Window Functions

What is a Window Function?

A window function(AKA **Analytical Functions**) performs a **calculation across a set of rows related to the current row**, without collapsing rows like GROUP BY.

Key idea

- GROUP BY → reduces rows
- Window function → **keeps** all rows and adds calculated values

Why Use Window Functions?

They are useful when you want:

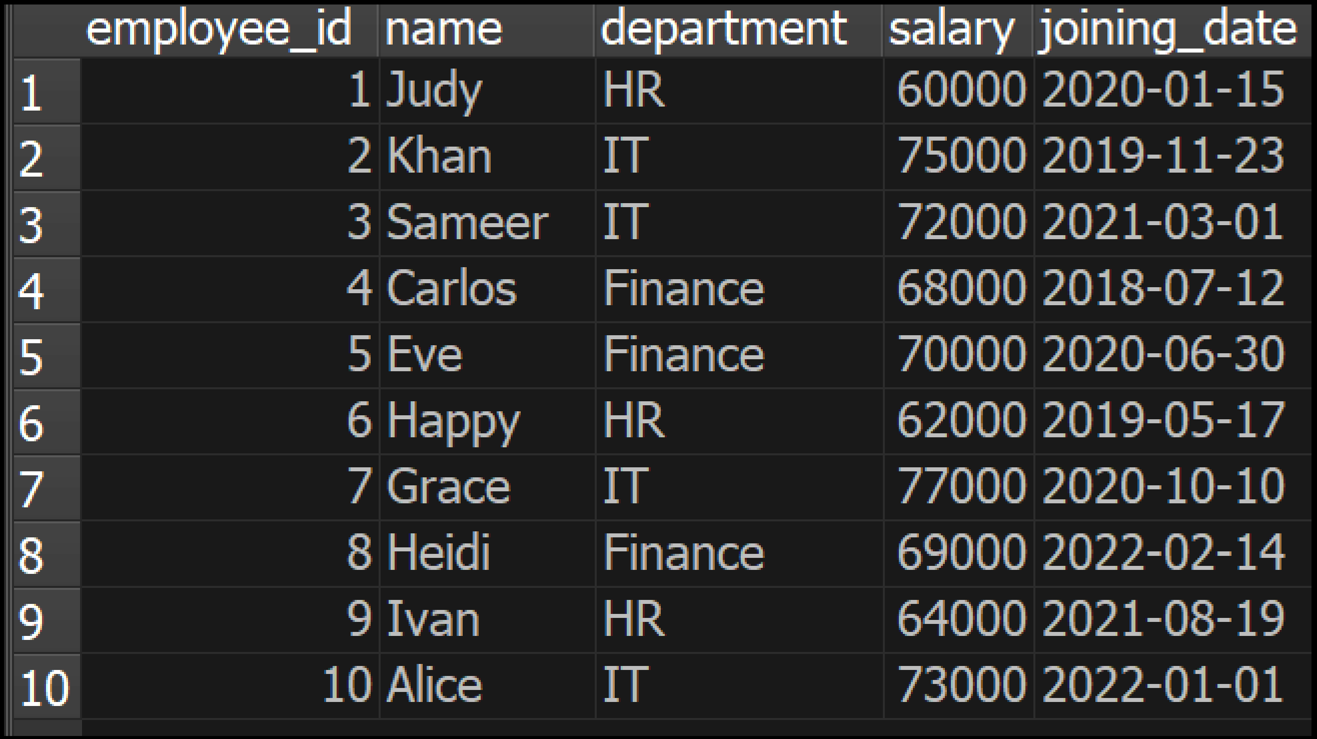
- Running totals
- Ranking (1st, 2nd, 3rd…)
- Comparing **current row** with **previous/next row**
- Aggregates **without losing row-level detail**

Basic Syntax (Very Important)

```
function_name(...) OVER (
    PARTITION BY column_name
    ORDER BY column_name
)
```

Part	Meaning
`function_name`	Aggregate or analytic function
`OVER`	Defines the window
`PARTITION BY`	Splits data into groups
`ORDER BY`	Defines order within each group

```
CREATE TABLE employees (
   employee_id INTEGER NOT NULL PRIMARY KEY,
   name VARCHAR(100),
   department VARCHAR(50),
   salary INTEGER,
   joining_date DATE
);

INSERT INTO employees (employee_id, name,
department, salary, joining_date) VALUES
(1, 'Judy', 'HR', 60000, '2020-01-15'),
(2, 'Khan', 'IT', 75000, '2019-11-23'),
(3, 'Sameer', 'IT', 72000, '2021-03-01'),
(4, 'Carlos', 'Finance', 68000, '2018-07-12'),
(5, 'Eve', 'Finance', 70000, '2020-06-30'),
(6, 'Happy', 'HR', 62000, '2019-05-17'),
(7, 'Grace', 'IT', 77000, '2020-10-10'),
(8, 'Heidi', 'Finance', 69000, '2022-02-14'),
(9, 'Ivan', 'HR', 64000, '2021-08-19'),
(10, 'Alice', 'IT', 73000, '2022-01-01');
```

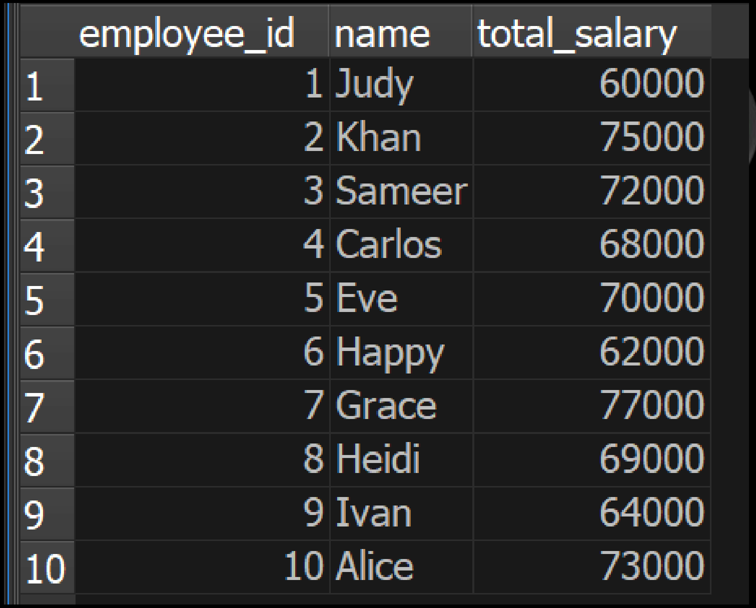


	employee_id	name	department	salary	joining_date
1	1	Judy	HR	60000	2020-01-15
2	2	Khan	IT	75000	2019-11-23
3	3	Sameer	IT	72000	2021-03-01
4	4	Carlos	Finance	68000	2018-07-12
5	5	Eve	Finance	70000	2020-06-30
6	6	Happy	HR	62000	2019-05-17
7	7	Grace	IT	77000	2020-10-10
8	8	Heidi	Finance	69000	2022-02-14
9	9	Ivan	HR	64000	2021-08-19
10	10	Alice	IT	73000	2022-01-01

Running totals

With Group by clause, you **cannot get running total**:

```
SELECT
   employee_id,
   name,
   SUM(salary) AS total_salary
FROM employees
GROUP BY employee_id, name;
```

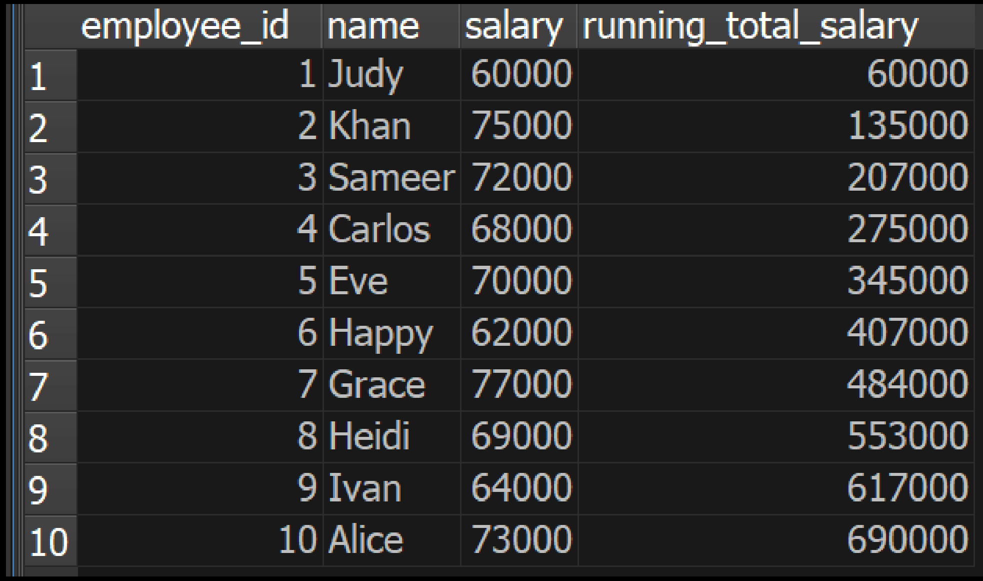


	employee_id	name	total_salary
1	1	Judy	60000
2	2	Khan	75000
3	3	Sameer	72000
4	4	Carlos	68000
5	5	Eve	70000
6	6	Happy	62000
7	7	Grace	77000
8	8	Heidi	69000
9	9	Ivan	64000
10	10	Alice	73000

With Window function **you can get Running Total** Example (No partition, no extra clauses). This is same as getting **cumulative sum**

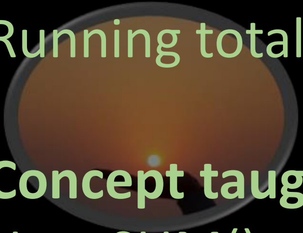
```
SELECT
   employee_id,
   name,
   salary,
   SUM(salary) OVER (ORDER BY employee_id) AS running_total_salary
FROM employees;
```

Here the order is by employee_id



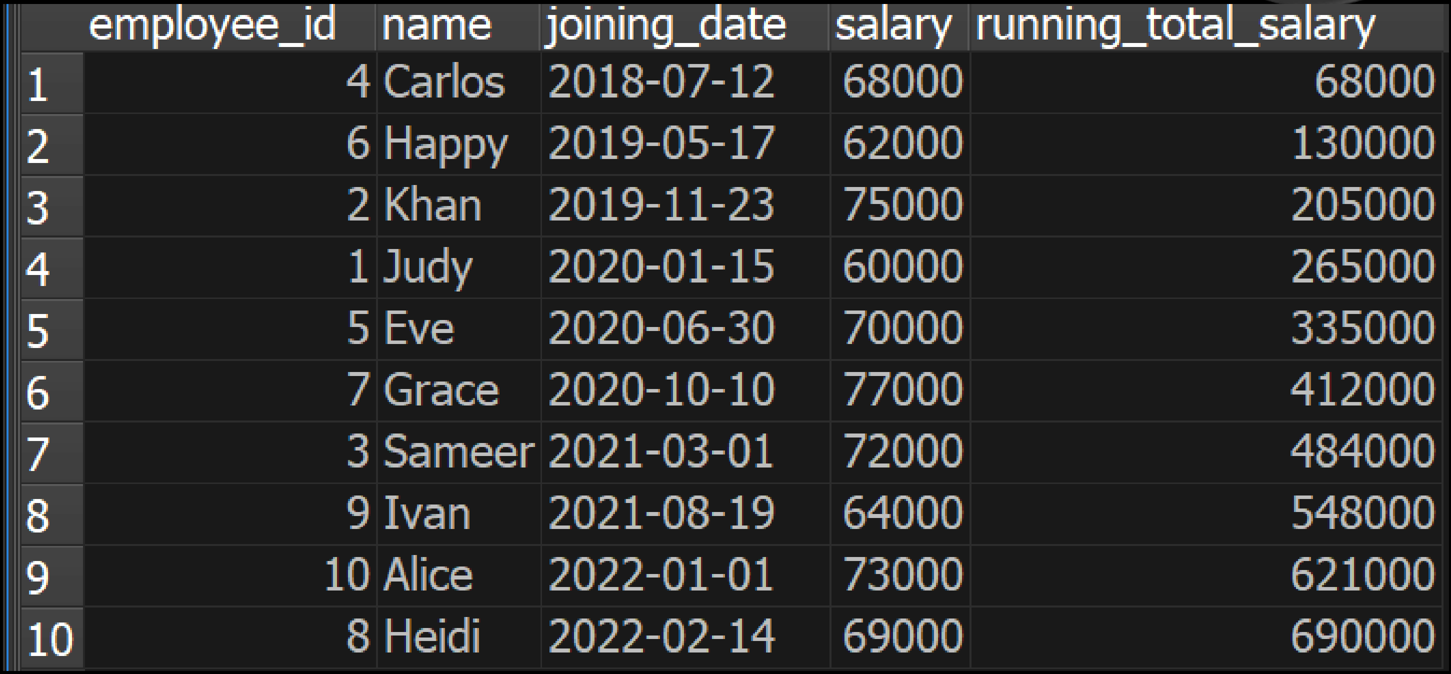
	employee_id	name	salary	running_total_salary
1	1	Judy	60000	60000
2	2	Khan	75000	135000
3	3	Sameer	72000	207000
4	4	Carlos	68000	275000
5	5	Eve	70000	345000
6	6	Happy	62000	407000
7	7	Grace	77000	484000
8	8	Heidi	69000	553000
9	9	Ivan	64000	617000
10	10	Alice	73000	690000

Running total of **salary by joining date (company-wide)**



Concept taught:
How SUM() with OVER() works and how ORDER BY defines the running sequence.

```
SELECT
   employee_id,
   name,
   joining_date,
   salary,
   SUM(salary) OVER (
      ORDER BY joining_date
      ROWS BETWEEN UNBOUNDED PRECEDING AND CURRENT ROW
   ) AS running_total_salary
FROM employees
ORDER BY joining_date;
```



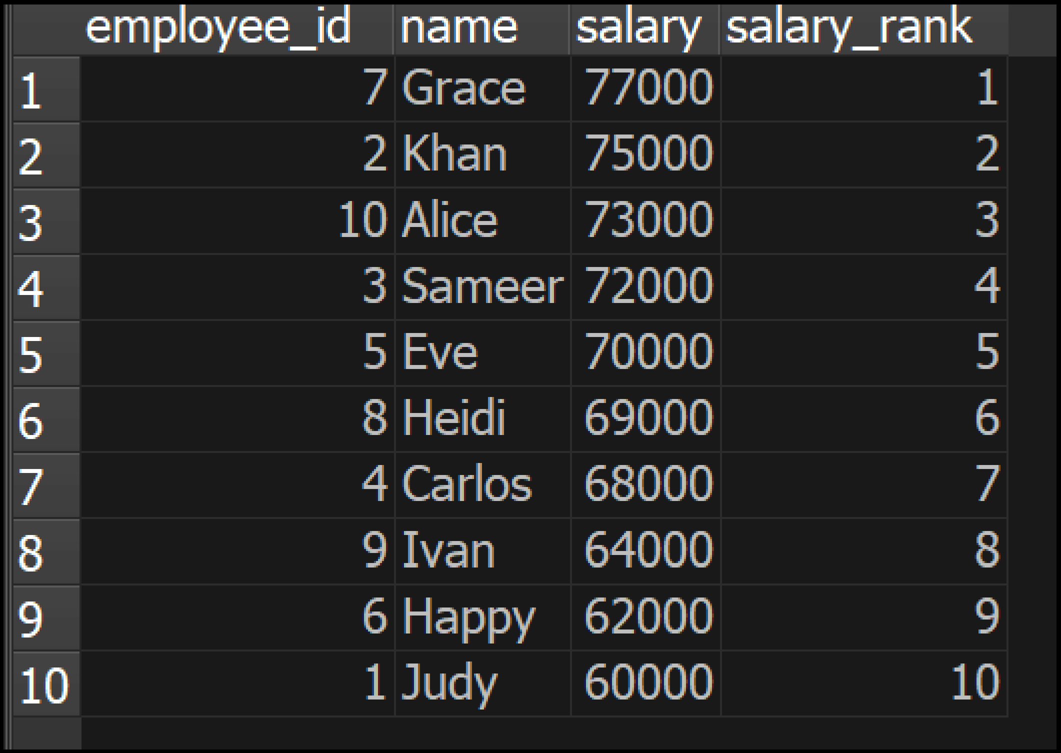
	employee_id	name	joining_date	salary	running_total_salary
1	4	Carlos	2018-07-12	68000	68000
2	6	Happy	2019-05-17	62000	130000
3	2	Khan	2019-11-23	75000	205000
4	1	Judy	2020-01-15	60000	265000
5	5	Eve	2020-06-30	70000	335000
6	7	Grace	2020-10-10	77000	412000
7	3	Sameer	2021-03-01	72000	484000
8	9	Ivan	2021-08-19	64000	548000
9	10	Alice	2022-01-01	73000	621000
10	8	Heidi	2022-02-14	69000	690000

Here the order is by joining_date

Ranking (1st, 2nd, 3rd…)

Hard way: Using subquery to rank employees by **salary** **(highest to lowest)**

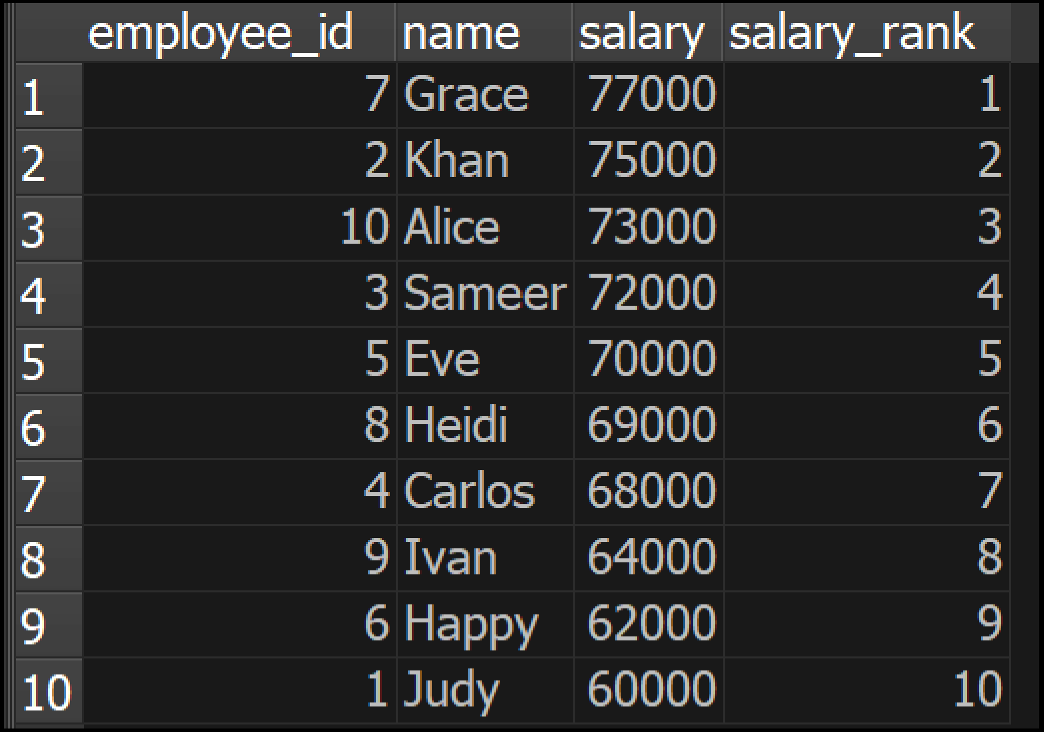
```
SELECT
e1.employee_id,
e1.name,
e1.salary,
(  SELECT COUNT(DISTINCT e2.salary)
   FROM employees e2
   WHERE e2.salary > e1.salary
 ) + 1 AS salary_rank

FROM employees e1

ORDER BY salary_rank;
```



	employee_id	name	salary	salary_rank
1	7	Grace	77000	1
2	2	Khan	75000	2
3	10	Alice	73000	3
4	3	Sameer	72000	4
5	5	Eve	70000	5
6	8	Heidi	69000	6
7	4	Carlos	68000	7
8	9	Ivan	64000	8
9	6	Happy	62000	9
10	1	Judy	60000	10

Easy way: Using Window function to rank employees by **salary (highest to lowest)**

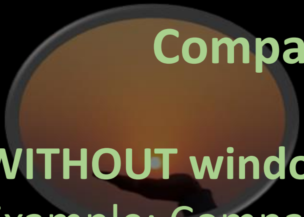
```
SELECT
   employee_id,
   name,
   salary,
   RANK() OVER (ORDER BY salary DESC) AS salary_rank

FROM employees;
```



	employee_id	name	salary	salary_rank
1	7	Grace	77000	1
2	2	Khan	75000	2
3	10	Alice	73000	3
4	3	Sameer	72000	4
5	5	Eve	70000	5
6	8	Heidi	69000	6
7	4	Carlos	68000	7
8	9	Ivan	64000	8
9	6	Happy	62000	9
10	1	Judy	60000	10

Comparing current row with previous / next row

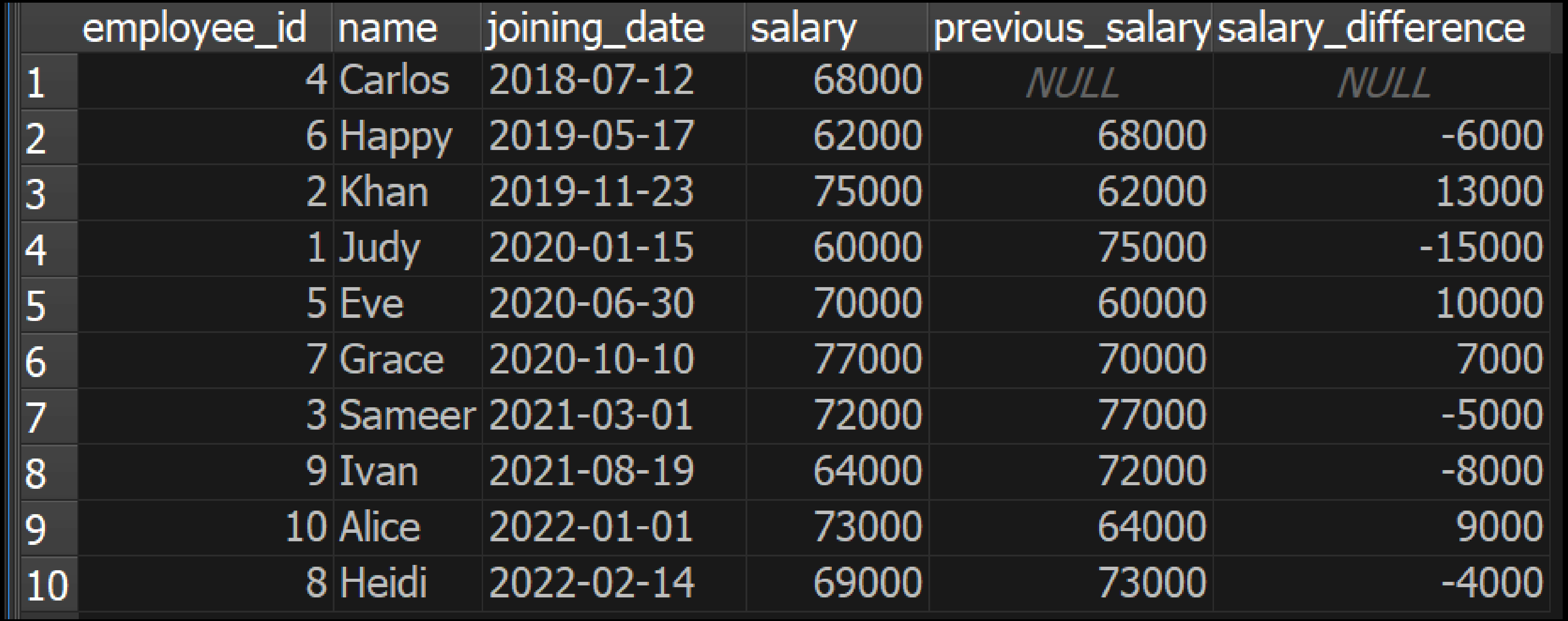
Compare each employee's salary with the previous employee's salary (order by joining_date)



WITHOUT window functions (correlated subquery)

Example: Compare current salary with previous joining employee

```
SELECT
   e1.employee_id,
   e1.name,
   e1.joining_date,
   e1.salary,

   (
      SELECT e2.salary
      FROM employees e2
      WHERE e2.joining_date < e1.joining_date
      ORDER BY e2.joining_date DESC
      LIMIT 1
   ) AS previous_salary,

   e1.salary -
   (
      SELECT e2.salary
      FROM employees e2
      WHERE e2.joining_date < e1.joining_date
      ORDER BY e2.joining_date DESC
      LIMIT 1
   ) AS salary_difference
FROM employees e1
ORDER BY e1.joining_date;
```



	employee_id	name	joining_date	salary	previous_salary	salary_difference
1	4	Carlos	2018-07-12	68000	*NULL*	*NULL*
2	6	Happy	2019-05-17	62000	68000	-6000
3	2	Khan	2019-11-23	75000	62000	13000
4	1	Judy	2020-01-15	60000	75000	-15000
5	5	Eve	2020-06-30	70000	60000	10000
6	7	Grace	2020-10-10	77000	70000	7000
7	3	Sameer	2021-03-01	72000	77000	-5000
8	9	Ivan	2021-08-19	64000	72000	-8000
9	10	Alice	2022-01-01	73000	64000	9000
10	8	Heidi	2022-02-14	69000	73000	-4000

What's happening (painfully)

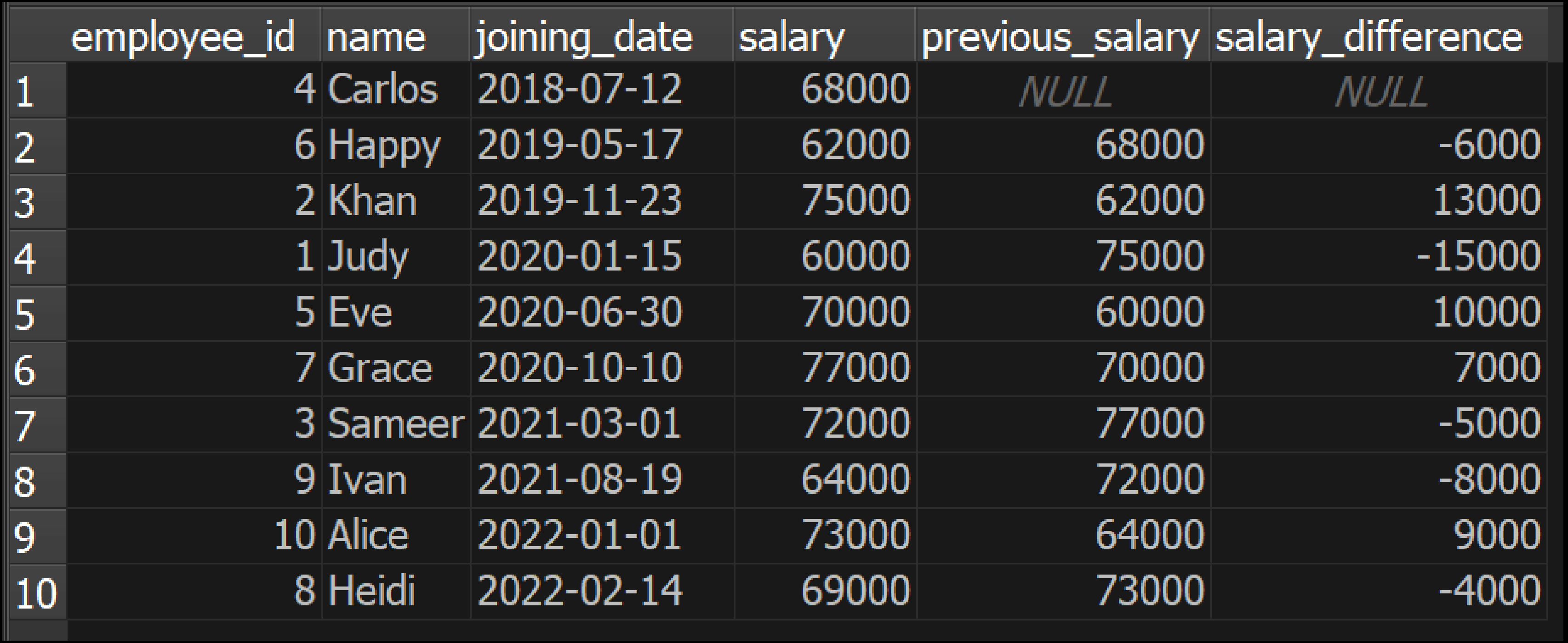
For **every row**:

1. Search the table again
2. Find the immediately previous joining employee
3. Fetch their salary
4. Subtract salaries

Compare each employee's salary with the previous employee's salary (order by joining_date)

WITH window functions (LAG)

Same logic as previous but it is **clean and readable**

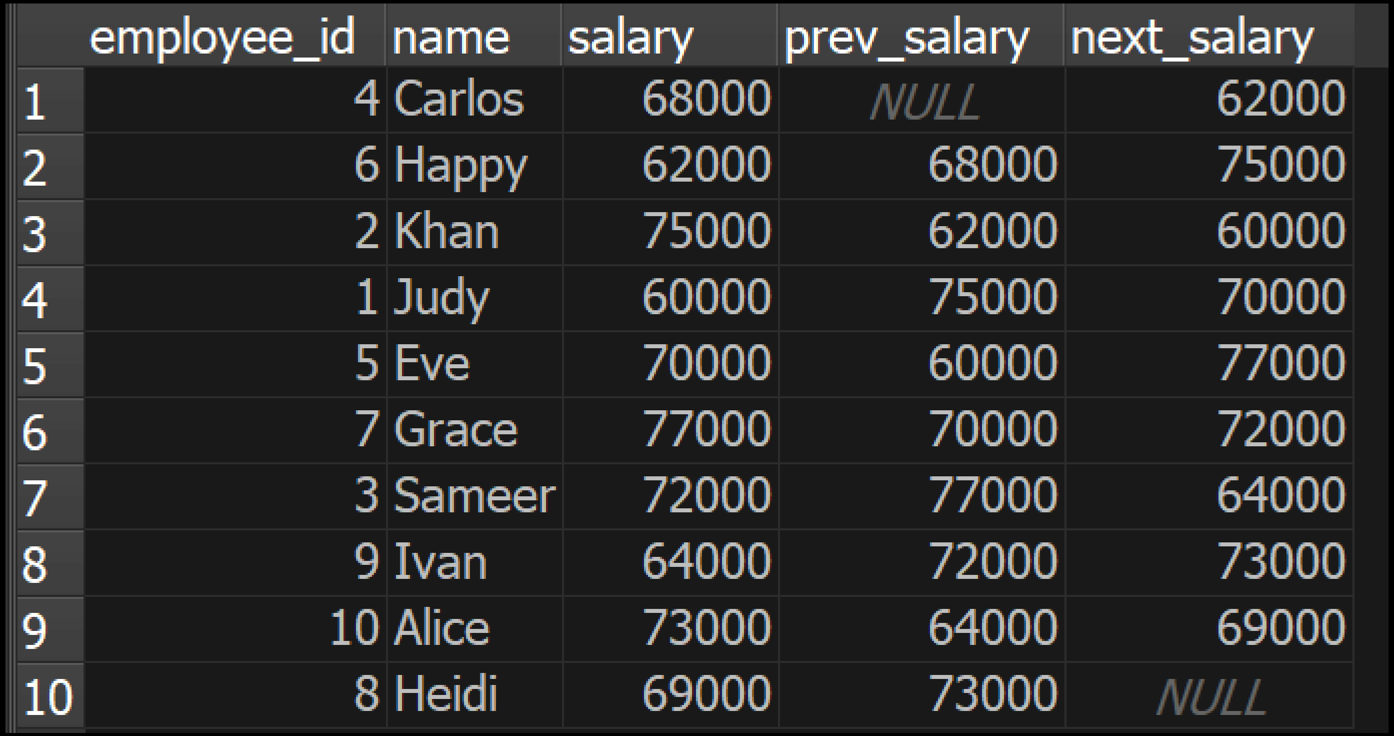


	employee_id	name	joining_date	salary	previous_salary	salary_difference
1	4	Carlos	2018-07-12	68000	NULL	NULL
2	6	Happy	2019-05-17	62000	68000	-6000
3	2	Khan	2019-11-23	75000	62000	13000
4	1	Judy	2020-01-15	60000	75000	-15000
5	5	Eve	2020-06-30	70000	60000	10000
6	7	Grace	2020-10-10	77000	70000	7000
7	3	Sameer	2021-03-01	72000	77000	-5000
8	9	Ivan	2021-08-19	64000	72000	-8000
9	10	Alice	2022-01-01	73000	64000	9000
10	8	Heidi	2022-02-14	69000	73000	-4000

```
SELECT
    employee_id,
    name,
    joining_date,
    salary,
    LAG(salary)          OVER (ORDER BY joining_date) AS previous_salary,
    salary - LAG(salary) OVER (ORDER BY joining_date) AS salary_difference

FROM employees
ORDER BY joining_date;
```

What is IMPOSSIBLE (or impractical) without window functions

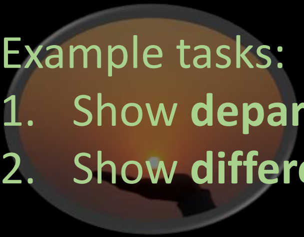
Compare with both previous and next row using window function



	employee_id	name	salary	prev_salary	next_salary
1	4	Carlos	68000	NULL	62000
2	6	Happy	62000	68000	75000
3	2	Khan	75000	62000	60000
4	1	Judy	60000	75000	70000
5	5	Eve	70000	60000	77000
6	7	Grace	77000	70000	72000
7	3	Sameer	72000	77000	64000
8	9	Ivan	64000	72000	73000
9	10	Alice	73000	64000	69000
10	8	Heidi	69000	73000	NULL

```
SELECT
   employee_id,
   name,
   salary,
   LAG(salary)  OVER (ORDER BY joining_date) AS prev_salary,
   LEAD(salary) OVER (ORDER BY joining_date) AS next_salary

FROM employees;
```

Aggregates
without losing row-level detail

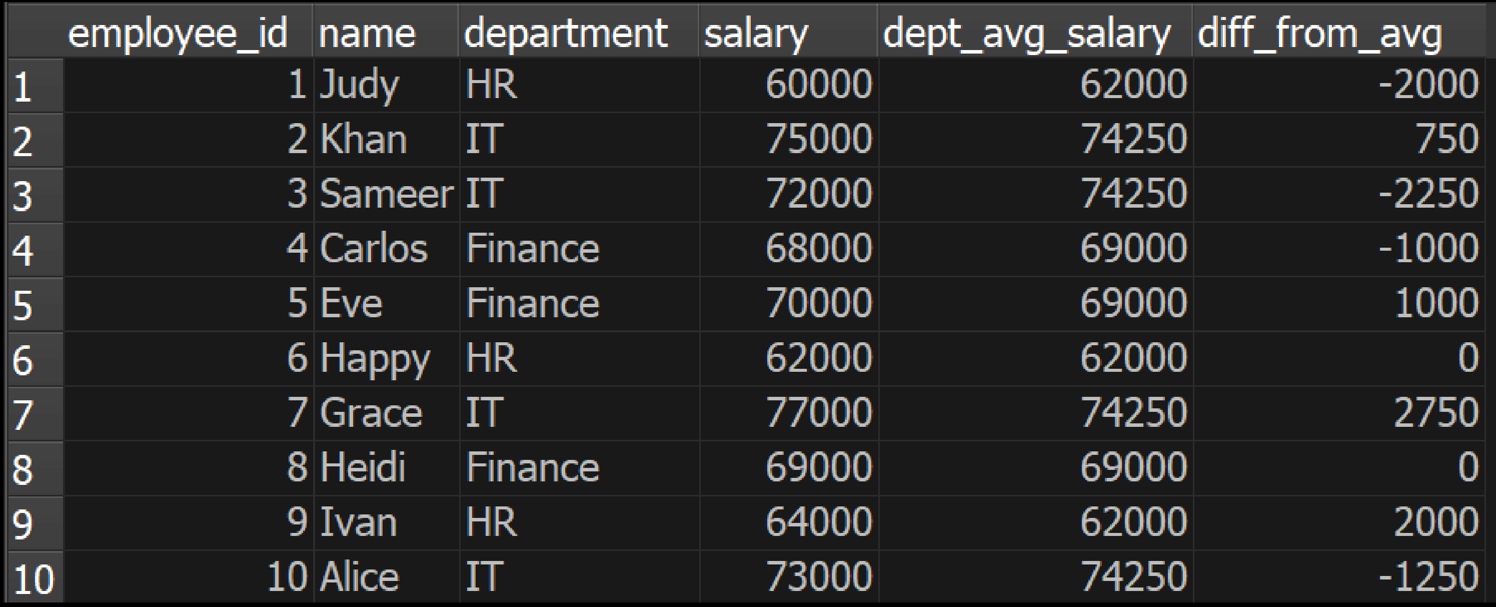


Example tasks:

1. Show **department average salary** alongside each employee
2. Show **difference between employee salary and department average**

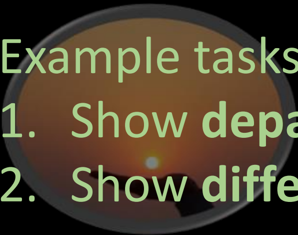
WITHOUT window functions (JOIN + GROUP BY)

```
SELECT
    e.employee_id,
    e.name,
    e.department,
    e.salary,
    d.dept_avg_salary,
    e.salary - d.dept_avg_salary AS diff_from_avg
FROM employees e
JOIN (
    SELECT
        department,
        AVG(salary) AS dept_avg_salary
    FROM employees
    GROUP BY department
) d
ON e.department = d.department;
```



	employee_id	name	department	salary	dept_avg_salary	diff_from_avg
1	1	Judy	HR	60000	62000	-2000
2	2	Khan	IT	75000	74250	750
3	3	Sameer	IT	72000	74250	-2250
4	4	Carlos	Finance	68000	69000	-1000
5	5	Eve	Finance	70000	69000	1000
6	6	Happy	HR	62000	62000	0
7	7	Grace	IT	77000	74250	2750
8	8	Heidi	Finance	69000	69000	0
9	9	Ivan	HR	64000	62000	2000
10	10	Alice	IT	73000	74250	-1250

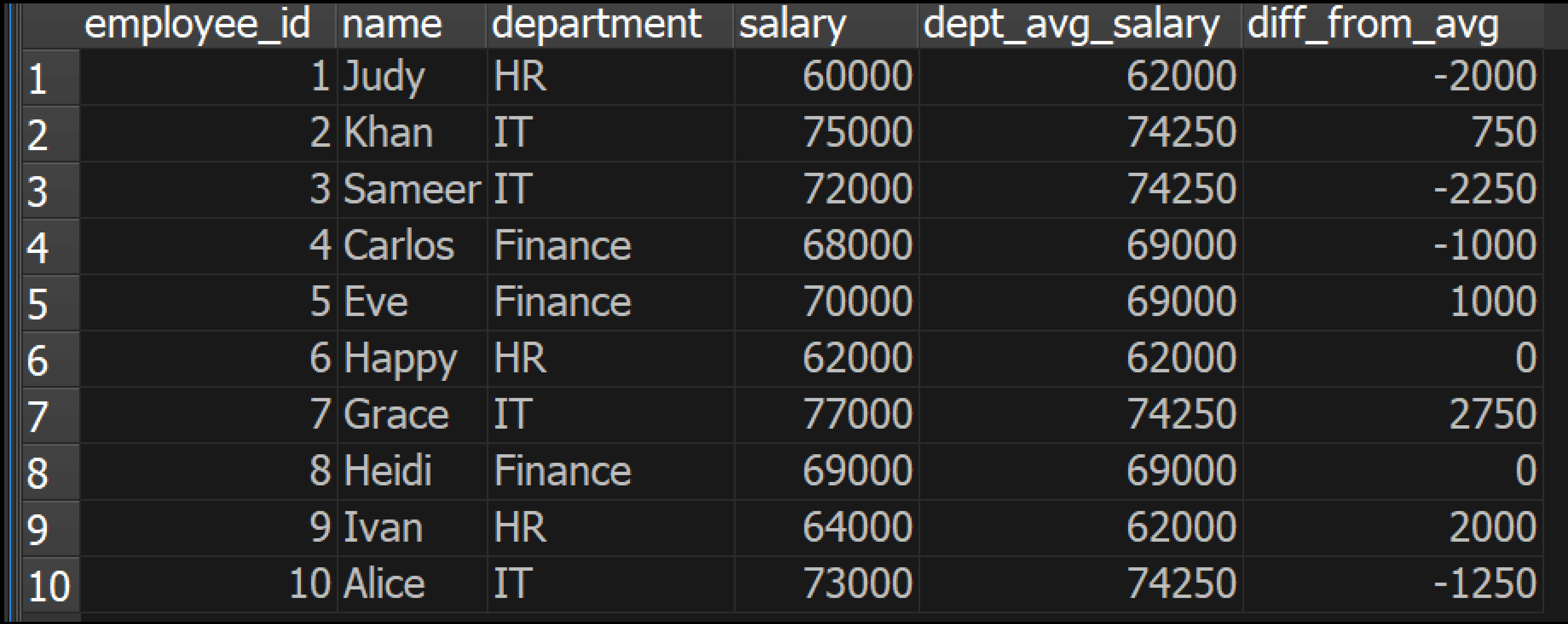
Issue with this method	**Why it hurts**
Two queries	Harder to read
Join required	Extra mental overhead
Easy to break	Wrong joins = wrong results
Scaling logic	Becomes unreadable



Example tasks:

1. Show **department average salary** alongside each employee
2. Show **difference between employee salary and department average**

WITH window functions



	employee_id	name	department	salary	dept_avg_salary	diff_from_avg
1	1	Judy	HR	60000	62000	-2000
2	2	Khan	IT	75000	74250	750
3	3	Sameer	IT	72000	74250	-2250
4	4	Carlos	Finance	68000	69000	-1000
5	5	Eve	Finance	70000	69000	1000
6	6	Happy	HR	62000	62000	0
7	7	Grace	IT	77000	74250	2750
8	8	Heidi	Finance	69000	69000	0
9	9	Ivan	HR	64000	62000	2000
10	10	Alice	IT	73000	74250	-1250

```
SELECT
employee_id,
name,
department,
salary,
AVG(salary) OVER (PARTITION BY department) AS dept_avg_salary,
salary - AVG(salary) OVER (PARTITION BY department) AS diff_from_avg

FROM employees
ORDER BY employee_id;
```

Window Functions Supported in SQLite3

SQLite (≥ 3.25) supports:

- SUM, AVG, MIN, MAX
- ROW_NUMBER
- RANK, DENSE_RANK
- LAG, LEAD
- NTILE

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