DuckDB & SQL

Lecture 18

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SQL

Structures Query Language is a special purpose language for interacting with (querying and modifying) indexed tabular data.

- ANSI Standard but with dialect divergence (MySql, Postgres, SQLite, etc.)
- This functionality maps very closely (but not exactly) with the data manipulation verbs present in dplyr.
- SQL is likely to be a foundational skill if you go into industry - learn it and put it on your CV

DuckDB

> DuckDB is an open-source column-oriented relational database management system (RDBMS) originally developed by Mark Raasveldt and Hannes Mühleisen at the Centrum Wiskunde & Informatica (CWI) in the Netherlands and first released in 2019. The project has over 6 million downloads per month. It is designed to provide high performance on complex queries against large databases in embedded configuration, such as combining tables with hundreds of columns and billions of rows. Unlike other embedded databases (for example, SQLite) DuckDB is not focusing on transactional (OLTP) applications and instead is specialized for online analytical processing (OLAP) workloads.
>
> From Wikipedia - DuckDB

DuckDB & DBI

DuckDB is a relational database just like SQLite and can be interacted with using DBI and the duckdb package.

```
1 library(DBI)
2 (con = dbConnect(duckdb::duckdb()))
```

```
<duckdb_connection c4800 driver=<duckdb_driver dbdir=':memory:' read_only=FALSE
bigint=numeric>>
```

```
1 dbWriteTable(con, "flights", nycflights13::flights)
2 dbListTables(con)
```

```
[1] "flights"
```

```r
dbGetQuery(con, "SELECT * FROM flights") |>
  as_tibble()
```

```
# A tibble: 336,776 × 19
    year month   day dep_time sched_dep_time dep_delay arr_time
   <int> <int> <int>    <int>          <int>     <dbl>    <int>
 1  2013     1     1      517            515         2      830
 2  2013     1     1      533            529         4      850
 3  2013     1     1      542            540         2      923
 4  2013     1     1      544            545        -1     1004
 5  2013     1     1      554            600        -6      812
 6  2013     1     1      554            558        -4      740
 7  2013     1     1      555            600        -5      913
 8  2013     1     1      557            600        -3      709
 9  2013     1     1      557            600        -3      838
10  2013     1     1      558            600        -2      753
# ℹ 336,766 more rows
```

```r
library(dplyr)
tbl(con, "flights") |>
  filter(month == 10, day == 30) |>
  count(origin, dest) |>
  arrange(desc(n))
```

```
# Source:     SQL [?? x 3]
# Database:   DuckDB v1.1.1 [root@Darwin 24.1.0:R 4.4.1/:memory:]
# Ordered by: desc(n)
  origin dest      n
  <chr>  <chr> <dbl>
1 JFK    LAX      32
2 LGA    ORD      30
3 LGA    ATL      29
4 JFK    SFO      24
5 LGA    CLT      21
6 EWR    ORD      18
7 EWR    SFO      16
8 LGA    BOS      16
9 JFK    BOS      16
```

DuckDB CLI

Connecting via CLI

```
cr173@katherinej [class_2024_10_30]$ duckdb employees.duckdb

v1.1.2 f680b7d08f
Enter ".help" for usage hints.
D
```

Table information

Dot commands are expressions that begins with `.` and are specific to the DuckDB CLI, some examples include:

```
D .tables
## employees
```

```
D .schema employees
## CREATE TABLE employees("name" VARCHAR, email VARCHAR, salary DOUBLE, dept VAR
```

```
D .indexes employees
```

```
D .maxrows 20
D .maxwidth 80
```

A full list of available dot commands can be found here or listed via `.help` in the CLI.

SELECT Statements

```
D SELECT * FROM employees;
```

name	email	salary	dept
varchar	varchar	double	varchar
Alice	alice@company.com	52000.0	Accounting
Bob	bob@company.com	40000.0	Accounting
Carol	carol@company.com	30000.0	Sales
Dave	dave@company.com	33000.0	Accounting
Eve	eve@company.com	44000.0	Sales
Frank	frank@comany.com	37000.0	Sales

Output formats

The format of duckdb's output (in the CLI) is controled via `.mode` - the default is duckbox, see other possible output formats.

```
D .mode csv
D SELECT * FROM employees;

## name,email,salary,dept
## Alice,alice@company.com,52000.0,Accounting
## Bob,bob@company.com,40000.0,Accounting
## Carol,carol@company.com,30000.0,Sales
## Dave,dave@company.com,33000.0,Accounting
## Eve,eve@company.com,44000.0,Sales
## Frank,frank@comany.com,37000.0,Sales
```

```
D .mode markdown
D SELECT * FROM employees;

## | name  |       email        | salary  |    dept
## |-------|--------------------|--------:|----------
## | Alice | alice@company.com  | 52000.0 | Accountin
## | Bob   | bob@company.com    | 40000.0 | Accountin
## | Carol | carol@company.com  | 30000.0 | Sales
## | Dave  | dave@company.com   | 33000.0 | Accountin
## | Eve   | eve@company.com    | 44000.0 | Sales
## | Frank | frank@comany.com   | 37000.0 | Sales
```

```
D .mode json
D SELECT * FROM employees;
## [{"name":"Alice","email":"alice@company.com","sal
## {"name":"Bob","email":"bob@company.com","salary":
## {"name":"Carol","email":"carol@company.com","sala
## {"name":"Dave","email":"dave@company.com","salary
## {"name":"Eve","email":"eve@company.com","salary":
## {"name":"Frank","email":"frank@comany.com","salar
```

```
D .mode insert
D SELECT * FROM employees;
INSERT INTO "table"("name",email,salary,dept) VALUES
INSERT INTO "table"("name",email,salary,dept) VALUES
INSERT INTO "table"("name",email,salary,dept) VALUES
INSERT INTO "table"("name",email,salary,dept) VALUES
INSERT INTO "table"("name",email,salary,dept) VALUES
INSERT INTO "table"("name",email,salary,dept) VALUES
```

select() using SELECT

We can subset for certain columns (and rename them) using `SELECT`

```
D SELECT name AS first_name, salary FROM employees;

##  ┌──────────────┬──────────┐
##  │ first_name   │ salary   │
##  │  varchar     │ double   │
##  ├──────────────┼──────────┤
##  │ Alice        │ 52000.0  │
##  │ Bob          │ 40000.0  │
##  │ Carol        │ 30000.0  │
##  │ Dave         │ 33000.0  │
##  │ Eve          │ 44000.0  │
##  │ Frank        │ 37000.0  │
##  └──────────────┴──────────┘
```

arrange() using ORDER BY

We can sort our results by adding `ORDER BY` to our `SELECT` statement and reverse the ordering by include `DESC`.

```
D SELECT name AS first_name, salary FROM employees
  ORDER BY salary;
```

```
## ┌──────────────┬──────────┐
## │ first_name   │ salary   │
## │  varchar     │ double   │
## ├──────────────┼──────────┤
## │ Carol        │ 30000.0  │
## │ Dave         │ 33000.0  │
## │ Frank        │ 37000.0  │
## │ Bob          │ 40000.0  │
## │ Eve          │ 44000.0  │
## │ Alice        │ 52000.0  │
## └──────────────┴──────────┘
```

```
D SELECT name AS first_name, salary FROM employees
  ORDER BY salary DESC;
```

```
## ┌──────────────┬──────────┐
## │ first_name   │ salary   │
## │  varchar     │ double   │
## ├──────────────┼──────────┤
## │ Alice        │ 52000.0  │
## │ Eve          │ 44000.0  │
## │ Bob          │ 40000.0  │
## │ Frank        │ 37000.0  │
## │ Dave         │ 33000.0  │
## │ Carol        │ 30000.0  │
## └──────────────┴──────────┘
```

filter() using WHERE

We can filter rows using a `WHERE` clause

```
D SELECT * FROM employees WHERE salary < 40000;
```

```
## ┌─────────┬──────────────────────┬─────────┬────────────┐
## │  name   │        email         │ salary  │    dept    │
## │ varchar │       varchar        │ double  │  varchar   │
## ├─────────┼──────────────────────┼─────────┼────────────┤
## │ Carol   │ carol@company.com    │ 30000.0 │ Sales      │
## │ Dave    │ dave@company.com     │ 33000.0 │ Accounting │
## │ Frank   │ frank@comany.com     │ 37000.0 │ Sales      │
## └─────────┴──────────────────────┴─────────┴────────────┘
```

```
D SELECT * FROM employees WHERE salary < 40000 AND dept = 'Sales';
```

```
## ┌─────────┬──────────────────────┬─────────┬─────────┐
## │  name   │        email         │ salary  │  dept   │
## │ varchar │       varchar        │ double  │ varchar │
## ├─────────┼──────────────────────┼─────────┼─────────┤
## │ Carol   │ carol@company.com    │ 30000.0 │ Sales   │
## │ Frank   │ frank@comany.com     │ 37000.0 │ Sales   │
## └─────────┴──────────────────────┴─────────┴─────────┘
```

group_by() and summarize() using GROUP BY with aggregation functions

We can create groups for the purpose of summarizing using `GROUP BY`.

```
D SELECT dept, COUNT(*) AS n FROM employees GROUP BY dept;

##  ┌──────────────┬─────────┐
##  │     dept     │    n    │
##  │   varchar    │  int64  │
##  ├──────────────┼─────────┤
##  │ Sales        │       3 │
##  │ Accounting   │       3 │
##  └──────────────┴─────────┘
```

head() using LIMIT

We can limit the number of results we get by using `LIMIT`

```
D SELECT * FROM employees LIMIT 3;
## ┌─────────┬──────────────────────┬─────────┬─────────────┐
## │  name   │        email         │ salary  │    dept     │
## │ varchar │       varchar        │ double  │   varchar   │
## ├─────────┼──────────────────────┼─────────┼─────────────┤
## │ Alice   │ alice@company.com    │ 52000.0 │ Accounting  │
## │ Bob     │ bob@company.com      │ 40000.0 │ Accounting  │
## │ Carol   │ carol@company.com    │ 30000.0 │ Sales       │
## └─────────┴──────────────────────┴─────────┴─────────────┘
```

Exercise 1

Using duckdb calculate the following quantities for `employees.duckdb`,

1. The total costs in payroll for this company
2. The average salary within each department

Reading from CSV files

DuckDB has a neat trick in that it can treat files as tables (for supported formats), this lets you query them without having to explicitly read them into the database and create a table.

We can also make this explicit by using the `read_csv()` function, which is useful if we need to use custom options (e.g. specify a different delimeter)

```
D SELECT * FROM 'phone.csv';
## ┌─────────┬──────────────┐
## │  name   │    phone     │
## │ varchar │   varchar    │
## ├─────────┼──────────────┤
## │ Bob     │ 919 555-1111 │
## │ Carol   │ 919 555-2222 │
## │ Eve     │ 919 555-3333 │
## │ Frank   │ 919 555-4444 │
## └─────────┴──────────────┘
```

```
D SELECT * FROM read_csv('phone.csv', delim = ',');
## ┌─────────┬──────────────┐
## │  name   │    phone     │
## │ varchar │   varchar    │
## ├─────────┼──────────────┤
## │ Bob     │ 919 555-1111 │
## │ Carol   │ 919 555-2222 │
## │ Eve     │ 919 555-3333 │
## │ Frank   │ 919 555-4444 │
## └─────────┴──────────────┘
```

Tables from CSV

If we wanted to explicitly create a table from the CSV file this is also possible,

```
D .tables
## employees
D CREATE TABLE phone AS
  SELECT * FROM 'phone.csv';
D .tables
## employees  phone
D SELECT * FROM phone;
## ┌─────────┬────────────────┐
## │  name   │     phone      │
## │ varchar │    varchar     │
## ├─────────┼────────────────┤
## │ Bob     │ 919 555-1111   │
## │ Carol   │ 919 555-2222   │
## │ Eve     │ 919 555-3333   │
## │ Frank   │ 919 555-4444   │
## └─────────┴────────────────┘
```

Views from CSV

It is also possible to create a view from a file - this acts like a table but the data is not copied from the file

```
D .tables
## employees
D CREATE VIEW phone_view AS
  SELECT * FROM 'phone.csv';
D .tables
## employees  phone  phone_view
D SELECT * FROM phone_view;
##  ┌─────────┬────────────────┐
##  │  name   │     phone      │
##  │ varchar │    varchar     │
##  ├─────────┼────────────────┤
##  │ Bob     │ 919 555-1111   │
##  │ Carol   │ 919 555-2222   │
##  │ Eve     │ 919 555-3333   │
##  │ Frank   │ 919 555-4444   │
##  └─────────┴────────────────┘
```

Deleting tables and views

Tables and views can be deleted using `DROP`

```
D DROP TABLE phone;
D DROP VIEW phone_view;
```

Joins - Default

If not otherwise specified the default join in DuckDB will be an inner join - note that an `ON` or `USING` clause is required unless using `NATURAL`.

```
D SELECT * FROM employees JOIN phone;
## Parser Error: syntax error at or near ";"
## LINE 1: SELECT * FROM employees JOIN phone;
```

```
D SELECT * FROM employees NATURAL JOIN phone;

##
## ┌─────────┬──────────────────────┬─────────┬─────────────┬──────────────┐
## │  name   │        email         │ salary  │    dept     │    phone     │
## │ varchar │       varchar        │ double  │   varchar   │   varchar    │
## ├─────────┼──────────────────────┼─────────┼─────────────┼──────────────┤
## │ Bob     │ bob@company.com      │ 40000.0 │ Accounting  │ 919 555-1111 │
## │ Carol   │ carol@company.com    │ 30000.0 │ Sales       │ 919 555-2222 │
## │ Eve     │ eve@company.com      │ 44000.0 │ Sales       │ 919 555-3333 │
## │ Frank   │ frank@comany.com     │ 37000.0 │ Sales       │ 919 555-4444 │
## └─────────┴──────────────────────┴─────────┴─────────────┴──────────────┘
```

Inner Join - Explicit

```
D SELECT * FROM employees JOIN phone ON employees.name = phone.name;
##┌─────────┬────────────────────┬─────────┬────────────┬─────────┬────────────────┐
##│  name   │       email        │ salary  │    dept    │  name   │     phone      │
##│ varchar │      varchar       │ double  │  varchar   │ varchar │    varchar     │
##├─────────┼────────────────────┼─────────┼────────────┼─────────┼────────────────┤
##│ Bob     │ bob@company.com    │ 40000.0 │ Accounting │ Bob     │ 919 555-1111   │
##│ Carol   │ carol@company.com  │ 30000.0 │ Sales      │ Carol   │ 919 555-2222   │
##│ Eve     │ eve@company.com    │ 44000.0 │ Sales      │ Eve     │ 919 555-3333   │
##│ Frank   │ frank@comany.com   │ 37000.0 │ Sales      │ Frank   │ 919 555-4444   │
##└─────────┴────────────────────┴─────────┴────────────┴─────────┴────────────────┘```
```

to avoid the duplicate `name` column we can specify `USING` instead of `ON`

```
D SELECT * FROM employees JOIN phone USING(name);
## ┌─────────┬────────────────────┬─────────┬────────────┬────────────────┐
## │  name   │       email        │ salary  │    dept    │     phone      │
## │ varchar │      varchar       │ double  │  varchar   │    varchar     │
## ├─────────┼────────────────────┼─────────┼────────────┼────────────────┤
## │ Bob     │ bob@company.com    │ 40000.0 │ Accounting │ 919 555-1111   │
## │ Carol   │ carol@company.com  │ 30000.0 │ Sales      │ 919 555-2222   │
## │ Eve     │ eve@company.com    │ 44000.0 │ Sales      │ 919 555-3333   │
## │ Frank   │ frank@comany.com   │ 37000.0 │ Sales      │ 919 555-4444   │
## └─────────┴────────────────────┴─────────┴────────────┴────────────────┘
```

Left Join - Natural

```
D SELECT * FROM employees NATURAL LEFT JOIN phone;
```

name	email	salary	dept	phone
varchar	varchar	double	varchar	varchar
Bob	bob@company.com	40000.0	Accounting	919 555-1111
Carol	carol@company.com	30000.0	Sales	919 555-2222
Eve	eve@company.com	44000.0	Sales	919 555-3333
Frank	frank@comany.com	37000.0	Sales	919 555-4444
Alice	alice@company.com	52000.0	Accounting	
Dave	dave@company.com	33000.0	Accounting	

Left Join - Explicit

```
D SELECT * FROM employees LEFT JOIN phone ON employees.name = phone.name;
```

name	email	salary	dept	name	phone
varchar	varchar	double	varchar	varchar	varchar
Bob	bob@company.com	40000.0	Accounting	Bob	919 555-1111
Carol	carol@company.com	30000.0	Sales	Carol	919 555-2222
Eve	eve@company.com	44000.0	Sales	Eve	919 555-3333
Frank	frank@comany.com	37000.0	Sales	Frank	919 555-4444
Alice	alice@company.com	52000.0	Accounting		
Dave	dave@company.com	33000.0	Accounting		

duplicate `name` column can be avoided by more selective `SELECT`,

```
D SELECT employees.*, phone FROM employees LEFT JOIN phone ON employees.name = phone.name;
```

name	email	salary	dept	phone
varchar	varchar	double	varchar	varchar
Bob	bob@company.com	40000.0	Accounting	919 555-1111
Carol	carol@company.com	30000.0	Sales	919 555-2222
Eve	eve@company.com	44000.0	Sales	919 555-3333
Frank	frank@comany.com	37000.0	Sales	919 555-4444
Alice	alice@company.com	52000.0	Accounting	

Other Joins

As you would expect all other standard joins are supported including `RIGHT JOIN`, `FULL JOIN`, `CROSS JOIN`, `SEMI JOIN`, `ANTI JOIN`, etc.

```
D SELECT employees.*, phone FROM employees NATURAL FULL JOIN phone;
```

name	email	salary	dept	phone
varchar	varchar	double	varchar	varchar
Bob	bob@company.com	40000.0	Accounting	919 555-1111
Carol	carol@company.com	30000.0	Sales	919 555-2222
Eve	eve@company.com	44000.0	Sales	919 555-3333
Frank	frank@comany.com	37000.0	Sales	919 555-4444
Alice	alice@company.com	52000.0	Accounting	
Dave	dave@company.com	33000.0	Accounting	

```
D SELECT employees.*, phone FROM employees NATURAL RIGHT JOIN phone;
```

name	email	salary	dept	phone
varchar	varchar	double	varchar	varchar
Bob	bob@company.com	40000.0	Accounting	919 555-1111
Carol	carol@company.com	30000.0	Sales	919 555-2222
Eve	eve@company.com	44000.0	Sales	919 555-3333
Frank	frank@comany.com	37000.0	Sales	919 555-4444

Subqueries

We can nest tables within tables for the purpose of queries.

```
D SELECT * FROM (
    SELECT * FROM employees NATURAL LEFT JOIN phone
  ) combined WHERE phone IS NULL;
```

name	email	salary	dept	phone
varchar	varchar	double	varchar	varchar
Alice	alice@company.com	52000.0	Accounting	
Dave	dave@company.com	33000.0	Accounting	

```
D SELECT * FROM (
    SELECT * FROM employees NATURAL LEFT JOIN phone
  ) combined WHERE phone IS NOT NULL;
```

name	email	salary	dept	phone
varchar	varchar	double	varchar	varchar
Bob	bob@company.com	40000.0	Accounting	919 555-1111
Carol	carol@company.com	30000.0	Sales	919 555-2222
Eve	eve@company.com	44000.0	Sales	919 555-3333
Frank	frank@comany.com	37000.0	Sales	919 555-4444

Exercise 2

Lets try to create a table that has a new column - `abv_avg` which contains how much more (or less) than the average, for their department, each person is paid.

Hint - This will require joining a subquery.

Query plan

Setup

To give us a bit more variety (and data), we have created another SQLite database `flights.sqlite` that contains both `nycflights13::flights` and `nycflights13::planes`, the latter of which has details on the characteristics of the planes in the dataset as identified by their tail numbers.

```
db = DBI::dbConnect(duckdb::duckdb(), "flights.duckdb")
dplyr::copy_to(db, nycflights13::flights, name = "flights", temporary = FALSE
dplyr::copy_to(db, nycflights13::planes, name = "planes", temporary = FALSE,
DBI::dbDisconnect(db)
```

All of the following code will be run in the DuckDB command line interface, make sure you've created the database and copied both the flights and planes tables into the db.

Opening `flights.sqlite`

The database can then be opened from the terminal tab using,

```
> duckdb flights.duckdb
```

As before we should set a couple of configuration options so that our output is readable, we include `.timer on` so that we get time our queries.

```
D .maxrows 20
D .maxwidth 80
D .timer on
```

flights

```
D SELECT * FROM flights LIMIT 10;
## ┌─────────┬─────────┬─────────┬───┬──────────┬─────────┬─────────┬─────────────────────┐
## │  year   │  month  │   day   │ … │ distance │  hour   │ minute  │      time_hour      │
## │  int32  │  int32  │  int32  │   │  double  │ double  │ double  │      timestamp      │
## ├─────────┼─────────┼─────────┼───┼──────────┼─────────┼─────────┼─────────────────────┤
## │    2013 │       1 │       1 │ … │   1400.0 │     5.0 │    15.0 │ 2013-01-01 10:00:00 │
## │    2013 │       1 │       1 │ … │   1416.0 │     5.0 │    29.0 │ 2013-01-01 10:00:00 │
## │    2013 │       1 │       1 │ … │   1089.0 │     5.0 │    40.0 │ 2013-01-01 10:00:00 │
## │    2013 │       1 │       1 │ … │   1576.0 │     5.0 │    45.0 │ 2013-01-01 10:00:00 │
## │    2013 │       1 │       1 │ … │    762.0 │     6.0 │     0.0 │ 2013-01-01 11:00:00 │
## │    2013 │       1 │       1 │ … │    719.0 │     5.0 │    58.0 │ 2013-01-01 10:00:00 │
## │    2013 │       1 │       1 │ … │   1065.0 │     6.0 │     0.0 │ 2013-01-01 11:00:00 │
## │    2013 │       1 │       1 │ … │    229.0 │     6.0 │     0.0 │ 2013-01-01 11:00:00 │
## │    2013 │       1 │       1 │ … │    944.0 │     6.0 │     0.0 │ 2013-01-01 11:00:00 │
## │    2013 │       1 │       1 │ … │    733.0 │     6.0 │     0.0 │ 2013-01-01 11:00:00 │
## ├─────────┴─────────┴─────────┴───┴──────────┴─────────┴─────────┴─────────────────────┤
## │ 10 rows                                                  19 columns (7 shown)      │
## └────────────────────────────────────────────────────────────────────────────────────┘
## Run Time (s): real 0.020 user 0.000784 sys 0.002284
```

planes

```
D SELECT * FROM planes LIMIT 10;
```

tailnum	year	type	…	seats	speed	engine
varchar	int32	varchar		int32	int32	varchar
N10156	2004	Fixed wing multi e…	…	55		Turbo-fan
N102UW	1998	Fixed wing multi e…	…	182		Turbo-fan
N103US	1999	Fixed wing multi e…	…	182		Turbo-fan
N104UW	1999	Fixed wing multi e…	…	182		Turbo-fan
N10575	2002	Fixed wing multi e…	…	55		Turbo-fan
N105UW	1999	Fixed wing multi e…	…	182		Turbo-fan
N107US	1999	Fixed wing multi e…	…	182		Turbo-fan
N108UW	1999	Fixed wing multi e…	…	182		Turbo-fan
N109UW	1999	Fixed wing multi e…	…	182		Turbo-fan
N110UW	1999	Fixed wing multi e…	…	182		Turbo-fan

10 rows 9 columns (6 shown)

```
Run Time (s): real 0.003 user 0.000819 sys 0.000018
```

Exercise 3

Write a query that determines the total number of seats available on all of the planes that flew out of New York in 2013.

Incorrect

```
D SELECT sum(seats) FROM flights NATURAL LEFT JOIN planes;
## ┌──────────────┐
## │ sum(seats)   │
## │    int128    │
## ├──────────────┤
## │       614366 │
## └──────────────┘
## Run Time (s): real 0.012 user 0.016061 sys 0.002386
```

Why?

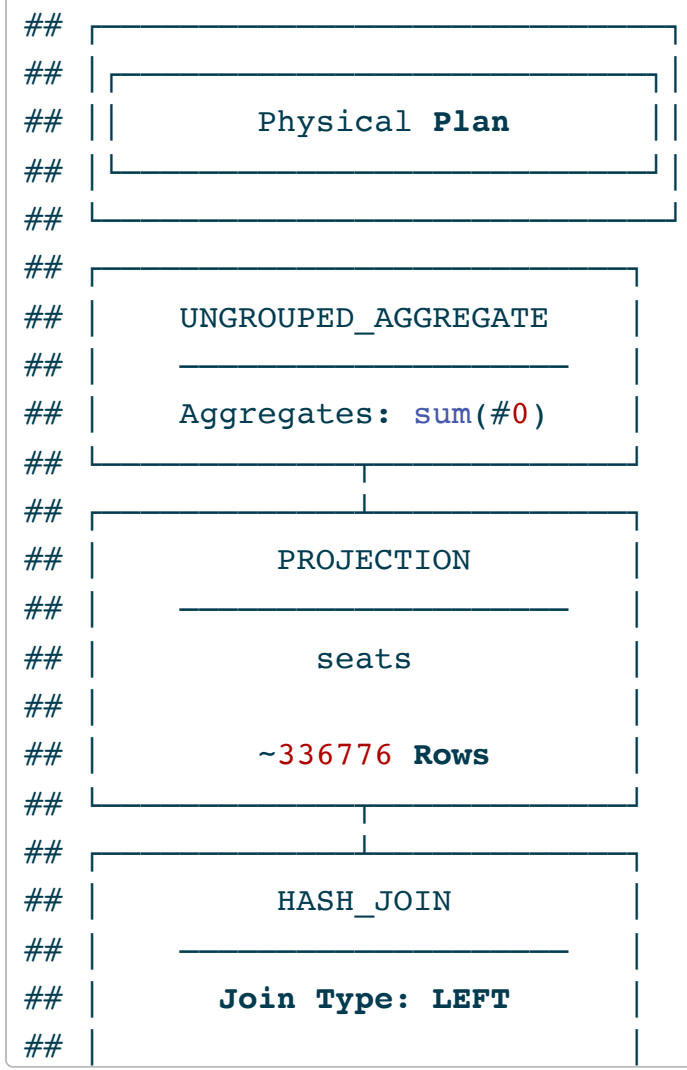
Correct

Join and select:

```
D SELECT sum(seats) FROM flights LEFT JOIN planes USING (tailnum);
## ┌──────────────┐
## │ sum(seats)   │
## │    int128    │
## ├──────────────┤
## │    38851317  │
## └──────────────┘
## Run Time (s): real 0.005 user 0.010150 sys 0.000291
```

EXPLAIN

```
D EXPLAIN SELECT sum(seats) FROM flights LEFT JOIN planes USING (tailnum);
```



EXPLAIN ANALYZE

```
D EXPLAIN ANALYZE SELECT sum(seats) FROM flights LEFT JOIN planes USING (tailnum);
## ┌─────────────────────────────────────┐
## │┌───────────────────────────────────┐│
## ││    Query Profiling Information    ││
## │└───────────────────────────────────┘│
## └─────────────────────────────────────┘
## EXPLAIN ANALYZE SELECT sum(seats) FROM flights LEFT JOIN planes USING (tailnum);
## ┌─────────────────────────────────────────────┐
## │┌───────────────────────────────────────────┐│
## ││              Total Time: 0.0045s          ││
## │└───────────────────────────────────────────┘│
## └─────────────────────────────────────────────┘
## ┌───────────────────────────┐
## │           QUERY           │
## └─────────────┬─────────────┘
## ┌─────────────┴─────────────┐
## │      EXPLAIN_ANALYZE      │
## │    ────────────────────   │
## │           0 Rows          │
## │          (0.00s)          │
## └─────────────┬─────────────┘
## ┌─────────────┴─────────────┐
## │    UNGROUPED_AGGREGATE    │
```

dplyr

```r
library(dplyr)
flights = nycflights13::flights
planes = nycflights13::planes

system.time({
  flights |>
    left_join(nycflights13::planes, by = c("tailnum" = "tailnum")) |>
    summarise(total_seats = sum(seats, na.rm = TRUE))
})
```

```
   user  system elapsed 
  0.059   0.003   0.062 
```

NYC Taxi Demo