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Super-powered Data Transformation with PostgreSQL

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Agenda

01 ETL vs ELT

02 Loading Data

03-10 7 SQL/PostgreSQL Features

Bonus Community

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2022

WORDLE

A DAILY WORD GAME

A few functions are only included with PostgreSQL >=14

01/10
ETL vs ELT

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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

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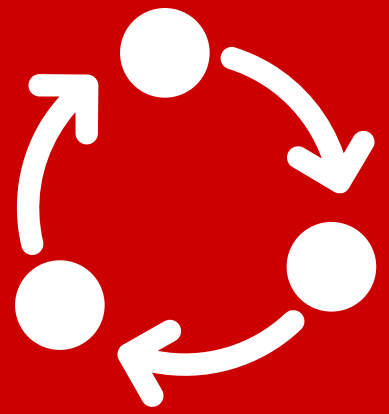
Convert non-relational data into relational, tabular data.

Why Has ETL Been So Popular?

- External tools could more quickly bring specialized functionality to data processing
- 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

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

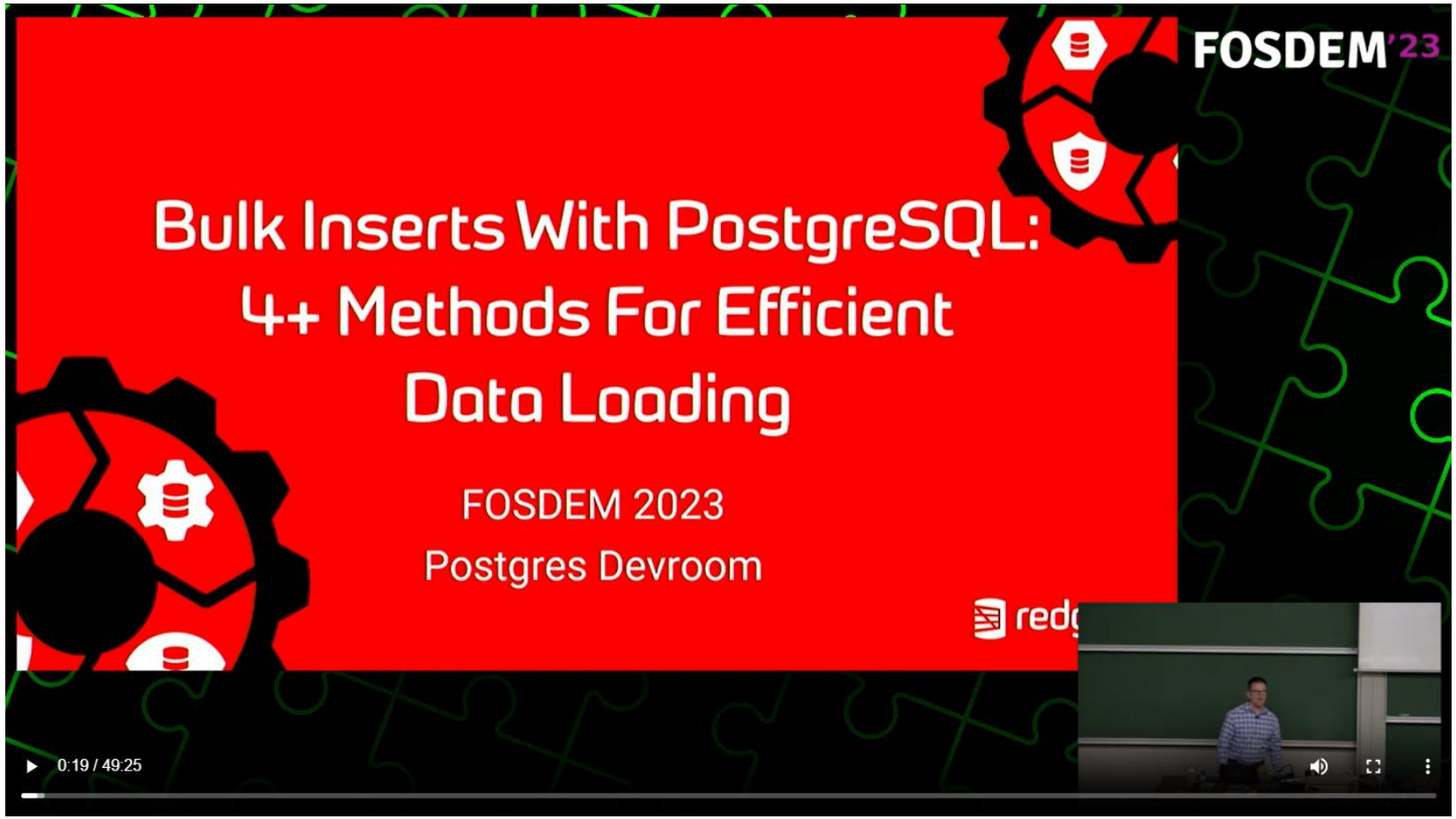
- Quickly dump data to tables and keep the schema simple
- Post-process JSON, XML, strings, arrays, etc.
- Use `COPY`:
  - most supported method of getting data in quickly
  - CSV or custom delimiters
- Use code:
  - work in batches of rows to reduce transaction overhead

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



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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 dec05 (
    id integer generated by default as identity,
    puzzle_input text
);

-- COPY the text into the appropriate columns
\COPY dec05 (puzzle_input) FROM input_05.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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03/10
Common Table Expression

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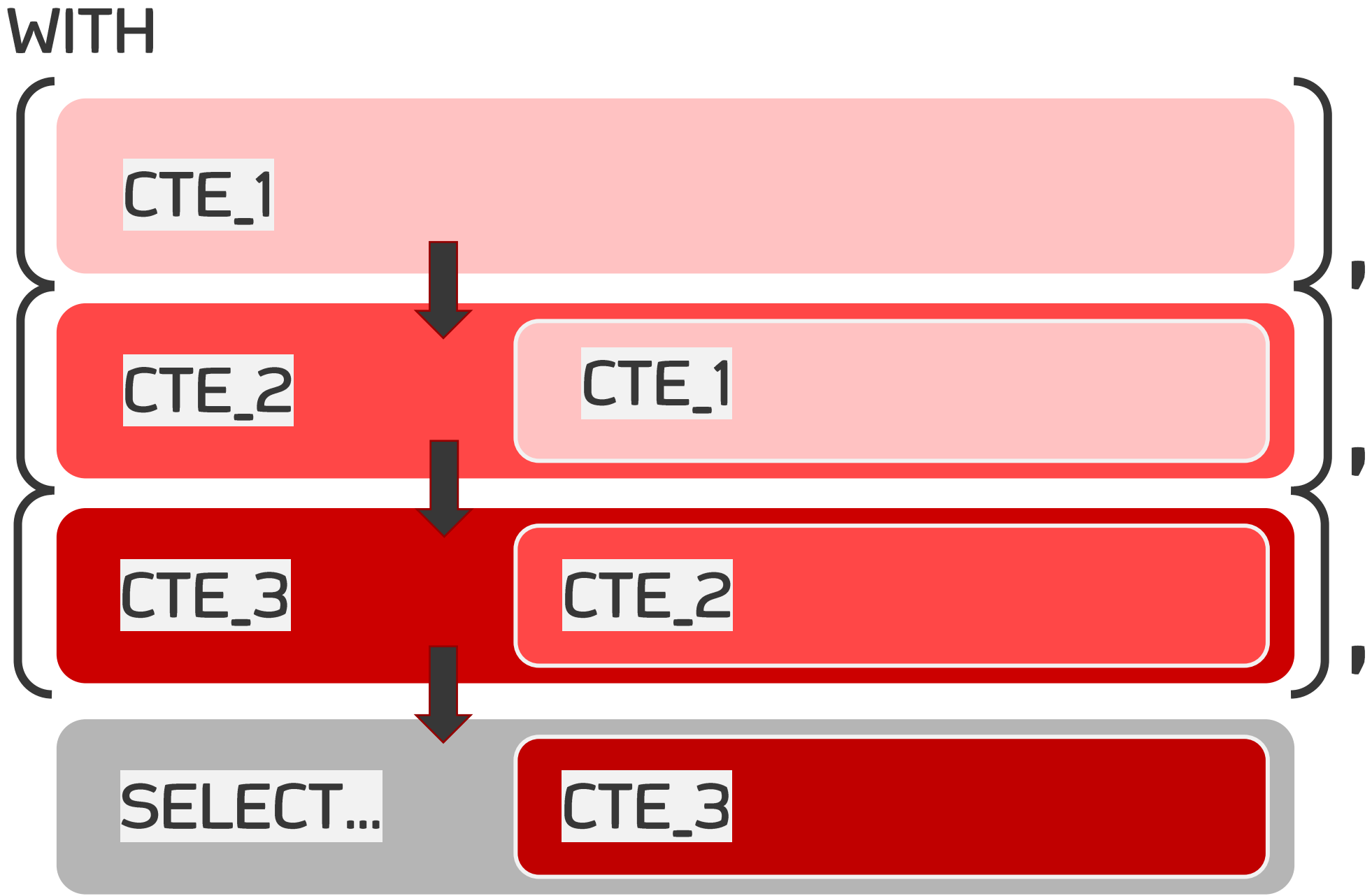
Common Table Expression (CTE)

- 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

CTEs

```
SELECT
  nullif(calories, ''::bigint AS calories,
  count(*) FILTER (WHERE calories is null) OVER (ORDER BY id) AS elf,
  id
FROM
  dec01
```

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CTEs

```
WITH inventory AS (
  SELECT
    nullif(calories, '')::bigint AS calories,
    count(*) FILTER (WHERE calories is null) OVER (ORDER BY id) AS elf,
    id
  FROM
    dec01
)
```

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CTEs

```
WITH inventory AS (
  SELECT
    nullif(calories, '')::bigint AS calories,
    count(*) FILTER (WHERE calories is null) OVER (ORDER BY id) AS elf,
    id
  FROM
    dec01
)
SELECT sum(calories) as c
FROM inventory
GROUP BY elf
ORDER BY 1 desc;
```

CTEs

```
WITH inventory (calories, elf) AS (
  SELECT
    nullif(calories, '')::bigint,
    count(*) FILTER (WHERE calories is null) OVER (ORDER BY id),
    id
  FROM
    dec01
)
SELECT sum(calories) as c
FROM inventory
GROUP BY elf
ORDER BY 1 desc;
```

04/10
Recursive CTEs

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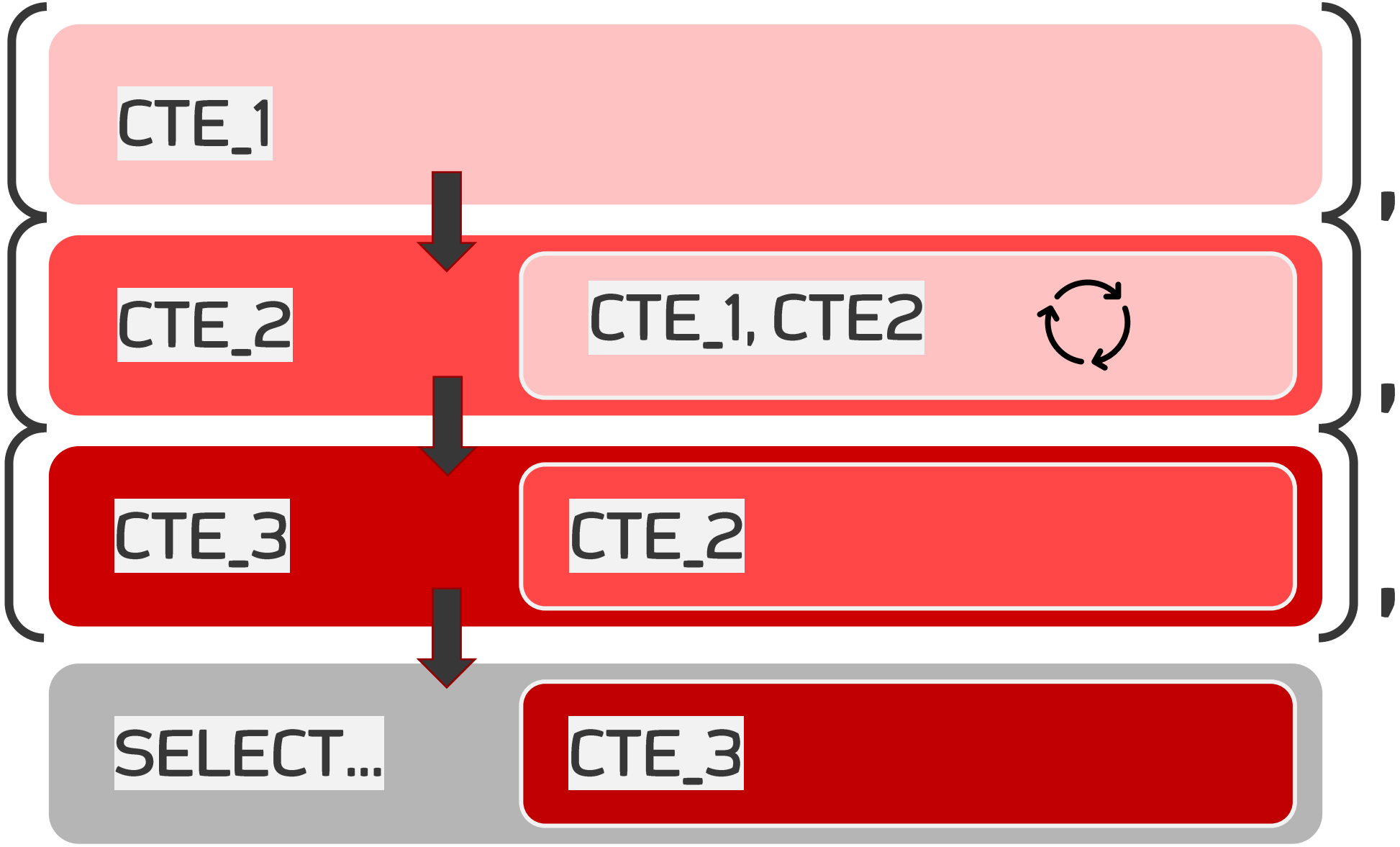
Recursive CTEs

- 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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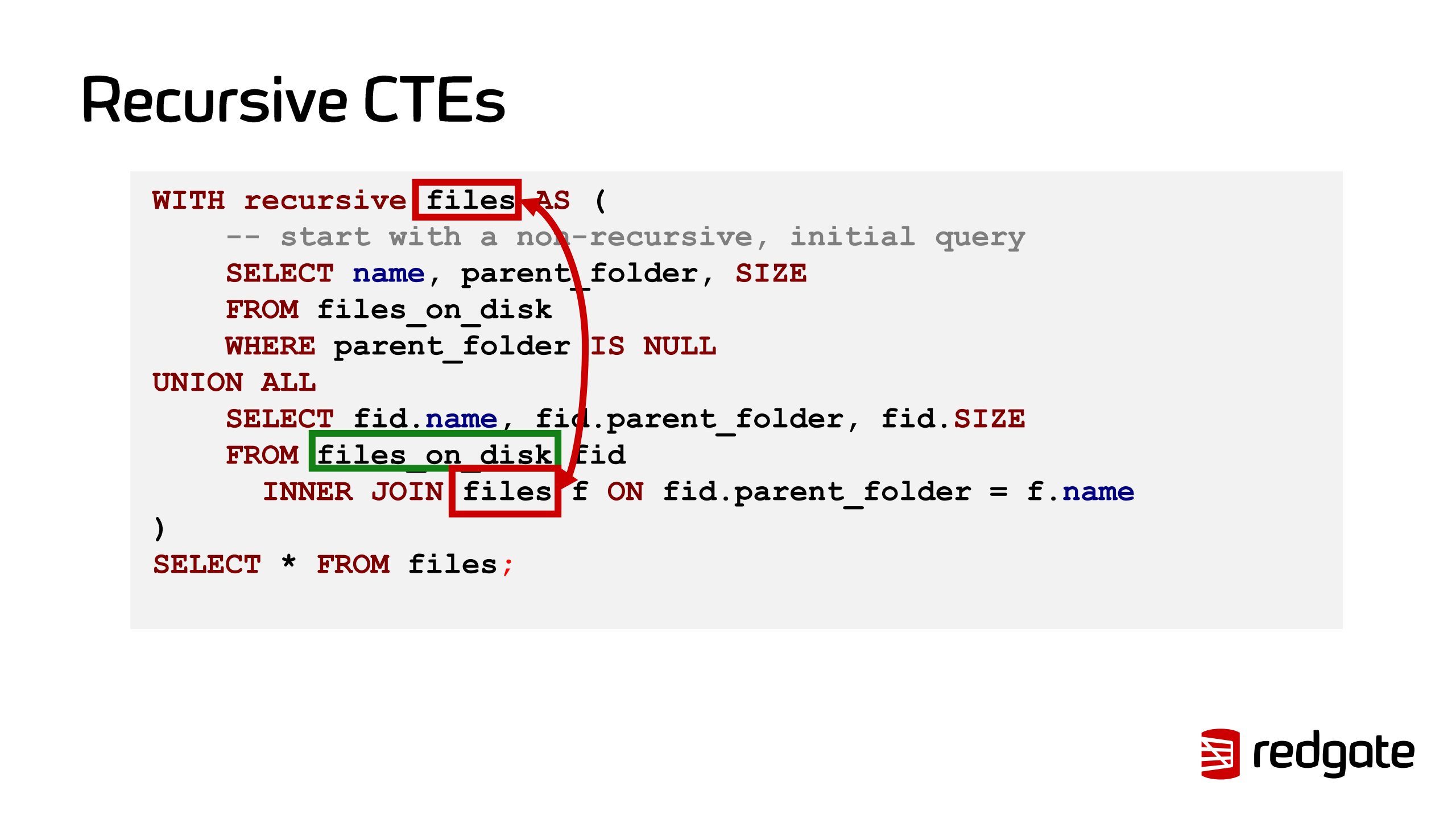
Recursive CTEs

```
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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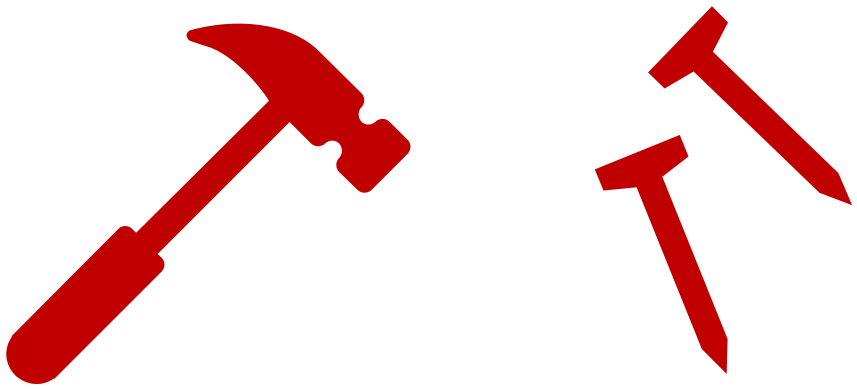
Recursive CTEs

```
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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05/10
FILTER Clause

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FILTER Clause

- Available for many aggregate and window functions
- An internal predicate for the aggregate as rows pass through
- Useful in place of pivot-type queries

06/10

Text to...

Convert text to...

- Arrays, JSON, Tables
- Arrays and JSON are helpful as intermediate stores, particularly in recursive queries
- Both are fully supported datatypes in PostgreSQL, including indexing
- Many functions can output either datatype

Arrays, Tables, & JSON

- Some functions for converting text
  - string_to_array
  - regexp_matches
  - regexp_split_to_table
  - string_to_table
  - json_each & json_object_agg

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07/10
CROSS JOIN LATERAL

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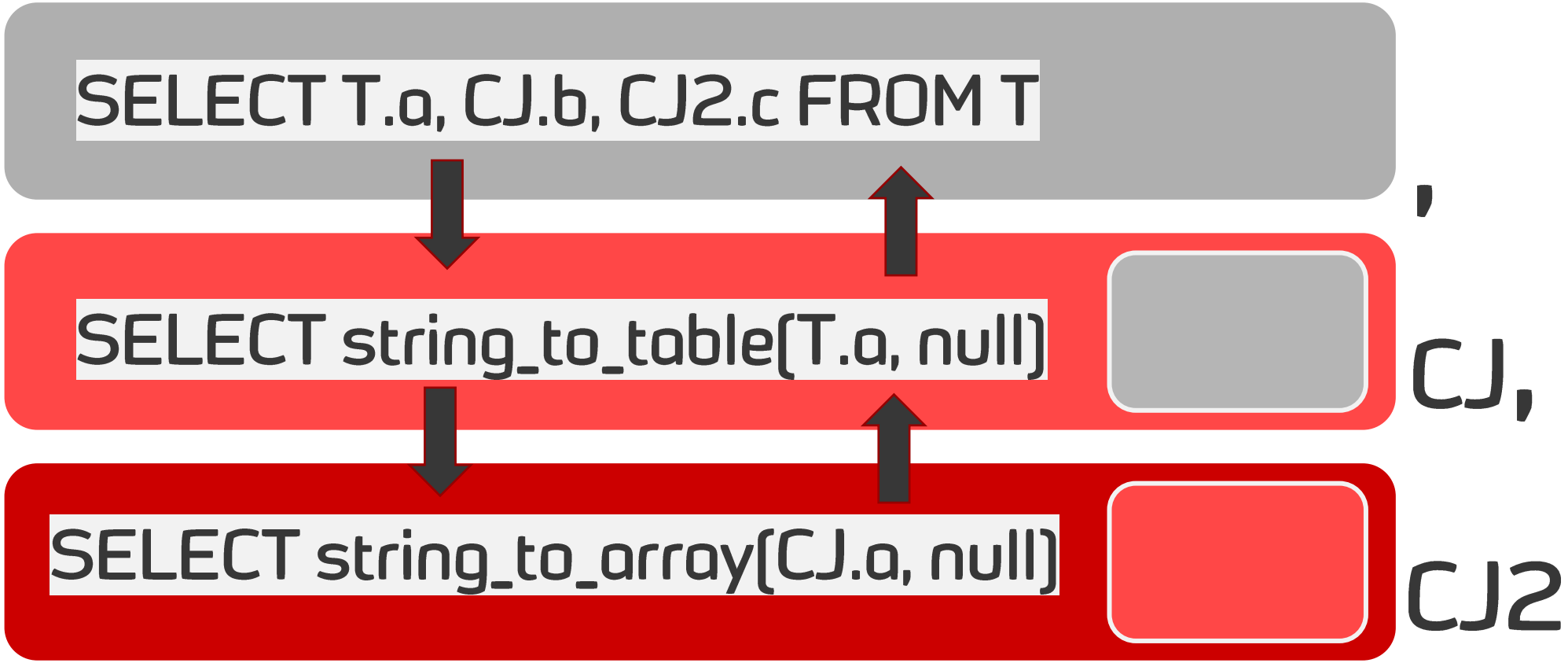
CROSS JOIN LATERAL

- For every row on the left, execute query on the right
- Output is the product of both sets
- Allows chained queries to "reach back" to previous result sets for data
- Very useful with Set Returning Functions (SRF)


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 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)
...
```

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)
...
```

WITH ORDINALITY

WITH ORDINALITY

- Any Set Returning Function can also return the ordinal value of each row
- Faster than ROW_NUMBER()
- Retains order without an ORDER BY

09/10

WINDOW Functions

WINDOW Functions

- Aggregates on steroids that work in context of the current query row
- Look backwards and forwards
- Powerful data analysis tool that can be challenging to master…
- …but worth the investment!

10/10
Range Type

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Range Type

- Ranges of dates and numbers
- Multi-range values supported in PostgreSQL 14+
- Can be inclusive or exclusive of each bound
- Many built-in range operators for easy comparison
- Indexable!

Bonus
Community

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PostgreSQL Community

- X
- Slack
- Discord
- LinkedIn
- Postgres Weekly Newsletter
- PostgreSQL.life Interviews
- #PGSQLPhriday monthly blog event

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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