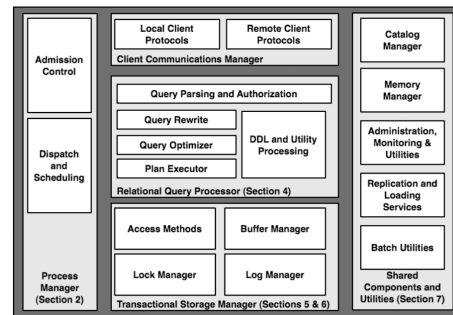


61A Lecture 33

Announcements

Database Management Systems

Database Management System Architecture



Architecture of a Database System by Hellerstein, Stonebreaker, and Hamilton

Query Planning

The manner in which tables are filtered, sorted, and joined affects execution time

Select the parents of curly-furred dogs:

```
select parent from parents, dogs
where child = name and fur = "curly";
```

Join all rows of parents to all rows of dogs, filter by `child = name` and `fur = "curly"`

Join only rows of parents and dogs where `child = name`, filter by `fur = "curly"`

Filter dogs by `fur = "curly"`, join result with all rows of parents, filter by `child = name`

Filter dogs by `fur = "curly"`, join only rows of result and parents where `child = name`

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";
```

parents:	
Parent	Child
abraham	barack
abraham	clinton
delano	herbert
fillmore	abraham
fillmore	delano
fillmore	grover
eisenhower	fillmore

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
...
with
best(dog) as (
  select "eisenhower" union
  select "barack"
)
select parent from parents, best where child=dog;
```

The diagram illustrates the execution of the query. It shows a tree structure of joins:

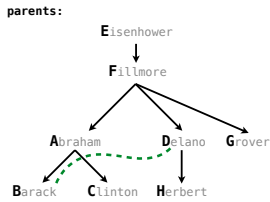
- The root node is **Fillmore**, which is a local table only existing for this select.
- Fillmore is joined to **Abraham**, **Clinton**, and **Delano**.
- Abraham is joined to **Barack** and **Clinton**.
- Delano is joined to **Herbert**.
- The **best** table (containing **eisenhower** and **barack**) is joined to the **parent** column of the **parents** table.

(Demo)

Example: Relationships

- (A) What are appropriate names for the columns in this result?
- (B) How many rows and columns will result?

```
with
siblings
not(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 nephew, second as uncle
from parents, siblings
where parent=first;
nephew uncle
```



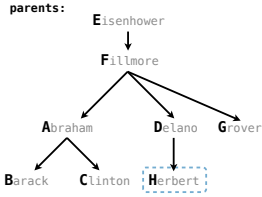
parent	child	first	second
abraham	barack	abraham	delano

Recursive Local Tables

Local Tables can be Declared Recursively

An ancestor is your parent or an ancestor of your parent

```
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";
```



ancestor
delano
fillmore
eisenhower

Global Names for Recursive Tables

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

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

n
1
3
5
7
9
11
13
15

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

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

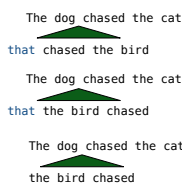
with
ints(x) as (
  select 1 union
  select x-1 from ints union
  select x+1 from ints
)
select x from ints;
Nope!

with
ints(x) as (
  select 1 union
  select a.x + b.x
  from ints as a, ints as b
)
select x from ints;
Nope!
```

String Examples

Language is Recursive

Noun phrases can contain relative pronouns that introduce relative clauses



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

```
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?

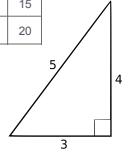
(Demo)

Example: Pythagorean Triples

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

```
with
  i(n) as (
    select 1 union select n+1 from i where n < 20
  )
select a.n as a, b.n as b, c.n as c
from _____
  i as a, i as b, i as c
where _____ and a.n*a.n + b.n*b.n = c.n*c.n;
```

a	b	c
3	4	5
5	12	13
6	8	10
8	15	17
9	12	15
12	16	20



Example: Fibonacci Sequence

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

```
create table fibs as
with
  fib(previous, current) as (
    select 0, 1 union
    select current, previous+current from fib
    where current <= _____
  )
select _____ as n from fib;
```

Local table	
n	fib: previous current
0	0 1
1	1 1
1	1 2
2	2 3
3	3 5
5	5 8
8	8 13
13	13 21

A Very Interesting Number

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

(Demo)