Relational databases: usage principles

Database Structuring and Querying with SQL

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- Structured Query Language
- A standard language designed for managing data held in a relational database management system (RDBMS).
- Very highlevel language for querying and manipulating data.
- Helps in defining the structure of the data, modifying the data and specifying the security constraints.
- Uses a combination of relational algebra and relational calculus constructs.





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Syntax

 SQL keywords are case-insensitive, however, they are often written in uppercase.

Same: SELECT, Select, select

Same: City, city

Values are case-sensitive.
 Different: 'Paris', 'paris'

- Some database systems require a semicolon at the end of each SQL statement.
- Each clause in a statement begin on a new line.

```
SELECT *
FROM Capitals
WHERE name='Paris';
```





Tables

- A relation or table is a multiset of tuples having the attributes specified by the schema.
- An attribute (or column) is a typed data entry present in each tuple in the relation.
- A tuple (or row) is a single entry in the table having the attributes.
 Also referred to sometimes as a record specified by the schema.





Data types

- Numbers: INT, SMALLINT, BIGINT, FLOAT
- Characters: CHAR(20), VARCHAR(50)
- Others: MONEY, DATETIME, ...





Table Schema

- The schema of a table is the table name, its attributes, and their types.
- A key is an attribute whose values are unique; we underline a key.

Building (id:float, name:string, address:string)





DDL and DML

SQL is a:

- Data Definition Language (DDL)
 Define relational schema.
 Create/alter/delete tables and their attributes.
- Data Manipulation Language (DML) Insert/delete/modify tuples in tables.
 Query one or more tables.





Data Manipulation

- SELECT, FROM, WHERE
- ORDER BY
- DISTINCT, AND, OR, NOT, LIKE
- JOINs





SELECT ... FROM

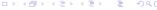
The operation of producing an output table that have a subset of the prior attributes.

```
SELECT <attributes>
FROM <relations>;
```

To select all the fields available in the table:

```
SELECT *
FROM <relations>;
```





SELECT ... FROM

```
SELECT id, surface, level
FROM Apartment;
```

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 102 | 51 | 200 | 2 | 1 |
| 103 | 52 | 50 | 5 | 1 |
| 104 | 43 | 75 | 3 | 1 |
| 200 | 1 | 150 | 0 | 2 |
| 201 | 2 | 250 | 1 | 2 |
| 202 | 3 | 250 | 2 | 2 |

Apartment

| id | surface | level |
|-----|---------|-------|
| 102 | 200 | 2 |
| 103 | 50 | 5 |
| 104 | 75 | 3 |
| 200 | 150 | 0 |
| 201 | 250 | 1 |
| 202 | 250 | 2 |





DISTINCT

To eliminate duplicates:

```
SELECT DISTINCT <attributes>
FROM <relations>;
```





DISTINCT

```
SELECT idBuilding
FROM Apartment;
```

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 102 | 51 | 200 | 2 | 1 |
| 103 | 52 | 50 | 5 | 1 |
| 104 | 43 | 75 | 3 | 1 |
| 200 | 1 | 150 | 0 | 2 |
| 201 | 2 | 250 | 1 | 2 |
| 202 | 3 | 250 | 2 | 2 |

| idBuilding | | | | | | |
|------------|--|--|--|--|--|--|
| 1 | | | | | | |
| 1 | | | | | | |
| 1 | | | | | | |
| 2 | | | | | | |
| 2 | | | | | | |
| 2 | | | | | | |





DISTINCT

SELECT DISTINCT idBuilding FROM Apartment;

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 102 | 51 | 200 | 2 | 1 |
| 103 | 52 | 50 | 5 | 1 |
| 104 | 43 | 75 | 3 | 1 |
| 200 | 1 | 150 | 0 | 2 |
| 201 | 2 | 250 | 1 | 2 |
| 202 | 3 | 250 | 2 | 2 |



WHERE

The operation of filtering a relation's tuples on some condition.

```
SELECT <attributes>
FROM <relations>
WHERE <conditions>;
```

WHERE clause is not only used in SELECT statements, it is also used in UPDATE, DELETE, ...





WHERE

```
SELECT *
FROM Apartment
WHERE level = 2;
```

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 102 | 51 | 200 | 2 | 1 |
| 103 | 52 | 50 | 5 | 1 |
| 104 | 43 | 75 | 3 | 1 |
| 200 | 1 | 150 | 0 | 2 |
| 201 | 2 | 250 | 1 | 2 |
| 202 | 3 | 250 | 2 | 2 |

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 102 | 51 | 200 | 2 | 1 |
| 202 | 3 | 250 | 2 | 2 |



AND, OR and NOT

To filter records based on more than one condition:

```
WHERE NOT condition;
WHERE condition1 AND condition2;
WHERE condition1 OR condition2;
```

- AND operator displays a record if all the conditions separated by AND are TRUE.
- OR operator displays a record if any of the conditions separated by OR is TRUE.
- NOT operator displays a record if the condition(s) is NOT TRUE.



AND

```
SELECT *
FROM Apartment
WHERE idBuilding = 1 AND surface > 60;
```

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 102 | 51 | 200 | 2 | 1 |
| 103 | 52 | 50 | 5 | 1 |
| 104 | 43 | 75 | 3 | 1 |
| 200 | 1 | 150 | 0 | 2 |
| 201 | 2 | 250 | 1 | 2 |
| 202 | 3 | 250 | 2 | 2 |

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 102 | 51 | 200 | 2 | 1 |
| 104 | 43 | 75 | 3 | 1 |



OR

```
SELECT *
FROM Apartment
WHERE idBuilding = 1 OR surface > 60;
```

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 102 | 51 | 200 | 2 | 1 |
| 103 | 52 | 50 | 5 | 1 |
| 104 | 43 | 75 | 3 | 1 |
| 200 | 1 | 150 | 0 | 2 |
| 201 | 2 | 250 | 1 | 2 |
| 202 | 3 | 250 | 2 | 2 |

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 102 | 51 | 200 | 2 | 1 |
| 103 | 52 | 50 | 5 | 1 |
| 104 | 43 | 75 | 3 | 1 |
| 200 | 1 | 150 | 0 | 2 |
| 201 | 2 | 250 | 1 | 2 |
| 202 | 3 | 250 | 2 | 2 |





NOT

```
SELECT *
FROM Apartment
WHERE NOT idBuilding = 1;
```

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 102 | 51 | 200 | 2 | 1 |
| 103 | 52 | 50 | 5 | 1 |
| 104 | 43 | 75 | 3 | 1 |
| 200 | 1 | 150 | 0 | 2 |
| 201 | 2 | 250 | 1 | 2 |
| 202 | 3 | 250 | 2 | 2 |

| Ia | no | surrace | ievei | labullaing |
|-----|----|---------|-------|------------|
| 200 | 1 | 150 | 0 | 2 |
| 201 | 2 | 250 | 1 | 2 |
| 202 | 3 | 250 | 2 | 2 |
| | | | | |

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For simple string pattern matching.

```
SELECT <attributes>
FROM <relations>
WHERE A LIKE P;
```

A LIKE P: pattern matching on strings P may contain two special symbols:

- ullet % = any sequence of characters
- _ = any single character





```
SELECT *
FROM Building
WHERE address LIKE '%Grand%';
```

| id | name | address |
|----|----------|-----------------------|
| 1 | Koudalou | 3 rue des Martyrs |
| 2 | Barabas | 2 allée du Grand Turc |

| id | name | address |
|----|---------|-----------------------|
| 2 | Barabas | 2 allée du Grand Turc |

Building





ORDER BY

Sorting the Results

```
SELECT <attributes>
FROM <relations>
ORDER BY <attributes>;
```

For descending order:

```
SELECT <attributes>
FROM <relations>
ORDER BY <attributes> DESC;
```





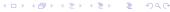
ORDER BY

```
SELECT *
FROM Apartment
ORDER BY surface;
```

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 102 | 51 | 200 | 2 | 1 |
| 103 | 52 | 50 | 5 | 1 |
| 104 | 43 | 75 | 3 | 1 |
| 200 | 1 | 150 | 0 | 2 |
| 201 | 2 | 250 | 1 | 2 |
| 202 | 3 | 250 | 2 | 2 |

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 103 | 52 | 50 | 5 | 1 |
| 104 | 43 | 75 | 3 | 1 |
| 200 | 1 | 150 | 0 | 2 |
| 102 | 51 | 200 | 2 | 1 |
| 201 | 2 | 250 | 1 | 2 |
| 202 | 3 | 250 | 2 | 2 |





ORDER BY

```
SELECT *
FROM Apartment
ORDER BY no DESC;
```

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 102 | 51 | 200 | 2 | 1 |
| 103 | 52 | 50 | 5 | 1 |
| 104 | 43 | 75 | 3 | 1 |
| 200 | 1 | 150 | 0 | 2 |
| 201 | 2 | 250 | 1 | 2 |
| 202 | 3 | 250 | 2 | 2 |

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 103 | 52 | 50 | 5 | 1 |
| 102 | 51 | 200 | 2 | 1 |
| 104 | 43 | 75 | 3 | 1 |
| 202 | 3 | 250 | 2 | 2 |
| 201 | 2 | 250 | 1 | 2 |
| 200 | 1 | 150 | 0 | 2 |





Cartesian product

```
SELECT *
FROM <relation1, relation2, ...>;
```

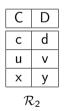




Cartesian product

```
SELECT * FROM \mathcal{R}_1, \mathcal{R}_2;
```





| Α | В | С | D |
|---|---|---|---|
| а | b | С | d |
| а | b | u | V |
| а | b | Х | у |
| Χ | у | С | d |
| Χ | у | u | ٧ |
| Х | y | Х | y |
| | y | | у |

$$\mathcal{R}_1 \times \mathcal{R}_2$$





Returns records that have matching values in both tables.

```
SELECT <attributes>
FROM <relation1>
INNER JOIN <relation2>
ON <condition>;
```

Example:

```
SELECT *
FROM Capitals
INNER JOIN Presidents
ON Capitals.State = Presidents.State;
```

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INNER JOIN

| Capital | State |
|---------|---------|
| Paris | France |
| Madrid | Spain |
| Berlin | Germany |
| | |

 ${\sf Capitals}$

| State | President |
|---------|-------------------------|
| France | Emmanuel Macron |
| Germany | Frank-Walter Steinmeier |
| Italy | Sergio Mattarella |

Presidents

| Capital | State | President |
|---------|---------|-------------------------|
| Paris | France | Emmanuel Macron |
| Berlin | Germany | Frank-Walter Steinmeier |

 $\mathsf{Capitals} \bowtie \mathsf{Presidents}$





27 Database Hiba ALQASIR 2021-2022

Returns all records from the left table, and the matched records from the right table.

```
SELECT <attributes>
FROM <relation1>
LEFT JOIN <relation2>
ON <condition>;
```

Example:

```
SELECT *
FROM Capitals
LEFT JOIN Presidents
ON Capitals.State = Presidents.State;
```





LEFT JOIN

| Capital | State |
|---------|---------|
| Paris | France |
| Madrid | Spain |
| Berlin | Germany |

 ${\sf Capitals}$

| State | President |
|---------|-------------------------|
| France | Emmanuel Macron |
| Germany | Frank-Walter Steinmeier |
| Italy | Sergio Mattarella |

Presidents

| Capital | State | President |
|---------|---------|-------------------------|
| Paris | France | Emmanuel Macron |
| Madrid | Spain | NULL |
| Berlin | Germany | Frank-Walter Steinmeier |

 $\mathsf{Capitals} \bowtie \mathsf{Presidents}$





9 Database Hiba ALQASIR 2021-2022

Returns all records from the right table, and the matched records from the left table.

```
SELECT <attributes>
FROM <relation1>
RIGHT JOIN <relation2>
ON <condition>;
```

Example:

```
SELECT *
FROM Capitals
RIGHT JOIN Presidents
ON Capitals.State = Presidents.State;
```



RIGHT JOIN

| Capital | State |
|---------|---------|
| Paris | France |
| Madrid | Spain |
| Berlin | Germany |

 ${\sf Capitals}$

| State | President |
|---------|-------------------------|
| France | Emmanuel Macron |
| Germany | Frank-Walter Steinmeier |
| Italy | Sergio Mattarella |

Presidents

| Capital | State | President |
|---------|---------|-------------------------|
| Paris | France | Emmanuel Macron |
| Berlin | Germany | Frank-Walter Steinmeier |
| NULL | Italy | Sergio Mattarella |

 $\mathsf{Capitals} \bowtie \mathsf{Presidents}$



31

FULL OUTER JOIN

Returns all records when there is a match in either left or right table.

```
SELECT <attributes>
FROM <relation1>
FULL OUTER JOIN <relation2>
ON <condition>;
```

Example:

```
SELECT *
FROM Capitals
FULL OUTER JOIN Presidents
ON Capitals.State = Presidents.State;
```





FULL OUTER JOIN

| Capital | State |
|---------|---------|
| Paris | France |
| Madrid | Spain |
| Berlin | Germany |

 ${\sf Capitals}$

| State | President |
|---------|-------------------------|
| France | Emmanuel Macron |
| Germany | Frank-Walter Steinmeier |
| Italy | Sergio Mattarella |

Presidents

| Capital | State | President |
|---------|---------|-------------------------|
| Paris | France | Emmanuel Macron |
| Madrid | Spain | NULL |
| Berlin | Germany | Frank-Walter Steinmeier |
| NULL | Italy | Sergio Mattarella |

 $\mathsf{Capitals} \bowtie \mathsf{Presidents}$



Data Definition

- Creating, deleting, altering a table (schema object).
- Inserting, deleting, updating values (schema instance).





Creating a table

```
CREATE TABLE \mathcal{R}(
A_1D_1 ,
A_2D_2 ,
... ,
A_nD_n
```

- Each A_i represents an attribute in the schema of relation \mathcal{R} .
- Each D_i denotes the data type of values in the domain for the corresponding attribute A_i .





Creating a table

```
CREATE TABLE Apartment(
    id int,
    no int,
    surface float,
    level int,
    idBuilding int
);
```

| id | no | surface | level | idBuilding |
|----|----|---------|-------|------------|
| | | | | |
| | | | | |





Deleting a table

To delete (drop) an existing table:

```
DROP TABLE \mathcal{R};
```

Example

```
DROP TABLE Apartment;
```





Altering a table

A typical SQL query for altering:

```
ALTER TABLE {\cal R} <action> <description>;
```

- action: ADD, MODIFY, DROP, RENAME.
- description: the modification command associated with action.





Altering a table

A typical SQL query for altering a table by adding attributes:

```
ALTER TABLE {\cal R} ADD A_i D_i ;
```

Example:

```
ALTER TABLE Apartment ADD street varchar (255);
```

| id | no | surface | level | idBuilding | street |
|----|----|---------|-------|------------|--------|
| | | | | | |
| | | | | | |





Altering a table

A typical SQL query for altering a table by deleting attributes:

```
ALTER TABLE {\cal R} DROP COLUMN A_i;
```

Example:

```
ALTER TABLE Apartment DROP COLUMN level;
```

| id | no | surface | idBuilding | street |
|----|----|---------|------------|--------|
| | | | | |
| | | | | |





```
INSERT INTO \mathcal{R}(A_1, A_2, ...)
VALUES (value<sub>1</sub>, value<sub>2</sub>, ...);
```

Or:

```
INSERT INTO \mathcal{R}
VALUES (value<sub>1</sub>, value<sub>2</sub>, ... value<sub>k</sub>);
```

- Each A_i represents an attribute in the schema of relation \mathcal{R} .
- Each *value*; denotes the value for the corresponding attribute A_i .





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Inserting values

```
INSERT INTO Apartment(id, no, surface, level, idBuilding)
VALUES ( 100, 1, 150, 14 , 1);
INSERT INTO Apartment
VALUES ( 101, 34, 150, 15 , 1);
```

| id | no | surface | level | idBuilding |
|----|----|---------|-------|------------|
| | | | | |
| | | | | |

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 100 | 1 | 150 | 14 | 1 |
| 101 | 34 | 50 | 15 | 1 |





Deleting values

```
DELETE FROM \mathcal{R}
WHERE <condition>;
```

• WHERE clause specifies which record(s) should be deleted.





Deleting values

```
DELETE FROM Apartment
WHERE id = 101;
```

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 100 | 1 | 150 | 14 | 1 |
| 101 | 34 | 50 | 15 | 1 |

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 100 | 1 | 150 | 14 | 1 |
| | | | | |





Updating values

```
UPDATE \mathcal{R}

SET A_1 = value_1, A_2 = value_2, ...

WHERE <condition>;
```

- Each A_i represents an attribute in the schema of relation \mathcal{R} .
- Each *value*; denotes the value for the corresponding attribute A_i .
- WHERE clause specifies which record(s) should be updated.





Updating values

```
UPDATE Apartment
SET idBuilding = 77, no = 10
WHERE id = 100;
```

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 100 | 1 | 150 | 14 | 1 |
| | | | | |

| id | no | surface | level | idBuilding |
|-----|----|---------|-------|------------|
| 100 | 10 | 150 | 14 | 77 |
| | | | | |





Create a table

SQLizer
Easily convert files into SQL databases
https://sqlizer.io





Understanding the concepts in a better way

RAT
Relational Algebra Translator
http://www.slinfo.una.ac.cr/rat/rat.html



