SQLAlchemy

Introduction to SQLAlchemy and ORMs

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Companion Package Download:

~~http://techspot.zzzeek.org/sqlalchemy_tutorial.zip~~

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Prerequisite Knowledge

- This tutorial assumes some basic knowledge about SQL (in order of importance):
  - structure: tables, columns, CREATE TABLE, etc.
  - querying: selecting rows with SELECT
  - modifying data with INSERT, UPDATE, DELETE
  - joins, grouping
  - transactions

SQLAlchemy – Overview

- the Database Toolkit for Python
- introduced 2005
- end-to-end system for working with the Python DBAPI, relational databases, and the SQL language
- Current release 0.8.2, 0.9 almost ready
- 1.0 will happen

SQLAlchemy Goals

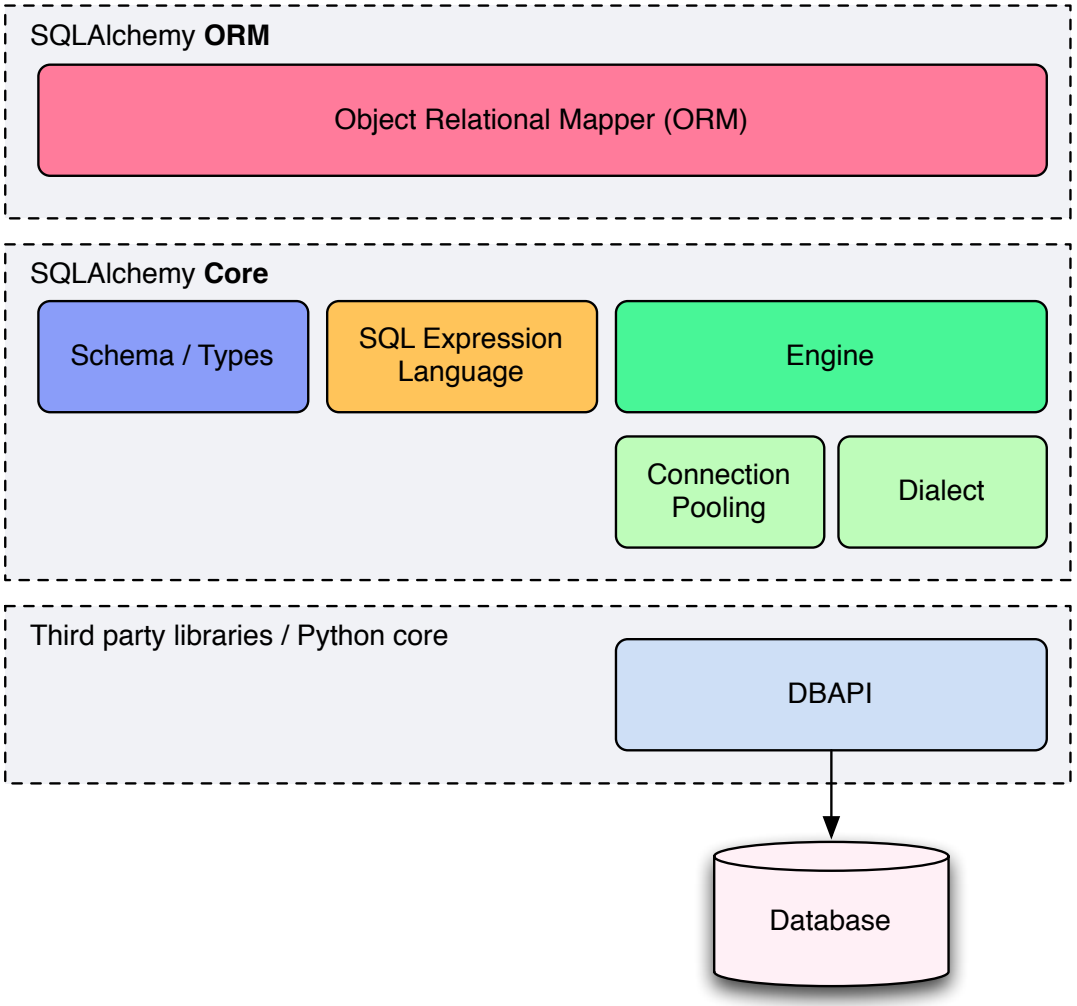
- Provide helpers, tools and components to assist and automate database development at every level
- Provide a consistent and fully featured facade over the Python DBAPI
- Provide an industrial strength, but optional, object relational mapper (ORM)
- Act as the foundation for any number of third party or in-house tools

SQLAlchemy Philosophies

- Bring the usage of different databases and adapters to an interface as consistent as possible…
- …but still expose distinct behaviors and features of each backend.
- Never "hide" the database or its concepts - developers must know / continue to think in SQL…
- Instead….provide automation and DRY
- Allow expression of DB/SQL tasks using declarative patterns

SQLAlchemy Overview

SQLAlchemy consists of the **Core** and the **ORM**



SQLAlchemy – Core

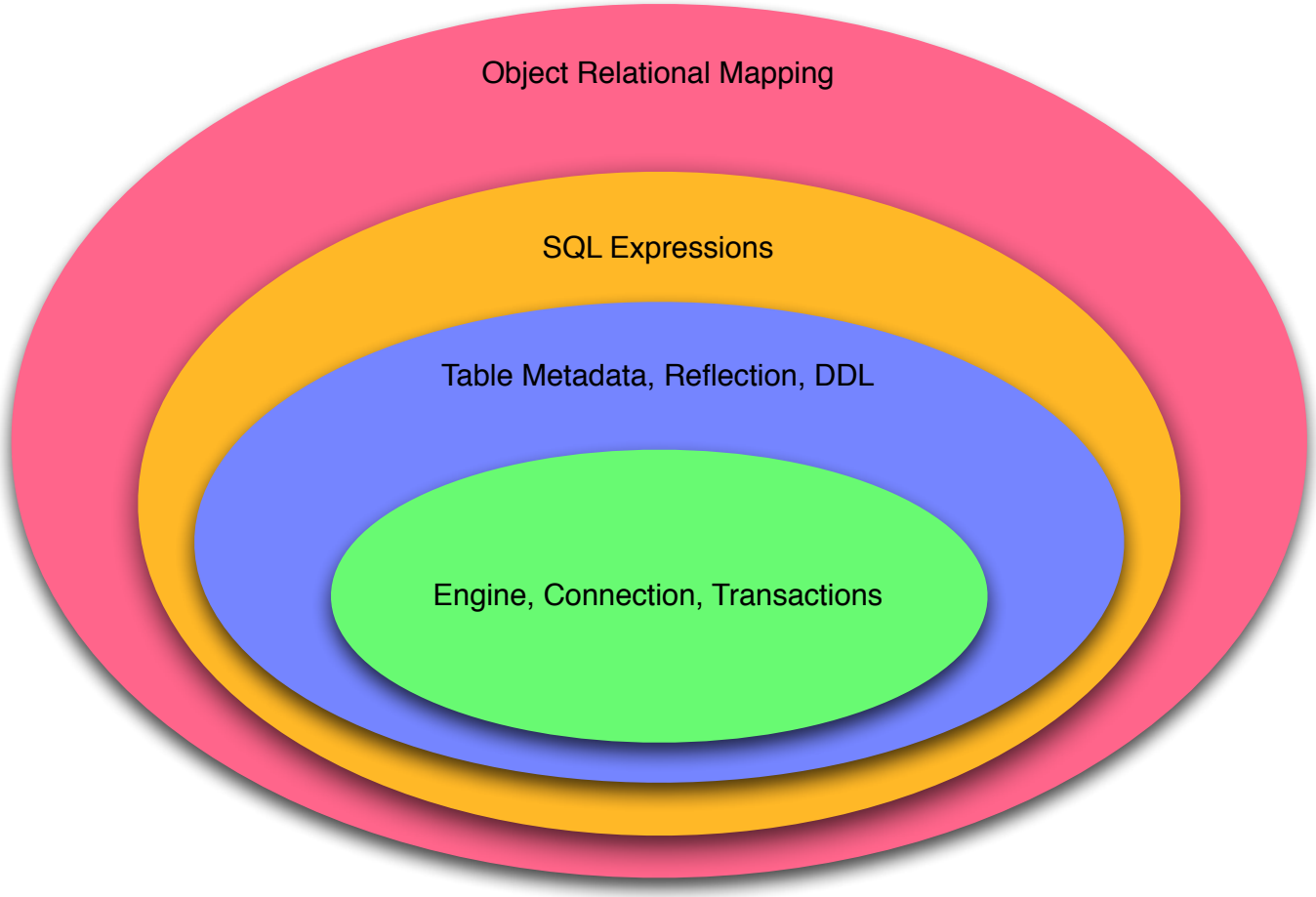
- **Engine** - a registry which provides connectivity to a particular database server.
- **Dialect** - interprets generic SQL and database commands in terms of a specific DBAPI and database backend.
- **Connection Pool** - holds a collection of database connections in memory for fast re-use.
- **SQL Expression Language** - Allows SQL statements to be written using Python expressions
- **Schema / Types** - Uses Python objects to represent tables, columns, and datatypes.

SQLAlchemy – ORM

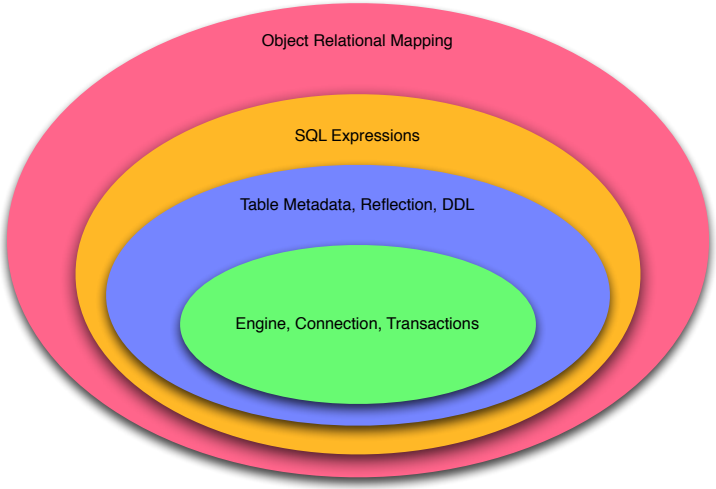
- Allows construction of Python objects which can be **mapped** to relational database tables.
- Transparently persists objects into their corresponding database tables using the **unit of work** pattern.
- Provides a query system which loads objects and attributes using SQL generated from mappings.
- Builds on top of the **Core** - uses the Core to generate SQL and talk to the database.
- Presents a slightly more **object centric** perspective, as opposed to a **schema centric** perspective.

SQLAlchemy is like an Onion

Can be learned from the inside out, or outside in



Level 1, Engine, Connection, Transactions



The Python DBAPI

- DBAPI - PEP-0249, Python Database API
- The de-facto system for providing Python database interfaces
- There are many DBAPI implementations available, most databases have more than one
- Features/performance/stability/API quirks/ maintenance vary wildly

DBAPI – Nutshell

```
import psycopg2
connection = psycopg2.connect("scott", "tiger", "test")

cursor = connection.cursor()
cursor.execute(
          "select emp_id, emp_name from employee "
          "where emp_id=%(emp_id)s",
          {'emp_id':5})
emp_name = cursor.fetchone()[1]
cursor.close()

cursor = connection.cursor()
cursor.execute(
          "insert into employee_of_month "
          "(emp_name) values (%(emp_name)s)",
          {"emp_name":emp_name})
cursor.close()

connection.commit()
```

Important DBAPI Facts

- DBAPI assumes that a *transaction is always in progress*. There is no begin() method, only commit() and rollback().
- DBAPI encourages bound parameters, via the execute() and executemany() methods. But has six different formats.
- All DBAPIs have inconsistencies regarding datatypes, primary key generation, custom database features, result/cursor behavior
- DBAPI has it's own exception hierarchy, which SQLAlchemy exposes directly in a generic namespace.

SQLAlchemy and the DBAPI

- The first layer in SQLAlchemy is known as the **Engine**, which is the object that maintains the classical DBAPI interaction.

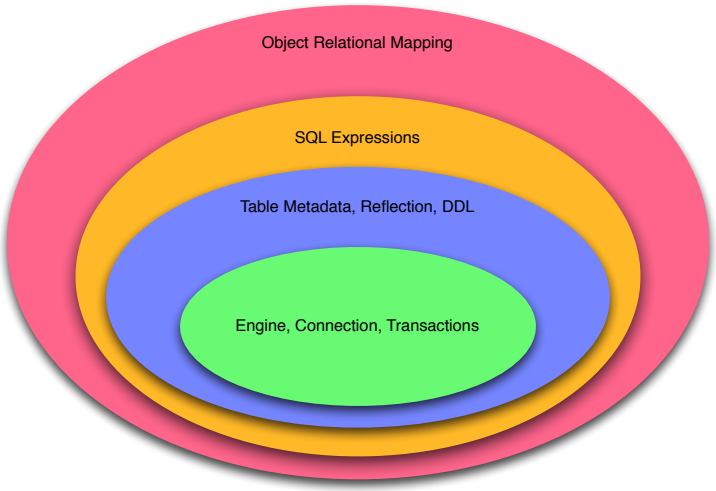
Engine - Usage

```
.venv/bin/sliderepl 01_engine.py
```

Engine Facts

- Executing via the `Engine` directly is called **connectionless execution** - the Engine connects and disconnects for us.
- Using a `Connection` is called **explicit execution**. We control the span of a connection in use.
- Engine usually uses a connection pool, which means "disconnecting" often means the connection is just returned to the pool.
- The SQL we send to engine.execute() as a string is not modified, is consumed by the DBAPI verbatim.

Level 2, Table Metadata, Reflection, DDL



What is "Metadata"?

- Popularized by Martin Fowler, *Patterns of Enterprise Architecture*
- Describes the structure of the database, i.e. tables, columns, constraints, in terms of data structures in Python
- Serves as the basis for SQL generation and object relational mapping
- Can generate *to* a schema
- Can be generated *from* a schema

MetaData and Table

```
.venv/bin/sliderepl 02_metadata.py
```

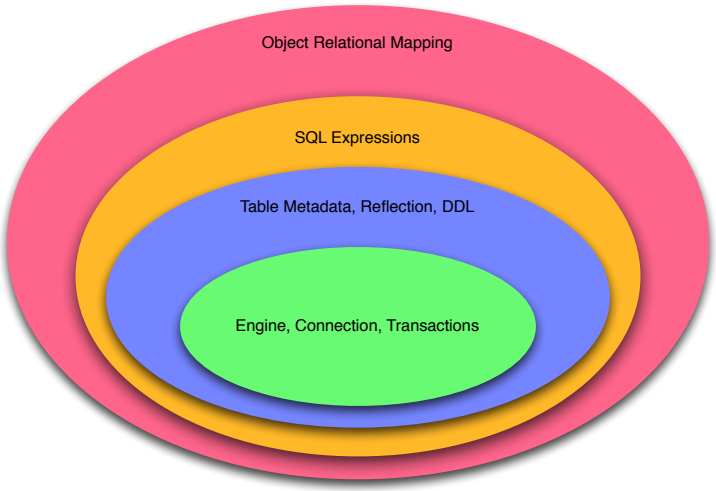
Some Basic Types

- `Integer()` - basic integer type, generates INT
- `String()` - ASCII strings, generates `VARCHAR`
- `Unicode()` - Unicode strings - generates `VARCHAR`, `NVARCHAR` depending on database
- Boolean() - generates `BOOLEAN`, `INT`, `TINYINT`
- `DateTime()` - generates `DATETIME` or `TIMESTAMP`, returns Python `datetime()` objects
- `Float()` - floating point values
- `Numeric()` - precision numerics using Python `Decimal()`

CREATE and DROP

- `metadata.create_all(engine, checkfirst=<`**`True`**`|False>)` emits CREATE statements for all tables.
- `table.create(engine, checkfirst=<True|`**`False`**`>)` emits CREATE for a single table.
- `metadata.drop_all(engine, checkfirst=<`**`True`**`|False>)` emits DROP statements for all tables.
- `table.drop(engine, checkfirst=<True|`**`False`**`>)` emits DROP for a single table.

Level 3, SQL Expressions



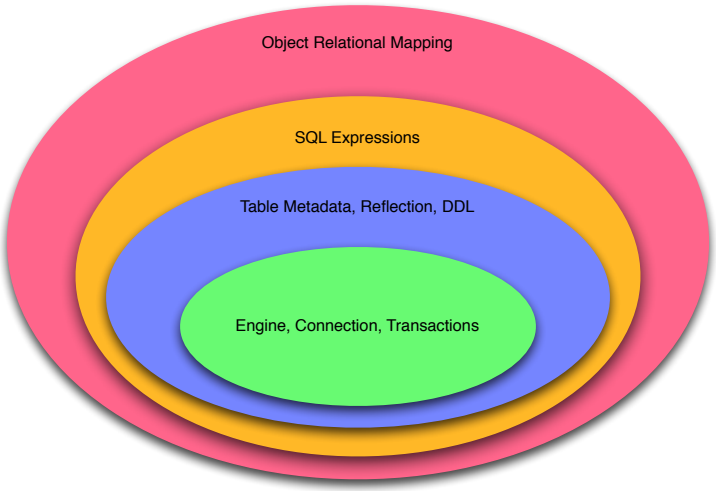
SQL Expressions

- The **SQL Expression** system builds upon **Table Metadata** in order to compose SQL statements in Python.
- We will build Python objects that represent individual SQL strings (statements) we'd send to the database.
- These objects are composed of other objects that each represent some unit of SQL, like a comparison, a SELECT statement, a conjunction such as AND or OR.
- We work with these objects in Python, which are then converted to strings when we "execute" them (as well as if we `print` them).

SQL Expressions

```
.venv/bin/sliderepl 03_sql_expressions.py
```

Level 4, Object Relational Mapping

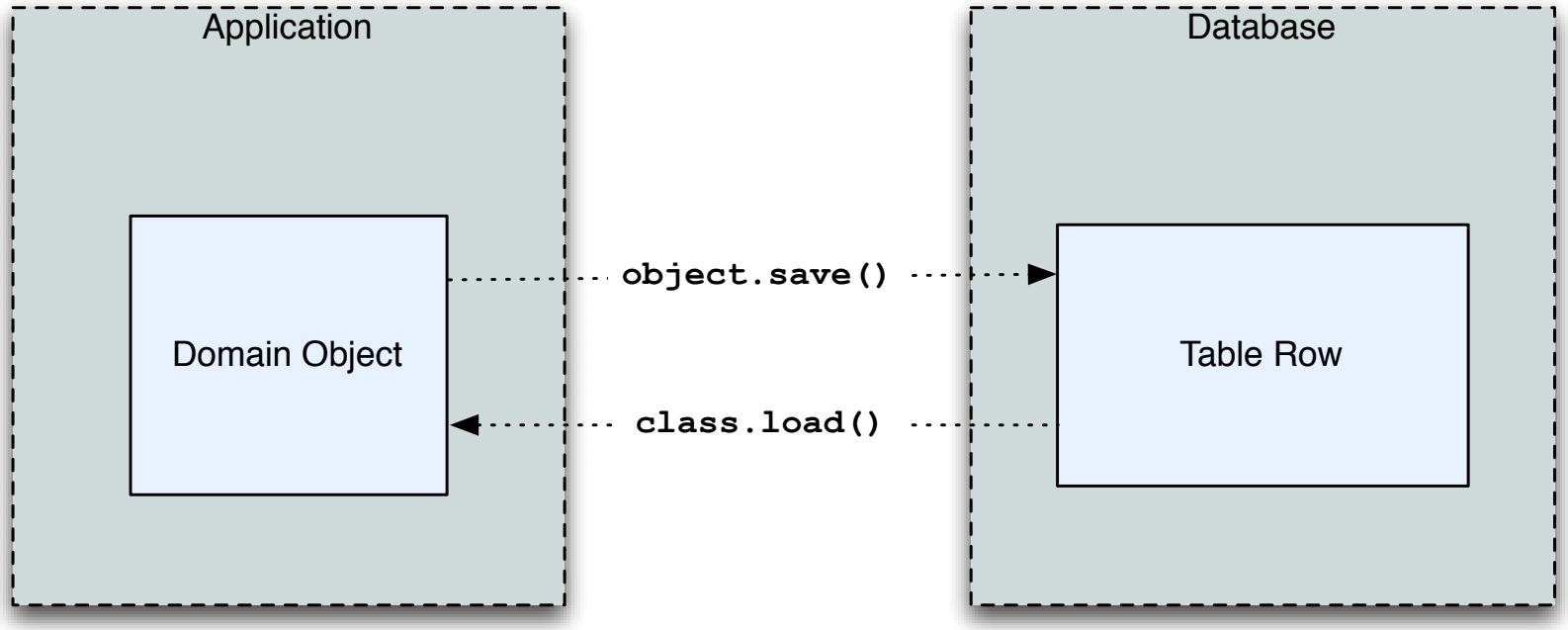


Object Relational Mapping

- Object Relational Mapping, or ORM, is the process of associating object oriented classes with database tables.
- We refer to the set of object oriented classes as a **domain model**.

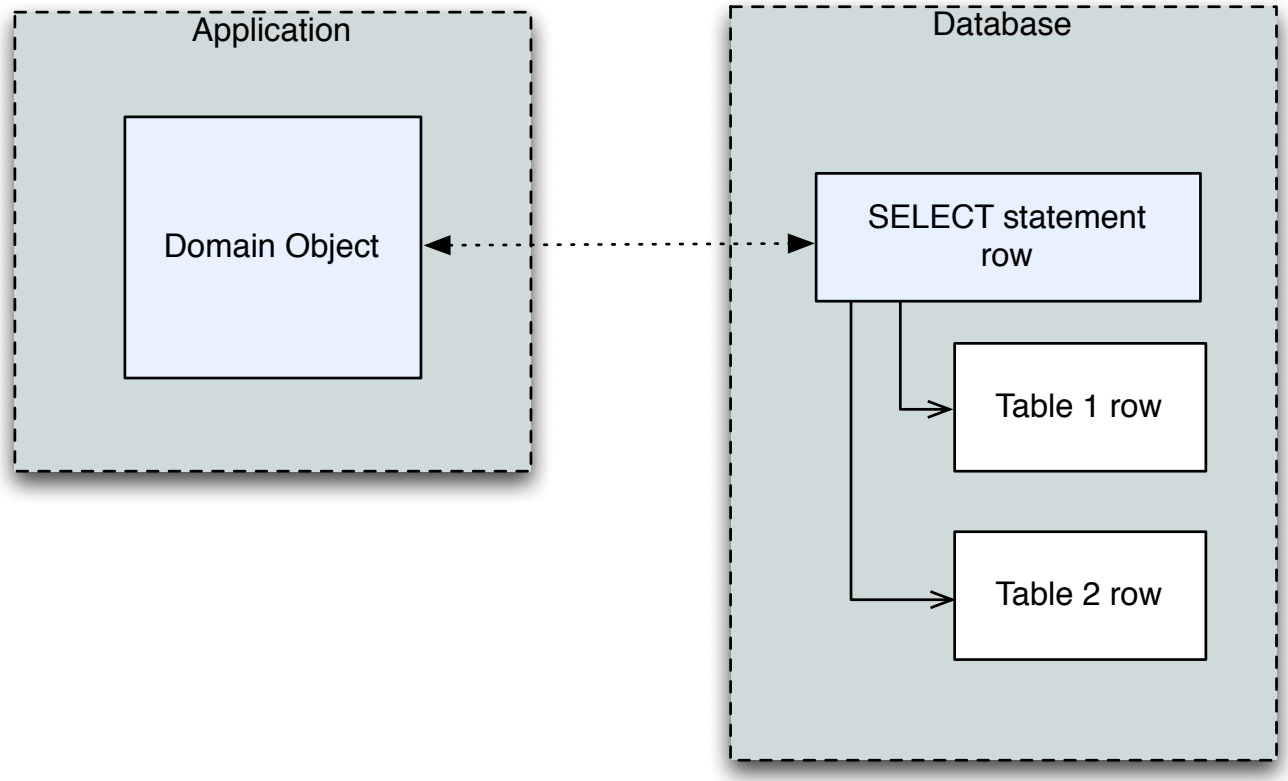
What does an ORM Do?

The most basic task is to translate between a domain object and a table row.



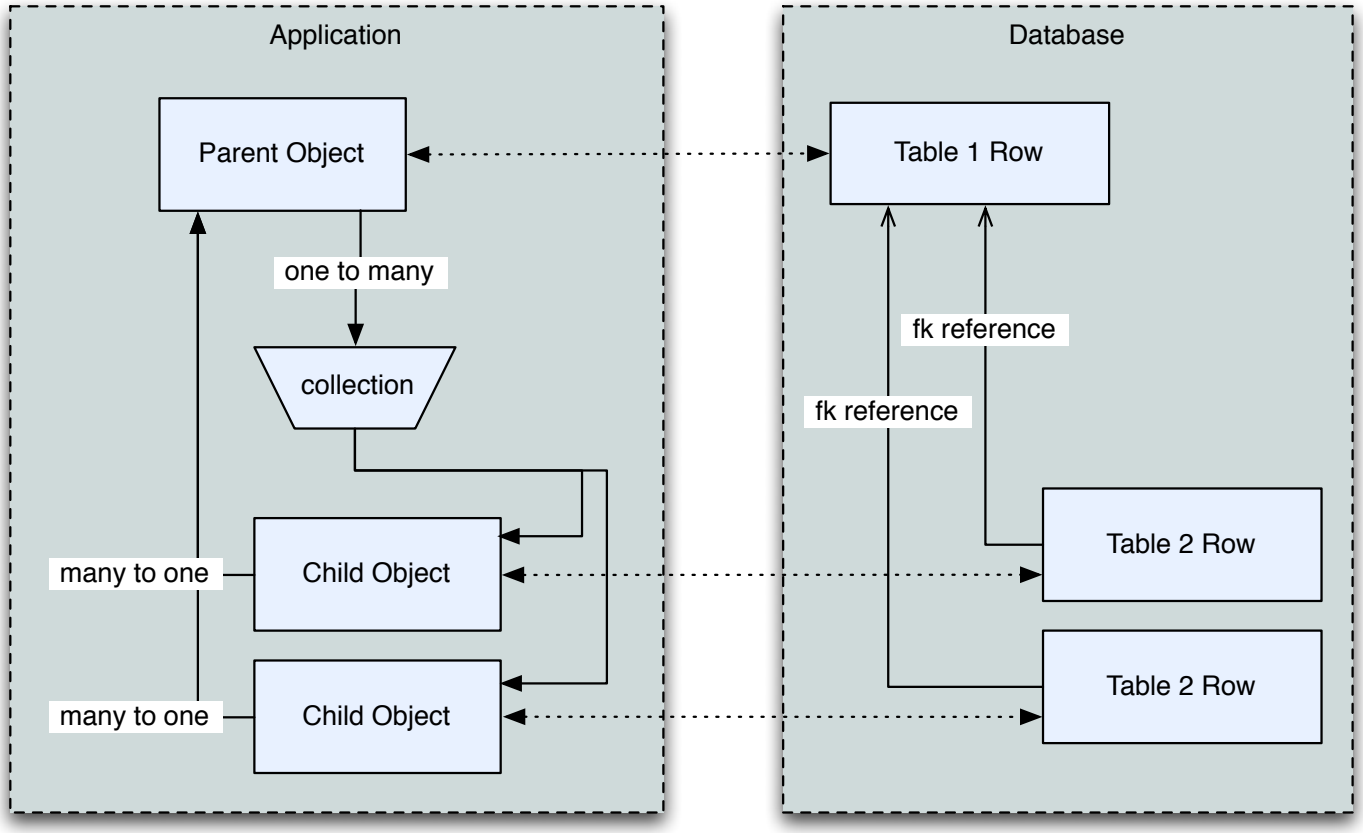
What does an ORM Do?

Some ORMs can also represent *arbitrary* rows as domain objects within the application, that is, rows derived from SELECT statements or views.



What does an ORM Do?

Most ORMs also represent basic *compositions*, primarily **one-to-many** and **many-to-one**, using **foreign key associations**.



What does an ORM Do?

- Other things ORMs do:
  - provide a means of querying the database in terms of the domain model structure
  - Some can represent class inheritance hierarchies using a variety of schemes
  - Some can handle "sharding" of data, i.e. storing a domain model across multiple schemas or databases
  - Provide various patterns for concurrency, including row versioning
  - Provide patterns for data validation and coercion

Flavors of ORM

The two general styles of ORM are **Active Record** and **Data Mapper**. **Active Record** has domain objects handle their own persistence:

```
user_record = User(name="ed", fullname="Ed Jones")
user_record.save()

user_record = User.query(name='ed').fetch()
user_record.fullname = "Edward Jones"
user_record.save()
```

Flavors of ORM

The **Data Mapper** approach tries to keep the details of persistence *separate* from the object being persisted.

```
dbsession = start_session()

user_record = User(name="ed", fullname="Ed Jones")

dbsession.add(user_record)

user_record = dbsession.query(User).filter(name='ed').first()
user_record.fullname = "Edward Jones"

dbsession.commit()
```

Flavors of ORM

ORMs may also provide different configurational patterns. Most use an "all-at-once", or **declarative** style where class and table information is together.

```
# a hypothetical declarative system

class User(ORMObject):
    tablename = 'user'

    name = String(length=50)
    fullname = String(length=100)

class Address(ORMObject):
    tablename = 'address'

    email_address = String(length=100)
    user = many_to_one("User")
```

Flavors of ORM

A less common style keeps the declaration of domain model and table metadata separate.

```
# class is declared without any awareness of database
class User(object):
    def __init__(self, name, username):
        self.name = name
        self.username = username


# elsewhere, it's associated with a database table
mapper(
     User,
     Table("user", metadata,
           Column("name", String(50)),
           Column("fullname", String(100))
     )
)
```

SQLAlchemy ORM

- The SQLAlchemy ORM is essentially a data mapper style ORM.
- Modern versions use declarative configuration; the "domain and schema separate" configuration model is present underneath this layer.
- The ORM builds upon SQLAlchemy Core, and many of the SQL Expression concepts are present when working with the ORM as well.
- In contrast to the SQL Expression language, which presents a schema-centric view of data, it presents a domain-model centric view of data.

Key ORM Patterns

- **Unit of Work** - objects are maintained by a system that tracks changes over the course of a transaction, and **flushes** pending changes periodically, in a transparent or semi-transparent manner
- **Identity Map** - objects are tracked by their primary key within the unit of work, and are kept *unique* on that primary key identity.
- **Lazy Loading** - Some attributes of an object may emit additional SQL queries when they are accessed.
- **Eager Loading** - Multiple tables are queried at once in order to load related objects and collections.
- **Method Chaining** - queries are composed using a string of method calls which each return a new query object.

ORM Walkthrough

```
.venv/bin/sliderepl 04_orm.py
```

SQLAlchemy

Object Relational Mapper

SQL Expressions

Thanks !

Table Metadata, Reflection, DDL

http://www.sqlalchemy.org

Engine, Connection, Transactions

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