Programming the SQL Way with Common Table Expressions

BRUCE MOMJIAN

Common Table Expressions (CTEs) allow queries to be more imperative, allowing looping and processing hierarchical structures that are normally associated only with imperative languages.

 http://momjian.us/presentations

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Outline

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Imperative vs. Declarative: Imperative Programming Languages

In computer science, **imperative** programming is a programming paradigm that describes computation in terms of statements that change a program state. In much the same way that imperative mood in natural languages expresses commands to take action, imperative programs define sequences of commands for the computer to perform.

http://en.wikipedia.org/wiki/Imperative_programming

Declarative Programming Languages

The term is used in opposition to **declarative** programming, which expresses what the program should accomplish without prescribing how to do it in terms of sequence.

Imperative

BASIC:

```
10 PRINT "Hello";
20 GOTO 10
```

C:

```
while (1)
    printf("Hello\n");
```

Perl:

```
print("Hello\n") while (1);
```

Declarative

SQL:

```
SELECT 'Hello'
UNION ALL
SELECT 'Hello'
UNION ALL
SELECT 'Hello'
UNION ALL
SELECT 'Hello'
```

…
An infinite loop is not easily implemented in simple SQL.

Imperative Database Options

- Client application code (e.g. libpq, JDBC, DBD::Pg)
- Server-side programming (e.g. PL/pgSQL, PL/Perl, C)
- **Common table expressions**

Common Table Expression Syntax (CTE)

```
WITH [ RECURSIVE ] with_query_name [ ( column_name [, ...] ) ] AS
     ( select ) [ , ... ]
SELECT ...
```

CTE support was added in Postgres 8.4.

A Simple CTE

```
WITH source AS (
        SELECT 1
)
SELECT * FROM source;
 ?column?
----------
        1
(1 row)
```

The CTE created a *source* table that was referenced by the outer SELECT.
All queries in this presentation can be downloaded from http://momjian.us/main/writings/pgsql/cte.sql

Let's Name the Returned CTE Column

```
WITH source AS (
        SELECT 1 AS col1
)
SELECT * FROM source;
 col1
------
    1
(1 row)
```

The CTE returned column is *source.col1*.

The Column Can Also Be Named in the WITH Clause

```
WITH source (col1) AS (
        SELECT 1
)
SELECT * FROM source;
 col1
------
    1
(1 row)
```

Columns Can Be Renamed

```
WITH source (col2) AS (
        SELECT 1 AS col1
)
SELECT col2 AS col3 FROM source;
 col3
------
    1
(1 row)
```

The CTE column starts as *col1,* is renamed in the WITH clause as *col2,* and the outer SELECT renames it to *col3.*

Multiple CTE Columns Can Be Returned

```
WITH source AS (
        SELECT 1, 2
)
SELECT * FROM source;
 ?column? | ?column?
----------+----------
        1 |        2
(1 row)
```

UNION Refresher

```
SELECT 1
UNION
SELECT 1;
 ?column?
----------
        1
(1 row)
```

```
SELECT 1
UNION ALL
SELECT 1;
 ?column?
----------
        1
        1
(2 rows)
```

Possible To Create Multiple CTE Results

```
WITH source AS (
        SELECT 1, 2
),
     source2 AS (
        SELECT 3, 4
)
SELECT * FROM source
UNION ALL
SELECT * FROM source2;
 ?column? | ?column?
----------+----------
        1 |        2
        3 |        4
(2 rows)
```

CTE with Real Tables

```
WITH source AS (
        SELECT lanname, rolname
        FROM pg_language JOIN pg_roles ON lanowner = pg_roles.oid
)
SELECT * FROM source;
 lanname  | rolname
----------+----------
 internal | postgres
 c        | postgres
 sql      | postgres
 plpgsql  | postgres
(4 rows)
```

CTE Can Be Processed More than Once

```
WITH source AS (
        SELECT lanname, rolname
        FROM pg_language JOIN pg_roles ON lanowner = pg_roles.oid
        ORDER BY lanname
)
SELECT * FROM source
UNION ALL
SELECT MIN(lanname), NULL
FROM source;
 lanname  | rolname
----------+----------
 c        | postgres
 internal | postgres
 plpgsql  | postgres
 sql      | postgres
 c        |
(5 rows)
```

CTE Can Be Joined

```
WITH class (oid, relname) AS (
        SELECT oid, relname
        FROM pg_class
        WHERE relkind = 'r'
)
SELECT class.relname, attname
FROM pg_attribute, class
WHERE class.oid = attrelid
ORDER BY 1, 2
LIMIT 5;
   relname     |   attname
--------------+--------------
 pg_aggregate | aggfinalfn
 pg_aggregate | aggfnoid
 pg_aggregate | agginitval
 pg_aggregate | aggsortop
 pg_aggregate | aggtransfn
(5 rows)
```

Imperative Control With CASE

```
CASE
WHEN condition THEN result
ELSE result
END
```

For example:

```
SELECT col,
    CASE
        WHEN col > 0 THEN 'positive'
        WHEN col = 0 THEN 'zero'
        ELSE 'negative'
    END
FROM tab;
```

Recursive CTEs: Looping

```
WITH RECURSIVE source AS (
        SELECT 1
)
SELECT * FROM source;
 ?column?
----------
        1
(1 row)
```

This does not loop because *source* is not mentioned in the CTE.

This Is an Infinite Loop

```
SET statement_timeout = '1s';
SET
WITH RECURSIVE source AS (
        SELECT 1
        UNION ALL
        SELECT 1 FROM source
)
SELECT * FROM source;
ERROR:  canceling statement due to statement timeout
```

```
WITH RECURSIVE source AS (
    SELECT 1
    UNION ALL
    SELECT 1 FROM source
)
SELECT * FROM source;
```

The 'Hello' Example in SQL

```
WITH RECURSIVE source AS (
        SELECT 'Hello'
        UNION ALL
        SELECT 'Hello' FROM source
)
SELECT * FROM source;
ERROR:  canceling statement due to statement timeout
RESET statement_timeout;
RESET
```

UNION without ALL Avoids Recursion

```
WITH RECURSIVE source AS (
        SELECT 'Hello'
        UNION
        SELECT 'Hello' FROM source
)
SELECT * FROM source;
?column?
----------
 Hello
(1 row)
```

CTEs Are Useful When Loops Are Constrained

```
WITH RECURSIVE source (counter) AS (
        -- seed value
        SELECT 1
        UNION ALL
        SELECT counter + 1
        FROM source
        -- terminal condition
        WHERE counter < 10
)
SELECT * FROM source;
```

Output

```
 counter
---------
       1
       2
       3
       4
       5
       6
       7
       8
       9
      10
(10 rows)
```

Of course, this can be more easily accomplished using *generate_series(1, 10).*

Perl Example

```
for (my $i = 1; $i <= 10; $i++)
{
        print "$i\n";
}
```

Perl Using Recursion

```
sub f
{
        my $arg = shift;
        print "$arg\n";
        f($arg + 1) if ($arg < 10);
}
f(1);
```

Perl Recursion Using an Array

```
my @table;
sub f
{
        my $arg = shift;
        push @table, !defined($arg) ? 1 : $arg;
        f($arg + 1) if ($arg < 10);
}
f();
map {print "$_\n"} @table;
```

This is the most accurate representation of CTEs because it accumultes results in an array (similar to a table result).

Examples: Ten Factorial Using CTE

```
WITH RECURSIVE source (counter, product) AS (
        SELECT 1, 1
        UNION ALL
        SELECT counter + 1, product * (counter + 1)
        FROM source
        WHERE counter < 10
)
SELECT counter, product FROM source;
```

Output

```
 counter | product
---------+---------
       1 |       1
       2 |       2
       3 |       6
       4 |      24
       5 |     120
       6 |     720
       7 |    5040
       8 |   40320
       9 |  362880
      10 | 3628800
(10 rows)
```

Only Display the Desired Row

```
WITH RECURSIVE source (counter, product) AS (
        SELECT 1, 1
        UNION ALL
        SELECT counter + 1, product * (counter + 1)
        FROM source
        WHERE counter < 10
)
SELECT counter, product
FROM source
WHERE counter = 10;
 counter | product
---------+---------
      10 | 3628800
(1 row)
```

Ten Factorial in Perl

```
my @table;
sub f
{
        my ($counter, $product) = @_;
        my ($counter_new, $product_new);
        if (!defined($counter)) {
                $counter_new = 1;
                $product_new = 1;
        } else {
                $counter_new = $counter + 1;
                $product_new = $product * ($counter + 1);
        }
        push(@table, [$counter_new, $product_new]);
        f($counter_new, $product_new) if ($counter < 10);
}
f();
map {print "@$_\n" if ($_->[0]) == 10} @table;
```

String Manipulation Is Also Possible

```
WITH RECURSIVE source (str) AS (
        SELECT 'a'
        UNION ALL
        SELECT str || 'a'
        FROM source
        WHERE length(str) < 10
)
SELECT * FROM source;
```

Output

```
    str
------------
 a
 aa
 aaa
 aaaa
 aaaaa
 aaaaaa
 aaaaaaa
 aaaaaaaa
 aaaaaaaaa
 aaaaaaaaaa
(10 rows)
```

Characters Can Be Computed

```
WITH RECURSIVE source (str) AS (
        SELECT 'a'
        UNION ALL
        SELECT str || chr(ascii(substr(str, length(str))) + 1)
        FROM source
        WHERE length(str) < 10
)
SELECT * FROM source;
```

Output

```
    str
------------
 a
 ab
 abc
 abcd
 abcde
 abcdef
 abcdefg
 abcdefgh
 abcdefghi
 abcdefghij
(10 rows)
```

ASCII Art Is Even Possible

```
WITH RECURSIVE source (counter) AS (
        SELECT -10
        UNION ALL
        SELECT counter + 1
        FROM source
        WHERE counter < 10
)
SELECT  repeat(' ', 5 - abs(counter) / 2) ||
        'X' ||
        repeat(' ', abs(counter)) ||
        'X'
FROM source;
```

Output

```
   ?column?
--------------
 X          X
  X         X
  X        X
   X       X
   X      X
    X     X
    X    X
     X   X
     X  X
      X X
      XX
      X X
     X  X
     X   X
    X    X
    X     X
   X      X
   X       X
  X        X
  X         X
 X          X
(21 rows)
```

How Is that Done?

```
WITH RECURSIVE source (counter) AS (
        SELECT -10
        UNION ALL
        SELECT counter + 1
        FROM source
        WHERE counter < 10
)
SELECT  counter,
        repeat(' ', 5 - abs(counter) / 2) ||
        'X' ||
        repeat(' ', abs(counter)) ||
        'X'
FROM source;
```

This generates Integers from -10 to 10, and these numbers are used to print an appropriate number of spaces.

Output

```
 counter |   ?column?
---------+--------------
     -10 | X          X
      -9 |  X         X
      -8 |  X        X
      -7 |   X       X
      -6 |   X      X
      -5 |    X     X
      -4 |    X    X
      -3 |     X   X
      -2 |     X  X
      -1 |      X X
       0 |      XX
       1 |      X X
       2 |     X  X
       3 |     X   X
       4 |    X    X
       5 |    X     X
       6 |   X      X
       7 |   X       X
       8 |  X        X
       9 |  X         X
      10 | X          X
(21 rows)
```

ASCII Circles Are Even Possible

```sql
WITH RECURSIVE source (counter) AS (
        SELECT -10
        UNION ALL
        SELECT counter + 1
        FROM source
        WHERE counter < 10
)
SELECT  repeat(' ', abs(counter)/2) ||
        'X' ||
        repeat(' ', 10 - abs(counter)) ||
        'X'
FROM source;
```

A Diamond

```
   ?column?
--------------
      XX
     X X
     X  X
    X   X
    X    X
   X     X
   X      X
  X       X
  X        X
 X         X
 X          X
 X         X
  X        X
  X       X
   X      X
   X     X
    X    X
    X   X
     X  X
     X X
      XX
(21 rows)
```

More Rounded

```
WITH RECURSIVE source (counter) AS (
        SELECT -10
        UNION ALL
        SELECT counter + 1
        FROM source
        WHERE counter < 10
)
SELECT  repeat(' ', int4(pow(counter, 2)/10)) ||
        'X' ||
        repeat(' ', 2 * (10 - int4(pow(counter, 2)/10))) ||
        'X'
FROM source;
```

An Oval

```
        ?column?
------------------------
           XX
         X    X
       X        X
      X          X
     X            X
   X                X
   X                X
  X                  X
 X                    X
 X                    X
 X                    X
 X                    X
 X                    X
  X                  X
   X                X
   X                X
     X            X
      X          X
       X        X
         X    X
           XX
(21 rows)
```

A Real Circle

```
WITH RECURSIVE source (counter) AS (
        SELECT -10
        UNION ALL
        SELECT counter + 1
        FROM source
        WHERE counter < 10
)
SELECT  repeat(' ', int4(pow(counter, 2)/5)) ||
        'X' ||
   repeat(' ', 2 * (20 - int4(pow(counter, 2)/5))) ||
        'X'
FROM source;
```

Output

```
                  ?column?
--------------------------------------------
                     XX
                 X        X
              X              X
           X                    X
        X                          X
      X                              X
    X                                  X
   X                                    X
  X                                      X
 X                                        X
 X                                        X
 X                                        X
  X                                      X
   X                                    X
    X                                  X
      X                              X
        X                          X
           X                    X
              X              X
                 X        X
                     XX
(21 rows)
```

Prime Factors

The prime factors of X are the prime numbers that must be multiplied to equal a X, e.g.:

10 = 2 * 5
27 = 3 * 3 * 3
48 = 2 * 2 * 2 * 2 * 3
66 = 2 * 3 * 11
70 = 2 * 5 * 7
100 = 2 * 2 * 5 * 5

Prime Factorization in SQL

```
WITH RECURSIVE source (counter, factor, is_factor) AS (
        SELECT 2, 56, false
        UNION ALL
        SELECT
                CASE
                        WHEN factor % counter = 0 THEN counter
                        ELSE counter + 1
                END,
                CASE
                        WHEN factor % counter = 0 THEN factor / counter
                        ELSE factor
                END,
                CASE
                        WHEN factor % counter = 0 THEN true
                        ELSE false
                END
        FROM source
        WHERE factor <> 1
)
SELECT * FROM source;
```

Output

```
 counter | factor | is_factor
---------+--------+-----------
       2 |     56 | f
       2 |     28 | t
       2 |     14 | t
       2 |      7 | t
       3 |      7 | f
       4 |      7 | f
       5 |      7 | f
       6 |      7 | f
       7 |      7 | f
       7 |      1 | t
(10 rows)
```

Only Return Prime Factors

```
WITH RECURSIVE source (counter, factor, is_factor) AS (
        SELECT 2, 56, false
        UNION ALL
        SELECT
                CASE
                        WHEN factor % counter = 0 THEN counter
                        ELSE counter + 1
                END,
                CASE
                        WHEN factor % counter = 0 THEN factor / counter
                        ELSE factor
                END,
                CASE
                        WHEN factor % counter = 0 THEN true
                        ELSE false
                END
        FROM source
        WHERE factor <> 1
)
SELECT * FROM source WHERE is_factor;
```

Output

```
 counter | factor | is_factor
---------+--------+-----------
       2 |     28 | t
       2 |     14 | t
       2 |      7 | t
       7 |      1 | t
(4 rows)
```

Factors of 322434

```
WITH RECURSIVE source (counter, factor, is_factor) AS (
        SELECT 2, 322434, false
        UNION ALL
        SELECT
                CASE
                        WHEN factor % counter = 0 THEN counter
                        ELSE counter + 1
                END,
                CASE
                        WHEN factor % counter = 0 THEN factor / counter
                        ELSE factor
                END,
                CASE
                        WHEN factor % counter = 0 THEN true
                        ELSE false
                END
        FROM source
        WHERE factor <> 1
)
SELECT * FROM source WHERE is_factor;
```

Output

```
 counter | factor | is_factor
---------+--------+-----------
       2 | 161217 | t
       3 |  53739 | t
       3 |  17913 | t
       3 |   5971 | t
       7 |    853 | t
     853 |      1 | t
(6 rows)
```

Prime Factors of 66

```
WITH RECURSIVE source (counter, factor, is_factor) AS (
        SELECT 2, 66, false
        UNION ALL
        SELECT
                CASE
                        WHEN factor % counter = 0 THEN counter
                        ELSE counter + 1
                END,
                CASE
                        WHEN factor % counter = 0 THEN factor / counter
                        ELSE factor
                END,
                CASE
                        WHEN factor % counter = 0 THEN true
                        ELSE false
                END
        FROM source
        WHERE factor <> 1
)
SELECT * FROM source;
```

Inefficient

```
 counter | factor | is_factor
---------+--------+-----------
       2 |     66 | f
       2 |     33 | t
       3 |     33 | f
       3 |     11 | t
       4 |     11 | f
       5 |     11 | f
       6 |     11 | f
       7 |     11 | f
       8 |     11 | f
       9 |     11 | f
      10 |     11 | f
      11 |     11 | f
      11 |      1 | t
(13 rows)
```

Skip Evens >2, Exit Early with a Final Prime

```
WITH RECURSIVE source (counter, factor, is_factor) AS (
        SELECT 2, 66, false
        UNION ALL
        SELECT
                CASE
                        WHEN factor % counter = 0 THEN counter
                        -- is 'factor' prime?
                        WHEN counter * counter > factor THEN factor
                        -- now only odd numbers
                        WHEN counter = 2 THEN 3
                        ELSE counter + 2
                END,
                CASE
                        WHEN factor % counter = 0 THEN factor / counter
                        ELSE factor
                END,
                CASE
                        WHEN factor % counter = 0 THEN true
                        ELSE false
                END
        FROM source
        WHERE factor <> 1
)
SELECT * FROM source;
```

Output

```
 counter | factor | is_factor
---------+--------+-----------
       2 |     66 | f
       2 |     33 | t
       3 |     33 | f
       3 |     11 | t
       5 |     11 | f
      11 |     11 | f
      11 |      1 | t
(7 rows)
```

Return Only Prime Factors

```
WITH RECURSIVE source (counter, factor, is_factor) AS (
        SELECT 2,66, false
        UNION ALL
        SELECT
                CASE
                        WHEN factor % counter = 0 THEN counter
                        -- is 'factor' prime?
                        WHEN counter * counter > factor THEN factor
                        -- now only odd numbers
                        WHEN counter = 2 THEN 3
                        ELSE counter + 2
                        END,
                CASE
                        WHEN factor % counter = 0 THEN factor / counter
                        ELSE factor
                END,
                CASE
                        WHEN factor % counter = 0 THEN true
                        ELSE false
                END
        FROM source
        WHERE factor <> 1
)
SELECT * FROM source WHERE is_factor;
```

Output

```
 counter | factor | is_factor
---------+--------+-----------
       2 |     33 | t
       3 |     11 | t
      11 |      1 | t
(3 rows)
```

Optimized Prime Factors of 66 in Perl

```
my @table;
sub f
{
        my ($counter, $factor, $is_factor) = @_;
        my ($counter_new, $factor_new, $is_factor_new);
        if (!defined($counter)) {
                $counter_new = 2;
                $factor_new = 66;
                $is_factor_new = 0;
        } else {
                $counter_new = ($factor % $counter == 0) ?
                        $counter :
                ($counter * $counter > $factor) ?
                        $factor :
                ($counter == 2) ?
                        3 :
                        $counter + 2;
                $factor_new = ($factor % $counter == 0) ?
                        $factor / $counter :
                        $factor;
                $is_factor_new = ($factor % $counter == 0);
        }
        push(@table, [$counter_new, $factor_new, $is_factor_new]);
        f($counter_new, $factor_new) if ($factor != 1);
}
f();
map {print "$_->[0] $_->[1] $_->[2]\n" if ($_->[2]) == 1} @table;
```

Recursive Table Processing: Setup

```
CREATE TEMPORARY TABLE part (parent_part_no INTEGER, part_no INTEGER);
CREATE TABLE
INSERT INTO part VALUES (1, 11);
INSERT 0 1
INSERT INTO part VALUES (1, 12);
INSERT 0 1
INSERT INTO part VALUES (1, 13);
INSERT 0 1
INSERT INTO part VALUES (2, 21);
INSERT 0 1
INSERT INTO part VALUES (2, 22);
INSERT 0 1
INSERT INTO part VALUES (2, 23);
INSERT 0 1
INSERT INTO part VALUES (11, 101);
INSERT 0 1
INSERT INTO part VALUES (13, 102);
INSERT 0 1
INSERT INTO part VALUES (13, 103);
INSERT 0 1
INSERT INTO part VALUES (22, 221);
INSERT 0 1
INSERT INTO part VALUES (22, 222);
INSERT 0 1
INSERT INTO part VALUES (23, 231);
```

Use CTEs To Walk Through Parts Heirarchy

```
WITH RECURSIVE source (part_no) AS (
        SELECT 2
        UNION ALL
        SELECT part.part_no
        FROM source JOIN part ON (source.part_no = part.parent_part_no)
)
SELECT * FROM source;
 part_no
---------
       2
      21
      22
      23
     221
     222
     231
(7 rows)
```

Add Dashes

```
WITH RECURSIVE source (level, part_no) AS (
        SELECT 0, 2
        UNION ALL
        SELECT level + 1, part.part_no
        FROM source JOIN part ON (source.part_no = part.parent_part_no)
)
SELECT '+' || repeat('-', level * 2) || part_no::text AS part_tree
FROM source;
 part_tree
-----------
 +2
 +--21
 +--22
 +--23
 +----221
 +----222
 +----231
(7 rows)
```

The Parts in ASCII Order

```
WITH RECURSIVE source (level, tree, part_no) AS (
        SELECT 0, '2', 2
        UNION ALL
        SELECT level + 1, tree || ' ' || part.part_no::text, part.part_no
        FROM source JOIN part ON (source.part_no = part.parent_part_no)
)
SELECT '+' || repeat('-', level * 2) || part_no::text AS part_tree, tree
FROM source
ORDER BY tree;
 part_tree |   tree
-----------+----------
 +2        | 2
 +--21     | 2 21
 +--22     | 2 22
 +----221  | 2 22 221
 +----222  | 2 22 222
 +--23     | 2 23
 +----231  | 2 23 231
(7 rows)
```

The Parts in Numeric Order

```
WITH RECURSIVE source (level, tree, part_no) AS (
        SELECT 0, '{2}'::int[], 2
        UNION ALL
        SELECT level + 1, array_append(tree, part.part_no), part.part_no
        FROM source JOIN part ON (source.part_no = part.parent_part_no)
)
SELECT '+' || repeat('-', level * 2) || part_no::text AS part_tree, tree
FROM source
ORDER BY tree;
 part_tree |    tree
-----------+------------
 +2        | {2}
 +--21     | {2,21}
 +--22     | {2,22}
 +----221  | {2,22,221}
 +----222  | {2,22,222}
 +--23     | {2,23}
 +----231  | {2,23,231}
(7 rows)
```

Full Output

```
WITH RECURSIVE source (level, tree, part_no) AS (
        SELECT 0, '{2}'::int[], 2
        UNION ALL
        SELECT level + 1, array_append(tree, part.part_no), part.part_no
        FROM source JOIN part ON (source.part_no = part.parent_part_no)
)
SELECT *, '+' || repeat('-', level * 2) || part_no::text AS part_tree
FROM source
ORDER BY tree;
 level |    tree     | part_no | part_tree
-------+-------------+---------+-----------
     0 | {2}         |       2 | +2
     1 | {2,21}      |      21 | +--21
     1 | {2,22}      |      22 | +--22
     2 | {2,22,221}  |     221 | +----221
     2 | {2,22,222}  |     222 | +----222
     1 | {2,23}      |      23 | +--23
     2 | {2,23,231}  |     231 | +----231
(7 rows)
```

CTE for SQL Object Dependency

```
CREATE TEMPORARY TABLE deptest (x1 INTEGER);
CREATE TABLE
```

CTE for SQL Object Dependency

```
WITH RECURSIVE dep (classid, obj) AS (
        SELECT (SELECT oid FROM pg_class WHERE relname = 'pg_class'),
                oid
        FROM pg_class
        WHERE relname = 'deptest'
        UNION ALL
        SELECT pg_depend.classid, objid
        FROM pg_depend JOIN dep ON (refobjid = dep.obj)
)
SELECT  (SELECT relname FROM pg_class WHERE oid = classid) AS class,
        (SELECT typname FROM pg_type WHERE oid = obj) AS type,
        (SELECT relname FROM pg_class WHERE oid = obj) AS class,
        (SELECT relkind FROM pg_class where oid = obj::regclass) AS kind,
        (SELECT adsrc FROM pg_attrdef WHERE oid = obj) AS attrdef,
        (SELECT conname FROM pg_constraint WHERE oid = obj) AS constraint
FROM dep
ORDER BY obj;
```

Output

```
  class    |   type    |  class   | kind | attrdef | constraint
-----------+-----------+----------+------+---------+------------
 pg_class  |           | deptest  | r    |         |
 pg_type   | _deptest  |          |      |         |
 pg_type   | deptest   |          |      |         |
(3 rows)
```

Do Not Show *deptest*

```
WITH RECURSIVE dep (classid, obj) AS (
        SELECT classid, objid
        FROM pg_depend JOIN pg_class ON (refobjid = pg_class.oid)
        WHERE relname = 'deptest'
        UNION ALL
        SELECT pg_depend.classid, objid
        FROM pg_depend JOIN dep ON (refobjid = dep.obj)
)
SELECT  (SELECT relname FROM pg_class WHERE oid = classid) AS class,
        (SELECT typname FROM pg_type WHERE oid = obj) AS type,
        (SELECT relname FROM pg_class WHERE oid = obj) AS class,
        (SELECT relkind FROM pg_class where oid = obj::regclass) AS kind,
        (SELECT adsrc FROM pg_attrdef WHERE oid = obj) AS attrdef,
        (SELECT conname FROM pg_constraint WHERE oid = obj) AS constraint
FROM dep
ORDER BY obj;
```

Output

```
  class   |    type    | class | kind | attrdef | constraint
---------+----------+-------+------+---------+------------
 pg_type | _deptest |       |      |         |
 pg_type | deptest  |       |      |         |
(2 rows)
```

Add a Primary Key

```
ALTER TABLE deptest ADD PRIMARY KEY (x1);
NOTICE:  ALTER TABLE / ADD PRIMARY KEY will create implicit index "deptest_pkey" fo
ALTER TABLE
```

Output With Primary Key

```
WITH RECURSIVE dep (classid, obj) AS (
        SELECT (SELECT oid FROM pg_class WHERE relname = 'pg_class'),
                oid
        FROM pg_class
        WHERE relname = 'deptest'
        UNION ALL
        SELECT pg_depend.classid, objid
        FROM pg_depend JOIN dep ON (refobjid = dep.obj)
)
SELECT  (SELECT relname FROM pg_class WHERE oid = classid) AS class,
        (SELECT typname FROM pg_type WHERE oid = obj) AS type,
        (SELECT relname FROM pg_class WHERE oid = obj) AS class,
        (SELECT relkind FROM pg_class where oid = obj::regclass) AS kind,
        (SELECT adsrc FROM pg_attrdef WHERE oid = obj) AS attrdef,
        (SELECT conname FROM pg_constraint WHERE oid = obj) AS constraint
FROM dep
ORDER BY obj;
```

Output

```
     class      |   type   |     class     | kind | attrdef |  constraint
---------------+----------+--------------+------+---------+--------------
 pg_class       |          | deptest       | r    |         |
 pg_type        | _deptest |               |      |         |
 pg_type        | deptest  |               |      |         |
 pg_class       |          | deptest_pkey  | i    |         |
 pg_constraint  |          |               |      |         | deptest_pkey
(5 rows)
```

Add a SERIAL Column

```
ALTER TABLE deptest ADD COLUMN x2 SERIAL;
NOTICE:  ALTER TABLE will create implicit sequence "deptest_x2_seq" for serial column "deptest.x2"
ALTER TABLE
```

Output with SERIAL Column

```
WITH RECURSIVE dep (classid, obj) AS (
        SELECT (SELECT oid FROM pg_class WHERE relname = 'pg_class'),
                oid
        FROM pg_class
        WHERE relname = 'deptest'
        UNION ALL
        SELECT pg_depend.classid, objid
        FROM pg_depend JOIN dep ON (refobjid = dep.obj)
)
SELECT  (SELECT relname FROM pg_class WHERE oid = classid) AS class,
        (SELECT typname FROM pg_type WHERE oid = obj) AS type,
        (SELECT relname FROM pg_class WHERE oid = obj) AS class,
        (SELECT relkind FROM pg_class where oid = obj::regclass) AS kind,
        (SELECT adsrc FROM pg_attrdef WHERE oid = obj) AS attrdef
        -- column removed to reduce output width
FROM dep
ORDER BY obj;
```

Output

```
     class     |      type      |     class      | kind |               attrdef
---------------+----------------+----------------+------+-------------------------------------
 pg_class      |                | deptest        | r    |
 pg_type       | _deptest       |                |      |
 pg_type       | deptest        |                |      |
 pg_class      |                | deptest_pkey   | i    |
 pg_constraint |                |                |      |
 pg_class      |                | deptest_x2_seq | S    |
 pg_type       | deptest_x2_seq |                |      |
 pg_attrdef    |                |                |      | nextval('deptest_x2_seq'::regclass)
 pg_attrdef    |                |                |      | nextval('deptest_x2_seq'::regclass)
(9 rows)
```

Show Full Output

```
WITH RECURSIVE dep (level, tree, classid, obj) AS (
        SELECT 0, array_append(null, oid)::oid[],
                (SELECT oid FROM pg_class WHERE relname = 'pg_class'),
                oid
        FROM pg_class
        WHERE relname = 'deptest'
        UNION ALL
        SELECT level + 1, array_append(tree, objid),
                pg_depend.classid, objid
        FROM pg_depend JOIN dep ON (refobjid = dep.obj)
)
SELECT  tree,
        (SELECT relname FROM pg_class WHERE oid = classid) AS class,
        (SELECT typname FROM pg_type WHERE oid = obj) AS type,
        (SELECT relname FROM pg_class WHERE oid = obj) AS class,
        (SELECT relkind FROM pg_class where oid = obj::regclass) AS kind
        -- column removed to reduce output width
FROM dep
ORDER BY tree, obj;
```

Output

tree	class	type	class	kind
{16458}	pg_class		deptest	r
{16458,16460}	pg_type	deptest		
{16458,16460,16459}	pg_type	_deptest		
{16458,16462}	pg_constraint			
{16458,16462,16461}	pg_class		deptest_pkey	i
{16458,16463}	pg_class		deptest_x2_seq	S
{16458,16463,16464}	pg_type	deptest_x2_seq		
{16458,16463,16465}	pg_attrdef			
{16458,16465}	pg_attrdef			

(9 rows)

Writable CTEs

- Allow data-modification commands (INSERT/UPDATE/DELETE) in WITH clauses (Marko Tiikkaja, Hitoshi Harada)
  - These commands can use RETURNING to pass data up to the containing query.
- Allow WITH clauses to be attached to INSERT, UPDATE, DELETE statements (Marko Tiikkaja, Hitoshi Harada)
- Added in Postgres 9.1

Use INSERT, UPDATE, DELETE in WITH Clauses

```
CREATE TEMPORARY TABLE retdemo (x NUMERIC);
CREATE TABLE

INSERT INTO retdemo VALUES (random()), (random()), (random()) RETURNING x;
          x
---------------------
 0.00761545216664672
 0.85416117589920831
 0.10137318633496895
(3 rows)
INSERT 0 3

WITH source AS (
        INSERT INTO retdemo
        VALUES (random()), (random()), (random()) RETURNING x
)
SELECT AVG(x) FROM source;
          avg
---------------------
 0.46403147140517833
(1 row)
```

Use INSERT, UPDATE, DELETE in WITH Clauses

```
WITH source AS (
        DELETE FROM retdemo RETURNING x
)
SELECT MAX(x) FROM source;
        max
---------------------
 0.93468171451240821
(1 row)
```

Supply Rows to INSERT, UPDATE, DELETE Using WITH Clauses

```
CREATE TEMPORARY TABLE retdemo2 (x NUMERIC);
CREATE TABLE

INSERT INTO retdemo2 VALUES (random()), (random()), (random());
INSERT 0 3

WITH source (average) AS (
        SELECT AVG(x) FROM retdemo2
)
DELETE FROM retdemo2 USING source
WHERE retdemo2.x < source.average;
DELETE 2

SELECT * FROM retdemo2;
         x
-------------------
 0.777186767663807
(1 row)
```

Recursive WITH to Delete Parts

```
WITH RECURSIVE source (part_no) AS (
        SELECT 2
        UNION ALL
        SELECT part.part_no
        FROM source JOIN part ON (source.part_no = part.parent_part_no)
)
DELETE FROM part
USING source
WHERE source.part_no = part.part_no;
DELETE 6
```

Using Both Features

```
CREATE TEMPORARY TABLE retdemo3 (x NUMERIC);
CREATE TABLE

INSERT INTO retdemo3 VALUES (random()), (random()), (random());
INSERT 0 3

WITH source (average) AS (
        SELECT AVG(x) FROM retdemo3
),
     source2 AS (
        DELETE FROM retdemo3 USING source
        WHERE retdemo3.x < source.average
        RETURNING x
)
SELECT * FROM source2;
         x
-------------------
 0.185174203012139
 0.209731927141547
(2 rows)
```

Chaining Modification Commands

```
CREATE TEMPORARY TABLE orders (order_id SERIAL, name text);
CREATE TABLE

CREATE TEMPORARY TABLE items (order_id INTEGER, part_id SERIAL, name text);
CREATE TABLE

WITH source (order_id) AS (
        INSERT INTO orders VALUES (DEFAULT, 'my order') RETURNING order_id
)
INSERT INTO items (order_id, name) SELECT order_id, 'my part' FROM source;
INSERT 0 1

WITH source (order_id) AS (
        DELETE FROM orders WHERE name = 'my order' RETURNING order_id
)
DELETE FROM items USING source WHERE source.order_id = items.order_id;
DELETE 1
```

Mixing Modification Commands

```
CREATE TEMPORARY TABLE old_orders (order_id INTEGER);
CREATE TABLE

WITH source (order_id) AS (
        DELETE FROM orders WHERE name = 'my order' RETURNING order_id
), source2 AS (
        DELETE FROM items USING source WHERE source.order_id = items.order_id
)
INSERT INTO old_orders SELECT order_id FROM source;
INSERT 0 0
```

Why Use CTEs

- Allows imperative processing in SQL
- Merges multiple SQL queries and their connecting application logic into a single, unified SQL query
- Improves performance by issuing fewer queries
  - reduces transmission overhead, unless server-side functions are being used
  - reduces parsing/optimizing overhead, unless prepared statements are being used
- Uses the same row visibility snapshot for the entire query, rather than requiring serializable isolation mode
- Adds a optimizer barrier between each CTE and the outer query
  - helpful with writable CTEs
  - can hurt performance when a join query is changed to use CTEs

Conclusion

http://momjian.us/presentations

https://www.flickr.com/photos/theophilusphotography/