Principles of Database Systems (CS307)

Lecture 5: More on Join; Set Operators; Subqueries

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- Most contents are from slides made by Stéphane Faroult and the authors of Database System Concepts (7th Edition).
- Their original slides have been modified to adapt to the schedule of CS307 at SUSTech.

More on Join

The Old Way of Writing Joins

- Use commas to separate the tables
  - Example: The solution for the same question in the previous slide
- A little bit history:
  - `join` was introduced in SQL-1999 (later than this original way)
- Relationship to the relational algebra
  - Filtering based on the Cartesian product
    - movies × credits × people

```
select m.title, c.credited_as,
       p.first_name, p.surname
from movies m,
     credits c,
     people p
where c.movieid = m.movieid
  and p.peopleid = c.peopleid
  and m.country = 'cn'
```

The Old Way of Writing Joins

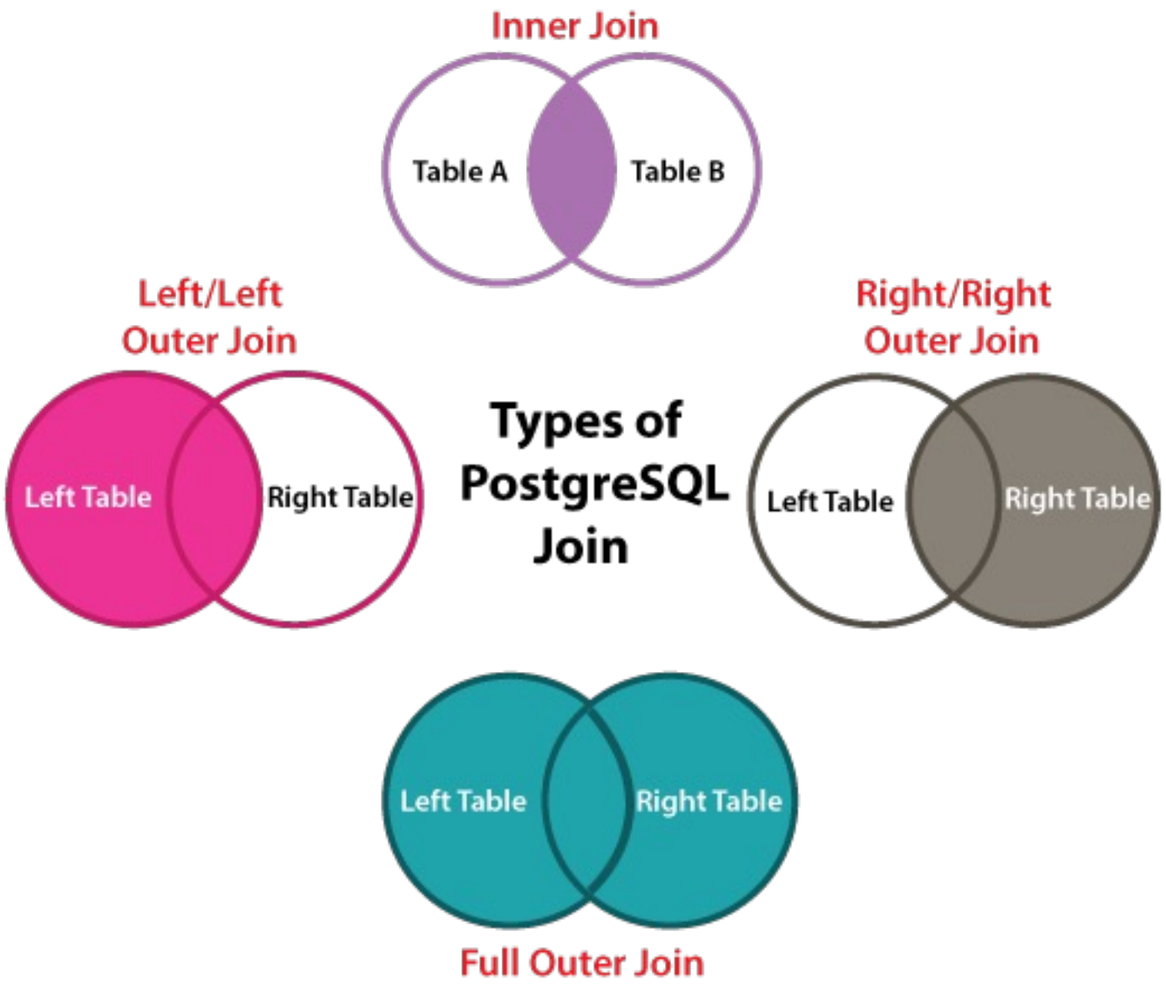
- Problems in the old way:
  - If you forget a comma, it will still work sometimes (interpreted as "renaming")
  - The semantic meaning of the `where` clause here is a little bit different from the `where` we introduced before
    - (join key vs. filtering condition)
    - If you forget `where`, the query will not return an error but to end up with **HUGE** amount of rows
      - `#movies * #credits * #people`

```
select m.title, c.credited_as,
       p.first_name, p.surname
from movies m,
     credits c,
     people p
where c.movieid = m.movieid
  and p.peopleid = c.peopleid
  and m.country = 'cn'
```

Inner and Outer Joins

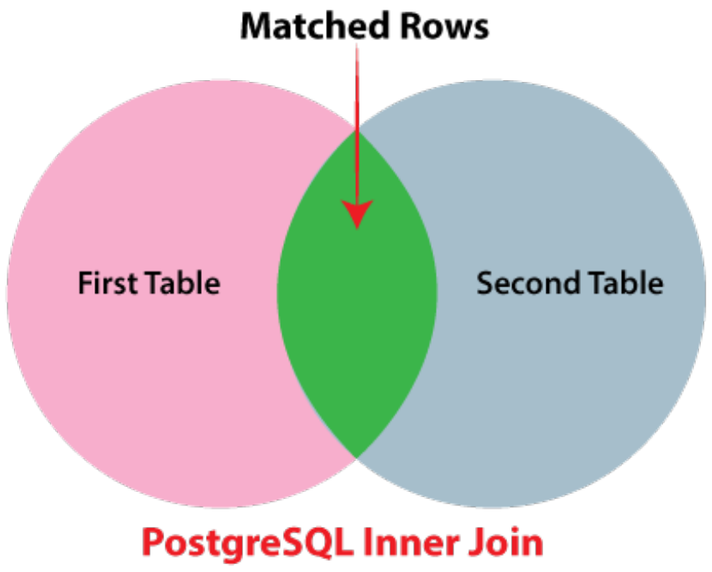
- So far, we only consider the rows with matching values on the corresponding columns
  - However, there are more things you can do with join

Inner and Outer Joins



Inner and Outer Joins

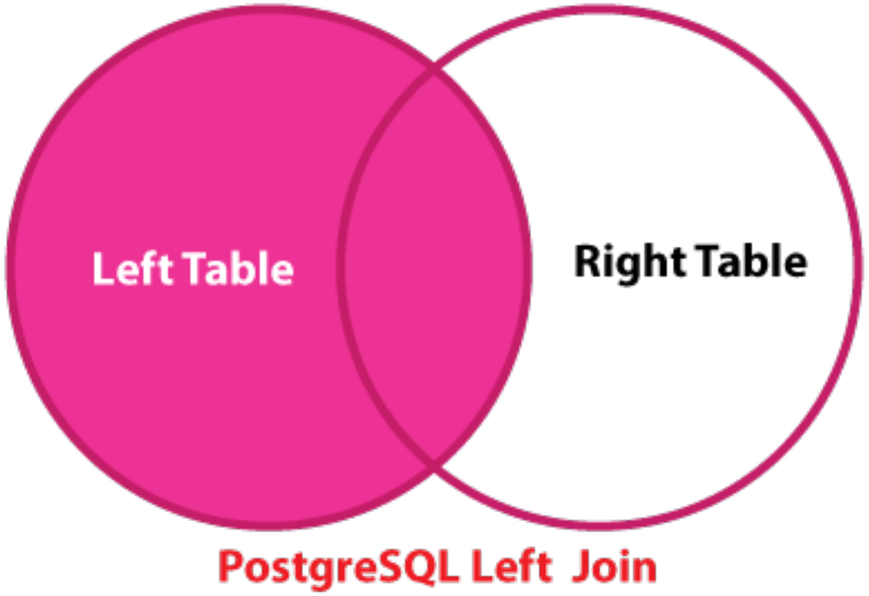
- Inner join
  - The default join type
  - Acturally, all examples before are considered inner joins
  - Only joined rows with matching values are selected




```
select title,
    country_name,
    year_released
    from movies
    join countries
    on country_code = country;
```

Inner and Outer Joins

- Left outer join
  - All the matching rows will be selected
  - … and the rows in the **left table** with **no matches** will be **selected** as well




```
select columns
from table1
LEFT [OUTER] join table2
on table1.column = table2.column;
```

Inner and Outer Joins

- Left outer join
  - Example: there is a movie in 2018 where there is no credit information
    - #9203 (A Wrinkle in Time)

```
select * from movies where movieid = 9203;
```

	movieid	title	country	year_released	runtime
1	9203	A Wrinkle in Time	us	2018	109

Inner and Outer Joins

- Left outer join
  - Example: there is a movie in 2018 where there is no credit information
    - #9203 (A Wrinkle in Time)
    - Inner join of all 2018 movies will not show any matching results for that movie

```
select *
from movies m join credits c
on m.movieid = c.movieid
where m.year_released = 2018;
```

	m.movieid	title	country	year_released	runtime	c.movieid	peopleid	credited_as
1	8987	Red Sparrow	us	2018	145	8987	4062	A
2	8987	Red Sparrow	us	2018	145	8987	6711	A
3	8987	Red Sparrow	us	2018	145	8987	8308	D
4	8987	Red Sparrow	us	2018	145	8987	8310	A
5	8987	Red Sparrow	us	2018	145	8987	11247	A
6	8987	Red Sparrow	us	2018	145	8987	12048	A
7	8987	Red Sparrow	us	2018	145	8987	13071	A
8	8988	Ready Player One	us	2018	0	8988	2934	A
9	8988	Ready Player One	us	2018	0	8988	9819	A
10	8988	Ready Player One	us	2018	0	8988	9971	A
11	8988	Ready Player One	us	2018	0	8988	11390	A
12	8988	Ready Player One	us	2018	0	8988	12758	A
13	8988	Ready Player One	us	2018	0	8988	13421	A
14	8988	Ready Player One	us	2018	0	8988	13850	D
15	8989	Guernsey	gb	2018	0	8989	1864	A
16	8989	Guernsey	gb	2018	0	8989	5280	A
17	8989	Guernsey	gb	2018	0	8989	6523	A
18	8989	Guernsey	gb	2018	0	8989	6836	A
19	8989	Guernsey	gb	2018	0	8989	10643	D
20	8989	Guernsey	gb	2018	0	8989	11261	A
21	8989	Guernsey	gb	2018	0	8989	11733	A
22	8989	Guernsey	gb	2018	0	8989	15708	A
23	8990	A Star Is Born	us	2018	0	8990	2431	A
24	8990	A Star Is Born	us	2018	0	8990	2759	A
25	8990	A Star Is Born	us	2018	0	8990	2939	A
26	8990	A Star Is Born	us	2018	0	8990	2939	D
27	8990	A Star Is Born	us	2018	0	8990	4158	A
28	8990	A Star Is Born	us	2018	0	8990	8105	A
29	8992	Mary Queen of Scots	us	2018	0	8992	272	A
30	8992	Mary Queen of Scots	us	2018	0	8992	2879	A
31	8992	Mary Queen of Scots	us	2018	0	8992	3056	A
32	8992	Mary Queen of Scots	us	2018	0	8992	3365	A
33	8992	Mary Queen of Scots	us	2018	0	8992	8892	A
34	8992	Mary Queen of Scots	us	2018	0	8992	11371	A
35	8992	Mary Queen of Scots	us	2018	0	8992	12435	A
36	8992	Mary Queen of Scots	us	2018	0	8992	12563	A
37	8992	Mary Queen of Scots	us	2018	0	8992	12636	D
38	8993	The Girl in the Spider's Web	se	2018	0	8993	4696	A
39	8993	The Girl in the Spider's Web	se	2018	0	8993	5543	A
40	8993	The Girl in the Spider's Web	se	2018	0	8993	16462	D
41	9202	Black Panther	us	2018	134	9202	3933	A
42	9202	Black Panther	us	2018	134	9202	5588	A
43	9202	Black Panther	us	2018	134	9202	15870	A

Inner and Outer Joins

- Left outer join
  - Example: there is a movie in 2018 where there is no credit information
    - #9203 (A Wrinkle in Time)
    - Inner join of all 2018 movies will not show any matching results for that movie
    - But, left (outer) join can give you a record for the movie (in the left table) where all right-table columns are null

Pay attention to the syntax:

- `left join` or `left outer join`
- But some databases recognize the `outer` keyword, some do not. Refer to the database manual if you meet any error.

```
select * from movies m left join credits c on m.movieid = c.movieid
where m.year_released = 2018;
```

	m.movieid	title	country	year_released	runtime	c.movieid	peopleid	credited_as
41	9202	Black Panther	us	2018	134	9202	3933	A
42	9202	Black Panther	us	2018	134	9202	5588	A
43	9202	Black Panther	us	2018	134	9202	15870	A
44	9203	A Wrinkle in Time	us	2018	109	<null>	<null>	<null>

Inner and Outer Joins

- Left outer join
  - Why? Why should we show the records in the left table with no matches?

  - Scenario: Movie Website (Douban, for example)
    - We cannot just ignore the movies with no credit information
    - Instead, we should list them and also show that credit information is missing
    - All things can be done in a single query
      - And we can distinguish between them by checking the values in the right-table columns

Inner and Outer Joins

- Left outer join
  - Another example: let's count how many movies we have per country (again)

Inner and Outer Joins

- Left outer join
  - Another example: let's count how many movies we have per country (again)

```
select c.country_name, number_of_movies
from countries c join (
    select country as stat_country_code,
        count(*) as number_of_movies
    from movies
    group by country
) stat
on c.country_code = stat_country_code;
```

85 rows

	country_name	number_of_movies
1	Algeria	2
2	Burkina Faso	2
3	Egypt	11
4	Ghana	1
5	Guinea-Bissau	1
6	Kenya	1
7	Libya	2
8	Mali	2
9	Morocco	2
10	Namibia	1
11	Niger	
12	Nigeria	
13	Senegal	

"85 rows":

- Problem
  - We have ~200 countries in total
  - How can we show the other countries?

Inner and Outer Joins

- Left outer join
  - All countries are here now
  - In addition, how can we replace nulls?

```sql
select c.country_name, number_of_movies
from countries c left join (
    select country as stat_country_code,
        count(*) as number_of_movies
    from movies
    group by country
) stat
on c.country_code = stat_country_code;
```

185 rows

	country_name	number_of_movies
1	Algeria	2
2	Angola	<null>
3	Benin	<null>
4	Botswana	<null>
5	Burkina Faso	2
6	Burundi	<null>
7	Cameroon	<null>
8	Central African Republic	<null>
9	Chad	<null>
10	Comoros	<null>
11	Congo Brazzaville	<null>
12	Congo Kinshasa	<null>
13	Cote d'Ivoire	<null>
14	Djibouti	<null>
15	Egypt	11
16	Equatorial Guinea	<null>
17	Eritrea	<null>

Inner and Outer Joins

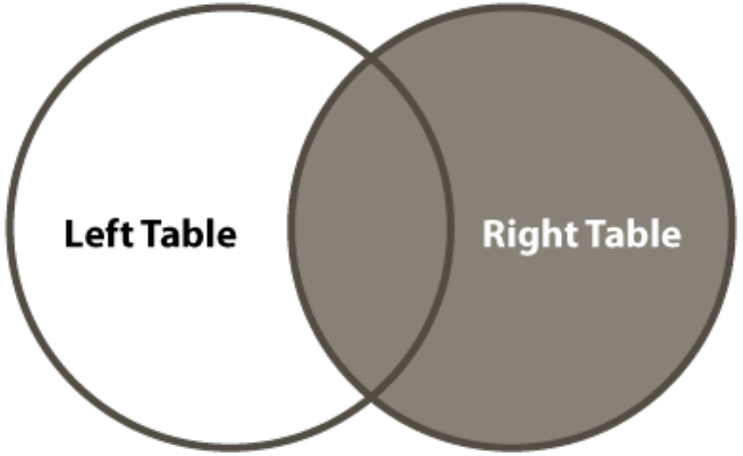
- Left outer join
  - All countries are here now
  - In addition, how can we replace nulls?
    - Add another CASE condition

```sql
select c.country_name,
       case
           when stat.number_of_movies is null then 0
           else stat.number_of_movies
       end
from countries c left join (
    select country as stat_country_code,
        count(*) as number_of_movies
    from movies
    group by country
) stat
on c.country_code = stat_country_code;
```

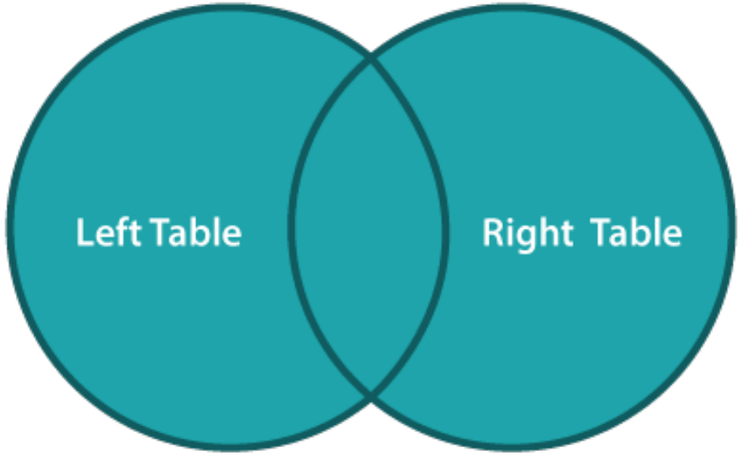
	country_name	number_of_movies
1	Algeria	2
2	Angola	0
3	Benin	0
4	Botswana	0
5	Burkina Faso	2
6	Burundi	0
7	Cameroon	0
8	Central African Republic	0
9	Chad	0
10	Comoros	0
11	Congo Brazzaville	0
12	Congo Kinshasa	0
13	Cote d'Ivoire	0
14	Djibouti	0
15	Egypt	11
16	Equatorial Guinea	0
17	Eritrea	0
18	Ethiopia	0

Inner and Outer Joins

- Right outer join, full outer join
  - Books always refer to three kinds of outer joins. Only one is useful and we can forget about anything but the LEFT OUTER JOIN
    - A right outer join can ALWAYS be rewritten as a left outer join (by swapping the order of tables in the join list)
    - A full outer join is seldom used



PostgreSQL Right Join



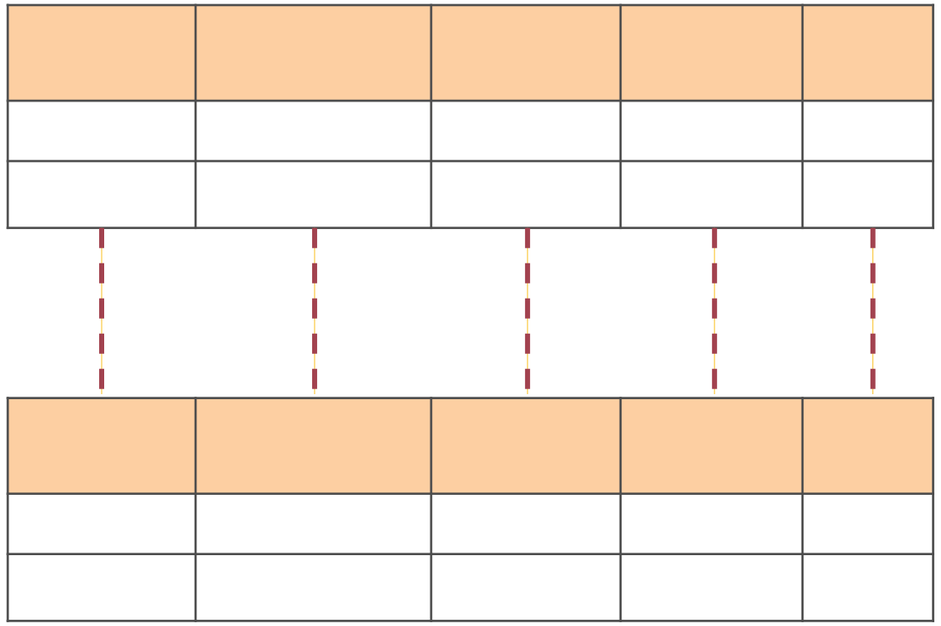
PostgreSQL Full Outer Join

Set Operators

Set Operators

- Union
  - Takes two result sets and combines them into a single result set

- Union requires two (commonsensical) conditions:
  - They must return the same number of columns
  - The data types of corresponding columns must match.



Set Operators

- Union
  - Example: Stack US and GB movies together

```sql
select movieid, title, year_released, country
from movies
where country = 'us'
  and year_released between 1940 and 1949

union

select movieid, title, year_released, country
from movies
where country = 'gb'
  and year_released between 1940 and 1949;
```

	movieid	title	year_released	country
1	3840	The Secret Life of Walter Mitty	1947	us
2	678	The Ox-Bow Incident	1943	us
3	3174	The Red House	1947	us
4	5152	Minesweeper	1943	us
5	1487	Kiss of Death	1947	us
6	3408	Ministry of Fear	1944	us
7	2543	The Way to the Stars	1945	gb
8	5341	All Through the Night	1942	us
9	1435	They Live by Night	1948	us
10	2644	Criminal Court	1946	us
11	7250	The Seventh Veil	1945	gb
12	7341	Mr. Lucky	1943	us

Set Operators

- Union
  - Usage scenario: combine movies from two tables, one for standard accounts and one for VIP accounts
    - We don’t want to miss the “standard movies” for the VIP accounts

Set Operators

- Union
  - Warning: `union` will remove duplicated rows
    - Instead, you can use `union all`

```
(select movieid, title, year_released, country
from movies limit 5 offset 0)
union
(select movieid, title, year_released, country
from movies limit 5 offset 3);
```

8 rows | Tx: Auto | DDL

	movieid	title	year_released	country
1	1	12 stulyev	1971	ru
2	5	Ardh Satya	1983	in
3	2	Al-mummia	1969	eg
4	6	Armaan	2003	in
5	7	Armaan	1966	pk
6	3	Ali Zaoua, prince de la rue	2000	ma
7	8	Babettes gæstebud	1987	dk
8	4	Apariencias	2000	ar

```
(select movieid, title, year_released, country
from movies limit 5 offset 0)
union all
(select movieid, title, year_released, country
from movies limit 5 offset 3);
```

10 rows | Tx: Auto | DDL

	movieid	title	year_released	country
1	1	12 stulyev	1971	ru
2	2	Al-mummia	1969	eg
3	3	Ali Zaoua, prince de la rue	2000	ma
4	4	Apariencias	2000	ar
5	5	Ardh Satya	1983	in
6	4	Apariencias	2000	ar
7	5	Ardh Satya	1983	in
8	6	Armaan	2003	in
9	7	Armaan	1966	pk
10	8	Babettes gæstebud	1987	dk

Set Operators

- Intersect (`intersect`)
  - Return the rows that appears in both tables
- Except (`except`)
  - Return the rows that appear in the first table but not the second one
  - Sometimes written as `minus` in some database products

- However, they are not used as much as union
  - intersect -> inner join
  - except -> left outer join with an “is null” condition

Subquery

Subquery

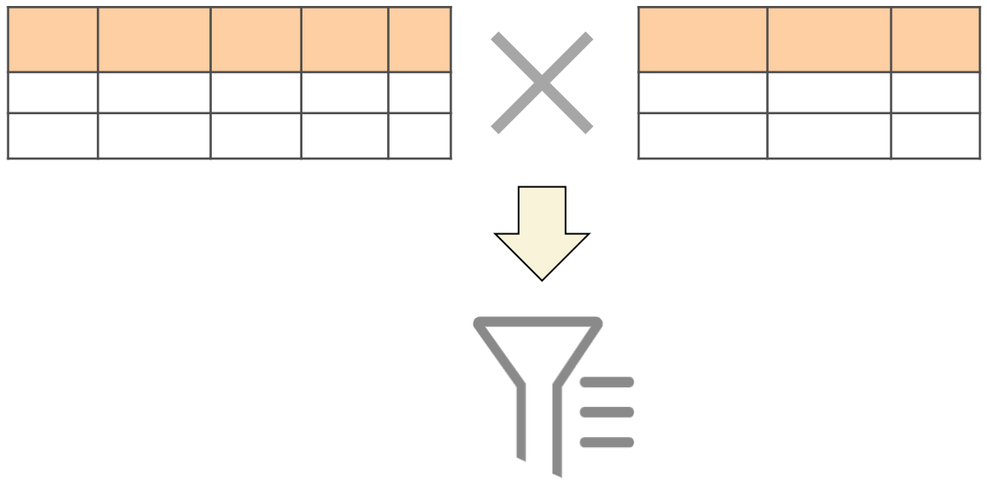
- We have used subqueries after `from` before
  - … in order to build queries upon a query result

- And, we can add subqueries after `select` and `where` as well

Subquery after Select

- Example: show titles, released years, and country names for non-US movies
  - Solution 1: Join

```
select m.title, m.year_released, c.country_name
from movies m join countries c
on m.country = c.country_code
where m.country <> 'us';
```



Subquery after Select

- Example: show titles, released years, and country names for non-US movies
  - Solution 2: Nested selection

```
select m.title,
       m.year_released,
       m.country
from movies m
where m.country <> 'us';
```

... still a country code though

- How can we replace it with the country name?

Subquery after Select

- Example: show titles, released years, and country names for non-US movies
  - Solution 2: Nested selection

```
select m.title,
       m.year_released,
       m.country
from movies m
where m.country <> 'us';
```

```
select m.title,
       m.year_released,
       (
           select c.country_name
           from countries c
           where c.country_code = m.country
       ) country_name
from movies m
where m.country <> 'us';
```

A subquery after select:

- For each selected row in the outer query, find the corresponding country name in the `countries` table

Subquery after Where

- Recall: the `in()` operator
  - It can be used as the equivalent for a series of equalities with OR (it has also other interesting uses)
  - It may make a comparison clearer than a parenthesized expression

```
where (country = 'us' or country = 'gb')
  and year_released between 1940 and 1949

where country in ('us', 'gb')
  and year_released between 1940 and 1949
```

Subquery after Where

- ... But `in()` is far more powerful than this
  - What is between parentheses may be, not only an explicit list, but also an implicit list of values generated by a query

```
in (select col
    from ...
    where ...)
```

Subquery after Where

- Example: Select all European movies
  - How can we specify the filtering condition?

```
select country,
       year_released,
       title
from movies
where [?]
```

Subquery after Where

- Example: Select all European movies
  - A horrible solution: list all European countries with `or`

```
select country,
       year_released,
       title
from movies
where country = 'fr' or country = 'de' or ...
```

Subquery after Where

- Example: Select all European movies
  - A (slightly better) solution: list all European countries in an `in` operator

```
select country,
       year_released,
       title
from movies
where country in('fr', 'de', ...)
```

Subquery after Where

- Example: Select all European movies
  - A (slightly better) solution: list all European countries in an `in` operator

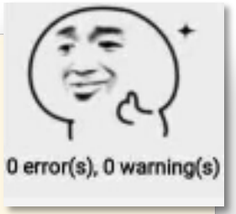
```
select country,
       year_released,
       title
from movies
where country in('fr', 'de', ...)
```


```
select * from countries where continent = 'EUROPE';
```

40 rows

Subquery after Where

- Example: Select all European movies
  - A proper solution: (dynamically) fill in the list of country codes in an `in` operator




```
select country,
       year_released,
       title
from movies
where country in(
    select country_code
    from countries
    where continent = 'EUROPE'
);
```

```
select country,
       year_released,
       title
from movies
where country in('fr', 'de', ...)
```

The same results (if you fill in all European country codes on the right side)

- But you can automatically generate this list
- Especially useful when the table in the subquery changes often

Subquery after Where

- Some products (Oracle, DB2, PostgreSQL with some twisting) even allow comparing a set of column values (the correct word is "tuple") to the result of a subquery.

```
(col1, col2) in
        (select col3, col4
         from t
         where …)
```

Subquery after Where

- Some important points for `in()`
  - `in()` means an <u>implicit distinct</u> in the subquery
    - `in('cn', 'us', 'cn', 'us', 'us')` is equal to `in('cn', 'us')`

Subquery after Where

- Some important points for `in()`
  - `in()` means an <u>implicit distinct</u> in the subquery
    - `in('cn', 'us', 'cn', 'us', 'us')` is equal to `in('cn', 'us')`
  - null values in `in()`
    - Be extremely cautious if you are using `not in(...)` with a null value in it

Subquery after Where

- Some important points for `in()`
  - `in()` means an <u>implicit distinct</u> in the subquery
    - `in('cn', 'us', 'cn', 'us', 'us')` is equal to `in('cn', 'us')`
  - null values in `in()`
    - Be extremely cautious if you are using `not in(...)` with a null value in it

```
value not in(2, 3, null)
⇒not (value=2 or value=3 or value=null)
⇒value<>2 and value<>3 and value<>null
⇒false  -- always false or null, never true
```

... however, `value=null` and `value<>null` are always not true:

- We should use `is [not] null` instead

Thus, the `not in()` expression always returns false, and hence no row will be selected and returned.

Update and Delete

So Far…

- We have learned:
  - How to access existing data in tables (select)
  - How to create new rows (insert)

- CRUD/CURD
  - create, read, update, delete
    - In SQL: insert, select, update, delete
    - In RESTful API: Post, Get, Put, Delete
  - Necessary operations for persistent storage

Update

- Make changes to the existing rows in a table
- `update` is the command that changes column values
  - You can even set a non-mandatory column to NULL
  - The change is applied to all rows selected by the `where`

```
update table_name
set column_name = new_value,
    other_col = other_new_val,
    ...
where ...
```

Update

- Remember
  - When you are doing any experiments with writing operations (update, delete), **backup the data first**
    - E.g., copy the tables

Update

- Example: A nobiliary particle is used in a surname or family name in many Western cultures to signal the nobility of a family.
  - We may want to modify some names in such a way as they sort as they should.

23 rows | Tx: Auto | DDL

	peopleid	first_name	surname	born	died	gender
1	16439	Axel	von Ambesser	1910	1988	M
2	16440	Daniel	von Bargen	1950	2015	M
3	16441	Eduard	von Borsody	1898	1970	M
4	16442	Suzanne	von Borsody	1957	<null>	F
5	16443	Tomas	von Brömssen	1943	<null>	M
6	16444	Erik	von Detten	1982	<null>	M
7	16445	Theodore	von Eltz	1893	1964	M
8	16446	Gunther	von Fritsch	1906	1988	M
9	16447	Katja	von Garnier	1966	<null>	F
10	16448	Harry	von Meter	1871	1956	M
11	16449	Jenna	von Oÿ	1977	<null>	F
12	16450	Alicia	von Rittberg	1993	<null>	F
13	16451	Daisy	von Scherler Mayer	1966	<null>	F
14	16452	Gustav	von Seyffertitz	1862	1943	M
15	16453	Josef	von Sternberg	1894	1969	M

John von Neumann

Update

- Example: A nobiliary particle is used in a surname or family name in many Western cultures to signal the nobility of a family.
  - We may want to modify some names in such a way as they sort as they should.

- First, how can we find these names?

Update

- Example: A nobiliary particle is used in a surname or family name in many Western cultures to signal the nobility of a family.
  - We may want to modify some names in such a way as they sort as they should.

- First, how can we find these names?
  - Wildcards

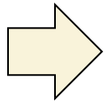
```
select * from people_1 where surname like 'von %';
```

Update

- Example: A nobiliary particle is used in a surname or family name in many Western cultures to signal the nobility of a family.
  - We may want to modify some names in such a way as they sort as they should.

- Then, how should we update the names?

```
(first_name) John
(surname) von Neumann
```



```
(first_name) John
(surname) Neumann (von)
```

  - Try the transformation with select:

```
select replace('von Neumann', 'von ', '') || ' (von)';
```

	?column?
1	Neumann (von)

Update

- Example: A nobiliary particle is used in a surname or family name in many Western cultures to signal the nobility of a family.
  - We may want to modify some names in such a way as they sort as they should.

- Finally, the `update` statement:

```sql
-- Specify the table
update people

-- Set the update rule
set surname = replace(surname, 'von ', '') || ' (von)'

-- Find the rows that need to be updated
where surname like 'von %';
```

This could be used to postfix all surnames starting by 'von' with '(von)' and turn for instance 'von Stroheim' into 'Stroheim (von)'

Update

- The `where` clause specifies the affected rows
  - However, you can use update without `where`, where the updates will be applied to all rows in the table
    - Use with caution!
    - Sometimes, there will be a warning in IDEs such as DataGrip

Update

- The update operation may not be successful when constraints are violated
  - For example, update the primary key but with duplicated values

```
update people set peopleid = 1 where peopleid < 10;
```

```
[23505] ERROR: duplicate key value violates unique constraint "people_pkey"
Detail: Key (peopleid)=(1) already exists.
```

  - This is why we need constraints when creating tables: avoid unacceptable writing operations that break the integrity of the tables

Update

- Subqueries in update
  - Complex update operations where values are based on a query result

- Example: Add a column in people table to record the number of movies one has joined (either directed or played a role in)

Update

- Example: Add a column in people table to record the number of movies one has joined (either directed or played a role in)
  - First, how do we count the movies for a person?
    - (Used as the subquery part in the update statement)

```
select count(*) from credits c where c.peopleid = [some peopleid];
```

Update

- Example: Add a column in people table to record the number of movies one has joined (either directed or played a role in)
  - First, how do we count the movies for a person?
    - (Used as the subquery part in the update statement)
  - Then, let's update the data

```sql
update people p

set num_movies = (
    select count(*) from credits c where c.peopleid = p.peopleid
)

where peopleid < 500;
-- This where is only for testing purpose;
-- You should change it (or remove it) when in actual use.
```

Delete

- As the name shows, `delete` removes rows from tables

```
delete from table_name
where ...
```

  - If you omit the WHERE clause, then (as with UPDATE) the statement affects all rows and you **end up with an empty table!**

  - Well,
    - many database products provide a roll-back mechanism when deleting rows
    - Transactions can also protect you (to some extent)

Delete

- One important point with constraints (foreign keys in particular) is that they guarantee that data remains consistent
  - They don't only work with `insert`, but with `update` and `delete` as well.
  - Example: Try to delete some rows in the `country` table

```
delete from countries where country_code = 'us';
```

```
[23503] ERROR: update or delete on table "countries" violates foreign key constraint "movies_country_fkey" on table "movies"
Detail: Key (country_code)=(us) is still referenced from table "movies".
```

    - Foreign-key constraints are especially useful in controlling `delete` operations

Constraints

- This is why constraints are so important:
  - They ensure that whatever happens, you'll always be able to make sense of ALL pieces of data in your database.