ANALYTICAL FUNCTIONS IN POSTGRESQL: MODERN ALTERNATIVE TO AGGREGATES

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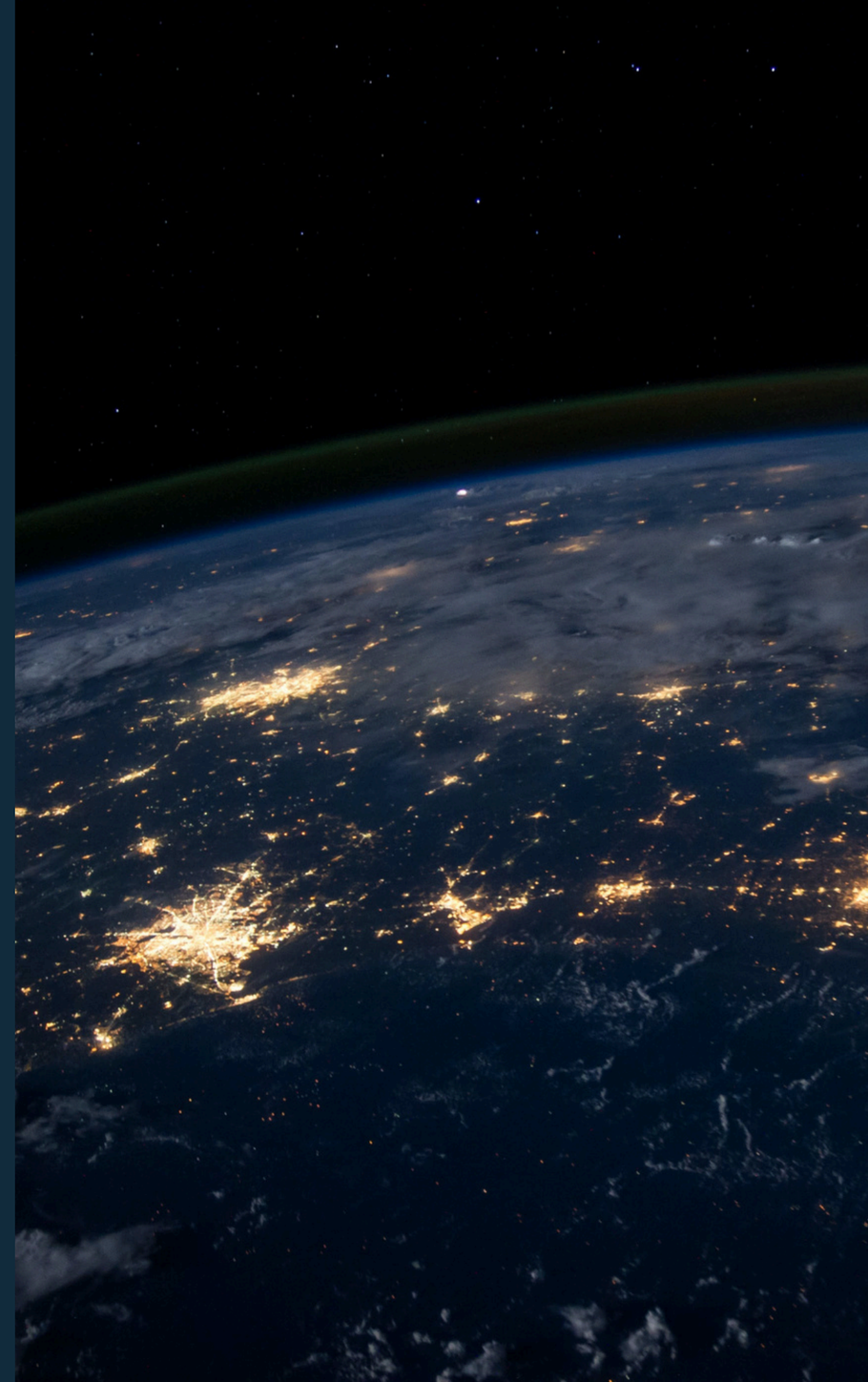

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- More than 25 years of experience in database services, data governance and cloud innovation
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Why did the SQL query love window functions?

Because they always kept things in "order" while staying "partitioned"!

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Agenda:

- INTRODUCTION
- HISTORY OF ANALYTICAL FUNCTIONS
- PURPOSE OF ANALYTICAL FUNCTIONS
- WHY ANALYTICAL FUNCTIONS ARE UNDERUTILISED
- THEORETICAL INTRODUCTION TO ANALYTICAL FUNCTIONS
- WHEN TO REPLACE AGGREGATE FUNCTIONS
- PRACTICAL EXAMPLES OF QUERY OPTIMISATION

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What are analytical functions?

- Allow calculations across a result set without collapsing rows.
- Enable operations like rankings, running totals, and moving averages.

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Why are they important?

- Modern alternative to aggregates.
- Solve complex SQL problems efficiently.
- Key to optimising performance in PostgreSQL.

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History of analytical functions

- Oracle 8i in 1999
- SQL-1999 standard (SQL3)

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PostgreSQL Milestones

- Version 8.4 (2009): Initial support for window functions.
- Enhanced functionality: Advanced ranking and value-based operations

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Purpose of analytical functions

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Key use cases:

- **RANKING** (RANK, DENSE_RANK, ROW_NUMBER)
- **COMPARING BY OFFSET** (neighbouring elements and boundaries)
- **AGGREGATION** (sum and average)
- **ROLLING AGGREGATES** (sum and average in dynamics)

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Core syntax:

```sql
SELECT
    column1,
    column2,
    window_function(column1) OVER w
FROM
    table_name
WINDOW
    w AS (PARTITION BY column2 ORDER BY column3);
```

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Why analytical functions are underutilised

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Our goal today:

- Highlight practical examples.
- Show the efficiency of PostgreSQL’s engine.

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PostgreSQL Efficiency:

- Engine optimised for window functions.
- Proper indexing further enhances performance.

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Theoretical introduction to analytical functions

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Key Components of the OVER() Clause:

- PARTITION BY: Group data into subsets.
- ORDER BY: Define sorting within the partition
- Frames: Refine the range of rows for calculations.

Ranking functions:

- row_number() - assigns a unique sequential number to each row
- rank() - assigns a rank to each row with possible gaps
- dense_rank() - assigns a rank to each row
- ntile() - devides rows into n groups and assigns a group number to each row, starting from 1

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Offset functions:

- lag(v, n) – value n rows behind
- lead (v, n) – value n rows ahead
- first_value (v) – value from the first frame row
- last_value (v) – value from the last frame row
- nth_value (v, n) – value from the n-th row

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Aggregation functions:

- max(v) – maximum partition/frame value
- min(v) – minimum partition/frame value
- avg(v) – average partition/frame value
- count(v) – partition/frame row count
- sum(v) – partition/frame total

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Statistics functions:

- cume_dist() - cumulative distributrion
- percent_rank() - relative rank
- percentile_disc(n) - discrete percentile
- percentile_cont (n) - continuous percentile

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Frame:

- In general defined as:

```
{ rows | groups | range}
between frame_start and frame_end
[exclude exclusion]
```

- Default frame:

```
range between unbounded preceding and current row
exclude no others
```

Frames:

- Only supported by some functions:
  - offset functions: first_value, last_value, nth_value
  - all aggregation functions
- For other functions - frame = partition

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Frame type:

- rows – frames work with individual records
- groups – frames work with groups of records with the same ordering value
- range – frames work with groups of records whose order by column value falls within the specified range

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Frame boundaries:

- unbounded preceding – from the partition boundary
- N preceding
- current row – current record
- N following
- unbounded following – to the partition boundary

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unbounded preceding/following:

unbounded following

ROWS

name	salary asc
James	67
Michael	72
Anna	76
Tom	84
Mandy	92
Jack	92
Jessica	101
Dan	106
Adam	106
Phil	115

GROUPS

name	salary asc
James	67
Michael	72
Anna	76
Tom	84
Mandy	92
Jack	92
Jessica	101
Dan	106
Adam	106
Phil	115

RANGE

name	salary asc
James	67
Michael	72
Anna	76
Tom	84
Mandy	92
Jack	92
Jessica	101
Dan	106
Adam	106
Phil	115

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current row :

current row

ROWS

name	salary asc
James	67
Michael	72
Anna	76
Tom	84
Mandy	92
Jack	92
Jessica	101
Dan	106
Adam	106
Phil	115

GROUPS

name	salary asc
James	67
Michael	72
Anna	76
Tom	84
Mandy	92
Jack	92
Jessica	101
Dan	106
Adam	106
Phil	115

RANGE

name	salary asc
James	67
Michael	72
Anna	76
Tom	84
Mandy	92
Jack	92
Jessica	101
Dan	106
Adam	106
Phil	115

N-preceding/N-following :

2 following
ROWS

name	salary asc
James	67
Michael	72
Anna	76
Tom	84
Mandy	92
Jack	92
Jessica	101
Dan	106
Adam	106
Phil	115

2 following
GROUPS

name	salary asc
James	67
Michael	72
Anna	76
Tom	84
Mandy	92
Jack	92
Jessica	101
Dan	106
Adam	106
Phil	115

15 following
RANGE

name	salary asc
James	67
Michael	72
Anna	76
Tom	84
Mandy	92
Jack	92
Jessica	101
Dan	106
Adam	106
Phil	115

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EXCLUDE:

- **exclude no others** - default - don´t exclude anything
- **exclude current row**
- **exclude group** - exclude current record and all equal to it
- **exclude ties** - keep the current record but exclude equal to it

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FILTER:

```
func(column) filter (where condition) over window_name
```

- to filter a specific window frame
- alternative: CASE - more flexible

```
func(case when condition then expression else other end) over window_name
```

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When to replace aggregate functions

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Limitations of aggregate functions:

- Collapse rows, losing granularity.
- Cannot combine summary and detailed data.

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Practical examples of query optimisation

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Resources:

- https://antonz.org/sql-window-functions-book/

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Thank you