SQLAlchemy: Python SQL Toolkit and Object Relational Mapper

http://www.sqlalchemy.org/

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Outline

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The Session

The Mapper

The Magic

Conclusion

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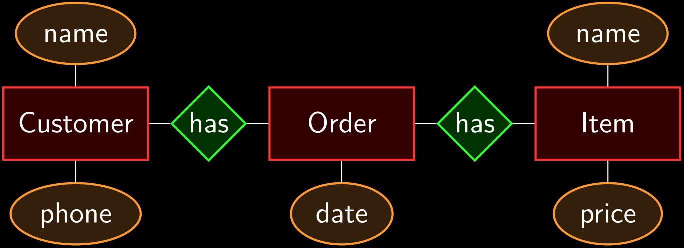
A Very Simple Database



Pure sqlite3 Code I

You start with something like this:

```
def open_db(path):
    conn = sqlite3.connect(path)
    conn.row_factory = sqlite3.Row
    return conn

def create_tables(conn):
    conn.execute("CREATE TABLE Customers (name text, phone text)")
    conn.execute("CREATE TABLE Orders (date text, customerid int)")
    conn.execute("CREATE TABLE OrderItems (orderid int, itemid int)")
    conn.execute("CREATE TABLE Items (name text, price real)")
    conn.commit()
```

Pure sqlite3 Code II

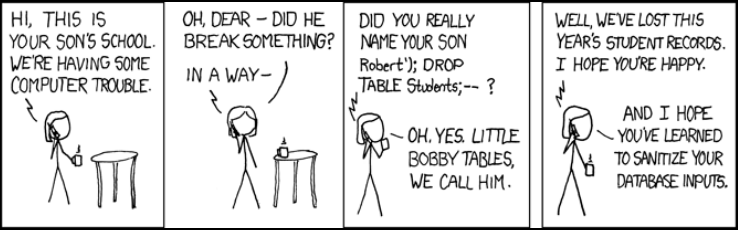
Let us model a Customer:

```python
class Customer:
    def __init__(self, name, phone, rowid=None):
        self.name = name
        self.phone = phone
        self.rowid = rowid
```

Pure sqlite3 Code III

You extend it with a class method to load a Customer:

```
class Customer: # ...
    @classmethod
    def load(cls, conn, rowid):
        cur = conn.execute("SELECT name, phone FROM Customers "
                           "WHERE rowid = ?", (rowid,))
        row = cur.fetchone()
        return cls(row["name"], row["phone"], rowid)
```


HI, THIS IS YOUR SON'S SCHOOL. WE'RE HAVING SOME COMPUTER TROUBLE.
OH, DEAR – DID HE BREAK SOMETHING?
IN A WAY–
DID YOU REALLY NAME YOUR SON Robert'); DROP TABLE Students;-- ?
OH. YES. LITTLE BOBBY TABLES, WE CALL HIM.
WELL, WE'VE LOST THIS YEAR'S STUDENT RECORDS. I HOPE YOU'RE HAPPY.
AND I HOPE YOU'VE LEARNED TO SANITIZE YOUR DATABASE INPUTS.

Pure sqlite3 Code IV

You also need to save them:

```
class Customer: # ...
    def save(self, conn):
        cur = conn.cursor()
        if self.rowid is None:
            cur.execute( "INSERT INTO Customers (name, phone) "
                          "VALUES (?, ?)", (self.name, self.phone))
            self.rowid = cur.lastrowid
        else:
            cur.execute("UPDATE Customers SET name = ?, phone = ? "
                         "WHERE rowid = ?",
                         (self.name, self.phone, self.rowid))
        conn.commit()
```

Pure sqlite3 Code V

You need similar code to handle Order objects:

```
class Order:
    def __init__(self, date, customer, rowid=None):
        self.date = date
        self.customer = customer
        self.rowid = rowid
        self.items = []
```

Pure sqlite3 Code VI

Loading an Order looks familiar:

```
class Order: # ...
    @classmethod
    def load(cls, conn, rowid):
        cur = conn.execute("SELECT date, customer "
                           "FROM Orders WHERE rowid = ?",
                           (rowid,))
        row = cur.fetchone()
        return cls(row["date"], Customer.load(row["customer"]), rowid)
```

Pure sqlite3 Code VII

Yet more familiar code:

```
class Order: # ...
    def save(self, conn):
        cur = conn.cursor()
        if self.rowid is None:
            cur.execute("INSERT INTO Orders (date, customerid) "
                        "VALUES (?, ?)",
                        (self.date, self.customer.rowid))
            self.rowid = cur.lastrowid
        else:
            cur.execute("UPDATE Orders SET date = ?, customerid = ? "
                        "WHERE rowid = ?",
                        (self.date, self.customer.rowid, self.rowid))
        conn.commit()
```

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Pure sqlite3 Code VIII

You would like to load orders for a Customer:

```
class Customer: # ...
    def orders(self, conn):
        sql = ("SELECT Orders.rowid, date, Items.rowid, name, price "
               "FROM Orders "
               " JOIN OrderItems ON Orders.rowid = OrderItems.orderid "
               " JOIN Items ON OrderItems.itemid = Items.rowid "
               "WHERE Orders.customerid = ?")
        results = []
        order_rowid = None
        for row in conn.execute(sql, (self.rowid,)):
            if order_rowid != row[0]:
                order = Order(date=row[1], customer=self, rowid=row[0])
                results.append(order)
                order_rowid = row[0]
            order.items.append(Item(row[3], row[4], row[2]))
        return results
```

SQLAlchemy to the Rescue! I

SQLAlchemy reduces the boiler-plate code significantly:

```
class Customer(Base):
    __tablename__ = "Customers"
    rowid = Column(Integer, primary_key=True)
    name = Column(String)
    phone = Column(String)
    orders = relationship("Order")

class Order(Base):
    __tablename__ = "Orders"
    rowid = Column(Integer, primary_key=True)
    date = Column(String)
    customer_id = Column(Integer, ForeignKey("Customers.rowid"))
```

SQLAlchemy to the Rescue! II

The Item table:

```
class Item(Base):
    __tablename__ = "Items"
    rowid = Column(Integer, primary_key=True)
    name = Column(String)
    price = Column(Integer)
```

SQLAlchemy to the Rescue! III

Order with a many-to-many relationship to Item:

```
order_items = Table("OrderItems", Base.metadata,
    Column("order_id", Integer, ForeignKey("Orders.rowid")),
    Column("item_id", Integer, ForeignKey("Items.rowid")))

class Order(Base):
    __tablename__ = "Orders"
    rowid = Column(Integer, primary_key=True)
    date = Column(String)
    customer_id = Column(Integer, ForeignKey("Customers.rowid"))
    items = relationship("Item", secondary=order_items)

class Item(Base):
    __tablename__ = "Items"
    rowid = Column(Integer, primary_key=True)
    name = Column(String)
    price = Column(Integer)
```

SQLAlchemy to the Rescue! IV

Setting up the code:

```
from sqlalchemy import Table, Column, Integer, String, ForeignKey
from sqlalchemy import create_engine
from sqlalchemy.orm import relationship
from sqlalchemy.ext.declarative import declarative_base

Base = declarative_base()

class Customer(Base): # ...
class Order(Base): # ...
class Item(Base): # ...

if __name__ == "__main__":
    engine = create_engine("sqlite:///:memory:", echo=True)
    Base.metadata.create_all(engine)
```

Overview

SQLAlchemy is a powerful library for working with databases:

- high performance
- mature and well-tested
- great documentation
- high abstraction level
- very feature rich

Features

Many. . . documentation spans 1100 pages!

When starting it's good to know that:

- scales well with your needs
- allows you to insert raw SQL when needed
- can be used with existing databases

Installation

SQLAlchemy is of course on PyPI:

```
$ pip install sqlalchemy
```

Install your favority DBAPI package too:

```
$ pip install psycopg2
```

SQLAlchemy has support for PostgreSQL, MySQL, SQLite, . . .

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The Session

The session is your interface to the DB:

- provides interface for queries
- implements transaction behavior
- maintains an identity map

```
from sqlalchemy.orm import sessionmaker
Session = sessionmaker(bind=engine)

def handle_request(request):
    session = Session()
    try:
        # use the session...
        session.commit()
    except:
        session.rollback()
    session.close()
```

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Adding and Deleting Objects

Simply add the object to the Session:

```
c1 = Customer(name="Roy Trenneman", phone="078 123 45 67")
c2 = Customer(name="Maurice Moss", phone="044 551 10 12")
session.add(c1)
session.add(c2)
```

Delete them in the same fashion:

```
session.delete(c1)
```

The changes are written to the DB when the session is committed:

```
session.commit()
```

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Querying the Database

Use the Session.query method to query the DB:

```
customers = session.query(Customer).filter_by(name="John Doe")
for customer in customers:
    order_count = len(customer.orders)
    print customer.name, "has", order_count, "orders"
    if order_count > 5:
        customer.name += " The Great"
```

Identity Map

The session keeps track of the DB rows:

```
c1 = session.query(Customer).filter_by(name="John Doe").one()
c2 = session.query(Customer).filter_by(phone="078 123 45 67").one()
assert c1.name == c2.name
assert c1.phone == c2.phone
assert c1 is c2
```

This ensure the application has a consistent view of the DB.

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The Mapper

The Mapper is mostly hidden:

- associates Python classes with DB tables
- decides which Python field corresponds to which DB column
- used indirectly when you create Column objects

Mapping Columns

Many possibilities:

```
class User(Base):
    __tablename__ = "users"
    user_id = Column("id", Integer, primary_key=True)
    firstname = Column(String)
    lastname = Column(String)
    name = column_property(firstname + " " + lastname)
    photo = deferred(Column(Binary))
```

Simple Computed Columns

With

```
class User(Base):
    # ...
    name = column_property(firstname + " " + lastname)
```

you can query on name:

```
jen = session.query(User).filter_by(name="Jen Barber").one()
```

SQLAlchemy will generate this SQL for SQLite:

```
SELECT users.id AS users_id,
  users.firstname || ? || users.lastname AS anon_1,
  users.firstname AS users_firstname,
  users.lastname AS users_lastname
FROM users
WHERE users.firstname || ? || users.lastname = ?
```

Advanced Computed Columns

Generate custom SQL on set and get:

```
class EmailAddress(Base):
    __tablename__ = "email_address"
    id = Column(Integer, primary_key=True)
    _email = Column("email", String)

    @hybrid_property
    def email(self):
        return self._email[:-12]

    @email.setter
    def email(self, email):
        self._email = email + "@example.com"

    @email.expression
    def email(cls):
        return func.substr(cls._email, 0, func.length(cls._email) - 12)
```

Custom Column Types I

Create new column type:

```
class PhoneColumn(TypeDecorator):
    impl = VARCHAR(15)
    number_format = phonenumbers.PhoneNumberFormat.E164

    def process_bind_param(self, value, dialect):
        if not isinstance(value, phonenumbers.PhoneNumber):
            value = phonenumbers.parse(value, "CH")
        return phonenumbers.format_number(value, self.number_format)

    def process_result_value(self, value, dialect):
        return phonenumbers.parse(value)
```

This stores phone numbers +41781234567 in DB.

Custom Column Types II

Use the new column like:

```
class Customer(Base):
    # ...
    phone = PhoneColumn()
```

Query for values based on new column:

```
customer = session.query(Customer).filter_by(phone="078 123 45 67")
print "Country code:", customer.phone.country_code
```

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Magic Fields

How does this really work:

```
customer.phone = '078 234 5678'
```

Fields of mapped classes

- transparently load data from DB
- transparently record modifications
- yet have the correct types (int, str, . . .)

What kind of magic is this?

The Descriptor Protocol I

Python has something called descriptors:

```
class VerboseField(object):
    def __init__(self, name):
        self.name = name
        self.data = weakref.WeakKeyDictionary()
    def __get__(self, instance, owner):
        print '*** reading', self.name
        return self.data[instance]
    def __set__(self, instance, value):
        print '*** setting', self.name, 'to', value
        self.data[instance] = value

class SomeClass(object):
    x = VerboseField()
```

The Descriptor Protocol II

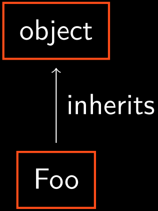
Now try accessing the x field:

```
>>> a = Foo()
>>> a.x
*** reading field
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "<stdin>", line 6, in __get__
  File "/usr/lib/python2.7/weakref.py", line 315, in __getitem__
    return self.data[ref(key)]
KeyError: <weakref at 0x7f2eb2cad158; to 'Foo' at 0x7f2eb2ca4d90>
>>> a.x = 'hello'
*** setting field to hello
>>> a.x
*** reading field
'hello'
```

Metaclasses

Metaclasses allow you to customize class construction:

- you can pass classes around in Python — they are objects
- a metaclass is the class invoked to create a “class object”



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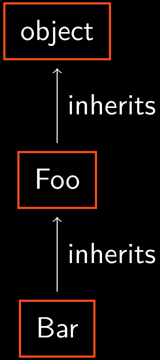

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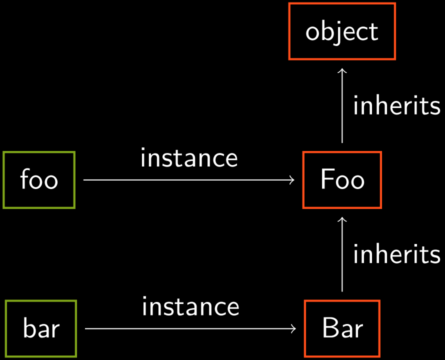

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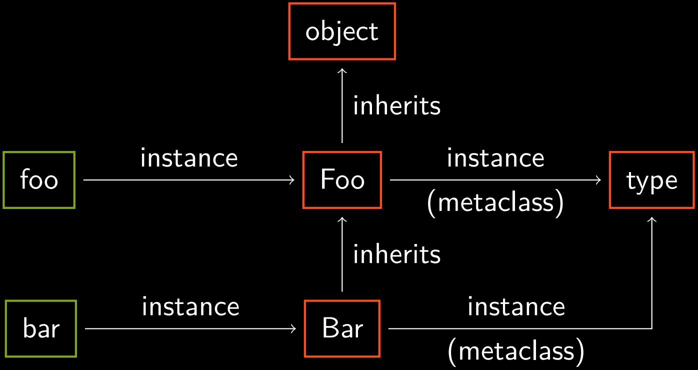

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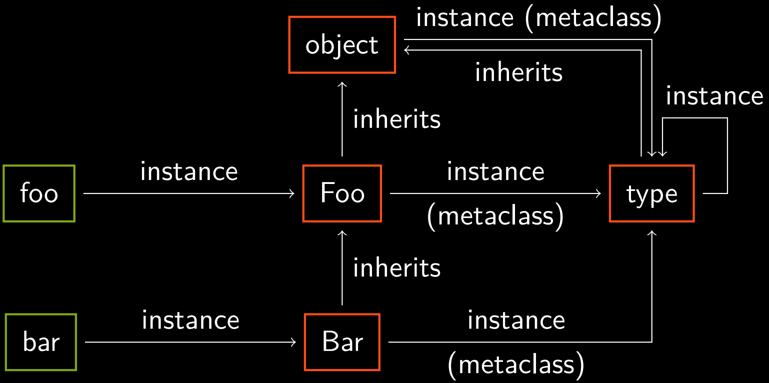

Metaclass Example

Simple example of a metaclass that marks everything private:

```python
class MakePrivate(type):
    def __new__(cls, name, bases, attrs):
        private = {}
        for key, value in attrs.iteritems():
            private['_' + key] = value
        return super(MakePrivate, cls).__new__(cls, name, bases, private)

class Foo(object):
    __metaclass__ = MakePrivate
    x = 10

foo = Foo()
print foo._x
```

This yields 10.

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SQLAlchemy makes databases fun again!

- easy things become easy
- difficult things are still possible

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Thank you! Questions?