Introduction to Database Systems

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Content

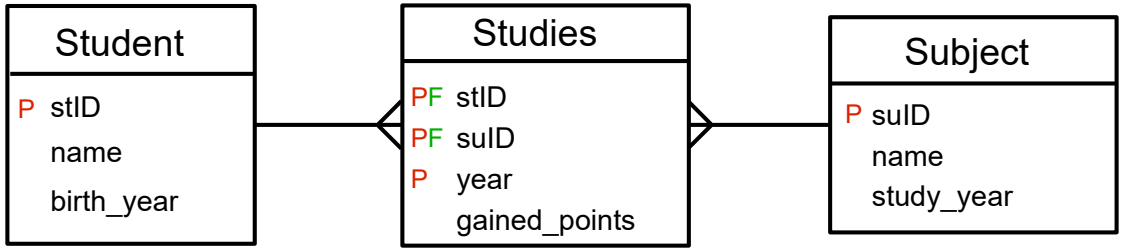
- Aggregation
- 3 value logic

Aggregate functions

- Aggregate functions and SELECT:

  SELECT $A_1, \ldots, A_n$ ← we can use functions such as AVG,
  FROM R_1 MIN, MAX, COUNT, SUM
  JOIN R_n ON *join_condition*
  WHERE *condition*

Example: Simple queries with aggregate functions



- *Find an average birth year of all students.*

```
SELECT AVG(birth_year) FROM Student
```

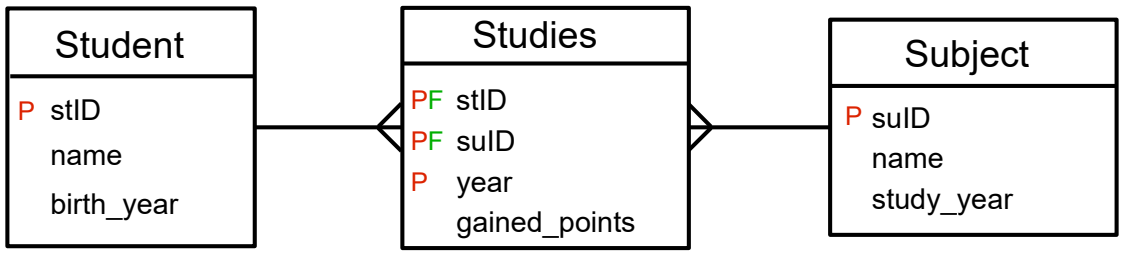
- *Find a birth year of the oldest student.*

```
SELECT MIN(birth_year) FROM Student
```

- *Find number of all students.*

```
SELECT COUNT(*) FROM Student
```

Example: Aggregate functions and NULL values



- *Find number of all students.*
  - `SELECT COUNT(*) FROM Student`
  - `SELECT COUNT(birth_year) FROM Student`
  - Aggregate functions ignore NULL values
  - Thus, the first above query is correct since the second one answers the question: *For how many students do we know the birth year?*

GROUP BY clause

- SELECT with grouping:

SELECT $A_1, \ldots, A_n$
FROM R_1
JOIN R_n ON *join_condition*
WHERE *condition*
GROUP BY $A_1, \ldots, A_n$

GROUP BY clause

- SELECT with grouping:

  SELECT $A_1, \ldots, A_n$
  FROM R_1
  JOIN R_n ON *join_condition*
  WHERE *condition*
  GROUP BY $A_1, \ldots, A_n$ - defines attributes that specify groups in the data

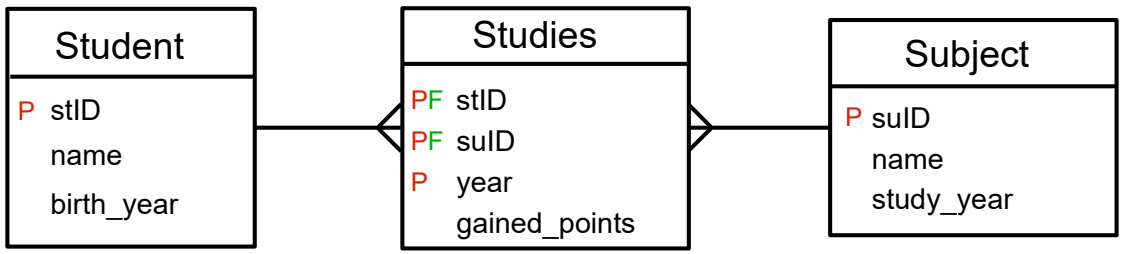
GROUP BY Operation

Studies

stID	suID	year	points
1	35	2010	23
1	35	2011	55
1	21	2010	89
2	11	2011	98
2	21	2011	null
3	46	2011	null

- GROUP BY create logical groups in the input relation
- ```
  SELECT stID, COUNT(*)
  FROM Studies
  GROUP BY stID
  ```
  ```

Example: GROUP BY with more attributes



- *Find number of students of particular subjects in particular years.*

```
SELECT P.suID, year, COUNT(*)
FROM Subject P
JOIN Studies S ON P.suID=S.suID
GROUP BY P.suID, year
```

- How to include students who did not studied anything?

GROUP BY Rule

Behind the SELECT we can have outside aggregation function only attributes that are behind GROUP BY!

```
SELECT year, COUNT(*)
  FROM Subject
  GROUP BY year
```

GROUP BY Rule

- *Find number of students of particular subjects in particular years.*

```
SELECT P.name, S.year, COUNT(*)
FROM Subject P
JOIN Studies S ON P.suID=S.suID
GROUP BY P.suID, S.year
```

- MS SQL Server and Oracle will not perform this query - they both require that GROUP BY is followed by all attributes following the SELECT clause except those attributes following SELECT which appear only in aggregate functions after SELECT (these can but do not have to follow GROUP BY)
- Therefore, even in this case when `name` is uniquely determined by the `suID` value, the query will not be performed

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GROUP BY Rule

- Some database systems such as MYSQL perform also this query:

```
SELECT suID, year, COUNT(*)
FROM Subject
GROUP BY year
```

- Note that more subjects with different suIDs can correspond to a single row - suID in the result is then random!
- Personally, I consider this behavior to be confusing, when less experienced users are not aware of the fact that a query returns random values

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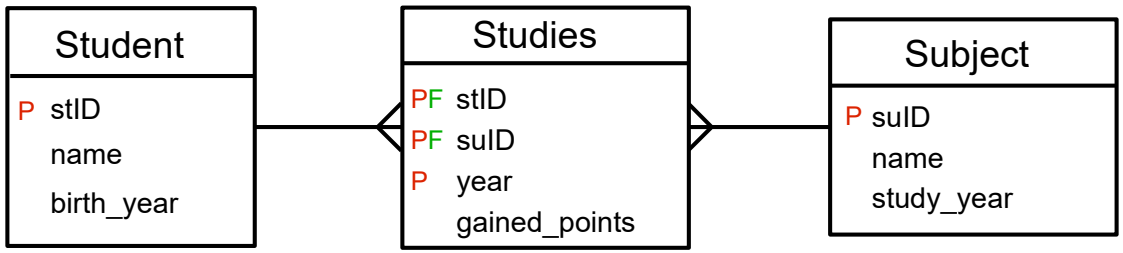
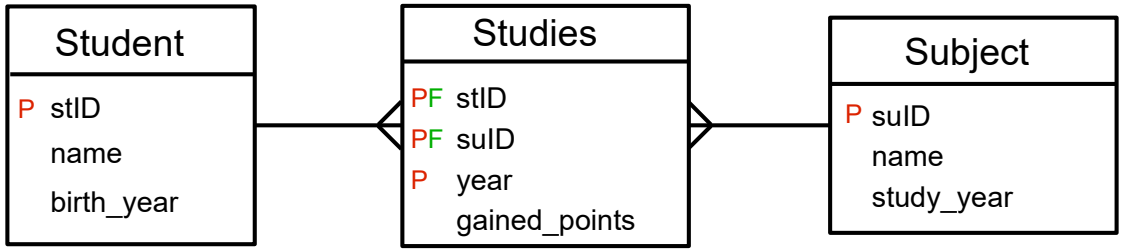
Example: GROUP BY, LEFT JOIN and cond.



- *List names of all subjects together with numbers of students who study or studied particular subjects in year 2010.*
  - ```
    SELECT Su.name, COUNT(distinct Su.suID)
    FROM Subject Su
    LEFT JOIN Studies Sy ON Su.suID = Sy.suID
    WHERE Sy.year = 2010
    GROUP BY Su.name
    ```
    ```

Example: GROUP BY, LEFT JOIN and cond.



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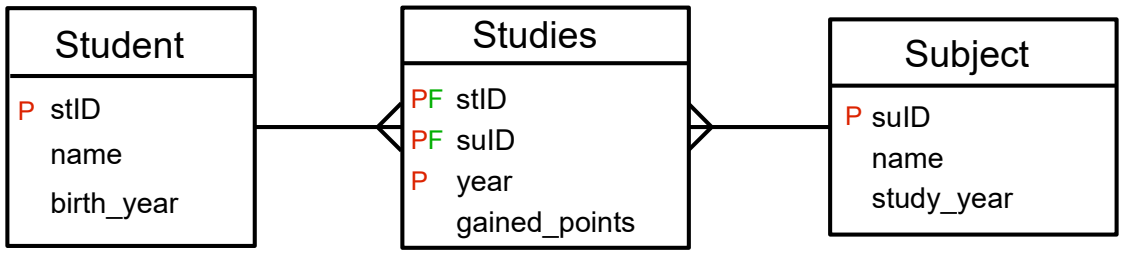
    ```
  - Incorrect! Condition has to be part of left join.
    ```

Example: GROUP BY, LEFT JOIN and cond.



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    ```

Subquery Behind SELECT

- We can rewrite the GROUP BY queries that there is no GROUP BY clause

```
SELECT year, COUNT(*)
FROM Subject
GROUP BY year
```

$\Rightarrow$

Subquery Behind SELECT

- We can rewrite the GROUP BY queries that there is no GROUP BY clause
- The solution uses *dependent subqueries* behind SELECT

```
SELECT year, COUNT(*)
FROM Subject
GROUP BY year
```

$\Rightarrow$

```
SELECT year, (
    SELECT COUNT(*)
    FROM Subject s2
    WHERE s1.year = s2.year
  )
FROM Subject s1
```

Subquery Behind SELECT

- In certain situations it may be easier to use dependent subqueries

```
SELECT st.stID,
       COUNT(*)
FROM Student st
LEFT JOIN Studies ss
  ON st.stID = ss.stID
GROUP BY st.stID
```

$\Rightarrow$

Subquery Behind SELECT

- In certain situations it may be easier to use dependent subqueries
- We can avoid LEFT JOIN as well [1]

```
SELECT st.stID,
       COUNT(*)
FROM Student st
LEFT JOIN Studies ss
  ON st.stID = ss.stID
GROUP BY st.stID
```

⇒

```
SELECT st.stID, (
    SELECT COUNT(*)
    FROM Studies ss
    WHERE st.stID = ss.stID
  )
FROM Student st
```

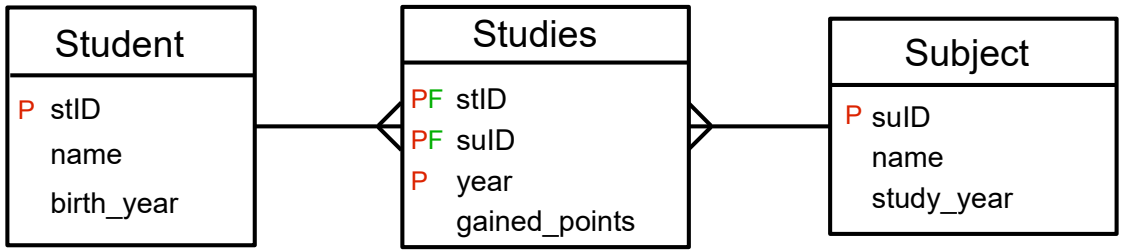
[1] Curious which solution is better?
https://github.com/RadimBaca/Postgre_aggregation

Having

- SELECT with grouping:

  SELECT $A_1, \ldots, A_n$
  FROM R_1
  JOIN R_2 ON *join_condition*
  WHERE *condition*1
  GROUP BY $A_1, \ldots, A_n$
  HAVING *condition*2 - condition using an aggregation

Example: HAVING

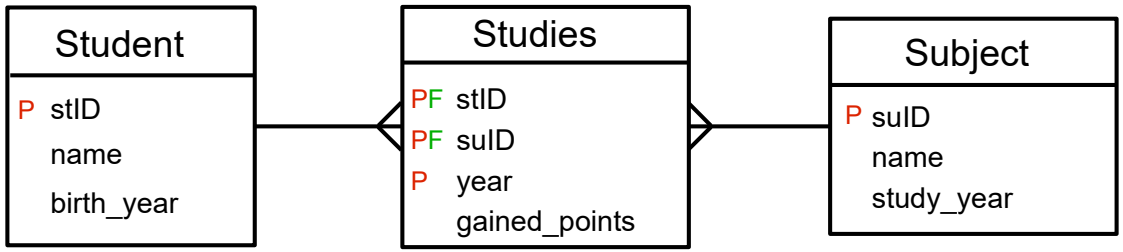


- *List names of all subjects that are/were studied at least by two students.*

```
SELECT suID FROM Studies
GROUP BY suID HAVING Count(distinct stID) > 1
```

- The HAVING clause primarily simplifies notation of such queries
- Again we can use dependent subqueries to avoid HAVING clause as well

Example: HAVING



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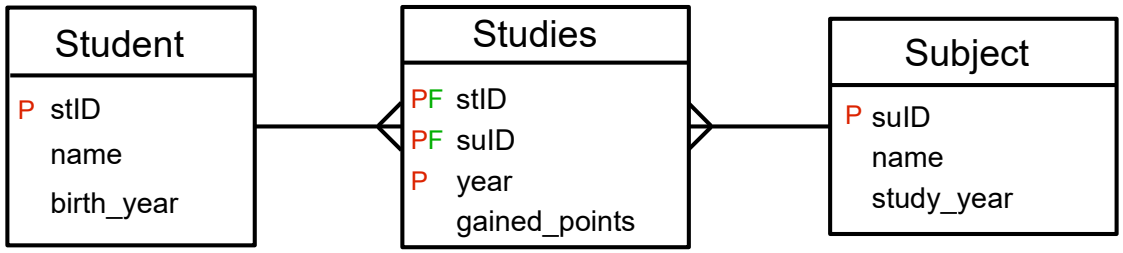
Example: HAVING



- *List names of all subjects that are/were studied at least by two students.*

```
SELECT distinct s1.suID
FROM Studies s1
WHERE 1 < (SELECT Count(distinct stID)
           FROM Studies s2
           WHERE s1.suID = s2.suID)
```

Clause Priority

1. `FROM`
2. `JOIN`
3. `WHERE`
4. `GROUP BY`
5. `HAVING`
6. `SELECT`
7. `DISTINCT`
8. `ORDER BY`
9. `FETCH/NEXT`

- Semantic order
- Not a query processing order!

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- Semantic order
- Not a query processing order!
- However this *is not* possible due to this ordering:
-
```
SELECT count(*) c
FROM Student
GROUP BY birth_year
HAVING c = 1
```

Order of Evaluation

1. `FROM`
2. `JOIN`
3. `WHERE`
4. `GROUP BY`
5. `HAVING`
6. `SELECT`
7. `DISTINCT`
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- Semantic order
- Not a query processing order!
- And this *is* possible:
- ```
  SELECT count(*) c
  FROM Student
  GROUP BY birth_year
  ORDER BY c
  ```
  ```

NULL

- `Null` value represent missing data
- We define whether an attribute can have a `null` value or not during the table definition (lecture 6)
- Primary key are the only type of attributes that can not have `null` values at all

Three Value Logic (3VL)

- Every condition in SQL is evaluated into `true`, `false` or `unknown`
- Row is in the result only if the result of the condition is `true`
- Examples when a predicate returns unknown:
  - `attribute = null`
  - `unknown and true`
  - `unknown or false`

3VL Paradoxes

- `P or not P` is not always true
- ```
  SELECT *
  FROM student
  WHERE birth_year = NULL or
      NOT birth_year = NULL
  ```
- The predicate is evaluated to `unknown` for each row since the comparisons are evaluated to `unknown`
  ```

3VL Paradoxes

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3VL Paradoxes

- `Attribute NOT IN (null)` is never true
- ```
  SELECT *
  FROM student
  WHERE birth_year NOT IN (1980, null)
  ```



- ```
  SELECT *
  FROM student
  WHERE birth_year != 1980 or
        birth_year != null
  ```

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  ⇓

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References

- Course home pages `http://dbedu.cs.vsb.cz`