LambdaQuery Documentation

Release 0.1

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Contents

CHAPTER 1

Motivation

SQL is a pain in the ass to write.

Shortcomings of SQL

CHAPTER 2

Installation

Complete the following instructions:

- `git clone https://github.com/xnmp/lambdaquery.git`
- `cd LambdaQuery`
- `python setup.py install`.

CHAPTER 3

Setting up Tables

In `Examples/example._tables.py` there is an example of setting up tables. The structure of this database is outlined in these docs under the "Querying" section.

CHAPTER 4

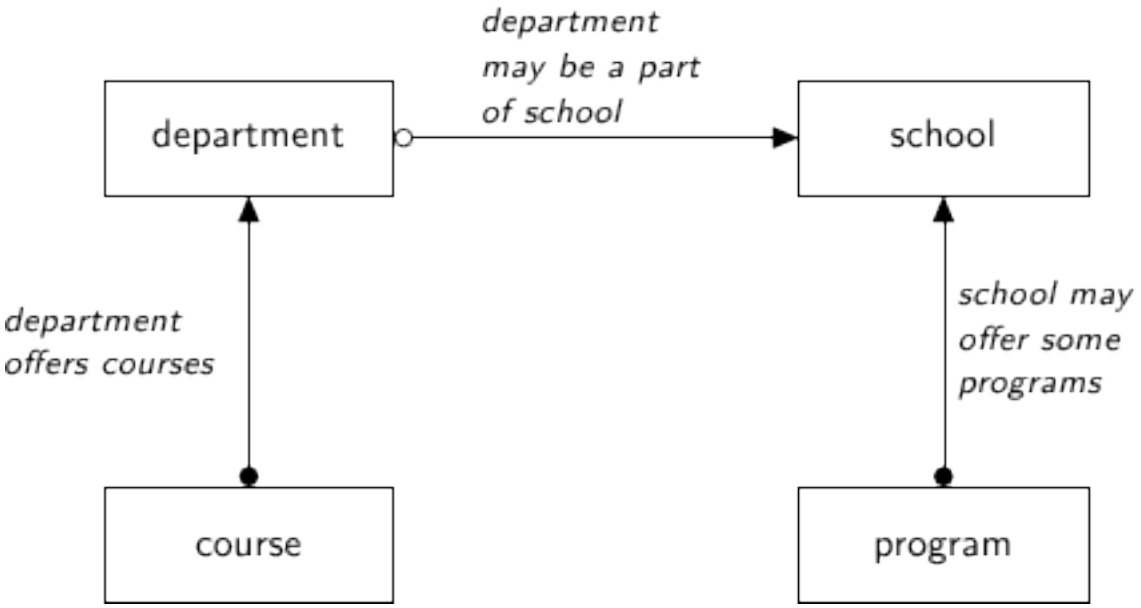
Querying

For this we're going to be using the same examples as can be found here. That is we have a database for a university, with four tables:

- Schools - a university may have several schools, for example the school of science, the school of arts, and the school of business. The school table has the following columns:
  - A code (primary key)
  - A name
  - A campus - north campus, south campus, etc.
- Programs - each school may offer several programs, or degrees - a bachelor of commerse, a bachelor of arts, or a master of arts. The program title has the following columns:
  - A code (primary key)
  - A school code (foreign key)
  - A title (e.g. bachelor of commerce)
  - A degree type - bachelor's, masters, phd, etc.
- Departments - for example, the physics department might be a part of the school of science. Each department has:
  - A code (primary key)
  - A name
  - A school code (foreign key)
- Courses - Departments offer courses, this is pretty self explanatory. each course has
  - A course code (primary key)
  - A department code (foreign key)
  - A number of credits
  - A description

- A title

This is summarized in the following diagram:



The Query Object

Tables are set up in the "Examples" folder of the github repo located at https://github.com/xnmp/lambdaquery. The boilerplate code should be fairly self-explanatory and it's worth glancing over it to see the syntax.

Use the `Query.sql` method to display the SQL of a query.

```
ex1 = School.query()
print(ex1.sql())
```

This will give the result:

```
SELECT DISTINCT
  sc_kda8.school_code AS code,
  sc_kda8.name AS name,
  sc_kda8.campus AS campus
FROM school AS sc_kda8
```

Filtering

Use the `.filter` method to filter:

```
School.query().filter(lambda x: x.campus == 'south')
```

Since this construction is so common, this can be abbreviated down to:

```
School.query(lambda x: x.campus == 'south')
```

The resulting SQL looks like:

```
SELECT DISTINCT
  sc_pob4.school_code AS code,
  sc_pob4.name AS name,
  sc_pob4.campus AS campus
FROM school AS sc_pob4
WHERE (sc_pob4.campus = 'south')
```

Selecting

To demonstrate selecting, we use the `fmap` method of the query object. Again, we can think of a query like a list, and the `fmap` method is like mapping a function over that list. Selection looks like:

```
School.query().fmap(lambda x: x.name % x.campus)
```

Here we can think of the query as a list of dictionaries where the entries of the dictionary can be accessed by using an attribute name. The `%` operator herre can be thought of the operator that combinbes two dictionaries.

Note that because this is so common, a simpler way to do this is via the `getitem` method as follows:

```
School.query()['name','campus']
```

This will give the result:

```
SELECT DISTINCT
  sc_pob4.name AS name,
  sc_pob4.campus AS campus
FROM school AS sc_pob4
```

Now there's always several ways to do things in LambdaQuery, and its strength lies in using a generator function to "unroll" a query. We can do this via the `yield` keyword, so that when we write `sc0 = yield School.query()` this can be thought of as `for sc0 in School.query():`. Then `sc0` is a single school, and we can apply functions that work on single schools to `sc0`, such as, say, the number of departments it has.

For reference, the above is written using the generator function as:

```
@do(Query)
def ex4():
    sc0 = yield School.query()
    returnM (sc0.name, sc0.campus)
```

which may be read as "for each school, return its name and campus".

Joining

Joining is very simple when we only have one foreign key. For example, if we have a school `sc0` and we want its departments, then this is simply `sc0.departments()` which is itself a query object. Note the open-and-close bracket at the end - this is to signify a one-to-many relationship. For a one-to-one relationship such as the school of a department `dept0`, we don't need the brackets and this is just `dept0.school`.

For example, suppose we wanted:

> for each department, return its name, the name of its school, and the campus of its school.

This is written as:

```
@do(Query)
def ex6():
    dept0 = yield Department.query()
    returnM (
              dept0.name,
              dept0.school.name,
              dept0.school.campus
             )
```

And the SQL generated is:

```
SELECT DISTINCT
  dept_ilso.name AS name,
  sc_im20.name AS name0,
  sc_im20.campus AS campus
FROM department AS dept_ilso
  JOIN school AS sc_im20 ON (sc_im20.school_code = dept_ilso.school_code)
```

CHAPTER 5

Aggregation

Now the query object has the `min`, `max`, `avg`, `sum`, and `count` methods, which collapse a query down into one number. So suppose for each school, we want the number of departments. This is written as:

```
@do(Query)
def ex5():
    sc0 = yield School.query()
    returnM (
              sc0.name,
              sc0.departments().count()
             )
```

The generated SQL is:

```
SELECT
  sc_xzqo.name AS name,
  COUNT(DISTINCT dept_y04o.dept_code) AS count_code
FROM school AS sc_xzqo
  JOIN department AS dept_y04o ON (dept_y04o.school_code = sc_xzqo.school_code)
GROUP BY 1
```

Encapsulation

Here we get our first glimpse into the enormous amount of composability offered by LambdaQuery. We can write the above a function as follows:

```
def num_dept(self):
    return self.departments().count()
```

And now the above can be written as:

```
@do(Query)
def ex5():
```

```
    sc0 = yield School.query()
    returnM (
             sc0.name,
             num_dept(sc0)
            )
```

If we want to use it as if it were an attribute, then we need to use the `@injective` decorator:

```
@injective()
def num_dept(self):
    return self.departments().count()
```

This enables us to write:

```
@do(Query)
def ex5():
    sc0 = yield School.query()
    returnM (
             sc0.name,
             sc0.num_dept
            )
```

In fact, as before we can now write `School.query()['name','num_dept']` to get the same result.

We can even filter on this: `School.query(lambda x:  x.num_dept > 3)` returns the SQL:

```
SELECT
  sc_7488.school_code AS code,
  sc_7488.name AS name,
  sc_7488.campus AS campus
FROM school AS sc_7488
  JOIN department AS dept_751s ON (dept_751s.school_code = sc_7488.school_code)
GROUP BY 1, 2, 3
HAVING (COUNT(DISTINCT dept_751s.dept_code) > 3)
```

In every respect the `num_dept` property that we have just defined may be treated as if it were just another column.

Explicit Grouping By

Grouping by is a matter of using the functions `max_`, `min_`, `count_` (with an underscore). Note that these functions take a single row to a single row, and are the only cases of breaking the intuition of thinking of queries as lists. Such functions should only be used inside the `returnM`.

Suppose we wanted to get the average number of credits of courses with a code that begins with "100". This looks like:

```
@do(Query)
def ex8():
    cs0 = yield Course.query()
    returnM (
             cs0.no.like_('100%'),
             cs0.credits.avg_()
            )
```

Generated SQL:

```
SELECT
  course_ie1k.course_code LIKE '100%' AS like_no,
  AVG(COALESCE(course_ie1k.credits, 0)) AS avg_credits
FROM course AS course_ie1k
GROUP BY 1
```

CHAPTER 6

Iteration

Suppose for each department, we wanted to know the number of 100 series courses it offered, and the same for 200 series, 300 series, and 400 series. In SQL, this looks like:

```
SELECT
  dept_ek40.name AS name,
  COUNT(DISTINCT CASE WHEN (course_fsu0.course_code > 100) AND (course_fsu0.course_
↪code < 199) THEN course_fsu0.course_code END) AS count_no,
  COUNT(DISTINCT CASE WHEN (course_fsu0.course_code > 200) AND (course_fsu0.course_
↪code < 299) THEN course_fsu0.course_code END) AS count_no0,
  COUNT(DISTINCT CASE WHEN (course_fsu0.course_code > 300) AND (course_fsu0.course_
↪code < 399) THEN course_fsu0.course_code END) AS count_no1,
  COUNT(DISTINCT CASE WHEN (course_fsu0.course_code > 400) AND (course_fsu0.course_
↪code < 499) THEN course_fsu0.course_code END) AS count_no2
FROM department AS dept_ek40
  JOIN course AS course_fsu0 ON (course_fsu0.dept_code = dept_ek40.dept_code)
GROUP BY 1
```

To write this out, one would usually copy and paste the column and replace the number every time. We can do better. To illustrate, let's first define a property for if the code is of a particular series number:

```
@Lifted
def coursestart(course, start):
    return (course.no > start) & (course.no < start + 99)
```

Note that this function can take a second argument: `start`. Now let's use it like so:

```
@do(Query)
def ex17():
    dept0 = yield Department.query()
    returnM (
             dept0.name,
             *[dept0.courses(lambda x: x.coursestart(i*100)).count()
                for i in range(1,5)]
            )
```

This is course what generated the original SQL.

CHAPTER 7

Left Joining

This is a matter of using the `lj` method. Intuitively, this turns an empty list into a list containing a single null value, and keeps every other list the same.

For example, suppose we want

> for each department, its name, and the number of courses with greater than 2 credits.

Note that it may be that a department offers no courses with greater than 2 credits, so this is a case where we need to left join. Namely:

```
@do(Query)
def ex15():
    dept0 = yield Department.query()
    returnM (
              dept0.name,
              dept0.courses(lambda x: x.credits > 2).lj().count().coalesce_(0)
             )
```

Generated SQL:

```
SELECT
  dept_18gw.name AS name,
  COALESCE(COUNT(DISTINCT course_1_rwa0.course_code), 0) AS coalesce_count_no
FROM department AS dept_18gw
  LEFT JOIN course AS course_1_rwa0 ON (course_1_rwa0.credits > 2)
    AND (course_1_rwa0.dept_code = dept_18gw.dept_code)
GROUP BY 1
```

Left Joining Dependent Tables

One annoying thing about SQL can be seen in the following example: suppose we wanted, for each school, the number of departments that had at least one course that offered a course with at least 2 credits.

We have to remember that the course table must be left joined as well, and any reference to the department table must come with the additional provisio that the course table is not null.

LambdaQuery:

```
@do(Query)
def ex15():
    sc0 = yield School.query()
    returnM (
             sc0.name,
             sc0.departments(lambda x: x.courses(lambda y: y.credits > 2)
                                        .exists())
                .lj().count().coalesce_(0)
            )
```

The generated SQL shows that all of the preceding concerns are handled for us:

```
SELECT
  sc_bgo0.name AS name,
  COALESCE(COUNT(DISTINCT CASE WHEN course_l_m7nk.course_code IS NOT NULL THEN dept_l_
↪m5yw.dept_code END), 0) AS coalesce_count_code
FROM school AS sc_bgo0
  LEFT JOIN department AS dept_l_m5yw ON (dept_l_m5yw.school_code = sc_bgo0.school_
↪code)
  LEFT JOIN course AS course_l_m7nk ON course_l_m7nk.course_code IS NOT NULL
    AND (course_l_m7nk.dept_code = dept_l_m5yw.dept_code)
    AND (course_l_m7nk.credits > 2)
GROUP BY 1
```

Pretty cool eh? This really is just the beginning. Most ORMs start getting really convoluted when you write more complex queries, and it's usually harder than just writing raw SQL. With LambdaQuery it remains simple and intuitive, and the SQL compiler works out all the bits of SQL logic so you don't have to.

We give just one more example here as a taste, and this is about as complex as it gets using the tables that we have. Suppose we want, for each school with a course that has at least 5 programs with a title that matches the school's name, the average number of high credit courses offered by its departments. Here a high credit course is one with greater than 3 departments.

Here we go:

```
@do(Query)
def ex19():
    sc0 = yield School.query(lambda x: x.programs(lambda y: y.title == x.name)
                                        .count() >= 5)
    returnM (
             sc0.name,
             sc0.departments()
                .fmap(lambda x: x.courses(lambda y: y.credits > 3).count())
                .lj().avg()
            )
```

Generated SQL:

```
SELECT
  query_upi0.reroute_uqjc AS name,
  AVG(COALESCE(query_upi0.count_no_upl4, 0)) AS avg_count_no
FROM (
        SELECT
          sc_j3io.school_code AS reroute_upew,
```

```
          sc_j3io.name AS reroute_uqjc,
          COUNT(DISTINCT course_l_tti0.course_code) AS count_no_upl4
        FROM school AS sc_j3io
          JOIN department AS dept_j0k8 ON (dept_j0k8.school_code = sc_j3io.school_
↪code)
          JOIN program AS prog_iy3k ON (prog_iy3k.school_code = sc_j3io.school_code)
            AND (prog_iy3k.title = sc_j3io.name)
          LEFT JOIN course AS course_l_tti0 ON (course_l_tti0.dept_code = dept_j0k8.
↪dept_code)
            AND (course_l_tti0.credits > 3)
        GROUP BY 1, 2, dept_j0k8.dept_code
        HAVING (COUNT(DISTINCT prog_iy3k.prog_code) >= 5)
        ) AS query_upi0
  JOIN program AS prog_copy_iypc ON (prog_copy_iypc.school_code = query_upi0.reroute_
↪upew)
    AND (prog_copy_iypc.title = query_upi0.reroute_uqjc)
GROUP BY 1
HAVING (COUNT(DISTINCT prog_copy_iypc.prog_code) >= 5)
```

One of the things to iron out in future versions is the redundant condition `HAVING (COUNT(DISTINCT prog_copy_q6g8.prog_code) >= 5)` appearing in both the innermost query and the outermost query.

CHAPTER 8

Defining Properties

This is where LambdaQuery really shines.

Injective (One-to-One) Properties

jjj

One-to-Many Properties

Use Kleisli decorator

CHAPTER 9

Composition

We can freely compose these functions.

CHAPTER 10

Advanced

Grouping By

Grouping by

Last Before

Using Kleisli and Lifted

If you wrap these you get a few benefits:

- The resulting columns have more readable names
- You can use the resulting functions as methods
- They add on the group bys of their source.

CHAPTER 11

How it Works

Basically the internal representation of a query is as a graph. Query combinators are just transformations on this graph. Before generating the SQL, LambdaQuery performs a reduction algorithm on this graph, and then the reduced graph is compiled to SQL. To see the SQL of the unreduced graph, use the `reduce=False` option for the `Query.sql` method.

CHAPTER 12

FAQ

Coming soon!

Please raise an issue on Github here.

This is a library that enables one to write composable SQL in pure python. It is heavily functional, enabling one to chain query combinators in incidentally very similar to the Rabbit query language.

The question that we solve - why is writing SQL so hard? How is it that something describable in two sentences in English becomes a monster of a query? How does one not become lost navigating the scoping rules and the throwaway names that become rampant when you have more than one layer of aggregation? LambdaQuery is the answer.

The main goals of LambdaQuery are to be a query API that:

- Removes as much syntactic noise as possible.
  - Joining by foreign keys automatically.
  - Handles all of the red tape in SQL.
  - Automatically assigns the throaway names to subqueries and columns of subqueries.
  - Knows which tables should be left joined and handles the null cases.
  - Knows which relationships are one to one, and choosing the group bys appropriately to preserve structure of the rows.
- Syntax that is very similar to manipulating in-memory Python lists.
  - Being able to work with particular elements of a list or the list as a whole.
  - Having CLEAN syntax just like actual Python.
- Maximize code reusability.
  - Define functions from rows to rows (a one-to-one relationship), from rows to lists (a one-to-many relationship), from lists to lists, or lists to rows (aggregation).
  - Such functions can include data from other tables.
- Minimize boilerplate - setting up tables should be as easy as it is in SQLAlchemy.

CHAPTER 13

Contributing

If you have a question then please raise an issue on Github here.