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Super-powered Data Transformation with PostgreSQL

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Agenda

01 ETL vs ELT

02 Loading Data

03 SQL/PostgreSQL Building Blocks

04 Common Table Expressions (CTE)

05 Recursive CTEs

Demo

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2022

WORDLE

A DAILY WORD GAME

A few functions are only included with PostgreSQL >=14

Advent of Code Examples

Dec 07 Puzzle (2023)

- Listing of 5 playing cards by face value
- Bid value to use later in puzzle
- Order of cards in hand is important

Dec 07 Puzzle (2022)

- List of commands to move around file system
- Translate commands into disk hierarchy and file sizes within each directory

01/10

ETL vs ELT

ETL vs ELT

Extract, Transform, Load

- External processing of non-relational data to create relational data
- Not SQL focused

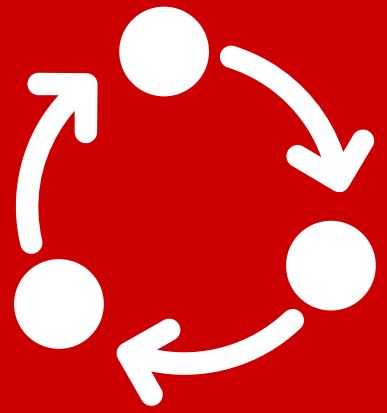
Extract, Load, Transform

- Internal processing of non-relational data to create relational data
- SQL focused

Convert non-relational data into relational, tabular data.

Why Has ETL Been So Popular?

- External tools could bring specialized functionality to data processing more quickly
- Databases didn't speak web languages well
  - ie. XML or JSON
- Specialized tools = specialized jobs



Iteration is slow

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Keep processing close to the data for faster iteration

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ELT in PostgreSQL

- Retain transactional consistency and control
- PostgreSQL has a plethora of functions for processing and transforming data
  - Regex
  - JSON
  - String
- Array and JSON output are particularly useful for processing

02/10

Inserting Data

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Inserting Data

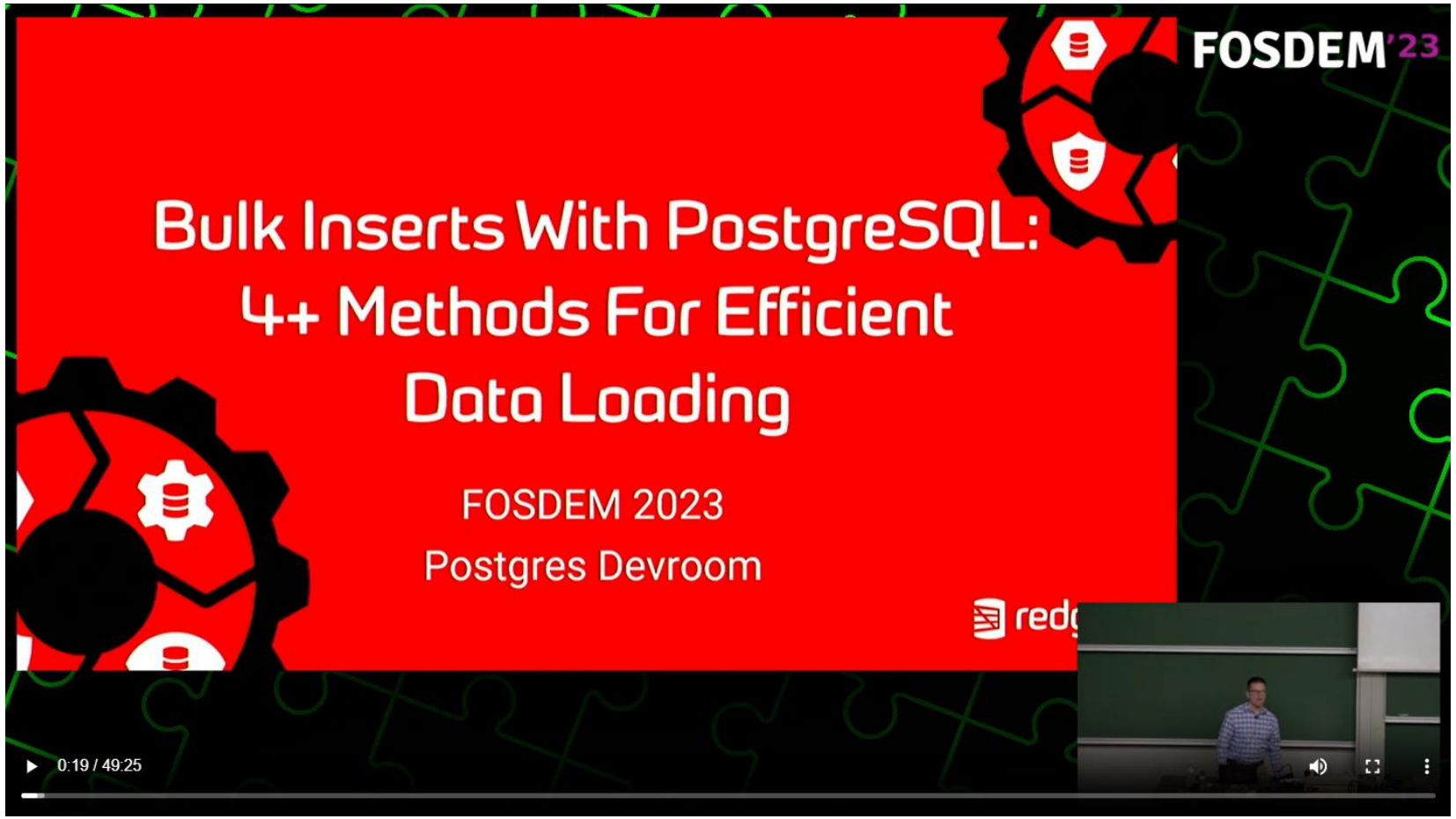
- Quickly dump data to tables and keep the schema simple
- Post-process JSON, XML, strings, arrays, etc.
- Use `COPY`:
  - most supported method of getting data in quickly
  - CSV or custom delimiters
- Use code:
  - work in batches of rows to reduce transaction overhead

COPY vs \copy

- COPY is a PostgreSQL command, not SQL standard
- `COPY` requires files local to the server
- My examples primarily use `psql \copy` command
- This streams data from local files to PostgreSQL `STDIN COPY`

COPY Caution

- Requires correct column order, matching data types, and clean data (no conversion)
- Options like pgloader overcome some limitations
  - pre-checks on certain columns of data



https://bit.ly/ryan-booz-2023-talks

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Data Import Rules – K.I.S.S

1. Create a generated ID for ordering later if needed
2. Add a timestamp column if it's time-series data
3. Pre-processes what makes sense, but don't go overboard

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K.I.S.S. – Advent of Code

```
create table dec07 (
       id integer generated by default as identity,
       lines text
);

-- COPY the text into the appropriate columns
\COPY dec07 (lines) FROM input.txt NULL '';
```

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K.I.S.S. – Wordle


```
    {
        "data": {
            "author_id": "395950789",
            "created_at": "2022-01-15T03:09:22.000Z",
            "id": "1482188130191122123",
            "text": "Wordle 209
3/6\n\n\u2b1b\u2b1b\u2b1b\ud83d\udfe9\u2b1b\n\u2b1b\u2b1b\ud83d\udfe8\u2b1b\ud83d\udfe8\n\ud83d\udfe9\ud83d\udfe9\ud83d\udfe9\ud8
3d\udfe9\ud83d\udfe9"
        },
        "includes": {
            "users": [
                {
                    "id": "395950789",
                    "location": "Cali",
                    "name": "Hall & Oates Enjoyer",
                    "username": "wordlemaster",
                    "verified": false
                }
            ]
        },
        "matching_rules": [
            {
                "id": "1482188147178053123",
                "tag": "wordle"
            }
        ]
    }
```

K.I.S.S. – Wordle

```
CREATE TABLE tweets_raw(
    ts timestamptz NOT NULL,
    tweet_id bigint NOT NULL,
    tweet_raw JSONB NOT null,
);
```

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K.I.S.S. – Wordle

```
CREATE TABLE wordle_tweet (
    ts timestamptz NOT NULL,
    created_at timestamptz NOT NULL,
    author_id bigint NOT NULL,
    author_handle TEXT NOT NULL,
    author_verified bool,
    author_location TEXT,
    tweet_id bigint NOT NULL,
    tweet TEXT NOT null,
    game int NULL,
    guess_total int null
);
```

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Derived Table for Quick Prototyping

```
SELECT regexp_split_to_table($$32T3K 765
T55J5 684
KK677 28
KTJJT 220
QQQJA 483$$,'\n') lines;

lines    |
---------+
32T3K 765|
T55J5 684|
KK677 28 |
KTJJT 220|
QQQJA 483|
```

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Derived Table for Quick Prototyping

```
WITH dec07 AS (
       SELECT * FROM regexp_split_to_table($$32T3K 765
       T55J5 684
       KK677 28
       KTJJT 220
       QQQJA 483$$,'\n') WITH ORDINALITY lines(lines,id)
)
SELECT id, lines FROM dec07;

id|lines    |
--+---------+
 1|32T3K 765|
 2|T55J5 684|
 3|KK677 28 |
 4|KTJJT 220|
 5|QQQJA 483|
```

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03/10
SQL/PostgreSQL Building Blocks

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WITH ORDINALITY

- Ordinal value of each row returned when a Set Returning Function is a FROM clause source
- Faster than ROW_NUMBER()
  - No need to rescan the entire table
- Retains order without an ORDER BY

CROSS JOIN

- For every row on the left table, iterate all rows on right table
- Output is the product of both sets

CROSS JOIN

```
SELECT * FROM
       generate_series(1,2) gs1
       CROSS JOIN generate_series(1,4) gs2;

gs1|gs2|
---+---+
  1|  1|
  1|  2|
  1|  3|
  1|  4|
  2|  1|
  2|  2|
  2|  3|
  2|  4|
```

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CROSS JOIN LATERAL

- When a Set Returning Function is the right-hand table, the join is implicitly a LATERAL
- Therefore, the functions can reference any column from any output columns to the left
- Allows chained queries to "reach back" to previous result sets for data

CROSS JOIN LATERAL

```
SELECT * FROM
       generate_series(1,2) gs1,
       generate_series(1,4) gs2;

gs1|gs2|
---+---+
  1|  1|
  1|  2|
  1|  3|
  1|  4|
  2|  1|
  2|  2|
  2|  3|
  2|  4|
```

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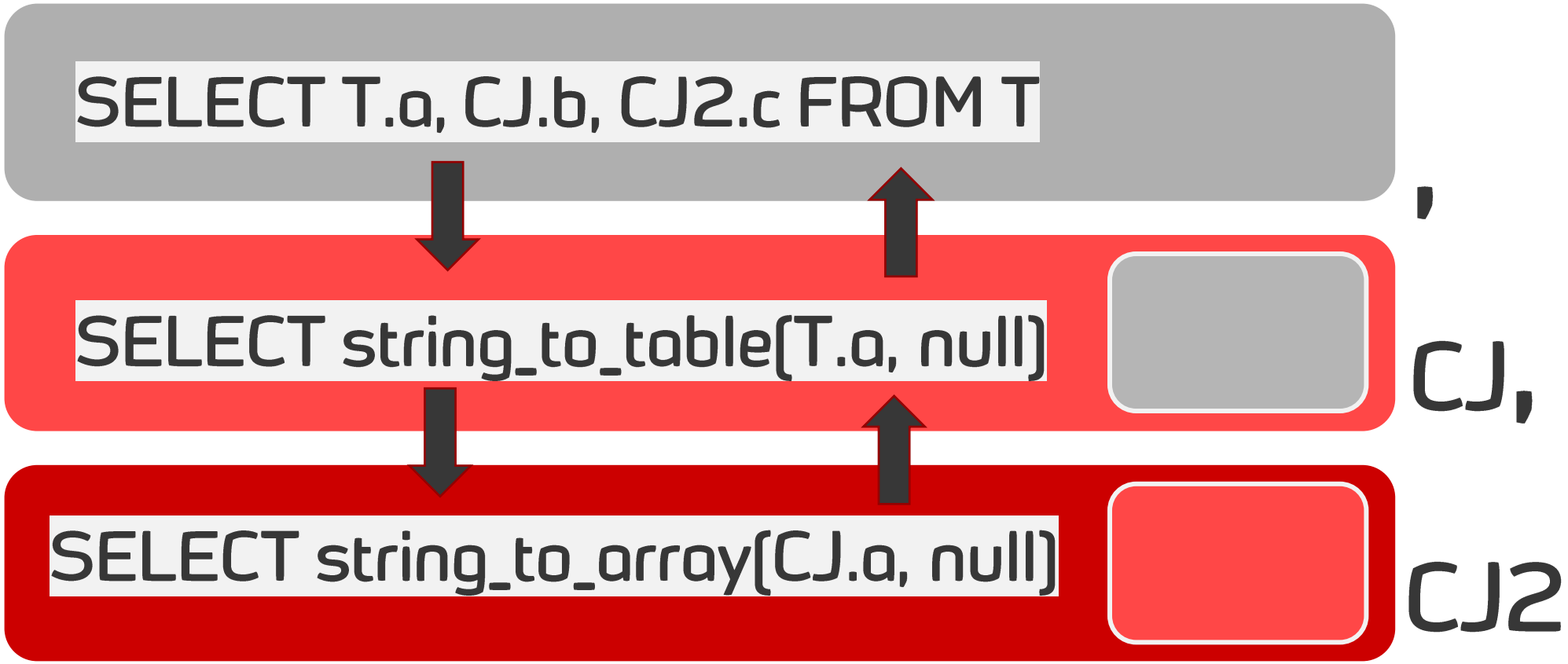
SELECT T.a, CJ.b, CJ2.c FROM T
SELECT string_to_table(T.a, null)
SELECT string_to_array(CJ.a, null)
,
CJ,
CJ2

CROSS JOIN LATERAL

- Also useful for simplifying SQL at a higher level by hiding calculations lower
- Reorganize data by returning VALUES

CROSS JOIN LATERAL

```
SELECT id AS hand,
       t.* AS card,
      (split_part(lines,' ',2)) AS bid
FROM dec07, -- Remember that comma is a CROSS JOIN LATERAL
     string_to_table(split_part(lines,' ',1)) t;
```

CROSS JOIN LATERAL

```
SELECT id AS hand,
    t.card,
    t.position,
    bid
FROM dec07,
     string_to_table(split_part(lines,' ',1),null)
             WITH ORDINALITY t(card,position),
     split_part(lines,' ',2) bid;
```

CROSS JOIN LATERAL

```
...
select hm.step,
       hm.x, hm.y,
       h.x, h.y,
       t.x, t.y
from tmove tm
  join hmove hm on tm.step+1 = hm.step
cross join lateral
    (VALUES (tm.hx+hm.x, tm.hy+hm.y)) as h(x,y)
cross join lateral
    (VALUES (
        case when abs(h.y-tm.ty) = 2 then h.x
             when abs(tm.tx-h.x) <= 1 then tm.tx
             else tm.tx + hm.x end,
        case when abs(h.x-tm.tx) = 2 then h.y
             when abs(tm.ty-h.y) <= 1 then tm.ty
             else tm.ty + hm.y end
)) t(x,y)
...
```

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CROSS JOIN LATERAL

```
...
select hm.step,
    hm.x, hm.y,
    h.x, h.y,
    t.x, t.y
from tmove tm
  join hmove hm on tm.step+1 = hm.step
cross join lateral
     (VALUES (tm.hx+hm.x, tm.hy+hm.y)) as h(x,y)
cross join lateral
     (VALUES (
         case when abs(h.y-tm.ty) = 2 then h.x
              when abs(tm.tx-h.x) <= 1 then tm.tx
              else tm.tx + hm.x end,
         case when abs(h.x-tm.tx) = 2 then h.y
              when abs(tm.ty-h.y) <= 1 then tm.ty
              else tm.ty + hm.y end
)) t(x,y)
...
```

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Common Table Expression

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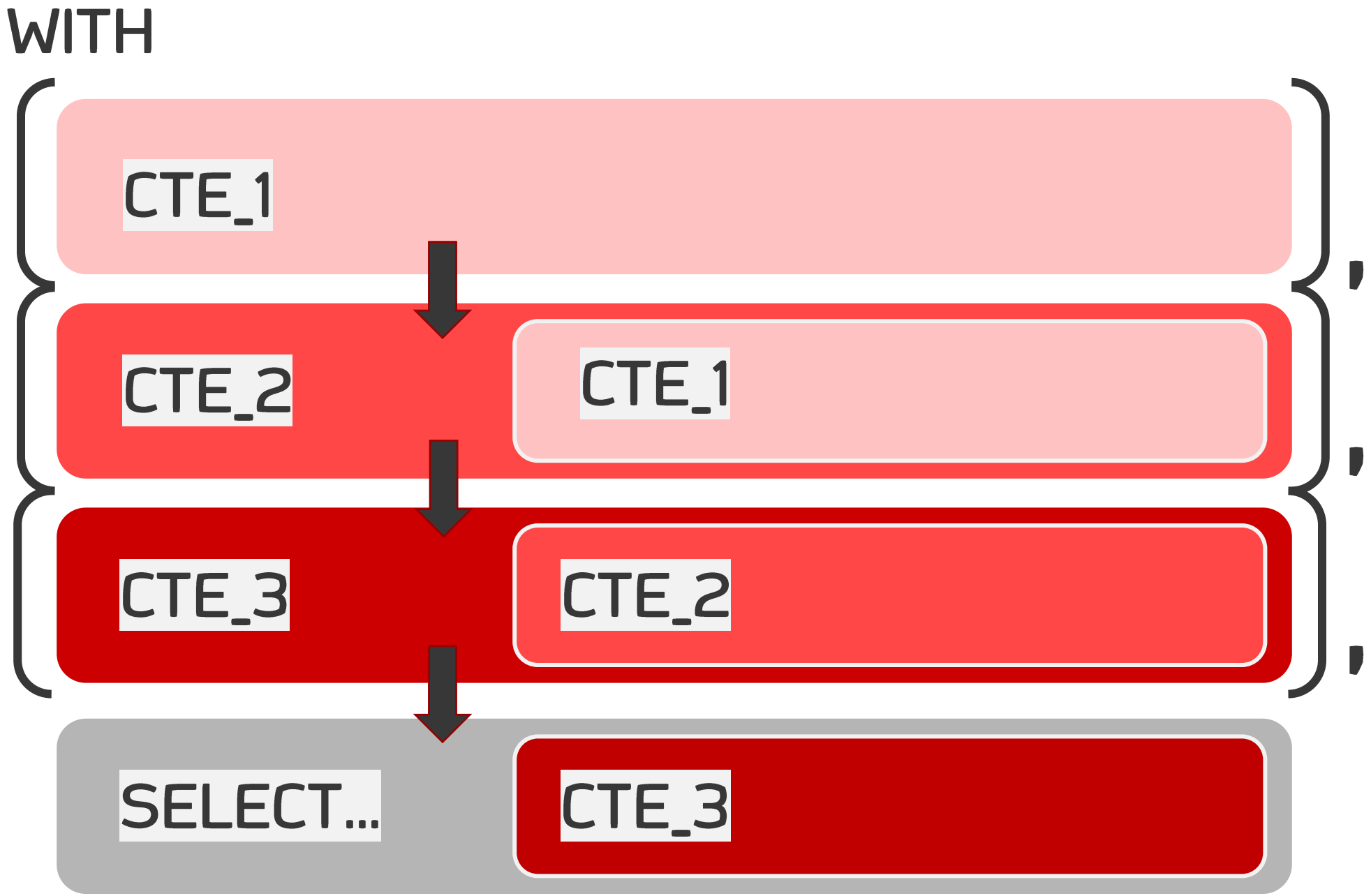
Common Table Expression (CTE)

- Also called WITH queries
- Reference the output of the query by a unique name
- Prior to Postgres 12 the CTE was materialized first
  - PG12+ planner attempts to in-line unless you add MATERIALIZED

Common Table Expression (CTE)

- Multiple CTEs can be chained together, referring to each other as you go
- Particularly helpful when you'll reuse a query more than once (readability)
- Name output columns with parenthesis


WITH
CTE_1
CTE_2
CTE_1
CTE_3
CTE_2
SELECT...
CTE_3

```
SELECT * FROM
        (SELECT id AS hand,
        t.*,
        bid
        FROM dec07,
                string_to_table(split_part(lines,' ',1),null)
                        WITH ORDINALITY t(card,position),
                split_part(lines,' ',2) bid
) cb
JOIN (
        SELECT * FROM (VALUES  ('2',2),
                        ('3',3),
                        ('4',4),
                        ('5',5),
                        ('6',6),
                        ('7',7),
                        ('8',8),
                        ('9',9),
                        ('T',10),
                        ('J',11),
                        ('Q',12),
                        ('K',13),
                        ('A',14)) AS t(card,value)
) vals USING (card)
ORDER BY hand, position;
```

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```
WITH given_hand (hand,card,position,bid) AS (
SELECT id, t.*, bid
        FROM dec07,
        string_to_table(split_part(lines,' ',1),null)
        WITH ORDINALITY t(card,position),
        split_part(lines,' ',2) bid
),
card_converter (card,value) AS (
                VALUES  ('2',2),
                        ('3',3),
                        ('4',4),
                        ('5',5),
                        ('6',6),
                        ('7',7),
                        ('8',8),
                        ('9',9),
                        ('T',10),
                        ('J',11),
                        ('Q',12),
                        ('K',13),
                        ('A',14)
)
SELECT * FROM given_hand
        JOIN card_converter USING (card);
```

Readability is often cited as the primary benefit.

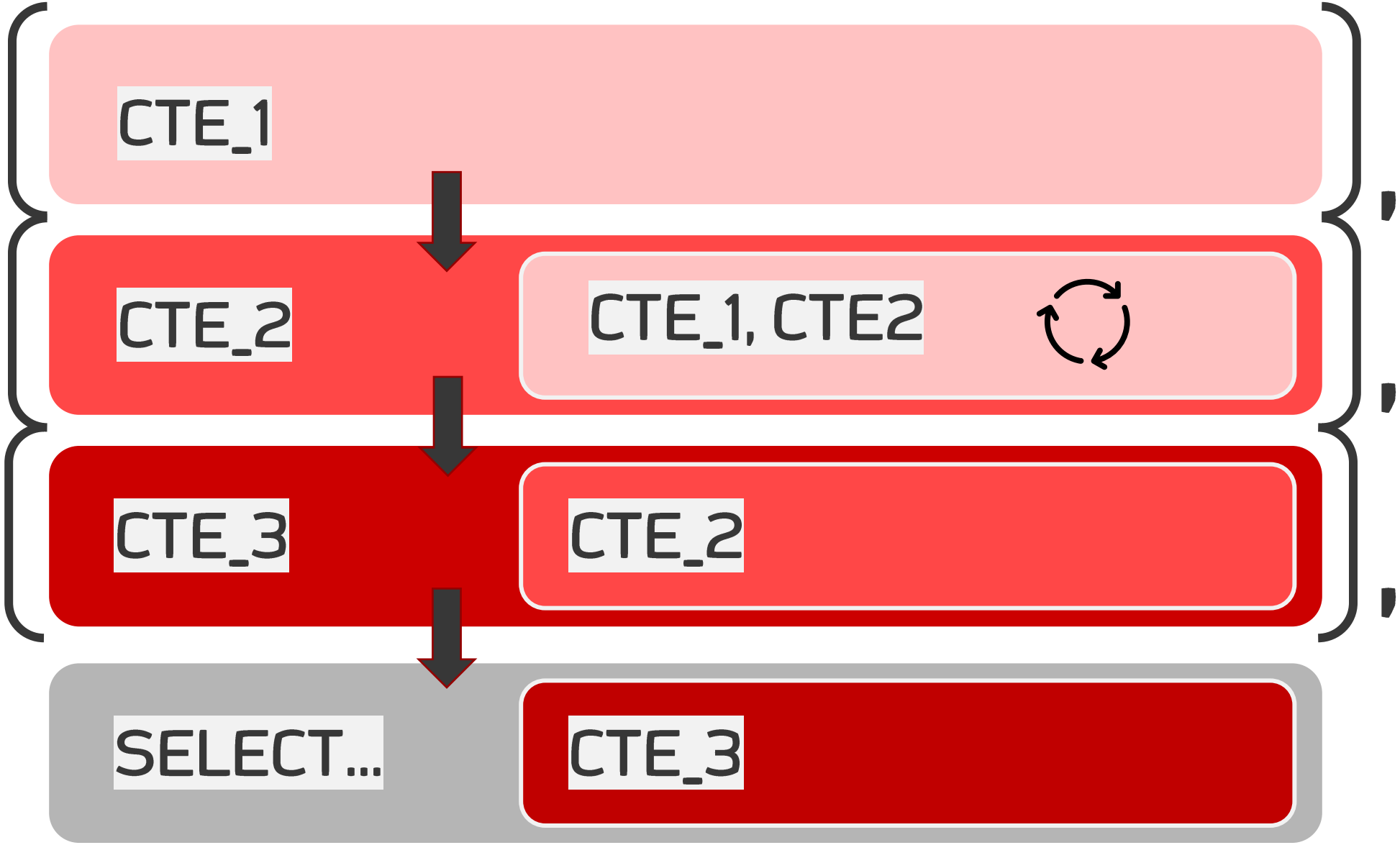
While true, increased complexity might be less performant

05/10
Recursive CTEs

Recursive CTEs

- The SQL language is declarative and batch-based by implementation
- Recursive CTEs provide iterative processing using SQL that wouldn't otherwise be possible
- Recursive CTEs allow SQL to be a Turing complete language

WITH RECURSIVE



name	parent_folder	size
Folder_A		
Folder_A_1	Folder_A	
Folder_B	Folder_A	
Folder_A_2	Folder_A	
Folder_B_1	Folder_B	
File_A1.txt	Folder_A	1234
File_A2.txt	Folder_A	9876
File_B1.txt	Folder_B	4567

Recursive CTEs

```
WITH recursive files AS (
    -- start with a non-recursive, initial query
    SELECT name, parent_folder, SIZE FROM files_on_disk
    WHERE parent_folder IS NULL
)
SELECT * FROM files;
```

```
name        |parent_folder|size|
------------+-------------+----+
Folder_A    |             |    |
```

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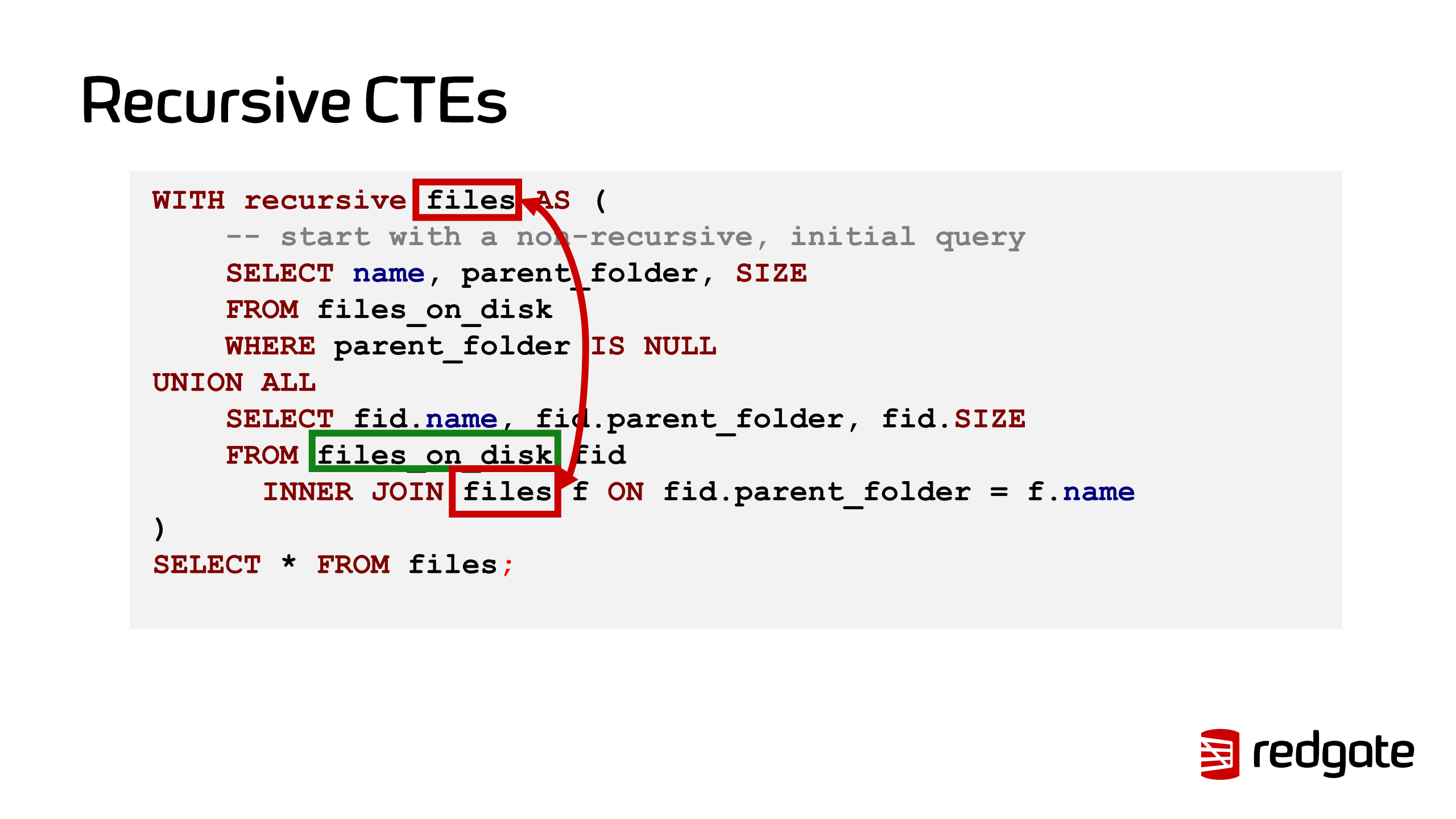
Recursive CTEs

```
WITH recursive files AS (
    -- start with a non-recursive, initial query
    SELECT name, parent_folder, SIZE
    FROM files_on_disk
    WHERE parent_folder IS NULL
UNION ALL
    SELECT fid.name, fid.parent_folder, fid.SIZE
    FROM files_on_disk fid
      INNER JOIN files f ON fid.parent_folder = f.name
)
SELECT * FROM files;
```



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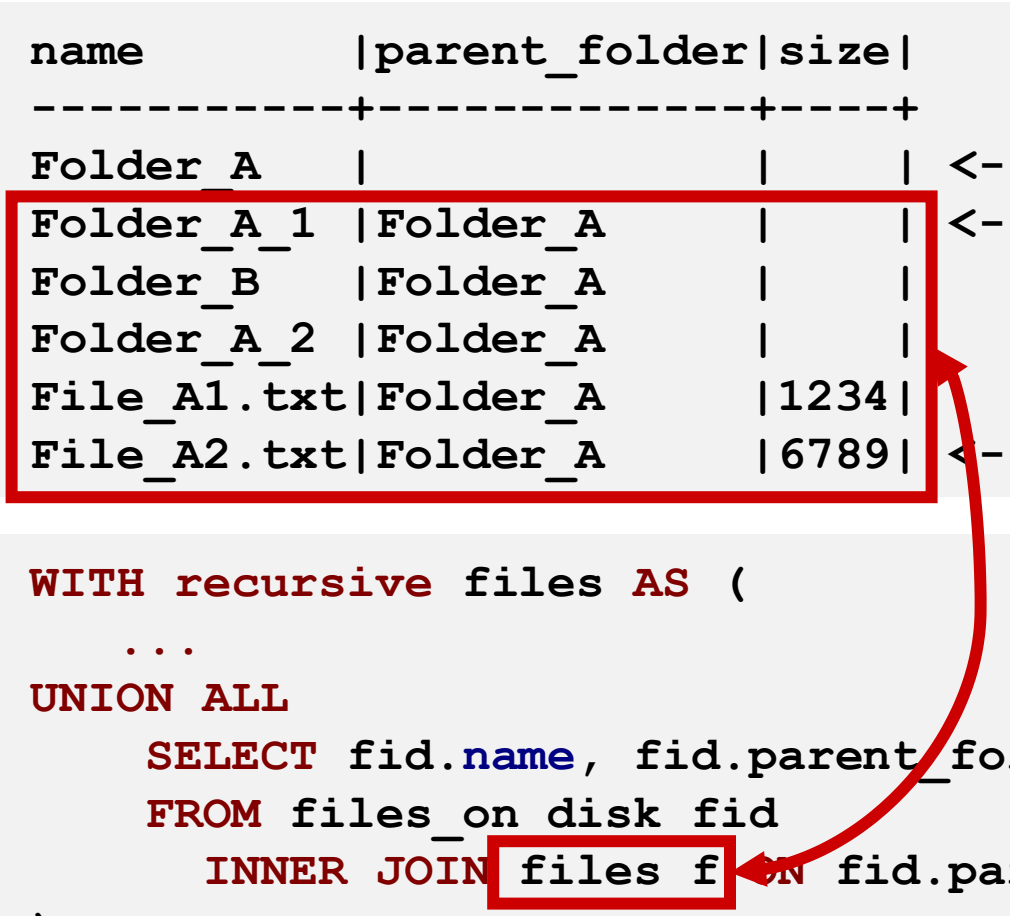
Recursive CTEs

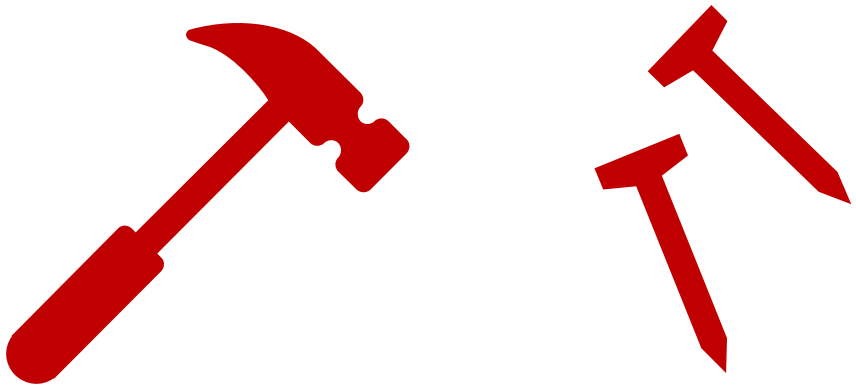
```
name         |parent_folder|size|
-------------+-------------+----+
Folder_A     |             |    | <-- Initial query
Folder_A_1   |Folder_A     |    | <--|
Folder_B     |Folder_A     |    |    |
Folder_A_2   |Folder_A     |    |    |- Result of first join
File_A1.txt  |Folder_A     |1234|    |
File_A2.txt  |Folder_A     |6789| <--|
```

```
WITH recursive files AS (
    ...
UNION ALL
    SELECT fid.name, fid.parent_folder, fid.SIZE
    FROM files_on_disk fid
      INNER JOIN files f ON fid.parent_folder = f.name
)
SELECT * FROM files;
```



Recursive CTEs – Caution!

- Recursion continues until working table is empty
- Make sure there is an ending point (or add one!)



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DEMO

PostgreSQL Community

- Vik Fearing
- Feike Steenbergen
- David Kohn
- Sven Klemm
- John Pruitt
- Tobias Petry
- Bruce Momjain
- Andreas Scherbaum
- Ryan Lambert
- More, more, more…

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What Questions do you have?

🎉 THANK YOU! 🎉

github.com/ryanbooz/presentations

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