This talk is about GeoAlchemy, which is an extension to SQLAlchemy for working with geospatial databases.

I am actually going to talk about three things:

- Geospatial databases, focusing on PostGIS,
- SQLAlchemy, the Python SQL toolkit,
- and GeoAlchemy, which makes it possible to use SQLAlchemy with geospatial databases.
My name is Éric Lemoine. I work at Oslandia. I've been using Postgres, PostGIS and SQLAlchemy for about 10 years.
Oslandia provides service on open-source software

- GIS
- 3D
- DATA

Oslandia is an open-source company working on GIS, 3D and Data Science. QGIS and PostGIS are examples of software components we are working on.
WHAT'S A SPATIAL DATABASE?

Quoting Wikipedia:

A spatial database, or geodatabase is a database that is optimized to store and query data that represents objects defined in a geometric space.
SPATIAL QUERIES

« Give me all the POIs within a given area »
SPATIAL QUERIES

« Give me all the POIs within a certain distance to a point »
And what you can ultimately do with geospatial databases is create beautiful maps. This one is a map of Europe drawn by its rivers and streams.
POSTGIS

The Spatial Database extender for PostgreSQL

http://postgis.net/
PostGIS provides "spatial" types, functions and operators, and indexes.
POSTGIS EXAMPLE #1

Enable PostGIS in a database

$ psql -d my-database
my-database=# create extension postgis;
POSTGIS EXAMPLE #2

Create a table with a "geometry" column

CREATE TABLE users (  
    id SERIAL,  
    name TEXT,  
    fullname TEXT,  
    geom GEOMETRY(POINT)  
);  
CREATE INDEX users_geom_idx ON users USING GIST (geom);
POSTGIS EXAMPLE #3

Insert a record with a geometry

```
INSERT INTO users (name, fullname, geom)
VALUES('pramsey', 'Paul Ramsey',
       ST_GeomFromText('POINT(-123 48')));
```
POSTGIS EXAMPLE #4

Select users within a distance of a point

```
SELECT name FROM users
WHERE ST_DWithin(users.geom, 'POINT(-123 49)', 1);
```
OpenStreetMap uses PostGIS.
SQLAlchemy

The Database Toolkit for Python

https://www.sqlalchemy.org/
SQLALCHEMY PHILOSOPHY

- Not about hiding the DB
- Relational form of data is preserved
- SQLA provides a rich vocabulary to express decisions made by the developer
SQLAlchemy Architecture

Two parts: SQLAlchemy Core and SQLAlchemy ORM

SQLAlchemy Core includes an SQL Expression Language for forming SQL constructs.
Define and create tables

```python
from sqlalchemy import (Table, Column, Integer, String, MetaData, ForeignKey)
metadata = MetaData()
users = Table('users', metadata,
    Column('id', Integer, primary_key=True),
    Column('name', String),
    Column('fullname', String),
)
addresses = Table('addresses', metadata,
    Column('id', Integer, primary_key=True),
    Column('user_id', None, ForeignKey('users.id')),
    Column('email_address', String, nullable=False)
)
metadata.create_all()
```
Insert records

```
insert = users.insert().values(name='jack', fullname='Jack Jones')
conn = engine.connect()  # get a connection
result = conn.execute(insert)
user_id = result.inserted_primary_key
```
from sqlalchemy.sql import select

s = select([users, addresses]).where(users.c.id == addresses.c.user_id)
result = conn.execute(s)
for row in result:
    print(row['name'], row['fullname'])
WITH JUST PSYCOPG2 (DBAPI)

```python
sql = "SELECT id, diameter, ST_AsGeoJSON(geom) FROM mytable"
if bbox:
    sql_ = "{} WHERE ST_Intersects(geom, ST_MakeEnvelope(" "%(xmin)s, %(ymin)s, %(xmax)s, %(ymax)s))".format(sql)
    vars_['xmin'] = bbox[0]
    vars_['ymin'] = bbox[1]
    vars_['xmax'] = bbox[2]
    vars_['ymax'] = bbox[3]

if limit:
    sql = "{} LIMIT %s".format(sql)
    vars_['limit'] = limit

with conn.cursor() as cursor:
    cursor.execute(sql, vars_)
```
WITH SQLALCHEMY

```python
q = select([column("id"),
            column("diameter"),
            func.ST_AsGeoJSON(column("geom"))])
q = q.select_from("mytable")

if bbox:
    q = q.where(func.ST_Intersects(
                column("geom"),
                func.ST_MakeEnvelope(bbox[0], bbox[1], bbox[2], bbox[3])
            )
    )

if limit:
    q = q.limit(limit)

conn.execute(q)
```
SQLALCHEMY ECOSYSTEM

- Alembic – DB migrations
- Flask-SQLAlchemy – Flask extension for SQLA
- ...

Flask-User depends on Flask-SQLAlchemy.
GEOALCHEMY

Provides extensions to SQLAlchemy for working with Spatial databases

https://geoalchemy-2.readthedocs.io/
A BIT OF HISTORY

- GeoAlchemy 1 created in 2009 (PostGIS only)
- MySQL, SpatiaLite, Oracle, MS SQL support added in 2010
- GeoAlchemy 2 created in 2012 (PostGIS only)
- SpatiaLite support added in 2018
GeoAlchemy Features

- Supports Geometry, Geography and Raster types
- Supports many PostGIS functions and operators
- Works with SQLAlchemy Core and SQLAlchemy ORM
- Integrates with Shapely

GeoAlchemy is actually a thin layer on top of SQLAlchemy.
Specify a geometry column

```python
from sqlalchemy import (Table, Column, Integer,
                        String, MetaData, ForeignKey)
from geoalchemy2 import Geometry

metadata = MetaData()
users = Table('users', metadata,
              Column('id', Integer, primary_key=True),
              Column('name', String),
              Column('fullname', String),
              Column('geom', Geometry('POINT'))
)
```
GEOALCHEMY EXAMPLE #2

Insert a "spatial" record

```python
insert = users.insert().values(
    name='jack', fullname='Jack Jones', geom='POINT(90 43)')
conn = engine.connect()
result = conn.execute(insert)
user_id = result.inserted_primary_key
```
Get the objects that are within a distance to a point

```python
from sqlalchemy.sql import select

s = select([users]).where(func.ST_DWithin(users.c.geom, 'POINT(90 43)', 1))
result = conn.execute(s)
for row in result:
    print(row['name'], row['fullname'])
```
Get the objects that are within a polygon

```python
s = select([users]).where(func.ST_Contains('POLYGON((80 40, 100 40, 100 50, 80 50))', users.c.geom))
result = conn.execute(s)
for row in result:
    print(row['name'], row['fullname'])
```
GeoAlchemy integrates well with

- Shapely
- geojson
- pyproj
CONCLUSION

- PostGIS is great. Use it!
- SQLA is great when working with DBs in Python
- GeoA is useful when using PostGIS (or SpatiaLite)
THANK YOU!
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