Databases
-
Chapter II: SQL

Rui Oliveira © rui.oliveira@ipleiria.pt

References

Further study required

- "SQL - Structured Query Language", Luís Damas, 6th Edition, FCA, 2005
- "Beginning Oracle SQL", Lex de Haan et al., APress, 2009

Programming languages

Generations

- 1st gen. => Machine code (0001010101)
- 2nd gen. => Assembly
- 3rd gen. => Java, C, Pascal, **PL/SQL**
- 4th gen. => LISP, PROLOG, **SQL**, Perl*, Python*

* 3GL with 4GL characteristics

Accessing Databases

Universal programming language

- SQL, *Structured Query Language*

Available basic data operations

- Insert new rows
- Update old data
- Delete old data
- Select existing data

SQL - queries

SQL example

CLIENTS

id	name	city	phoneNr
1	Valdemar Freitas	Leiria	244000001
2	Manuel da Silva	Lisboa	210000001
...	...	...	...
99	Pedro Passos Coelho	Lisboa	961000001
100	Maria de Sousa	Porto	

SQL query

```
SELECT name, phoneNr
FROM clients
WHERE city = 'Lisboa'
ORDER BY name;
```

=>

Information to user

```
NAME                  PHONENR
--------------------  ---------
Manuel da Silva       210000001
Pedro Passos Coelho   961000001
```

SQL statements

Data insertion

- Inserting new rows
  - `INSERT INTO clients (id,name,city) VALUES (101,'Rui Oliveira','Coimbra');`

CLIENTS

id	name	city	phoneNr
1	Valdemar Freitas	Leiria	244000001
2	Manuel da Silva	Lisboa	210000001
...	...	...	...
99	Pedro Passos Coelho	Lisboa	961000001
100	Maria de Sousa	Porto	
101	**Rui Oliveira**	**Coimbra**	

SQL statements

Other SQL basic statements

- Updating old data

  -
    ```
    UPDATE clients
    SET nome='Manuela da Silva'
    WHERE id=2;
    ```

CLIENTS

id	**name**	**city**	**phoneNr**
1	Valdemar Freitas	Leiria	244000001
2	**Manuela da Silva**	Lisboa	210000001
...	...	...	...
99	Pedro Passos Coelho	Lisboa	961000001
100	Maria de Sousa	Porto	
101	Rui Oliveira	Coimbra	

SQL statements

Other SQL basic statements

- Deleting old rows

  -
    ```
    DELETE
    FROM clients
    WHERE city='Leiria';
    ```

CLIENTS

id	name	city	phoneNr
~~1~~	~~Valdemar Freitas~~	~~Leiria~~	~~244000001~~
2	Manuela da Silva	Lisboa	210000001
...	...	...	...
99	Pedro Passos Coelho	Lisboa	961000001
100	Maria de Sousa	Porto	
101	Rui Oliveira	Coimbra	

SQL DML: SELECT statement

Basically...   :(

```
SELECT [DISTINCT | ALL]
              {*|<column name or expresion> [AS <new name>][, ...]}
FROM <table or view name> [new name] [,|JOIN [,...]]
[WHERE <row selection conditions>]
[GROUP BY <grouping criteria>
[HAVING <group selection conditions>]
[ORDER BY <column name or expression> [ASC|DESC] [,...]];
```

Reference: Oracle® Database SQL Language Reference 11g Release 1 (11.1) , pgs 19-4..19-52

SQL DML: SELECT statement

Meaning... :)

CLIENTS

id	name	city	phone_nr	birth_date	total_spent
1	António Freitas	Leiria	244244098	1980-04-06	1200
2	Rita Marujo	Lisboa	217769576	1983-01-06	1500
3	Carlos da Silva	Coimbra		1972-01-31	100
4	Ana Oliveira	LEIRIA	244987601	1978-11-09	5400

```
SELECT id,
       name AS “Nome”,
       city
FROM clients
WHERE phone_nr IS NOT NULL
ORDER BY name;
```

=

```
ID  Nome               CITY
--- ------------------ ----------
4   Ana Oliveira       LEIRIA
1   António Freitas    Leiria
2   Rita Marujo        Lisboa

3 rows selected
```

SQL DML: SELECT statement

Concepts

CLIENTS

id	name	city	phone_nr	birth_date	total_spent
1	António Freitas	Leiria	244244098	1980-04-06	1200
2	Rita Marujo	Lisboa	217769576	1983-01-06	1500
3	Carlos da Silva	Coimbra		1972-01-31	100
4	Ana Oliveira	LEIRIA	244987601	1978-11-09	5400

PROJECTION

```
SELECT id,
       name AS “Nome”,
       city
FROM clients
WHERE phone_nr IS NOT NULL
ORDER BY name;
```

=

```
ID  Nome                 CITY
--- -------------------- ----------
4   Ana Oliveira         LEIRIA
1   António Freitas      Leiria
2   Rita Marujo          Lisboa

3 rows selected
```

SQL DML: SELECT statement

Concepts

CLIENTS

id	name	city	phone_nr	birth_date	total_spent
1	António Freitas	Leiria	244244098	1980-04-06	1200
2	Rita Marujo	Lisboa	217769576	1983-01-06	1500
3	Carlos da Silva	Coimbra		1972-01-31	100
4	Ana Oliveira	LEIRIA	244987601	1978-11-09	5400

SELECTION

```
SELECT id,
       name AS "Nome",
       city
FROM clients
WHERE phone nr IS NOT NULL
ORDER BY name;
```

=

```
ID  Nome               CITY
--- ------------------ ----------
4   Ana Oliveira       LEIRIA
1   António Freitas    Leiria
2   Rita Marujo        Lisboa

3 rows selected
```

SELECT statement: SELECT clause

Useful operators

- Mathematical: `+, -, *, /`
- Others: `||`

Useful predicates

- DISTINCT

Exercises

- What is the amount spent by client with id `2`? (in U.S. dollars)

  `Rita Marujo spent 1950 US dollars`

- Which addresses have clients?

SELECT statement: WHERE clause

Purpose

- Perform a *selection*

Useful operators

- Mathematical: `>, <, >=, <=, <>, !=`
- Logical: `AND, OR, NOT`
- Others: `BETWEEN, IN, LIKE, IS NULL`

SELECT statement: ORDER BY clause

Predicates

- ASC
- DESC

Single expression vs Multiple expression sorting

- ORDER BY <*expression1*> [ASC|DESC] [, ...]

Example

```
SELECT id,
       name,
       address
FROM clients
ORDER BY address ASC, name DESC;
```

SELECT statement: *line functions*

Overall advantages of functions

- They simplify programming
- They allow output formatting

Properties of line functions in SQL

- Each function is executed once per retrieved row
- Each function returnn <u>one value</u> per row

Example

```
SELECT id, UPPER(name),
       LOWER(city) AS morada
FROM clients
ORDER BY id;
```

=

```
ID  NAME               MORADA
--- ------------------ ----------
1   ANTÓNIO FREITAS    leiria
2   RITA MARUJO        lisboa
3   CARLOS DA SILVA    coimbra
4   ANA OLIVEIRA       leiria

4 rows selected
```

SELECT statement: line functions

Examples of line functions

- TO_CHAR, TO_DATE, UPPER, NVL, DECODE, MONTHS_BETWEEN

Example

- *What is the address of clients born in 1975?*

```
SELECT id,
       DECODE (address,'Leiria','Cá da terra','De fora') AS "De onde"
FROM clients
WHERE TO_CHAR(birth_date,'yyyy')='1975'
ORDER BY name;
```

Exercises

CLIENTS

id	name	city	phone_nr	birth_date	spent	nr_children	gender
1	António Freitas	Leiria	244244098	1980-04-06	1200	1	M
2	Rita Marujo	Lisboa	217769576	1983-01-06	1500	0	F
3	Carlos da Silva	Coimbra		1972-01-31	100	3	M
4	Ana Oliveira	LEIRIA	244987601	1978-11-09	5400	2	F
5	João Silva	Coimbra	239876098	1978-12-04	650	0	M

Exercises

- Phone number of clients who spent more than 1200
- Clients who spent more than 1200 and who have kids
- Clients who spent 500 or more and 2000 or less
- Each client’s age
- Clients having more than 40 years of age
- Full list of clients with 2 or 3 kids

Grouping data

Grouping Data

Advantages

- Aggregate rows using specific criteria to generate summary information

Examples

- How many clients live <u>per city</u>?
- How much has been spent <u>per gender</u>?
- How much has been spent <u>per city</u>?
- How much has been spent <u>per city per capita</u>?

Grouping Data: Example (1)

"How many clients live per city?"

CLIENTS

id	name	city	phone_nr	birth_date	spent	nr_children	gender
1	António Freitas	LEIRIA	244244098	1980-04-06	1200	1	M
2	Rita Marujo	Lisboa	217769576	1983-01-06	1500	0	F
3	Carlos da Silva	Coimbra		1972-01-31	100	3	M
4	Ana Oliveira	LEIRIA	244987601	1978-11-09	5400	2	F
5	João Silva	Coimbra	239876098	1978-12-04	650	0	M

- How to solve this query mentally?
  - First, group rows based on the city name
  - Then, count how many rows exist in each group

Grouping Data: Example (2)

So, first create groups

CLIENTS

id	name	city	phone_nr	birth_date	spent	nr_children	gender
1	António Freitas	LEIRIA	244244098	1980-04-06	1200	1	M
2	Rita Marujo	Lisboa	217769576	1983-01-06	1500	0	F
3	Carlos da Silva	Coimbra		1972-01-31	100	3	M
4	Ana Oliveira	LEIRIA	244987601	1978-11-09	5400	2	F
5	João Silva	Coimbra	239876098	1978-12-04	650	0	M

=

GROUP 1

1	António Freitas	LEIRIA	244244098	1980-04-06	1200	1	M
4	Ana Oliveira	LEIRIA	244987601	1978-11-09	5400	2	F

+

GROUP 2

3	Carlos da Silva	Coimbra		1972-01-31	100	3	M
5	João Silva	Coimbra	239876098	1978-12-04	650	0	M

+

GROUP 3

2	Rita Marujo	Lisboa	217769576	1983-01-06	1500	0	F

Grouping Data: Example (3)

Then, count…

1	António Freitas	LEIRIA	244244098	1980-04-06	1200	1	M
4	Ana Oliveira	LEIRIA	244987601	1978-11-09	5400	2	F

=> 2 rows

3	Carlos da Silva	Coimbra		1972-01-31	100	3	M
5	João Silva	Coimbra	239876098	1978-12-04	650	0	M

=> 2 rows

2	Rita Marujo	Lisboa	217769576	1983-01-06	1500	0	F

=> 1 row

Grouping Data: Example (3)

And in SQL it goes like…

```
SELECT city, COUNT(*)
FROM clients
GROUP BY city;
```

=

```
CITY        COUNT(*)
----------- --------
LEIRIA      2
Coimbra     2
Lisboa      1
```

Grouping Data

"How much has been spent per gender?"

CLIENTS

id	name	city	phone_nr	birth_date	spent	nr_children	gender
1	António Freitas	Leiria	244244098	1980-04-06	1200	1	M
2	Rita Marujo	Lisboa	217769576	1983-01-06	1500	0	F
3	Carlos da Silva	Coimbra		1972-01-31	100	3	M
4	Ana Oliveira	LEIRIA	244987601	1978-11-09	5400	2	F
5	João Silva	Coimbra	239876098	1978-12-04	650	0	M

=

GROUP 1

2	Rita Marujo	Lisboa	217769576	1983-01-06	1500	0	F
4	Ana Oliveira	LEIRIA	244987601	1978-11-09	5400	2	F

+

GROUP 2

1	António Freitas	Leiria	244244098	1980-04-06	1200	1	M
3	Carlos da Silva	Coimbra		1972-01-31	100	3	M
5	João Silva	Coimbra	239876098	1978-12-04	650	0	M

GROUP BY clause

Syntax

- SELECT ...
  FROM ...
  GROUP BY <*expression1*> [, ...]

Group functions

Advantages

- Generate information from data stored in grouped rows

Rules

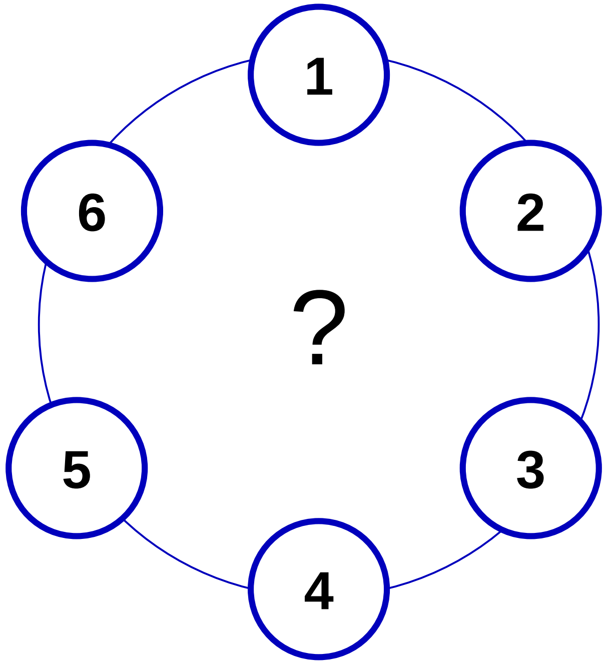
- Applied *per group* basis
- Each function returns one value per group

Examples

- COUNT
- SUM
- MIN, MAX, AVG

SELECT statement: *clause order*

```
5  SELECT ...
1  FROM ...
2  WHERE ...
3  GROUP BY ...
4  HAVING ...
6  ORDER BY ...
```



Filtering Grouped Data

Advantages

- Choose which of the groups can be used

Examples

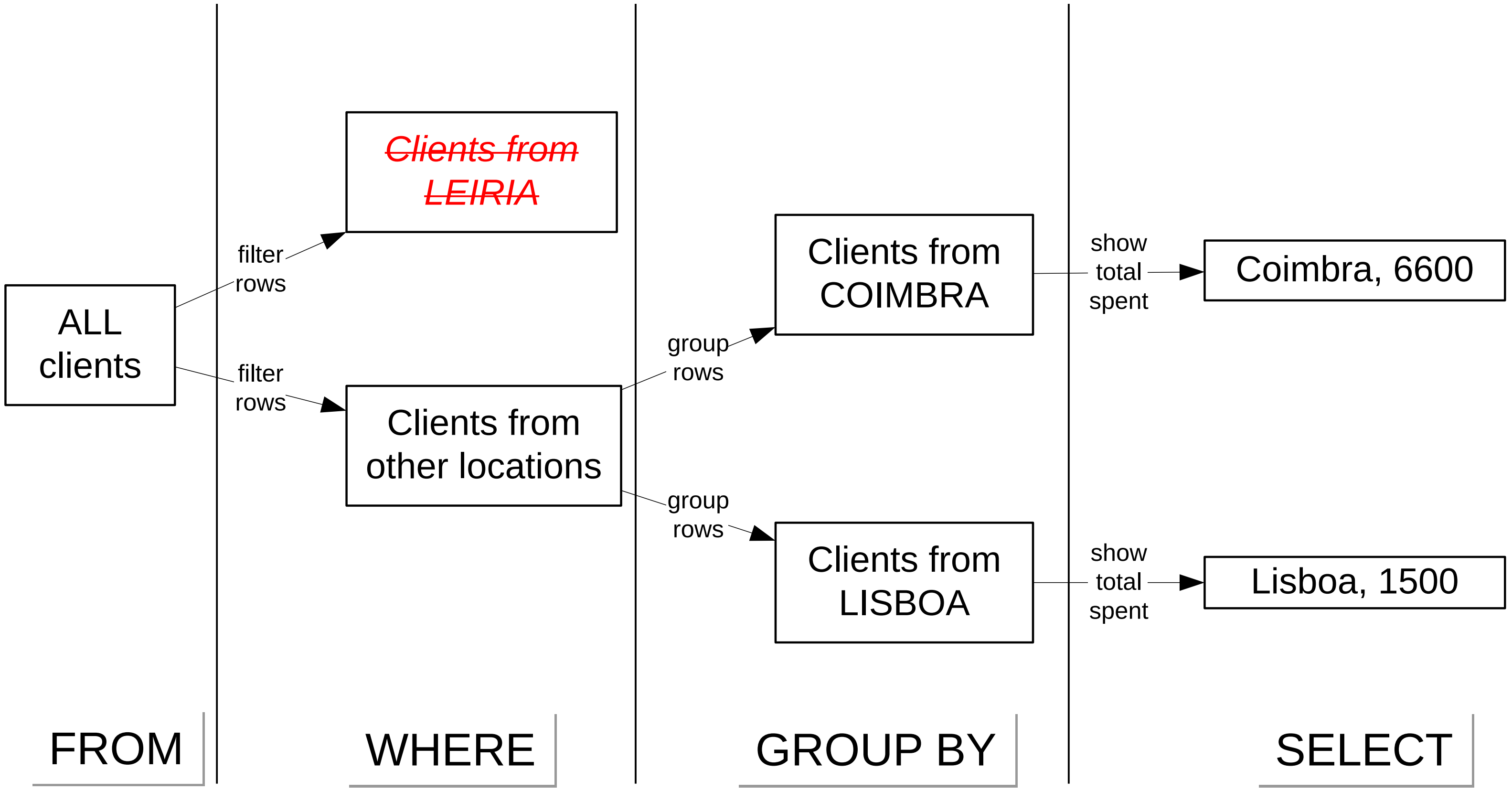
- How many clients live per city,
  but only in cities with 2 or more clients ?
- How much has been spent per city,
  except for the city of `Leiria` ?
- How much has been spent per city,
  but only in cities with more than 500 spent per capita ?

Attention

- WHERE ≠ HAVING

Filtering Grouped Data... visually

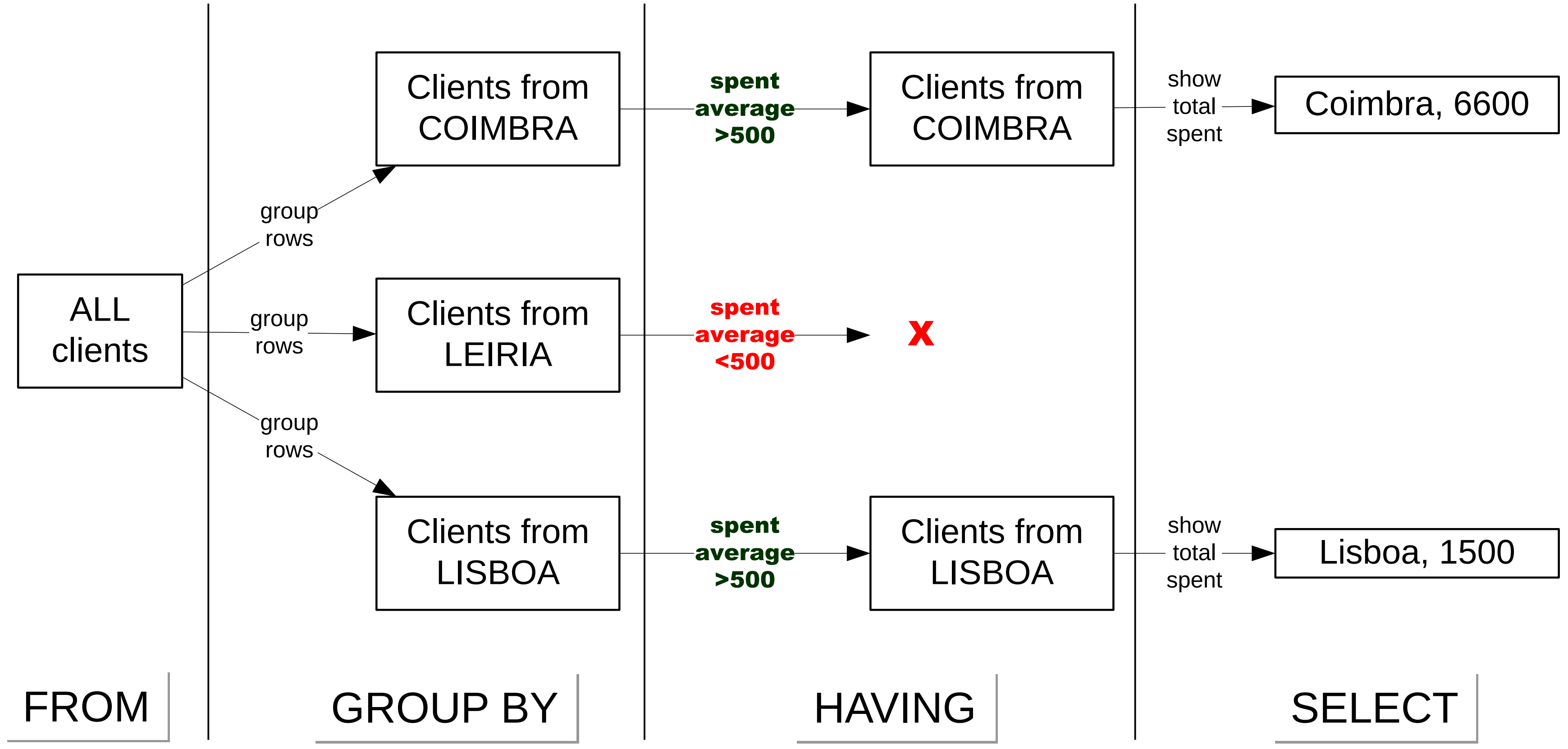
How much has been spent per city, *except for the city of `Leiria`* ?



Filtering Grouped Data... visually

How much has been spent per city,

but only in cities with more than 500 spent per capita ?



Exercises

CLIENTS

id	name	city	phone_nr	birth_date	spent	nr_children	gender
1	António Freitas	Leiria	244244098	1980-04-06	1200	1	M
2	Rita Marujo	Lisboa	217769576	1983-01-06	1500	0	F
3	Carlos da Silva	Coimbra		1972-01-31	100	3	M
4	Ana Oliveira	LEIRIA	244987601	1978-11-09	5400	2	F
5	João Silva	Coimbra	239876098	1978-12-04	650	0	M

Exercises

- What is the highest spent value?
- What is the highest spent value per city?
- Who spends more, women or men?
- Who spends more, clients *with* children or *without* children?
- What is the average age of clients?
- How many clients do not possess a phone number?

Retrieving data from multiple tables

Retrieving data from multiple tables

New scenario

CLIENTS

id	name	city_id	phone_nr	birth_date	spent	nr_children	gender
1	António Freitas	1	244244098	1980-04-06	1200	1	M
2	Rita Marujo	2	217769576	1983-01-06	1500	0	F
3	Carlos da Silva	3		1972-01-31	100	3	M
4	Ana Oliveira	1	244987601	1978-11-09	5400	2	F
5	João Silva	3	239876098	1978-12-04	650	0	M

CITIES

id	name
1	Leiria
2	Lisboa
3	Coimbra
4	Guarda

Retrieving data from multiple tables

Example: *Where does João Silva lives?*

CLIENTS

id	name	city_id	phone_nr	birth_date	spent	nr_children	gender
1	António Freitas	1	244244098	1980-04-06	1200	1	M
2	Rita Marujo	2	217769576	1983-01-06	1500	0	F
3	Carlos da Silva	3		1972-01-31	100	3	M
4	Ana Oliveira	1	244987601	1978-11-09	5400	2	F
5	João Silva	3	239876098	1978-12-04	650	0	M

CITIES

id	name
1	Leiria
2	Lisboa
3	Coimbra
4	Guarda

Retrieving data from multiple tables

Example: *Where does João Silva lives?*

How it happens?

CLIENTS

id	name	…	gender	city_id
1	António Freitas	…	M	1
2	Rita Marujo	…	F	2
3	Carlos da Silva	…	M	3
4	Ana Oliveira	…	F	1
5	João Silva	…	M	3

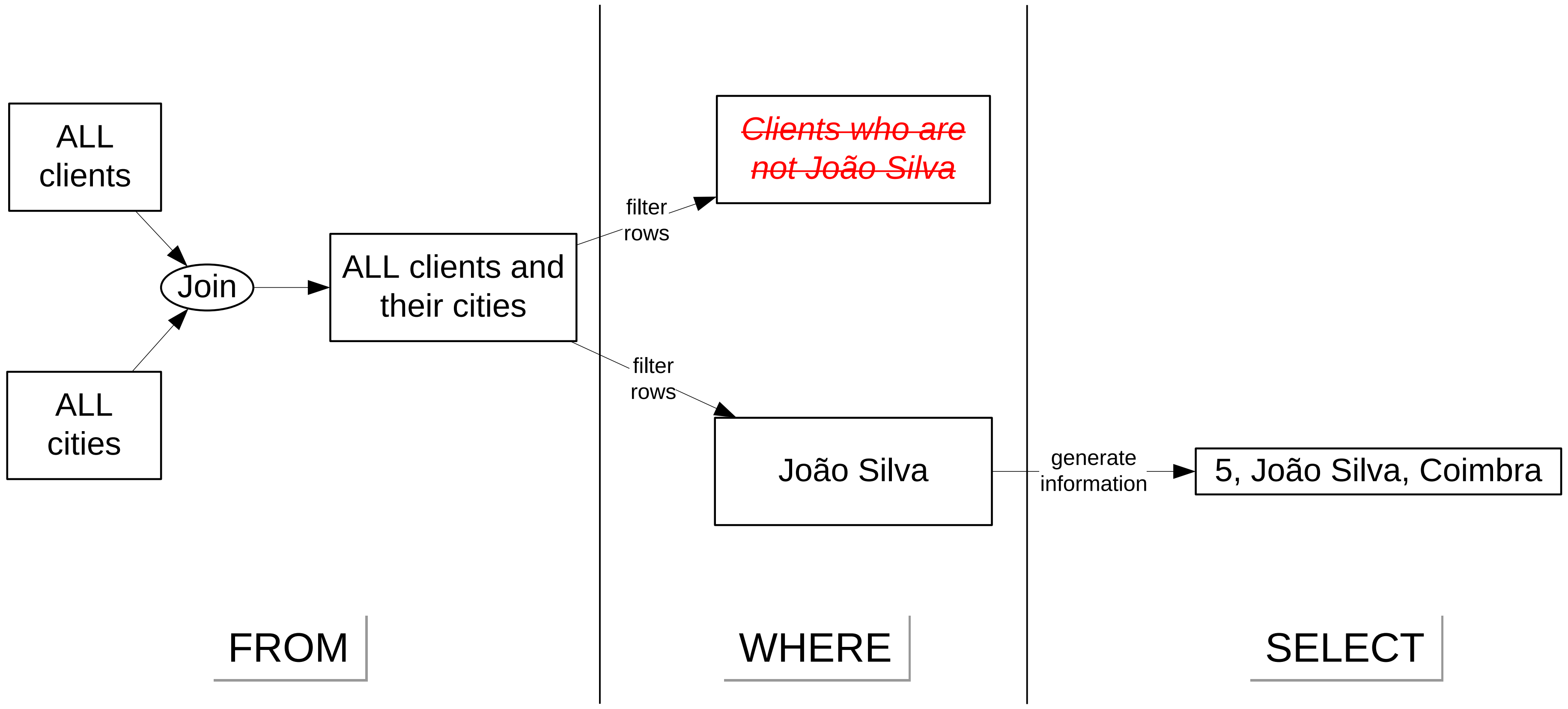
Join

cities.id	cities.name
1	Leiria
2	Lisboa
3	Coimbra
1	Leiria
3	Coimbra

1. Join
2. *Filter*

Joining Data... visually

Where does ‘João Silva’ lives?



Retrieving data from multiple tables

Example: *Where does João Silva lives?*

```
SELECT clients.id, clients.name, cities.name
FROM clients JOIN cities ON clients.city_id = cities.id
WHERE name = ‘João Silva’;
```

OR

```
SELECT clients.id, clients.name, cities.name
FROM clients, cities
WHERE clients.city_id = cities.id
      AND name = ‘João Silva’;
```

clients.id	clients.name	cities.name
5	João Silva	Coimbra

Retrieving data from multiple tables

Advantages

- Generate information from data stored in more than one table

Rules

- Available only in FROM and WHERE clauses
- A join condition <u>should always </u>be used, or else...

Retrieving data from multiple tables: *horizontal join*

Definition

- Find the line(s) of table *t2* that are *connected* to a specific line in table *t1* as long as a *connnection condition* exists

Types of horizontal joins

- Equijoin (=)
- Non-equijoin (BETWEEN, >, <)
- Self join
- Outer join
  - `LEFT, RIGHT, FULL`

Exercises

CLIENTS

id	name	city_id	phone_nr	birth_date	spent	nr_children	gender
1	António Freitas	1	244244098	1980-04-06	1200	1	M
2	Rita Marujo	2	217769576	1983-01-06	1500	0	F
3	Carlos da Silva	3		1972-01-31	100	3	M
4	Ana Oliveira	1	244987601	1978-11-09	5400	2	F
5	João Silva	3	239876098	1978-12-04	650	0	M

SALES

id	date	client_id
4000	2014-05-09	3
4001	2014-05-09	3
4002	2014-05-09	2
4003	2014-05-09	1

CITIES

id	name
1	Leiria
2	Lisboa
3	Coimbra
4	Guarda

Exercises

- Which sales belong to clients living in *Lisboa*?
- Total sales made last year in each city (show city name)
- How many clients exist per city (show city name)
- Which cities have no clients?
- Are there any clients without related sales?

Retrieving data from multiple tables: *vertical join*

Definition

- Merge the lines of queries *q1* and *q2* using a set operation

Set operations

- UNION
- UNION ALL
- INTERSECT
- MINUS

Retrieving data from multiple tables: *vertical join*

Example

CLIENTS_OLD

id	name	phone_nr	birth_date	spent	gender	years_as_client
12	António Costa	210009999	1971-08-06	130000	M	11
61	Celine Dion	239000111	1970-01-16	600000	F	12

- Show name and birth date of current and old clients

```
SELECT name, birth_date
FROM clients
UNION
SELECT name, birth_date
FROM clients_old
ORDER BY 1;
```

=

```
NAME               BIRTH_DATE
------------------ ----------
ANA OLIVEIRA       1978-11-09
ANTÓNIO COSTA      1971-08-06
ANTÓNIO FREITAS    1980-04-06
CARLOS DA SILVA    1972-01-31
CELINE DION        1970-01-16
JOÃO SILVA         1978-12-04
RITA MARUJO        1983-01-06
```

Retrieving data from multiple tables: *vertical join*

Exercises

- Which of the current clients have been clients before?
- Which of the old clients are not returning clients?

Subqueries

Subqueries

Definition

- SELECT statement *inside* another SELECT statement (*query inside query*)

Advantages

- Compute the result of an *inner* query and use that result to compute the result of an outer query

Example

② outer

① inner

```
SELECT id, name
FROM clients
WHERE city_id NOT IN (SELECT id
                      FROM cities
                      WHERE name IN (‘Leiria’, ‘Lisboa’)) ;
```

In-line Subqueries

Advantages

- Compute the result of an *inner* query and use that result to compute the result of an outer query

Example

② outer

① inner

```
SELECT id, name
FROM clients
WHERE city_id NOT IN (SELECT id
                      FROM cities
                      WHERE name IN (‘Leiria’, ‘Lisboa’)) ;
```

Subqueries

Special operators

- IN
- NOT IN
- ALL (with >, <)
- ANY (with >, <)

Exercise

- `List the name and id of all clients who bought something in the day with the highest ammount of sales in the previous year`

In-line Subqueries

Example

- List the clients who spent more than the overall average of spent money.

```
SELECT *
FROM clients
WHERE spent > (SELECT AVG(spent)
               FROM clients);
```

In-line Subqueries - Exercises

CLIENTS

id	name	city_id	phone_nr	birth_date	spent	nr_children	gender
1	António Freitas	1	244244098	1980-04-06	1200	1	M
2	Rita Marujo	2	217769576	1983-01-06	1500	0	F
3	Carlos da Silva	3		1972-01-31	100	3	M
4	Ana Oliveira	1	244987601	1978-11-09	5400	2	F
5	João Silva	3	239876098	1978-12-04	650	0	M

SALES

id	date	client_id
4000	2014-05-09	3
4001	2014-05-09	3
4002	2014-05-09	2
4003	2014-05-09	1

CITIES

id	name
1	Leiria
2	Lisboa
3	Coimbra
4	Guarda

Exercises

- Show the clients who spent the most
- Show the name of the cities with no clients (3 ≠ ways)
- Show clients who never bought products
- Show the city with the highest amount of spent money

Correlated Subqueries

Definition

- Subquery in which the outer query is executed once for each execution of the inner subquery (≠ linear subqueries)

Advantages

- Compute the result of the *inner* query **<u>once for each</u>** row given by the *outer* query

Correlated Subqueries

Show the clients who spent the most in their city

```
SELECT id, name
FROM clients cl1
WHERE spent = (SELECT MAX(spent)
               FROM clients cl2
               WHERE cl2.city_id = cl1.city_id) ;
```

① outer

② inner

CLIENTS

id	name	city_id	phone_nr	birth_date	spent	nr_children	gender
1	António Freitas	1	244244098	1980-04-06	1200	1	M
2	Rita Marujo	2	217769576	1983-01-06	1500	0	F
3	Carlos da Silva	3		1972-01-31	100	3	M
4	Ana Oliveira	1	244987601	1978-11-09	5400	2	F
5	João Silva	3	239876098	1978-12-04	650	0	M

Correlated Subqueries

Exercise: <*guess what this query returns*>

```
SELECT id, name, phone_nr
FROM clients cl1
WHERE EXISTS (SELECT id
              FROM clients cl2
              WHERE cl2.phone_nr = cl1.phone_nr
                    AND cl2.id != cl1.id);
```

Correlated Subqueries

Avoiding correlation of queries

- Substitute a *correlated* subquery by *linear* subqueries
- Correlated subqueries *can* harm performance

Exercises

- Remove correlation from the queries of the previous slides

SQL

All good things come to an end
☹