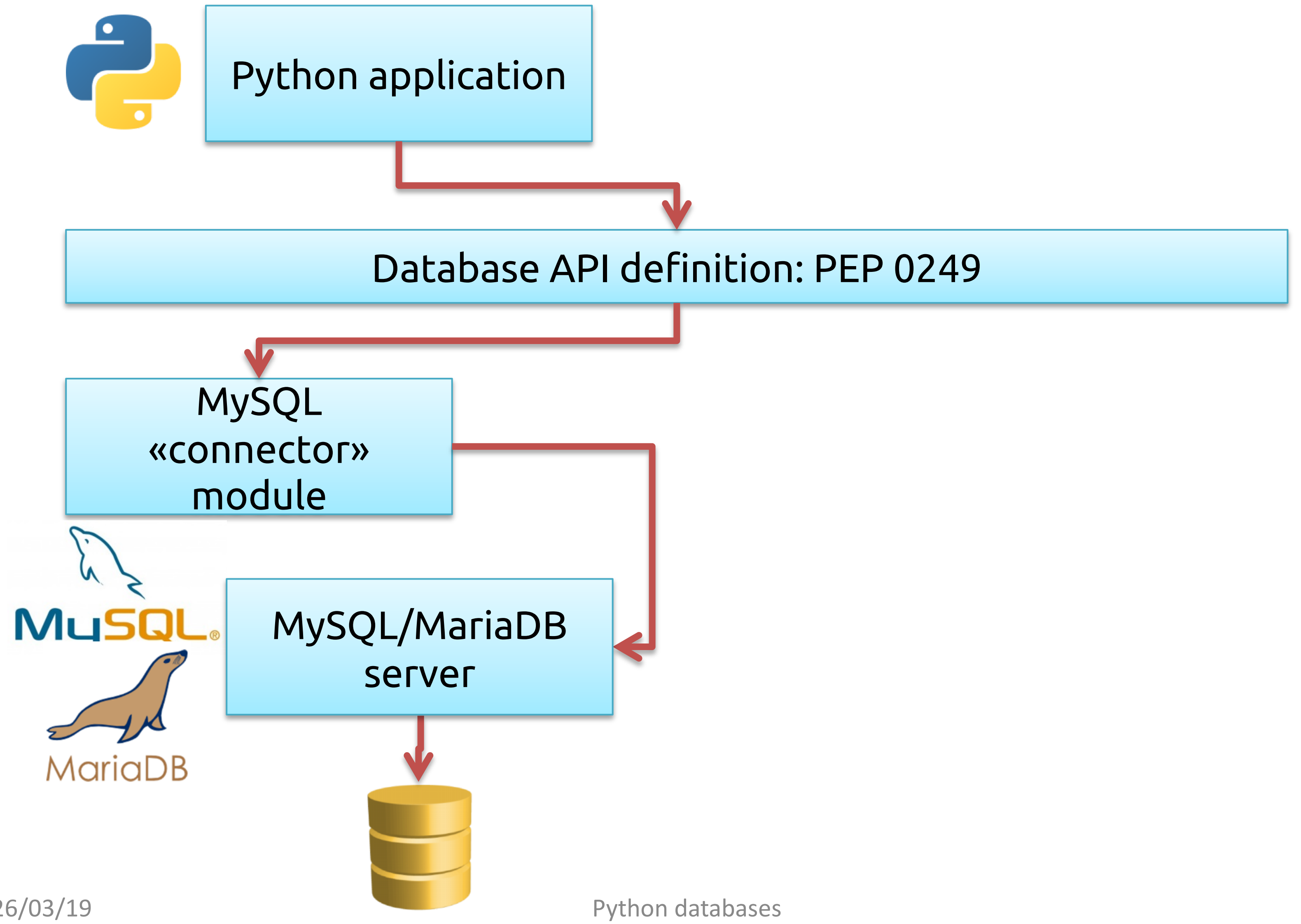
SQLite

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

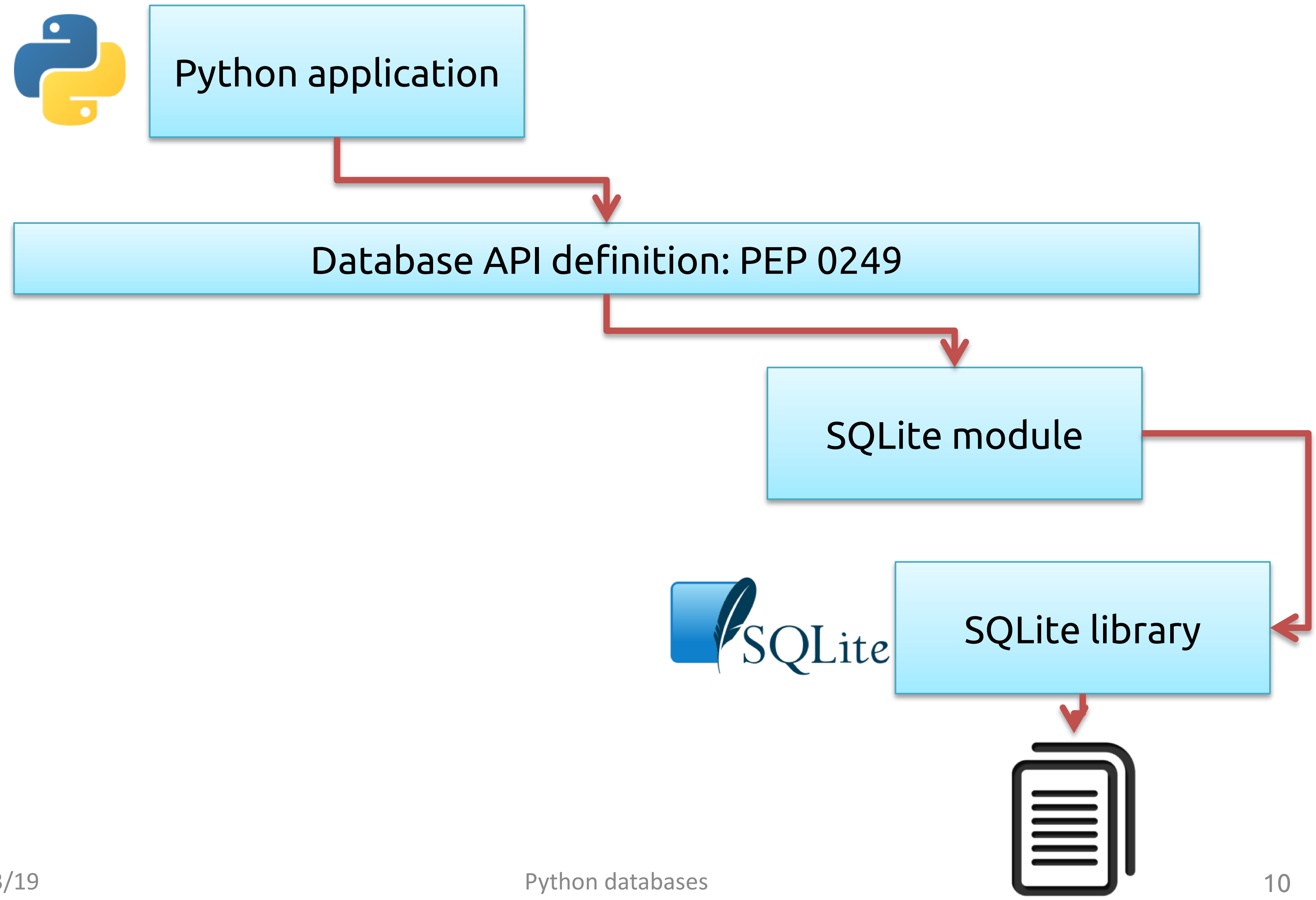
General Architecture



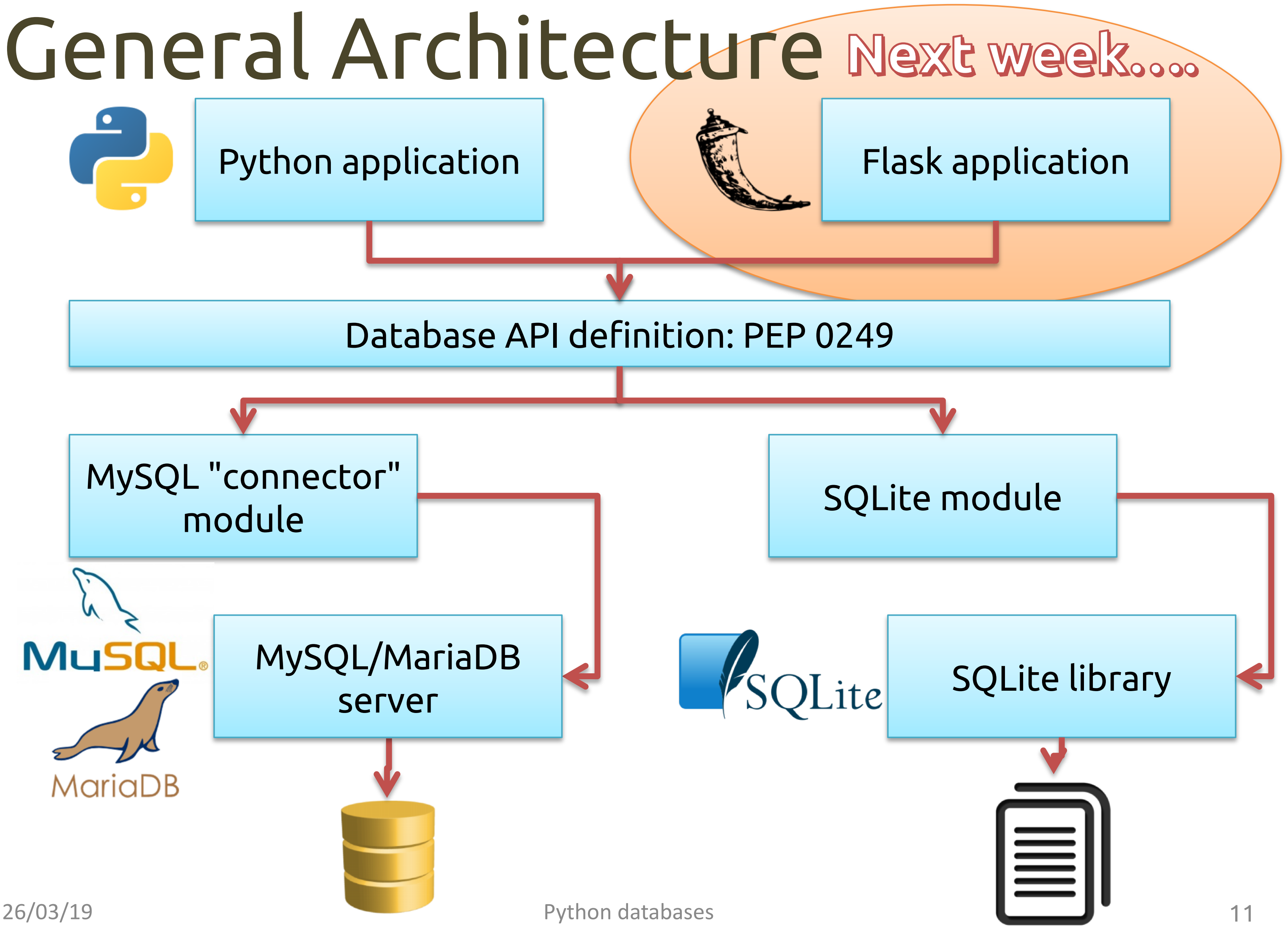
General Architecture



General Architecture



General Architecture



Other options

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

- Non-relational databases (‘NoSQL’)
  - won’t be 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
```

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

Step 1: defining the query

- 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
  - `sql = "INSERT INTO translation (original, modified) VALUES (%s, %s)"`
  - `sql = "INSERT INTO translation (original, modified) VALUES (?, ?)"`

Placeholders

- Never 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 the .execute call
- 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: Connecting to the database

- 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')`

Step 3: execute the query

- 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): Analyze the result

- 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()`
- Don't forget it, or you’ll lose your data

Step 5 (a): Clean up

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

Step 5 (b): Clean up

- Don’t forget to close the connection, thus freeing up resources on the database server
  - `conn.close()`
- Write the close statement immediately, otherwise you’ll 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 MySQL

- Pre-requisite: a working installation of the MySQL server
  - `sudo apt-get install mysql-server`
  - or download from http://dev.mysql.com/downloads/mysql/

… or …

- Pre-requisite: a working installation of the MariaDB server
  - `sudo apt-get install mariadb-server`

MySQL connectors

Official connector (Oracle)

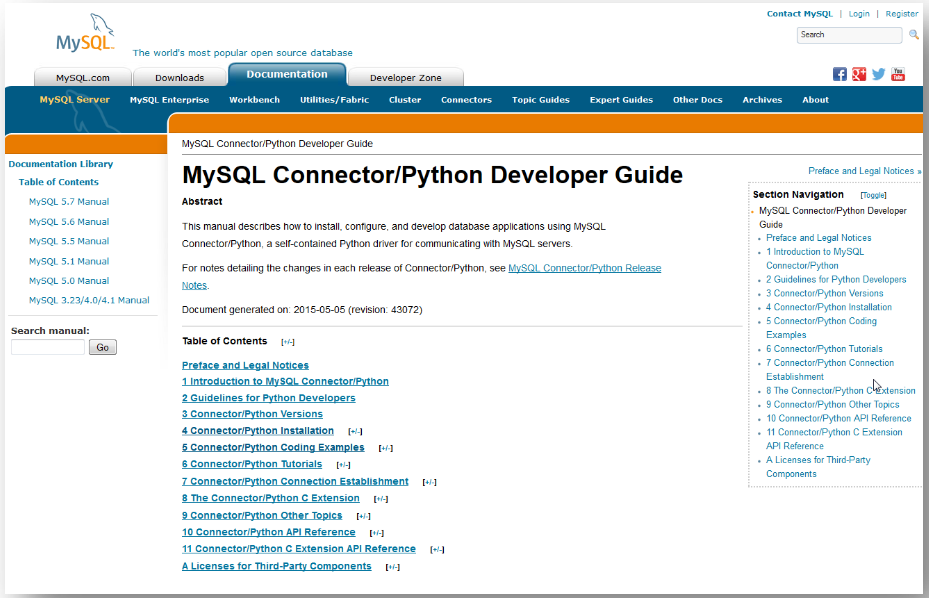
- Download and install the "MySQL Connector for Python"
  - http://dev.mysql.com/downloads/connector/python/
  - Provides the package "mysql.connector"

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



MySQL Connector/Python Developer Guide

Abstract

This manual describes how to install, configure, and develop database applications using MySQL Connector/Python, a self-contained Python driver for communicating with MySQL servers.

For notes detailing the changes in each release of Connector/Python, see MySQL Connector/Python Release Notes.

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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 MySQL (Oracle)

- Alternate form
  - `import mysql.connector`
  - `params = {`
    - `'user': 'joe',`
    - `'password': 'xxx',`
    - `'host': 'localhost',`
    - `'database': 'test',`
    - `'use_unicode': True }`
  - `cnx = mysql.connector.connect(**params)`

Connecting with PyMySQL

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

- ... Same connection parameters
- … Same placeholder (%s)
- … When in doubt, check the Oracle documentation

SQLite and Python

- 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 = ?

References and Links

- MySQL: http://dev.mysql.com/
- MariaDB: http://mariadb.org/
- SQLite (C library): https://www.sqlite.org/
- SQLite for Python (installed by default):
  - documentation: https://docs.python.org/3/library/sqlite3.html
  - developer: https://github.com/ghaering/pysqlite
- PEP 249 "Python Database API Specification v2.0": https://www.python.org/dev/peps/pep-0249/
- PyMySQL "pure python" connector
  - https://github.com/PyMySQL/PyMySQL

Questions?

01QZP AMBIENT INTELLIGENCE

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