61A Lecture 34

Friday, November 21
Announcements

• Project 4 due Friday 11/21 @ 11:59pm
• Please submit project 4 in two different ways:
  ▪ `python3 ok --submit` and set your group on ok.cs61a.org
  ▪ Copy files to class account and `submit proj4`
  ▪ A correction to tests/q20.py was released yesterday afternoon
• Homework 9 (6 pts) due Wednesday 11/26 @ 11:59pm
  ▪ Homework Party Monday evening, location TBD
• Guest in live lecture, TA Soumya Basu, on Monday 11/24 (videos by John)
• No lecture on Wednesday 11/26 (turkey)
• No lab next Tuesday 11/25 & Wednesday 11/26
Local Tables
Local Tables

A create table statement names a table globally

create table parents as
    select "abraham" as parent, "barack" as child union
    select "abraham", "clinton" union
    select "delano", "herbert" union
    select "fillmore", "abraham" union
    select "fillmore", "delano" union
    select "fillmore", "grover" union
    select "eisenhower", "fillmore";

<table>
<thead>
<tr>
<th>Parent</th>
<th>Child</th>
</tr>
</thead>
<tbody>
<tr>
<td>abraham</td>
<td>barack</td>
</tr>
<tr>
<td>abraham</td>
<td>clinton</td>
</tr>
<tr>
<td>delano</td>
<td>herbert</td>
</tr>
<tr>
<td>fillmore</td>
<td>abraham</td>
</tr>
<tr>
<td>fillmore</td>
<td>delano</td>
</tr>
<tr>
<td>fillmore</td>
<td>grover</td>
</tr>
<tr>
<td>eisenhower</td>
<td>fillmore</td>
</tr>
</tbody>
</table>
Local Tables

A create table statement names a table globally

A with clause of a select statement names a table that is local to the statement

create table parents as
  select "abraham" as parent, "barack" as child union
... Part of the select statement
with
  best(dog) as (  
    select "eisenhower" union
    select "barack"
  )
select parent from parents, best where child=dog;

<table>
<thead>
<tr>
<th>parent</th>
</tr>
</thead>
<tbody>
<tr>
<td>abraham</td>
</tr>
</tbody>
</table>

parents:

Local table only exists for this select

<table>
<thead>
<tr>
<th>best:</th>
</tr>
</thead>
<tbody>
<tr>
<td>dog</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
  eisenhower |
|  
  barack |

(Demo)
Example: Relationships

(A) What are appropriate names for the columns in this result?

(B) How many rows will result?

```
with siblings
what(first, second) as (
    select a.child, b.child
    from parents as a, parents as b
    where a.parent = b.parent and
        a.child != b.child
)

select child as _____________, second as ____________
from parents, what
where parent=first;
```

<table>
<thead>
<tr>
<th>parent</th>
<th>child</th>
<th>first</th>
<th>second</th>
</tr>
</thead>
<tbody>
<tr>
<td>abraham</td>
<td>barack</td>
<td>abraham</td>
<td>delano</td>
</tr>
</tbody>
</table>

![Diagram of family relationships]
Recursive Local Tables
Local Tables can be Declared Recursively

An ancestor is your parent or an ancestor of your parent

```sql
create table parents as
    select "abraham" as parent, "barack" as child union ...

with
    ancestors(ancestor, descendent) as (  
        select parent, child from parents union  
        select ancestor, child  
            from ancestors, parents  
            where parent = descendent  
    )  
select ancestor from ancestors where descendent="herbert";
```

```plaintext
parents:

- Delano
- Herbert
- Fillmore
- Abraham
- Barack
- Clinton
- Grover

<table>
<thead>
<tr>
<th>ancestor</th>
</tr>
</thead>
<tbody>
<tr>
<td>delano</td>
</tr>
<tr>
<td>fillmore</td>
</tr>
<tr>
<td>eisenhower</td>
</tr>
</tbody>
</table>
```
Global Names for Recursive Tables

To create a table with a global name, you need to select the contents of the local table

```sql
create table odds as
    with
        odds(n) as ( 
            select 1 union
            select n+2 from odds where n < 15; 
        )
    select n from odds;
```

Which names above can change without affecting the result?
Limits on Recursive Select Statements

Recursive table definitions are only possible within a with clause.

No mutual recursion: two or more tables cannot be defined in terms of each other.

```sql
with
  odds(x) as (  
    select 1 union select x+1 from evens
  ),
  evens(x) as (  
    select x+1 from odds
  )
select x from odds
```

No tree recursion: the table being defined can only appear once in a from clause.

```sql
with
  ints(x) as (  
    select 1 union
    select x-1 from ints union
    select x+1 from ints
  )
select x from ints;
```

```sql
with
  ints(x) as (  
    select 1 union
    select a.x + b.x from ints as a, ints as b
  )
select x from ints;
```
String Examples
Language is Recursive

Noun phrases can contain relative pronouns that introduce relative clauses

The dog chased the cat
   that chased the bird

The dog chased the cat
   that the bird chased

The dog chased the cat
   the bird chased

The dog the bird the cat chased chased chased me

Bulldogs bulldogs bulldogs fight fight fight

(Demo)
Integer Examples
Input-Output Tables

A table containing the inputs to a function can be used to map from output to input

```sql
create table pairs as
    with
    i(n) as (  
        select 1 union  
        select n+1 from i where n < 50
    )
    select a.n as x, b.n as y from i as a, i as b where a.n <= b.n;
```

What integers can I add/multiply together to get 24?

(Demo)
Example: Pythagorean Triples

All triples $a, b, c$ such that $a^2 + b^2 = c^2$

with

\[ i(n) \text{ as } (\]
\[ \text{select 1 union select n+1 from i where n < 20 } \]
\[ ) \]

\[ \text{select a.n as a, b.n as b, c.n as c} \]

\[ \text{from } \frac{\text{i as a, i as b, i as c}}{\text{a.n < b.n}} \]

\[ \text{where } \frac{\text{a.n < b.n}}{\text{a.n*a.n + b.n*b.n = c.n*c.n}}; \]
Example: Fibonacci Sequence

Computing the next Fibonacci number requires both the previous and current numbers.

\[
\text{create table fibs as} \\
\text{with} \\
\text{fib(previous, current) as (} \\
\text{select 0, 1 union} \\
\text{select current, previous+current from fib} \\
\text{where current <= 14.15926535} \\
\text{)} \\
\text{select previous as n from fib;}
\]

<table>
<thead>
<tr>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>13</td>
</tr>
</tbody>
</table>
A Very Interesting Number

The mathematician G. H. Hardy once remarked to the mathematician Srinivasa Ramanujan...

(Demo)