

Database Programming (Part 2)

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Objectives

- We will cover:
 - **Databases (DBs) and database management systems (DBMSs)...**
 - With a focus on **relational** DBs and DBMSs...
 - With a focus on the **SQLite** DBMS...
 - With a focus on **programming** with SQLite

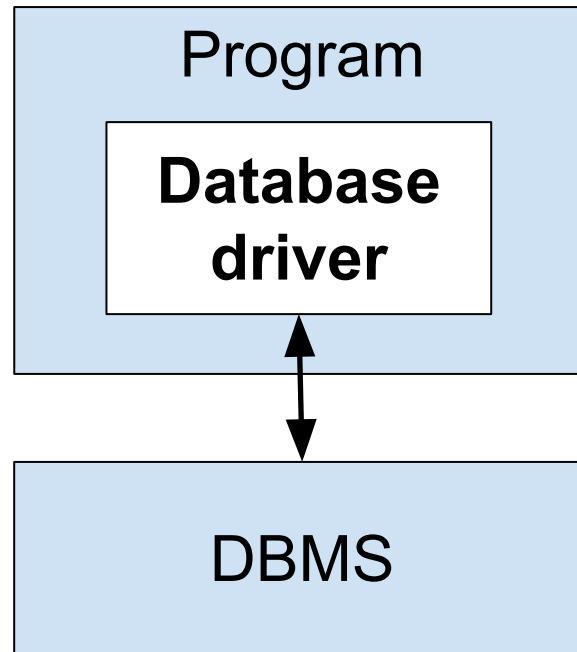
Objectives

- **Question:** How does one use SQLite?
- **Answer:** In this course:
 - Via the SQLite command-line client
 - Via programs that you compose...

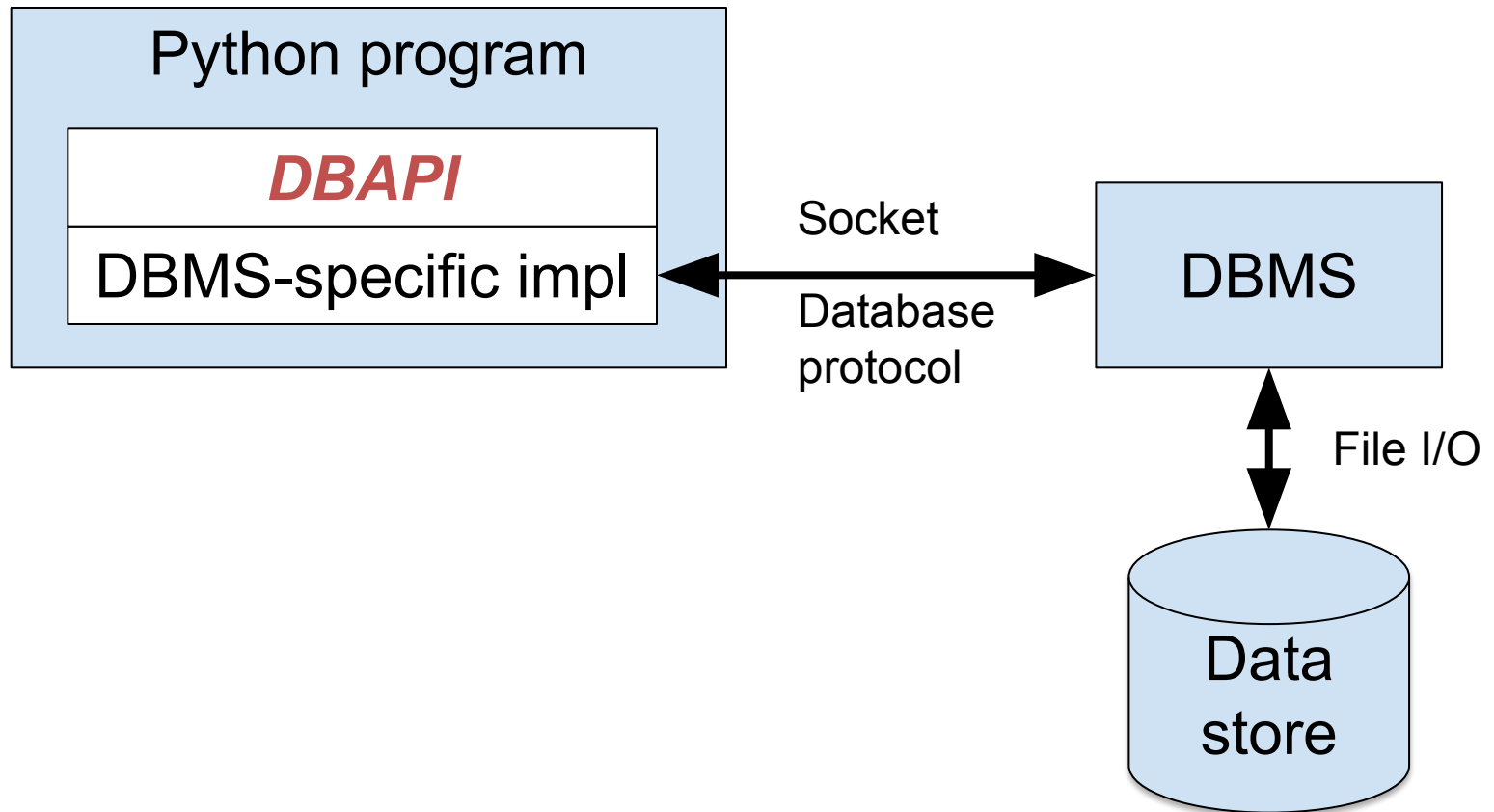
Agenda

- **Relational DB pgmming**
- Relational DB pgmming: prepared stmts

Relational DB Programming

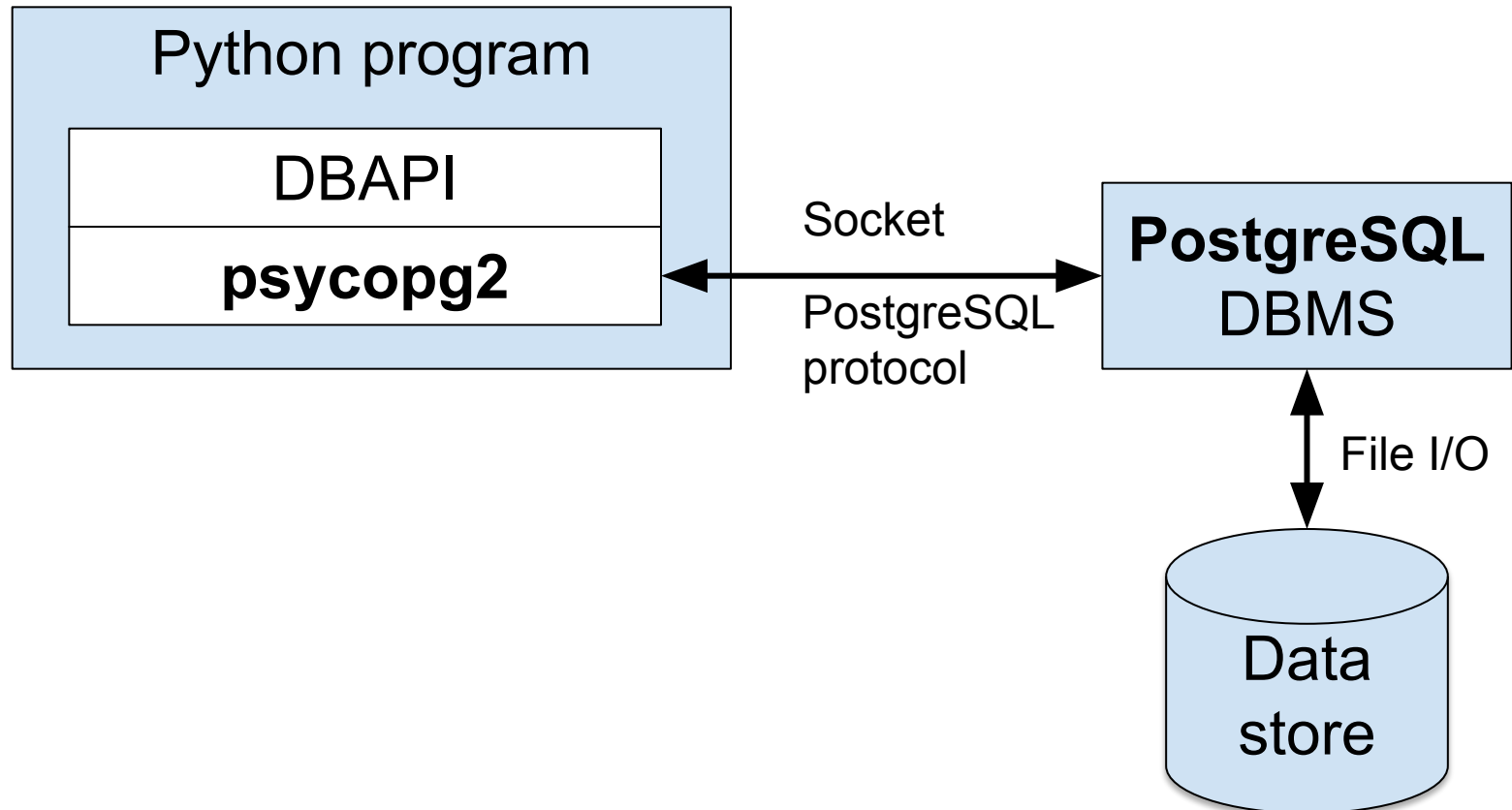


Relational DB Programming



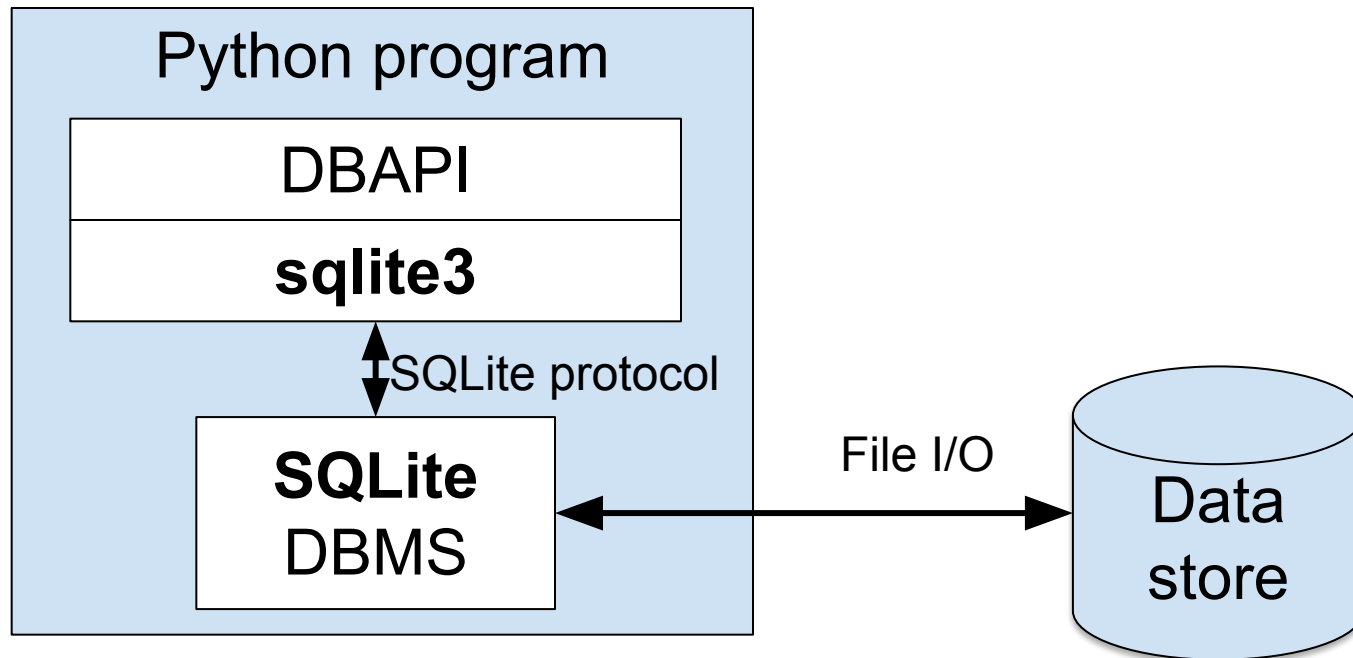
Relational DB Programming

When using PostgreSQL



Relational DB Programming

When using SQLite



Relational DB Programming

- Code structure

Baseline:

```
connection = connect(...)
...
...
connection.close()
```

Better:

```
connection = connect(...)
try:
    ...
    ...
finally:
    connection.close()
```

Better still:

```
with connect(...) as connection:
    ...
    ...
```

Relational DB Programming

- Code structure

Baseline:

```
cursor = connection.cursor()  
...  
...  
cursor.close()
```

Better:

```
cursor = connection.cursor(...)  
try:  
    ...  
    ...  
finally:  
    cursor.close()
```

Relational DB Programming

- Code structure

Better still:

```
with connection.cursor() as cursor:  
    ...  
    ...
```

```
import contextlib  
...  
with contextlib.closing(connection.cursor()) as cursor:  
    ...  
    ...
```

For more info: <https://realpython.com/python-with-statement/>

Relational DB Programming

- See [create.py](#)

```
$ python create.py  
$
```

Relational DB Programming

- See **display.py**

```
$ python display.py
```

```
books
```

```
-----  
( '123', 'The Practice of Programm  
( '234', 'The C Programming Langua  
( '345', 'Algorithms in C', 650)  
-----
```

```
authors
```

```
-----  
( '123', 'Kernighan')  
( '123', 'Pike')  
( '234', 'Kernighan')  
( '234', 'Ritchie')  
( '345', 'Sedgewick')  
-----
```

```
-----  
customers
```

```
-----  
( '111', 'Princeton', '114 Nassau St',  
'08540')  
( '222', 'Harvard', '1256 Mass Ave',  
'02138')  
( '333', 'MIT', '292 Main St', '02142')  
-----
```

```
zipcodes
```

```
-----  
( '08540', 'Princeton', 'NJ')  
( '02138', 'Cambridge', 'MA')  
( '02142', 'Cambridge', 'MA')  
-----
```

```
orders
```

```
-----  
( '123', '222', 20)  
( '345', '222', 100)  
( '123', '111', 30)  
-----
```

```
$
```

Relational DB Programming

- See **display.py** (cont.)
 - To use a cursor to select data:

```
cursor.execute("SELECT * FROM books")
table = cursor.fetchall()
for row in table:
    print(row)
```

or

```
cursor.execute("SELECT * FROM books")
row = cursor.fetchone()
while row is not None:
    print(row)
    row = cursor.fetchone()
```

Relational DB Programming

- See **authorsearch.py**

```
$ python authorsearch.py Kernighan
ISBN: 123
Title: The Practice of Programming
Quantity: 500

ISBN: 234
Title: The C Programming Language
Quantity: 800

$
```

Relational DB Programming

- See [order.py](#)

```
$ python display.py
...
-----
orders
-----
('123', '222', 20)
('345', '222', 100)
('123', '111', 30)
$ python order.py 123 222
$ python display.py
...
-----
orders
-----
('123', '222', 21)
('345', '222', 100)
('123', '111', 30)
$
```


Agenda

- Relational DB pgmming
- **Relational DB pgmming: prepared stmts**

Question (lecture04part2)

Consider this SQL statement executed by authorsearch.py:

```
SELECT books.isbn, title, quantity
FROM books, authors
WHERE books.isbn = authors.isbn
AND author = 'someauthor'
```

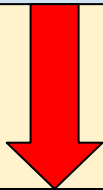
What happens if the user provides the author O'Reilly to authorsearch.py:

(Don't look at the next slides!)

Browse to <https://cos333attend.cs.princeton.edu> to answer

Answer

```
SELECT books.isbn, title, quantity
FROM books, authors
WHERE books.isbn = authors.isbn
AND author = 'someauthor'
```



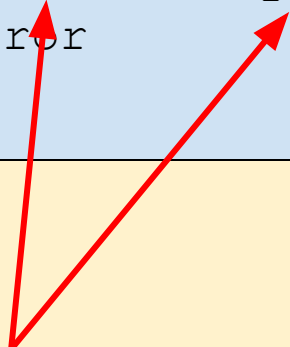
```
O'Reilly
```



```
SELECT books.isbn, title, quantity
FROM books, authors
WHERE books.isbn = authors.isbn
AND author = 'O'Reilly'
```

Answer

```
$ python authorsearch.py "O'Reilly"  
near "Reilly": syntax error  
$
```



Double quotes here tell bash to consider the single quote within `O'Reilly` to be an ordinary character

DB Pgmming: Prepared Stmt

- Malicious user provides this `someauthor` to `authorsearch.py`

```
junk' OR 'x'='x
```

DB Pgmming: Prepared Stmt

```
SELECT books.isbn, title, quantity
FROM books, authors
WHERE books.isbn = authors.isbn
AND author = 'someauthor'
```

junk' OR 'x'='x'

```
SELECT books.isbn, title, quantity
FROM books, authors
WHERE books.isbn = authors.isbn
AND author = 'junk' OR 'x'='x'
```

AND has higher precedence than OR

```
SELECT books.isbn, title, quantity
FROM books, authors
WHERE (books.isbn = authors.isbn
AND author = 'junk') OR ('x'='x')
```

DB Pgmming: Prepared Stmts

SQL injection attack

```
$ python authorsearch.py "junk' OR 'x'='x"
```

```
ISBN: 123  
Title: The Practice of Pro  
Quantity: 500
```

```
ISBN: 123  
Title: The Practice of Pro  
Quantity: 500
```

```
ISBN: 123  
Title: The Practice of Pro  
Quantity: 500
```

```
ISBN: 123  
Title: The Practice of Pro  
Quantity: 500
```

```
ISBN: 123  
Title: The Practice of Pro  
Quantity: 500
```

```
ISBN: 234  
Title: The C Programming Language  
Quantity: 800
```

```
ISBN: 234  
Title: The C Programming  
Quantity: 800
```

```
ISBN: 234  
Title: The C Programming  
Quantity: 800
```

```
ISBN: 234  
Title: The C Programming  
Quantity: 800
```

```
ISBN: 234  
Title: The C Programming  
Quantity: 800
```

```
ISBN: 345  
Title: Algorithms in C  
Quantity: 650
```

```
ISBN: 345  
Title: Algorithms in C  
Quantity: 650
```

```
ISBN: 345  
Title: Algorithms in C  
Quantity: 650
```

```
ISBN: 345  
Title: Algorithms in C  
Quantity: 650
```

```
ISBN: 345  
Title: Algorithms in C  
Quantity: 650
```

```
$
```

DB Pgmming: Prepared Stmts

- Problem (via another example)

Consider this SQL statement executed by order.py:

```
UPDATE orders SET quantity = quantity+1
  WHERE isbn='someisbn' AND custid='somecustid'
```


DB Pgmming: Prepared Stmts

- Malicious user provides this `someisbn`

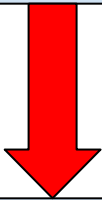
123

- ... and this `somecustid` to `order.py`:

222' OR 'x'='x

DB Pgmming: Prepared Stmts

```
UPDATE orders SET quantity = quantity+1
WHERE isbn='someisbn' AND custid='somecustid'
```



123

222' OR 'x'='x'

```
UPDATE orders SET quantity = quantity+1
WHERE isbn='123' AND custid='222' OR 'x'='x'
```



AND has higher precedence than OR

```
UPDATE orders SET quantity = quantity+1
WHERE (isbn='123' AND custid='222') OR ('x'='x')
```

DB Pgmming: Prepared Stmts

```
$ python display.py
...
-----
orders
-----
('123', '222', 20)
('345', '222', 100)
('123', '111', 30)
$ python order.py 123 "222" OR 'x'='x'
$ python display.py
...
-----
orders
-----
('123', '222', 21)
('345', '222', 101)
('123', '111', 31)
```

**SQL
injection
attack**

DB Pgmming: Prepared Stmtms

- For more examples of SQL injection attacks:
 - <http://unixwiz.net/techtips/sql-injection.html>

DB Pgmming: Prepared Stmtts

- A solution...
- *Prepared statements*

DB Pgmming: Prepared Stmt

- See [authorsearchprep.py](#)

```
$ python authorsearchprep.py Kernighan
ISBN: 123
Title: The Practice of Programming
Quantity: 500

ISBN: 234
Title: The C Programming Language
Quantity: 800

$
```

DB Pgmming: Prepared Stmt

- See [authorsearchprep.py](#) (cont.)

```
$ python authorsearchprep.py "O'Reilly"  
$
```

```
$ python authorsearchprep.py "junk' OR 'x'='x"  
$
```

DB Pgmming: Prepared Stmts

- See [orderprep.py](#)

```
$ python display.py
...
-----
orders
-----
('123', '222', 20)
('345', '222', 100)
('123', '111', 30)
$ python orderprep.py 123 222
$ python display.py
...
-----
orders
-----
('123', '222', 21)
('345', '222', 100)
('123', '111', 30)
$
```


DB Pgmming: Prepared Stmts

```
$ python display.py
...
-----
orders
-----
('123', '222', 20)
('345', '222', 100)
('123', '111', 30)
$ python orderprep.py 123 "junk" OR 'x'='x'
$ python display.py
...
-----
orders
-----
('123', '222', 20)
('345', '222', 100)
('123', '111', 30)
$
```

Summary

- We have covered:
 - Relational DB pgmming
 - Relational DB pgmming: prepared stmts