

8

Using Subqueries to Solve Queries

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Objectives

After completing this lesson, you should be able to do the following:

- Define subqueries
- Describe the types of problems that the subqueries can solve
- List the types of subqueries
- Write single-row, multiple-row, multiple-column subqueries

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In this lesson, you learn about the more advanced features of the `SELECT` statement. You can write subqueries in the `WHERE` clause of another SQL statement to obtain values based on an unknown conditional value. This lesson also covers single-row subqueries, multiple-row subqueries, and multiple-column subqueries.

Lesson Agenda

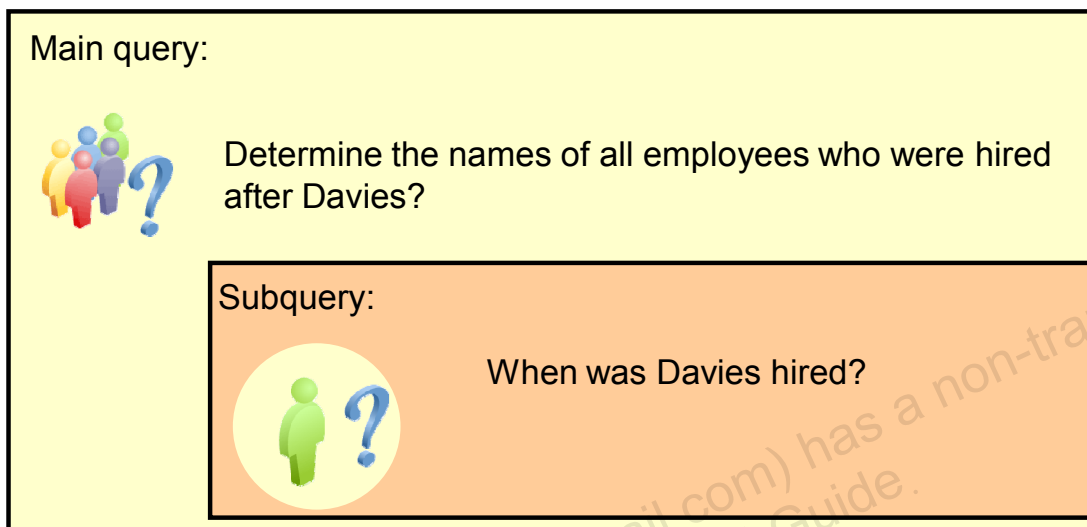
- Subquery: Types, syntax, and guidelines
- Single-row subqueries:
 - Group functions in a subquery
 - HAVING clause with subqueries
- Multiple-row subqueries
 - Using ALL or ANY operator
- Multiple-column subqueries
- Null values in a subquery

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Using a Subquery to Solve a Problem

Who is hired after Davies?



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Suppose you want to write a query to find out the names of all employees who were hired after Davies?

To solve this problem, you need *two* queries: one query to find when Davies was hired, and a second query to find who were hired after Davies.

You can solve this problem by combining the two queries, placing one query *inside* the other query.

The inner query (or *subquery*) returns a value that is used by the outer query (or *main query*). The execution plan of the query depends on the optimizer's decision on the structure of the subquery.

Subquery Syntax

- The subquery (inner query) executes *before* the main query (outer query).
- The result of the subquery is used by the main query.

```
SELECT    select_list
FROM      table
WHERE     expr operator
          (SELECT    select_list
           FROM      table);
```

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A subquery is a `SELECT` statement that is embedded in the clause of another `SELECT` statement. You can build powerful statements out of simple ones by using subqueries. They can be very useful when you need to select rows from a table with a condition that depends on the data in the table itself.

You can place the subquery in a number of SQL clauses, including the following:

- `WHERE` clause
- `HAVING` clause
- `FROM` clause

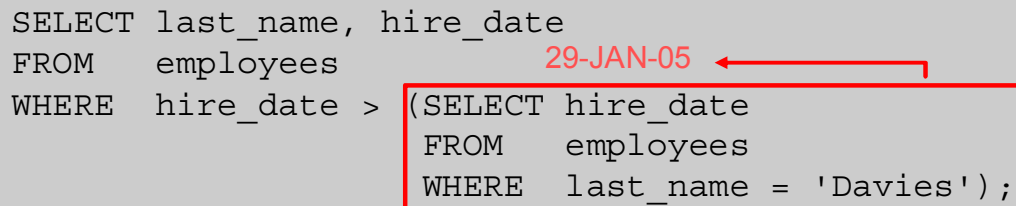
In the syntax:

operator includes a comparison condition such as `>`, `=`, or `IN`

The subquery is often referred to as a nested `SELECT`, sub-`SELECT`, or inner `SELECT` statement. The subquery generally executes first, and its output is used to complete the query condition for the main (or outer) query.

Using a Subquery

```
SELECT last_name, hire_date  
FROM   employees  
WHERE  hire_date > (SELECT hire_date  
                   FROM   employees  
                   WHERE  last_name = 'Davies');
```



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In the slide, the inner query determines the hire date of the employee Davies. The outer query takes the result of the inner query and uses this result to display all the employees who were hired after Davies.

Rules and Guidelines for Using Subqueries

- Enclose subqueries in parentheses.
- Place subqueries on the right side of the comparison condition for readability. (However, the subquery can appear on either side of the comparison operator.)
- Use single-row operators with single-row subqueries and multiple-row operators with multiple-row subqueries.

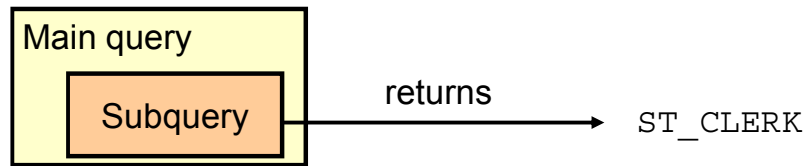
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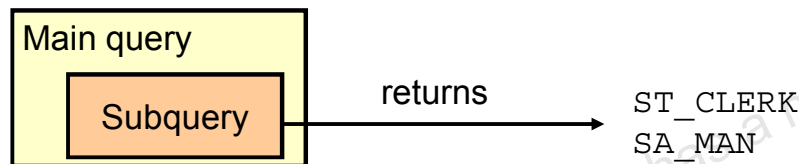
- A subquery must be enclosed in parentheses.
- Place the subquery on the right side of the comparison condition for readability. However, the subquery can appear on either side of the comparison operator.
- Two classes of comparison conditions are used in subqueries: single-row operators and multiple-row operators.

Types of Subqueries

- Single-row subquery



- Multiple-row subquery



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- **Single-row subqueries:** Queries that return only one row from the inner `SELECT` statement
- **Multiple-row subqueries:** Queries that return more than one row from the inner `SELECT` statement

Note: There are also multiple-column subqueries, which are queries that return more than one column from the inner `SELECT` statement. These are covered in the *Oracle Database: SQL Workshop II* course.

Lesson Agenda

- Subquery: Types, syntax, and guidelines
- Single-row subqueries:
 - Group functions in a subquery
 - HAVING clause with subqueries
- Multiple-row subqueries
 - Using ALL or ANY operator
- Multiple-column subqueries
- Null values in a subquery

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Single-Row Subqueries

- Return only one row
- Use single-row comparison operators

Operator	Meaning
=	Equal to
>	Greater than
>=	Greater than or equal to
<	Less than
<=	Less than or equal to
<>	Not equal to

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A single-row subquery is one that returns one row from the inner `SELECT` statement. This type of subquery uses a single-row operator. The slide gives a list of single-row operators.

Example

Display the employees whose job ID is the same as that of employee 141:

```
SELECT last_name, job_id
FROM   employees
WHERE  job_id =
        (SELECT job_id
         FROM   employees
         WHERE  employee_id = 141);
```

	LAST_NAME	JOB_ID
1	Rajs	ST_CLERK
2	Davies	ST_CLERK
3	Matos	ST_CLERK
4	Vargas	ST_CLERK

Executing Single-Row Subqueries

```
SELECT last_name, job_id, salary
FROM employees
WHERE job_id = (SELECT job_id
                FROM employees
                WHERE last_name = 'Taylor')
AND salary > (SELECT salary
              FROM employees
              WHERE last_name = 'Taylor');
```

	LAST_NAME	JOB_ID	SALARY
1	Abel	SA_REP	11000

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A SELECT statement can be considered as a query block. The example in the slide displays employees who do the same job as “Taylor,” but earn more salary than him.

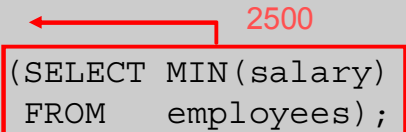
The example consists of three query blocks: the outer query and two inner queries. The inner query blocks are executed first, producing the query results `SA_REP` and `8600`, respectively. The outer query block is then processed and uses the values that were returned by the inner queries to complete its search conditions.

Both inner queries return single values (`SA_REP` and `8600`, respectively), so this SQL statement is called a single-row subquery.

Note: The outer and inner queries can get data from different tables.

Using Group Functions in a Subquery

```
SELECT last_name, job_id, salary
FROM employees
WHERE salary = (SELECT MIN(salary)
                FROM employees);
```

A red arrow points from the value '2500' to the equals sign in the WHERE clause. A red box highlights the subquery '(SELECT MIN(salary) FROM employees);'.

	LAST_NAME	JOB_ID	SALARY
1	Vargas	ST_CLERK	2500

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You can display data from a main query by using a group function in a subquery to return a single row. The subquery is in parentheses and is placed after the comparison condition.

The example in the slide displays the employee last name, job ID, and salary of all employees whose salary is equal to the minimum salary. The `MIN` group function returns a single value (2500) to the outer query.

HAVING Clause with Subqueries

- The Oracle server executes the subqueries first.
- The Oracle server returns results into the HAVING clause of the main query.

```
SELECT department_id, MIN(salary)
FROM employees
GROUP BY department_id
HAVING MIN(salary) > (SELECT MIN(salary)
                     FROM employees
                     WHERE department_id = 30);
```

	DEPARTMENT_ID	MIN(SALARY)
1	100	6900
2	(null)	7000
3	90	17000
4	20	6000
5	70	10000
6	110	8300
7	80	6100
8	40	6500
9	60	4200
10	10	4400

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You can use subqueries not only in the WHERE clause, but also in the HAVING clause. The Oracle server executes the subquery and the results are returned into the HAVING clause of the main query.

The SQL statement in the slide displays all the departments that have a minimum salary greater than that of department 30.

Example

Find the job with the lowest average salary.

```
SELECT job_id, AVG(salary)
FROM employees
GROUP BY job_id
HAVING AVG(salary) = (SELECT MIN(AVG(salary))
                     FROM employees
                     GROUP BY job_id);
```

What Is Wrong with This Statement?

```
SELECT employee_id, last_name
FROM   employees
WHERE  salary =
      (SELECT   MIN(salary)
       FROM     employees
       GROUP BY department_id);
```

```
ORA-01427: single-row subquery returns more than one row
01427. 00000 - "single-row subquery returns more than one row"
*Cause:
*Action:
```

Single-row operator with
multiple-row subquery

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A common error with subqueries occurs when more than one row is returned for a single-row subquery.

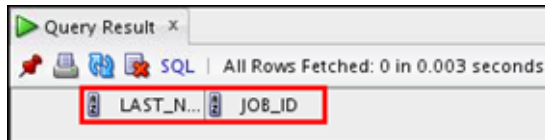
In the SQL statement in the slide, the subquery contains a `GROUP BY` clause, which implies that the subquery will return multiple rows, one for each group that it finds. In this case, the results of the subquery are 4400, 6000, 2500, 4200, 7000, 17000, and 8300.

The outer query takes those results and uses them in its `WHERE` clause. The `WHERE` clause contains an equal (`=`) operator, a single-row comparison operator that expects only one value. The `=` operator cannot accept more than one value from the subquery and, therefore, generates the error.

To correct this error, change the `=` operator to `IN`.

No Rows Returned by the Inner Query

```
SELECT last_name, job_id
FROM   employees
WHERE  job_id =
      (SELECT job_id
       FROM   employees
       WHERE  last_name = 'Haas');
```



Subquery returns no rows because there is no employee named "Haas."

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Another common problem with subqueries occurs when no rows are returned by the inner query.

In the SQL statement in the slide, the subquery contains a `WHERE` clause. Presumably, the intention is to find the employee whose name is Haas. The statement is correct, but selects no rows when executed because there is no employee named Haas. Therefore, the subquery returns no rows.

The outer query takes the results of the subquery (null) and uses these results in its `WHERE` clause. The outer query finds no employee with a job ID equal to `NULL`, and so returns no rows. If a job existed with a value of null, the row is not returned because comparison of two null values yields a null; therefore, the `WHERE` condition is not true.

Lesson Agenda

- Subquery: Types, syntax, and guidelines
- Single-row subqueries:
 - Group functions in a subquery
 - HAVING clause with subqueries
- Multiple-row subqueries
 - Use IN, ALL, or ANY
- Multiple-column subqueries
- Null values in a subquery

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Multiple-Row Subqueries

- Return more than one row
- Use multiple-row comparison operators

Operator	Meaning
IN	Equal to any member in the list
ANY	Must be preceded by =, !=, >, <, <=, >=. Returns TRUE if at least one element exists in the result set of the subquery for which the relation is TRUE.
ALL	Must be preceded by =, !=, >, <, <=, >=. Returns TRUE if the relation is TRUE for all elements in the result set of the subquery.

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Subqueries that return more than one row are called multiple-row subqueries. You use a multiple-row operator, instead of a single-row operator, with a multiple-row subquery. The multiple-row operator expects one or more values:

```
SELECT last_name, salary, department_id
FROM   employees
WHERE  salary IN (SELECT   MIN(salary)
                  FROM     employees
                  GROUP BY department_id);
```

Example

Find the employees who earn the same salary as the minimum salary for each department.

The inner query is executed first, producing a query result. The main query block is then processed and uses the values that were returned by the inner query to complete its search condition. In fact, the main query appears to the Oracle server as follows:

```
SELECT last_name, salary, department_id
FROM   employees
WHERE  salary IN (2500, 4200, 4400, 6000, 7000, 8300,
                8600, 17000);
```

Using the ANY Operator in Multiple-Row Subqueries

```
SELECT employee_id, last_name, job_id, salary
FROM   employees
WHERE  salary < ANY
      (SELECT salary
       FROM   employees
       WHERE  job_id = 'IT_PROG')
AND    job_id <> 'IT_PROG';
```

9000, 6000, 4200

EMPLOYEE_ID	LAST_NAME	JOB_ID	SALARY
1	144 Vargas	ST_CLERK	2500
2	143 Matos	ST_CLERK	2600
3	142 Davies	ST_CLERK	3100
4	141 Rajs	ST_CLERK	3500
5	200 Whalen	AD_ASST	4400
...			
9	206 Gietz	AC_ACCOUNT	8300
10	176 Taylor	SA_REP	8600

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The ANY operator (and its synonym, the SOME operator) compares a value to *each* value returned by a subquery. The slide example displays employees who are not IT programmers and whose salary is less than that of any IT programmer. The maximum salary that a programmer earns is \$9,000.

- <ANY means less than the maximum.
- >ANY means more than the minimum.
- =ANY is equivalent to IN.

Using the ALL Operator in Multiple-Row Subqueries

```
SELECT employee_id, last_name, job_id, salary
FROM   employees
WHERE  salary < ALL
      (SELECT salary
       FROM   employees
       WHERE  job_id = 'IT_PROG')
AND    job_id <> 'IT_PROG';
```

9000, 6000, 4200

	EMPLOYEE_ID	LAST_NAME	JOB_ID	SALARY
1	141	Rajs	ST_CLERK	3500
2	142	Davies	ST_CLERK	3100
3	143	Matos	ST_CLERK	2600
4	144	Vargas	ST_CLERK	2500

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The ALL operator compares a value to every value returned by a subquery. The example in the slide displays employees whose salary is less than the salary of all employees with a job ID of IT_PROG and whose job is not IT_PROG.

>ALL means more than the maximum and <ALL means less than the minimum.

The NOT operator can be used with IN, ANY, and ALL operators.

Multiple-Column Subqueries

- A multiple-column subquery returns more than one column to the outer query.
- Column comparisons in multiple column comparisons can be pairwise or nonpairwise.
- A multiple-column subquery can also be used in the `FROM` clause of a `SELECT` statement.

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A multiple-column subquery returns more than one column to the outer query and can be listed in the outer query's `FROM`, `WHERE`, or `HAVING` clause.

If you want to compare two or more columns, you must write a compound `WHERE` clause using logical operators. Multiple-column subqueries enable you to combine duplicate `WHERE` conditions into a single `WHERE` clause.

`IN` operator is used to check a value within a set of values. The list of values may come from the results returned by a subquery.

Syntax:

```
SELECT column, column, ...
FROM table
WHERE (column, column, ...) IN
      (SELECT column, column, ...
       FROM table
       WHERE condition);
```

Multiple-Column Subquery: Example

Display all the employees with the lowest salary in each department

```
SELECT first_name, department_id, salary
FROM employees
WHERE (salary, department_id) IN
    (SELECT min(salary), department_id
     FROM employees
     GROUP BY department_id)
ORDER BY department_id;
```

	FIRST_NAME	DEPARTMENT_ID	SALARY
1	Jennifer	10	4400
2	Pat	20	6000
3	Peter	50	2500
4	Diana	60	4200
5	Jonathon	80	8600
6	Neena	90	17000
7	Lex	90	17000
8	William	110	8300

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The example in the slide is that of a multiple-column subquery because the subquery returns more than one column.

The inner query is executed first, and it returns the lowest salary and department_id for each department. The main query block is then processed and uses the values that were returned by the inner query to complete its search condition.

Lesson Agenda

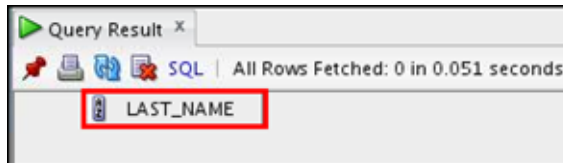
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Null Values in a Subquery

```
SELECT emp.last_name
FROM   employees emp
WHERE  emp.employee_id NOT IN
                                (SELECT mgr.manager_id
                                FROM   employees mgr);
```



Subquery returns no rows because one of the values returned by a subquery is null.

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The SQL statement in the slide attempts to display all the employees who do not have any subordinates. Logically, this SQL statement should have returned 12 rows. However, the SQL statement does not return any rows. One of the values returned by the inner query is a null value and, therefore, the entire query returns no rows.

The reason is that all conditions that compare a null value result in a null. So whenever null values are likely to be part of the results set of a subquery, do not use the NOT IN operator. The NOT IN operator is equivalent to \neq ALL.

Notice that the null value as part of the results set of a subquery is not a problem if you use the IN operator. The IN operator is equivalent to $=$ ANY. For example, to display the employees who have subordinates, use the following SQL statement:

```
SELECT emp.last_name
FROM   employees emp
WHERE  emp.employee_id IN
                                (SELECT mgr.manager_id
                                FROM   employees mgr);
```

Alternatively, a `WHERE` clause can be included in the subquery to display all employees who do not have any subordinates:

```
SELECT last_name FROM employees
WHERE  employee_id NOT IN
        (SELECT manager_id
         FROM   employees
         WHERE  manager_id IS NOT NULL);
```


Quiz

Using a subquery is equivalent to performing two sequential queries and using the result of the first query as the search values in the second query.

- a. True
- b. False

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Answer: a

Summary

In this lesson, you should have learned how to:

- Define subqueries
- Identify the types of problems that the subqueries can solve
- Write single-row, multiple-row, multiple-column subqueries

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In this lesson, you should have learned how to use subqueries. A subquery is a `SELECT` statement that is embedded in the clause of another SQL statement. Subqueries are useful when a query is based on a search criterion with unknown intermediate values.

Subqueries have the following characteristics:

- Can pass one row of data to a main statement that contains a single-row operator, such as `=`, `<>`, `>`, `>=`, `<`, or `<=`
- Can pass multiple rows of data to a main statement that contains a multiple-row operator, such as `IN`
- Are processed first by the Oracle server, after which the `WHERE` or `HAVING` clause uses the results
- Can contain group functions

Practice 8: Overview

This practice covers the following topics:

- Creating subqueries to query values based on unknown criteria
- Using subqueries to find out the values that exist in one set of data and not in another

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In this practice, you write complex queries using nested `SELECT` statements.

For practice questions, you may want to create the inner query first. Make sure that it runs and produces the data that you anticipate before you code the outer query.

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