Intro to SQL

Data stored in multiple tables

The `nycflights13` package contains information on flights from NYC airports in 2013. The data is stored across several data frames:

- `airlines`: information on each airline
- `airports`: information on each airport
- `flights`: information on each flight
- `planes`: information on each plane
- `weather`: hourly weather data

Limitations

```
nycflights13::flights |>
  object.size() |>
  print(units = "Mb")
```

```
38.8 Mb
```

- R stores objects in memory (RAM), which can be easily accessed
- The amount of RAM on your computer is a limit on the possible size of objects
- Objects larger than a few Gb are generally too big to load

Full airlines data

The `nycflights13` package contains a small subset of a database on 48 million flights. The `airlines` database includes the following tables:

- `airports`
- `carriers`
- `flights`
- `planes`

This data is too big to store locally, but can be on servers which we can access remotely.

Connecting to an SQL server

```
 1 library(tidyverse)
 2 library(mdsr)
 3 library(DBI)
 4
 5 db <- dbConnect_scidb("airlines")
 6
 7 query <- "
 8   SHOW TABLES;
 9 "
10 dbGetQuery(db, query)
```

```
  Tables_in_airlines
1           airports
2           carriers
3            flights
4    flights_summary
5             planes
```

An example query

```sql
SELECT
  name,
  SUM(1) AS N,
  SUM(arr_delay <= 15) / SUM(1) AS pct_ontime
FROM flights
JOIN carriers ON flights.carrier = carriers.carrier
WHERE year = 2015 AND month = 9
  AND dest = 'JFK'
GROUP BY name
HAVING N >= 100
ORDER BY pct_ontime DESC
LIMIT 0,4;
```

Warm-up

What do you think each part of this query is doing?

```sql
SELECT
  name,
  SUM(1) AS N,
  SUM(arr_delay <= 15) / SUM(1) AS pct_ontime
FROM flights
JOIN carriers ON flights.carrier = carriers.carrier
WHERE year = 2015 AND month = 9
  AND dest = 'JFK'
GROUP BY name
HAVING N >= 100
ORDER BY pct_ontime DESC
LIMIT 0,4;
```

	name	N	pct_ontime
1	Virgin America	322	0.8789
2	United Air Lines Inc.	356	0.8736
3	Delta Air Lines Inc.	2100	0.8505
4	American Airlines Inc.	1500	0.8113

General structure of an SQL query

```
1 SELECT ...
2 FROM ...
3 JOIN ...
4 WHERE ...
5 GROUP BY ...
6 HAVING ...
7 ORDER BY ...
8 LIMIT ...
```

- The SELECT and FROM clauses are *required*
- Clauses must be written in this order

SELECT ... FROM

```
1 SELECT * FROM carriers LIMIT 0, 10;
```

	carrier	name
1	02Q	Titan Airways
2	04Q	Tradewind Aviation
3	05Q	Comlux Aviation, AG
4	06Q	Master Top Linhas Aereas Ltd.
5	07Q	Flair Airlines Ltd.
6	09Q	Swift Air, LLC
7	0BQ	DCA
8	0CQ	ACM AIR CHARTER GmbH
9	0GQ	Inter Island Airways, d/b/a Inter Island Air
10	0HQ	Polar Airlines de Mexico d/b/a Nova Air

- `SELECT`: the columns to be retrieved
- `FROM`: the table containing the data
- `LIMIT`: limit the rows to return

SELECT ... FROM

```
SELECT ... FROM ... LIMIT 0, 10;
```

What if I want the `year`, `origin`, `dest`, `dep_delay`, and `arr_delay` columns from the `flights` table?

SELECT ... FROM

What if I want the `year`, `origin`, `dest`, `dep_delay`, and `arr_delay` columns from the `flights` table?

```
1 SELECT
2   year, origin, dest,
3   dep_delay, arr_delay
4 FROM flights
5 LIMIT 0, 5;
```

	year	origin	dest	dep_delay	arr_delay
1	2013	LAX	DFW	-8	-12
2	2013	SFO	ATL	5	1
3	2013	SFO	DFW	-4	-2
4	2013	SEA	ORD	19	4
5	2013	LAX	IAH	-1	-10

SELECT ... FROM

```
1 SELECT
2   year, origin, dest,
3   dep_delay, arr_delay
4 FROM flights
5 LIMIT 0, 5;
```

What if I also want to calculate the difference between arrival delay and departure delay?

SELECT ... FROM

What if I also want to calculate the difference between arrival delay and departure delay?

```
SELECT
  year, origin, dest, dep_delay, arr_delay,
  arr_delay - dep_delay AS delay_diff
FROM flights
LIMIT 0, 3;
```

	year	origin	dest	dep_delay	arr_delay	delay_diff
1	2013	LAX	DFW	-8	-12	-4
2	2013	SFO	ATL	5	1	-4
3	2013	SFO	DFW	-4	-2	2

What are the equivalent `dplyr` functions?

Converting from R to SQL

```r
flights <- tbl(db, "flights")

flights |>
  select(year, origin, dest, dep_delay, arr_delay) |>
  mutate(delay_diff = arr_delay - dep_delay) |>
  head() |>
  show_query()
```

```
<SQL>
SELECT
  `year`,
  `origin`,
  `dest`,
  `dep_delay`,
  `arr_delay`,
  `arr_delay` - `dep_delay` AS `delay_diff`
FROM `flights`
LIMIT 6
```

Calculating summary statistics

Back to our original SQL query:

```sql
SELECT
  SUM(1) AS N,
  SUM(arr_delay <= 15) / SUM(1) AS pct_ontime
FROM flights
LIMIT 0, 10;
```

```
         N pct_ontime
1 18008372     0.8091
```

Calculating summary statistics

SELECT can also be used to calculate summary statistics.

For example, if we want the average departure delay:

```
1 SELECT
2   AVG(dep_delay) AS mean_dep_delay
3 FROM flights
4 LIMIT 0, 10;
```

```
  mean_dep_delay
1         9.7471
```

WHERE

Now suppose that I only want the mean departure delay for flights from EWR in 2013:

```sql
SELECT
  AVG(dep_delay) AS mean_dep_delay
FROM flights
WHERE year = 2013 AND origin = 'EWR'
LIMIT 0, 10;
```

```
  mean_dep_delay
1         14.703
```

What do you think should I do if I want the mean delay for each airport in November 2013?

GROUP BY

```sql
SELECT
  AVG(dep_delay) AS mean_dep_delay
FROM flights
WHERE year = 2013 AND month = 11
GROUP BY origin
LIMIT 0, 10;
```

	mean_dep_delay
1	3.7766
2	2.2070
3	8.0122
4	-0.2985
5	5.2750
6	3.6619
7	8.2222
8	18.8750
9	-2.1042
10	8.0443

Do you notice anything about this output?

GROUP BY

```sql
SELECT
  origin,
  AVG(dep_delay) AS mean_dep_delay
FROM flights
WHERE year = 2013 AND month = 11
GROUP BY origin
LIMIT 0, 10;
```

	origin	mean_dep_delay
1	ABE	3.7766
2	ABI	2.2070
3	ABQ	8.0122
4	ABR	-0.2985
5	ABY	5.2750
6	ACT	3.6619
7	ACV	8.2222
8	ADK	18.8750
9	ADQ	-2.1042
10	AEX	8.0443

Class activity

Work on the class activity, and submit your rendered HTML on Canvas at the end of class.