

Grouping the aggregated rows and using sub queries

- The learning objectives for this week are:
 - Knowing how the `GROUP BY` clause operates and how it is related to the aggregate functions
 - Knowing how to use the aggregate functions in filtering with the `HAVING` clause
 - Knowing what are subqueries and how they can be used in a `SELECT` statement
 - Knowing different kind of use-cases for subqueries, including row filter criteria, correlated subqueries, in the `SELECT` list, in the `HAVING` clause, and in the `FROM` clause

Grouping the aggregated rows

- So, an aggregate function (such as `COUNT` and `SUM`) performs a calculation for **multiple rows so that the end result is a single value**
- However, in many cases we want to get a certain summarized information for specific group of rows, for example "*what's the average grade from each course?*" or "*what is the average grade of each student?*"
- To achieve this, we need to **group** the rows based on a specific column (such as `course_code` or `student_number`) and **perform the aggregate function for each group separately**
- This can be done using the `GROUP BY` clause

The GROUP BY clause

```
GROUP BY column_list [ HAVING group_filtering_condition ]
```

- The `GROUP BY` clause uses a column or a group of columns in a `SELECT` statement to form **groups of rows which the aggregate function operators on**:

```
-- what's the average grade from each course?  
SELECT course_code, AVG(grade) as average_grade FROM CourseGrade  
-- form the groups based on the course_code  
GROUP BY course_code
```

The GROUP BY clause

- The result table will have a row for **each distinct column value** of the `GROUP BY` column
- Each row has the corresponding aggregate function result for that group
- In the example's case the result table would contain the average grade for each distinct `course_code` :

<code>course_code</code>	<code>average_grade</code>
a290	2.5
a450	3.0
...	...

The GROUP BY clause

- As mentioned, the `GROUP BY` clause can have multiple columns
- In this case the result table will have a row for **each distinct combination of column values** of the `GROUP BY` columns

```
-- what's the average grade from each course instance?
```

```
SELECT course_code, instance_number, AVG(grade) as average_grade FROM CourseGrade  
-- form the groups based on the course_code and instance_number  
GROUP BY course_code, instance_number
```

The GROUP BY clause

- In the example's case the result table would contain the average grade for each distinct combination of `course_code` and `instance_number`:

```
-- what is the average grade of each course instance?
```

```
SELECT course_code, instance_number, AVG(grade) as average_grade FROM CourseGrade  
GROUP BY course_code, instance_number
```

course_code	instance_number	average_grade
a290	1	4.5
a290	2	3.0
a450	1	2.9
...

The GROUP BY clause

- It is worth noting that in the `SELECT` statement we can only select columns that are either aggregate functions or columns used in the `GROUP BY` clause:

```
-- ❌ student_number is not an aggregate function, nor it is in the GROUP BY clause.  
-- This will lead into an error  
SELECT course_code, student_number, AVG(grade) as average_grade FROM CourseGrade  
GROUP BY course_code
```

- This causes the following error:

"Column 'CourseGrade.student_number' is invalid in the select list because it is not contained in either an aggregate function or the GROUP BY clause"

Combining with the WHERE clause

- We can use the `WHERE` clause to apply filtering **before the grouping is done** by the `GROUP BY` clause:

```
-- how many employees whose salary is above 10000 there are in each department?
```

```
SELECT deptno, COUNT(*) AS number_of_employees  
FROM Employee  
WHERE salary > 10000 -- The WHERE clause is applied before grouping is done  
GROUP BY deptno  
ORDER BY deptno
```

Using aggregate functions in filtering

- The `WHERE` clause can't use aggregate functions because it is **applied before** the `GROUP BY` clause while the query is executed
- Instead, we can use the `HAVING` clause to filter based on aggregate functions:

```
-- which departments have more than 10 employees?  
-- ❌ can't use aggregate functions with the WHERE clause, this won't work  
SELECT deptno, COUNT(*) AS number_of_employees  
FROM Employee  
WHERE COUNT(*) > 10  
GROUP BY deptno
```

```
-- ✅ we should use the HAVING clause instead  
SELECT deptno, COUNT(*) AS number_of_employees  
FROM Employee  
GROUP BY deptno  
HAVING COUNT(*) > 10
```

Examples of GROUP BY clause

- What do we get from the following queries?

```
-- ? what do we get from this query?
```

```
SELECT campus_code, COUNT(campus_code) AS number_of_teachers  
FROM Teacher  
GROUP BY campus_code
```

```
-- ? what do we get from this query?
```

```
SELECT course_code, AVG(grade) AS average_grade  
FROM CourseGrade  
WHERE grade_date BETWEEN '2024-01-01' AND '2024-12-31'  
GROUP BY course_code  
HAVING COUNT(grade) > 10
```

SQL logical query processing order



- The following diagram represents **the logical query processing order** in SQL
- We can only use data from **the previous phases**, meaning that, for example a `WHERE` statement can't use data from a `GROUP BY` statement, but `ORDER BY` statement can

```
SELECT deptno, COUNT(*) AS number_of_employees
FROM Employee
-- ✗ Not ok, WHERE statement is processed before GROUP BY statement
WHERE COUNT(*) > 10
GROUP BY deptno
-- ✓ Ok, GROUP BY statement is processed before ORDER BY statement
ORDER BY number_of_employees
```

Subqueries

- A **subquery** is a query within another query, which is used to retrieve data that will be processed by the outer query
- The most common use case for a subquery is to use subquery result in a filtering condition in a `WHERE` clause
- Subqueries can also contain another subquery
- Most of our examples will cover usage of subqueries with the `SELECT` statement, but they can be used with e.g. `INSERT INTO` and `UPDATE` statements as well

```
--- who are the teachers with a above average salary?
```

```
SELECT first_name, surname, salary
FROM Teacher
WHERE salary > (
    -- subquery for calculating the average salary
    SELECT AVG(salary) FROM Teacher
)
```

Subqueries in a SELECT statement

- The subquery is placed inside brackets `()` and its result will be passed to the outer query
- In a `SELECT` statement, we can nest a subquery within a:
 - `WHERE` clause as a row filter criteria to be used in the condition
 - `WHERE` clause as a correlated subquery
 - `SELECT` list as a column expression or as a part of a column expression
 - `HAVING` clause as a group filter criteria within a `GROUP BY` clause
 - `FROM` clause to create a temporary derived table
 - `WITH` clause to create a temporary named result set, known as common table expression (CTE)

Subquery as a row filter criteria

- The most common use of the subquery is to use it as a row filter criteria similarly as e.g. literals:

```
-- using literal 5000 as a filter criteria
WHERE salary > 5000

-- using a subquery as a filter criteria (note the brackets wrapping the subquery)
WHERE salary > (
    -- the result of the subquery will be used in the comparison
    SELECT AVG(salary) FROM Teacher
)
```

Subquery as a row filter criteria

```
-- which countries have larger population than Australia?  
SELECT country_name, population  
FROM Country  
WHERE population > (  
    -- subquery for getting the population of Australia  
    SELECT population  
    FROM Country  
    WHERE country_name = 'Australia'  
)  
  
-- ? what do we get from this query?  
SELECT country_name, population  
FROM Country  
WHERE population = (SELECT MAX(population) FROM Country)  
  
-- ? what do we get from this query?  
SELECT empno, empname  
FROM Employee  
WHERE empno NOT IN (SELECT empno FROM Project_Employee)
```

Correlated subqueries

- A **correlated subquery** (inner query) uses one or more values from the outer query
- The correlated subquery is executed once for each row that is selected by the outer query

```
-- which students are from a city where there is a campus?  
SELECT city, surname, given_name, student_number  
FROM Student  
-- using a correlated subquery  
WHERE EXISTS (  
    -- does any such row EXIST in the Campus table where Campus.city = Student.city  
    SELECT * FROM Campus  
    WHERE Campus.city = Student.city  
)
```

Performance of correlated subqueries

- ─ 🐛 In the example, the correlated subquery is executed once per each student, which will degrade the query performance
- ─ 🚀 Sometimes It might be better to use a non-correlated subquery to improve readability and performance:

```
-- 🚀 same result, with using a non-correlated subquery
SELECT city, surname, given_name, student_number
FROM Student
WHERE city IN (SELECT city FROM Campus)
```

Subqueries within a SELECT list

- A subquery can be used in the `SELECT` list to calculate a value for a column that will be displayed in the result table:

```
-- what is the percentage of red cars?  
SELECT (SELECT 100.0 * COUNT(*) FROM Car WHERE colour = 'red') / COUNT(*)  
      AS percentage_of_red_cars  
FROM Car
```

```
-- what is the average grade for each student?  
SELECT  
student_number, (  
    SELECT AVG(grade) FROM CourseGrade  
    WHERE CourseGrade.student_number = Student.student_number  
) AS average_grade  
FROM Student
```

Subqueries within a HAVING clause

- Similarly as in the `WHERE` clause, a subquery can be used in the `HAVING` clause to filter the groups based on the aggregate function result:

```
-- in which departments the average salary is higher than the average salary of all employees?  
SELECT deptno, AVG(salary) AS average_salary  
FROM Employee  
GROUP BY deptno HAVING AVG(salary) > (SELECT AVG(salary) FROM Employee)
```

Subqueries within a FROM clause

- A subquery can be used in the `FROM` clause to create a temporary derived table that can be used in the outer query
- The subquery **must have an alias name** (`FROM (subquery) AS alias_name`)
- The subquery's result set can be used in the `FROM` clause similarly to a normal table
- Let's consider the following example:

"What is the count, and the minimum and the maximum grade point average (GPA) of such students who have passed more than 20 courses?"

Subqueries within a FROM clause

- First, we define a query for the grade point average of students who have passed more than 20 courses:

```
SELECT AVG(grade) AS gpa
FROM CourseGrade
WHERE grade > 0
GROUP BY student_number
HAVING COUNT(*) > 20
```

Subqueries within a FROM clause

- Then, we use this query as a subquery in the `FROM` clause:

```
SELECT COUNT(*) AS count, MIN(gpa) AS min_gpa, MAX(gpa) AS max_gpa
FROM (
    -- our subquery from the previous slide
    SELECT AVG(grade) AS gpa
    FROM CourseGrade
    WHERE grade > 0
    GROUP BY student_number
    HAVING COUNT(*) > 20
) AS GpaTable -- ! alias name for the subquery is required
```

Subqueries within a WITH clause

- A subquery can be used in the `WITH` clause to create a temporary named result set, known as common table expression (CTE)
- CTEs are useful for improving the readability of the query and can be used multiple times in the query
- Let's consider the following example:

"Which department has the highest number of employees"

Subqueries within a WITH clause

- First, we define a CTE with the `WITH` clause for the number of employees in each department:

```
-- common table expression
WITH DeptInfo (deptno, employee_count) AS (
    SELECT deptno, COUNT(*) AS employee_count
    FROM Employee
    GROUP BY deptno
)
```

Subqueries within a WITH clause

- Then, we use this CTE in the main query to find the department with the highest number of employees:

```
-- common table expression from the previous slide
WITH DeptInfo (deptno, employee_count) AS (
    SELECT deptno, COUNT(*) AS employee_count
    FROM Employee
    GROUP BY deptno
)

-- main query
SELECT deptno, employee_count
FROM DeptInfo -- using the CTE
WHERE employee_count = (SELECT MAX(employee_count) FROM DeptInfo) -- using the CTE again
```

Summary

- The `GROUP BY` clause is used to group the rows based on a specific column or columns
- The `HAVING` clause is used to filter the groups based on the aggregate function result
- Subqueries are queries within another query
- Subqueries can be used in a `SELECT` statement in the `WHERE` clause, `SELECT` list, `HAVING` clause, `FROM` clause, and `WITH` clause
- The `WITH` clause is used to create a temporary named result set, known as common table expression (CTE)