

Postgres Window Magic

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This presentation explains the many window function facilities and how they can be used to produce useful SQL query results.

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Outline

1. Introduction to window functions
2. Window function syntax
3. Window syntax with generic aggregates
4. Window-specific functions
5. Window function examples
6. Considerations

1. Introduction to Window Functions



<https://www.flickr.com/photos/conalg/>

Postgres Data Analytics Features

- ▶ Aggregates
- ▶ Optimizer
- ▶ Server-side languages, e.g., PL/R
- ▶ **Window functions**
- ▶ Bitmap heap scans
- ▶ Tablespaces
- ▶ Data partitioning
- ▶ Materialized views
- ▶ Common table expressions (CTE)
- ▶ BRIN indexes
- ▶ GROUPING SETS, ROLLUP, CUBE
- ▶ Just-in-time compilation (JIT)
- ▶ Parallelism
- ▶ Sharding (in progress)

What Is a Window Function?

A window function performs a calculation across a set of table rows that are somehow related to the current row. This is comparable to the type of calculation that can be done with an aggregate function. However, window functions do not cause rows to become grouped into a single output row like non-window aggregate calls would. Instead, the rows retain their separate identities. Behind the scenes, the window function is able to access more than just the current row of the query result.

<https://www.postgresql.org/docs/current/tutorial-window.html>

Keep Your Eye on the Red (Text)



<https://www.flickr.com/photos/alltheaces/>

Count to Ten

```
SELECT *  
FROM generate_series(1, 10) AS f(x);
```

```
x  
----  
1  
2  
3  
4  
5  
6  
7  
8  
9  
10
```

All the queries used in this presentation are available at <http://momjian.us/main/writings/pgsql/window.sql>.

Simplest Window Function

```
SELECT x, SUM(x) OVER ()  
FROM generate_series(1, 10) AS f(x);
```

x	sum
1	55
2	55
3	55
4	55
5	55
6	55
7	55
8	55
9	55
10	55

Two OVER Clauses

```
SELECT x, COUNT(x) OVER (), SUM(x) OVER ()  
FROM generate_series(1, 10) AS f(x);
```

x	count	sum
1	10	55
2	10	55
3	10	55
4	10	55
5	10	55
6	10	55
7	10	55
8	10	55
9	10	55
10	10	55

WINDOW Clause

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_series(1, 10) AS f(x)
WINDOW w AS ();
```

x	count	sum
1	10	55
2	10	55
3	10	55
4	10	55
5	10	55
6	10	55
7	10	55
8	10	55
9	10	55
10	10	55

Let's See the Defaults

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_series(1, 10) AS f(x)
WINDOW w AS (RANGE BETWEEN
              UNBOUNDED PRECEDING AND CURRENT ROW);
```

x	count	sum
1	10	55
2	10	55
3	10	55
4	10	55
5	10	55
6	10	55
7	10	55
8	10	55
9	10	55
10	10	55

2. Window Function Syntax



<https://www.flickr.com/photos/bgreenlee/>

Window Syntax

```
WINDOW (  
    [PARTITION BY ...]  
    [ORDER BY ...]  
    [  
        { RANGE | ROWS }  
        { frame_start | BETWEEN frame_start AND frame_end }  
    ]  
)
```

where *frame_start* and *frame_end* can be:

- ▶ UNBOUNDED PRECEDING
- ▶ *value* PRECEDING
- ▶ CURRENT ROW
- ▶ *value* FOLLOWING
- ▶ UNBOUNDED FOLLOWING

Bracketed clauses are optional, braces are selected.

<https://www.postgresql.org/docs/current/sql-expressions.html#SYNTAX-WINDOW-FUNCTIONS>

What Are the Defaults?

(**RANGE** BETWEEN **UNBOUNDED PRECEDING** AND **CURRENT ROW**)

- ▶ No PARTITION BY (the set is a single partition)
- ▶ No ORDER BY (all rows are peers of CURRENT ROW)
- ▶ RANGE, not ROWS (CURRENT ROW includes all peers)

Since PARTITION BY and ORDER BY are not defaults but RANGE is the default, CURRENT ROW defaults to representing all rows.

CURRENT ROW

CURRENT ROW can mean the:

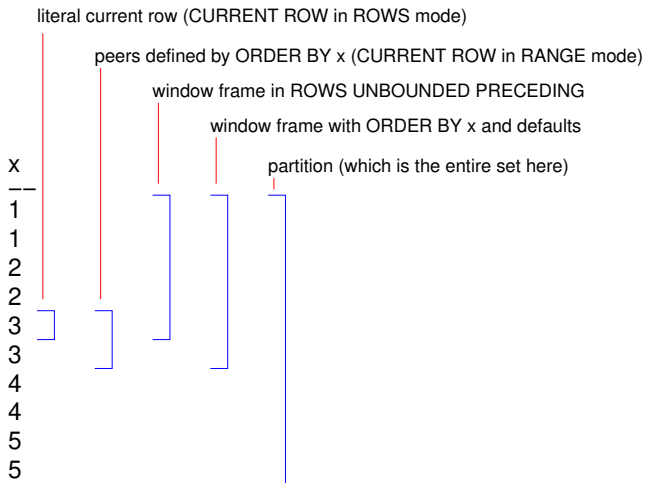
- ▶ Literal current row
- ▶ First or last row with the same ORDER BY value (first/last peer)
- ▶ First or last row of the partition

CURRENT ROW

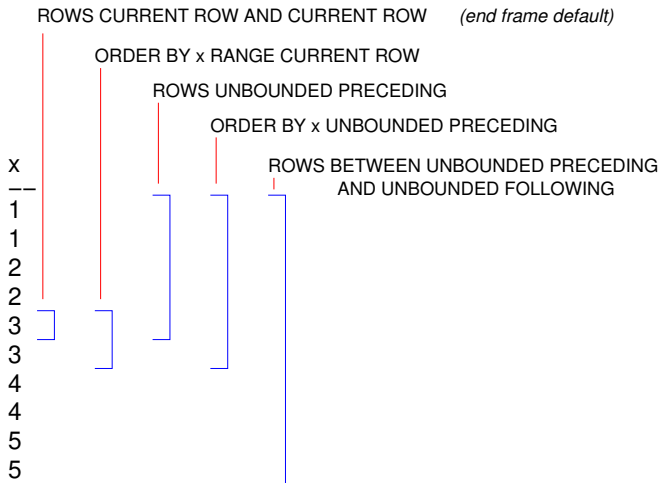
CURRENT ROW can mean the:

- ▶ Literal current row (ROWS mode)
- ▶ First or last row with the same ORDER BY value (first/last peer) (RANGE mode with ORDER BY)
- ▶ First or last row of the partition (RANGE mode without ORDER BY)

Visual Window Terms



SQL for Window Frames



3. Window Syntax with Generic Aggregates



<https://www.flickr.com/photos/azparrot/>

Back to the Last Query

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_series(1, 10) AS f(x)
WINDOW w AS (RANGE BETWEEN
              UNBOUNDED PRECEDING AND CURRENT ROW);
```

x	count	sum
1	10	55
2	10	55
3	10	55
4	10	55
5	10	55
6	10	55
7	10	55
8	10	55
9	10	55
10	10	55

ROWS Instead of RANGE

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_series(1, 10) AS f(x)
WINDOW w AS (ROWS BETWEEN
              UNBOUNDED PRECEDING AND CURRENT ROW);
```

x	count	sum
1	1	1
2	2	3
3	3	6
4	4	10
5	5	15
6	6	21
7	7	28
8	8	36
9	9	45
10	10	55

Default End Frame (CURRENT ROW)

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_series(1, 10) AS f(x)
WINDOW w AS (ROWS UNBOUNDED PRECEDING);
```

x	count	sum
1	1	1
2	2	3
3	3	6
4	4	10
5	5	15
6	6	21
7	7	28
8	8	36
9	9	45
10	10	55

Only CURRENT ROW

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_series(1, 10) AS f(x)
WINDOW w AS (ROWS BETWEEN
              CURRENT ROW AND CURRENT ROW);
```

x	count	sum
1	1	1
2	1	2
3	1	3
4	1	4
5	1	5
6	1	6
7	1	7
8	1	8
9	1	9
10	1	10

Use Defaults

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_series(1, 10) AS f(x)
WINDOW w AS (ROWS CURRENT ROW);
```

x	count	sum
1	1	1
2	1	2
3	1	3
4	1	4
5	1	5
6	1	6
7	1	7
8	1	8
9	1	9
10	1	10

UNBOUNDED FOLLOWING

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_series(1, 10) AS f(x)
WINDOW w AS (ROWS BETWEEN
              CURRENT ROW AND UNBOUNDED FOLLOWING);
```

x	count	sum
1	10	55
2	9	54
3	8	52
4	7	49
5	6	45
6	5	40
7	4	34
8	3	27
9	2	19
10	1	10

PRECEDING

```
SELECT x, COUNT(*) OVER w, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_series(1, 10) AS f(x)
WINDOW w AS (ROWS BETWEEN
             1 PRECEDING AND CURRENT ROW);
```

x	count	count	sum
1	1	1	1
2	2	2	3
3	2	2	5
4	2	2	7
5	2	2	9
6	2	2	11
7	2	2	13
8	2	2	15
9	2	2	17
10	2	2	19

PRECEDING ignores nonexistent rows; they are not NULLs.

Use FOLLOWING

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_series(1, 10) AS f(x)
WINDOW w AS (ROWS BETWEEN
              CURRENT ROW AND 1 FOLLOWING);
```

x	count	sum
1	2	3
2	2	5
3	2	7
4	2	9
5	2	11
6	2	13
7	2	15
8	2	17
9	2	19
10	1	10

3 PRECEDING

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_series(1, 10) AS f(x)
WINDOW w AS (ROWS BETWEEN
              3 PRECEDING AND CURRENT ROW);
```

x	count	sum
1	1	1
2	2	3
3	3	6
4	4	10
5	4	14
6	4	18
7	4	22
8	4	26
9	4	30
10	4	34

ORDER BY

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_series(1, 10) AS f(x)
WINDOW w AS (ORDER BY x);
```

x	count	sum
1	1	1
2	2	3
3	3	6
4	4	10
5	5	15
6	6	21
7	7	28
8	8	36
9	9	45
10	10	55

CURRENT ROW peers are rows with equal values for ORDER BY columns, or all partition rows if ORDER BY is not specified.

Default Frame Specified

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_series(1, 10) AS f(x)
WINDOW w AS (ORDER BY x RANGE BETWEEN
             UNBOUNDED PRECEDING AND CURRENT ROW);
```

x	count	sum
1	1	1
2	2	3
3	3	6
4	4	10
5	5	15
6	6	21
7	7	28
8	8	36
9	9	45
10	10	55

Only CURRENT ROW

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_series(1, 10) AS f(x)
WINDOW w AS (ORDER BY x RANGE CURRENT ROW);
```

x	count	sum
1	1	1
2	1	2
3	1	3
4	1	4
5	1	5
6	1	6
7	1	7
8	1	8
9	1	9
10	1	10

Create Table with Duplicates

```
CREATE TABLE generate_1_to_5_x2 AS  
    SELECT ceil(x/2.0) AS x  
    FROM generate_series(1, 10) AS f(x);
```

```
SELECT * FROM generate_1_to_5_x2;
```

```
x  
---  
1  
1  
2  
2  
3  
3  
4  
4  
5  
5
```


Empty Window Specification

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_1_to_5_x2
WINDOW w AS ();
```

x	count	sum
1	10	30
1	10	30
2	10	30
2	10	30
3	10	30
3	10	30
4	10	30
4	10	30
5	10	30
5	10	30

RANGE With Duplicates

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (ORDER BY x);
```

x	count	sum
1	2	2
1	2	2
2	4	6
2	4	6
3	6	12
3	6	12
4	8	20
4	8	20
5	10	30
5	10	30

Show Defaults

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (ORDER BY x RANGE BETWEEN
             UNBOUNDED PRECEDING AND CURRENT ROW);
```

x	count	sum
1	2	2
1	2	2
2	4	6
2	4	6
3	6	12
3	6	12
4	8	20
4	8	20
5	10	30
5	10	30

ROWS

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (ORDER BY x ROWS BETWEEN
             UNBOUNDED PRECEDING AND CURRENT ROW);
```

x	count	sum
1	1	1
1	2	2
2	3	4
2	4	6
3	5	9
3	6	12
4	7	16
4	8	20
5	9	25
5	10	30

RANGE on CURRENT ROW

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (ORDER BY x RANGE CURRENT ROW);
```

x	count	sum
1	2	2
1	2	2
2	2	4
2	2	4
3	2	6
3	2	6
4	2	8
4	2	8
5	2	10
5	2	10

ROWS on CURRENT ROW

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (ORDER BY x ROWS CURRENT ROW);
```

x	count	sum
1	1	1
1	1	1
2	1	2
2	1	2
3	1	3
3	1	3
4	1	4
4	1	4
5	1	5
5	1	5

PARTITION BY

```
SELECT x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (PARTITION BY x);
```

x	count	sum
1	2	2
1	2	2
2	2	4
2	2	4
3	2	6
3	2	6
4	2	8
4	2	8
5	2	10
5	2	10

Same as RANGE CURRENT ROW because the partition matches the window frame.

Create Two Partitions

```
SELECT int4(x >= 3), x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (PARTITION BY x >= 3);
```

int4	x	count	sum
0	1	4	6
0	1	4	6
0	2	4	6
0	2	4	6
1	3	6	24
1	3	6	24
1	4	6	24
1	4	6	24
1	5	6	24
1	5	6	24

ORDER BY

```
SELECT int4(x >= 3), x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (PARTITION BY x >= 3 ORDER BY x);
```

int4	x	count	sum
0	1	2	2
0	1	2	2
0	2	4	6
0	2	4	6
1	3	2	6
1	3	2	6
1	4	4	14
1	4	4	14
1	5	6	24
1	5	6	24

Show Defaults

```
SELECT int4(x >= 3), x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (PARTITION BY x >= 3 ORDER BY x RANGE BETWEEN
             UNBOUNDED PRECEDING AND CURRENT ROW);
```

int4	x	count	sum
0	1	2	2
0	1	2	2
0	2	4	6
0	2	4	6
1	3	2	6
1	3	2	6
1	4	4	14
1	4	4	14
1	5	6	24
1	5	6	24

ROWS

```
SELECT int4(x >= 3), x, COUNT(x) OVER w, SUM(x) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (PARTITION BY x >= 3 ORDER BY x ROWS BETWEEN
              UNBOUNDED PRECEDING AND CURRENT ROW);
```

int4	x	count	sum
0	1	1	1
0	1	2	2
0	2	3	4
0	2	4	6
1	3	1	3
1	3	2	6
1	4	3	10
1	4	4	14
1	5	5	19
1	5	6	24

4. Window-Specific Functions



<https://www.flickr.com/photos/michaeljohnbutton/>

ROW_NUMBER

```
SELECT x, ROW_NUMBER() OVER w
FROM generate_1_to_5_x2
WINDOW w AS ();
```

x	row_number
1	1
1	2
2	3
2	4
3	5
3	6
4	7
4	8
5	9
5	10

ROW_NUMBER takes no arguments and operates on partitions, not window frames. <https://www.postgresql.org/docs/current/functions-window.html>

LAG

```
SELECT x, LAG(x, 1) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (ORDER BY x);
```

x	lag
1	(null)
1	1
2	1
2	2
3	2
3	3
4	3
4	4
5	4
5	5

LAG(2)

```
SELECT x, LAG(x, 2) OVER w  
FROM generate_1_to_5_x2  
WINDOW w AS (ORDER BY x);
```

x	lag
1	(null)
1	(null)
2	1
2	1
3	2
3	2
4	3
4	3
5	4
5	4

LAG and LEAD

```
SELECT x, LAG(x, 2) OVER w, LEAD(x, 2) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (ORDER BY x);
```

x	lag	lead
1	(null)	2
1	(null)	2
2	1	3
2	1	3
3	2	4
3	2	4
4	3	5
4	3	5
5	4	(null)
5	4	(null)

These operate on partitions. Defaults can be specified for nonexistent rows.

FIRST_VALUE and LAST_VALUE

```
SELECT x, FIRST_VALUE(x) OVER w, LAST_VALUE(x) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (ORDER BY x);
```

x	first_value	last_value
1	1	1
1	1	1
2	1	2
2	1	2
3	1	3
3	1	3
4	1	4
4	1	4
5	1	5
5	1	5

These operate on window frames.

UNBOUNDED Window Frame

```
SELECT x, FIRST_VALUE(x) OVER w, LAST_VALUE(x) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (ORDER BY x ROWS BETWEEN
             UNBOUNDED PRECEDING AND UNBOUNDED FOLLOWING);
```

x	first_value	last_value
1	1	5
1	1	5
2	1	5
2	1	5
3	1	5
3	1	5
4	1	5
4	1	5
5	1	5
5	1	5

NTH_VALUE

```
SELECT x, NTH_VALUE(x, 3) OVER w, NTH_VALUE(x, 7) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (ORDER BY x);
```

x	nth_value	nth_value
1	(null)	(null)
1	(null)	(null)
2	2	(null)
2	2	(null)
3	2	(null)
3	2	(null)
4	2	4
4	2	4
5	2	4
5	2	4

This operates on window frames.

Show Defaults

```
SELECT x, NTH_VALUE(x, 3) OVER w, NTH_VALUE(x, 7) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (ORDER BY x RANGE BETWEEN
             UNBOUNDED PRECEDING AND CURRENT ROW);
```

x	nth_value	nth_value
1	(null)	(null)
1	(null)	(null)
2	2	(null)
2	2	(null)
3	2	(null)
3	2	(null)
4	2	4
4	2	4
5	2	4
5	2	4

UNBOUNDED Window Frame

```
SELECT x, NTH_VALUE(x, 3) OVER w, NTH_VALUE(x, 7) OVER w
FROM generate_1_to_5_x2
WINDOW w AS (ORDER BY x ROWS BETWEEN
             UNBOUNDED PRECEDING AND UNBOUNDED FOLLOWING);
```

x	nth_value	nth_value
1	2	4
1	2	4
2	2	4
2	2	4
3	2	4
3	2	4
4	2	4
4	2	4
5	2	4
5	2	4

RANK and DENSE_RANK

```
SELECT x, RANK() OVER w, DENSE_RANK() OVER w
FROM generate_1_to_5_x2
WINDOW w AS ();
```

x	rank	dense_rank
1	1	1
1	1	1
2	1	1
2	1	1
3	1	1
3	1	1
4	1	1
4	1	1
5	1	1
5	1	1

These operate on CURRENT ROW peers in the partition.

Show Defaults

```
SELECT x, RANK() OVER w, DENSE_RANK() OVER w
FROM generate_1_to_5_x2
WINDOW w AS (RANGE BETWEEN
             UNBOUNDED PRECEDING AND CURRENT ROW);
```

x	rank	dense_rank
1	1	1
1	1	1
2	1	1
2	1	1
3	1	1
3	1	1
4	1	1
4	1	1
5	1	1
5	1	1

ROWS

```
SELECT x, RANK() OVER w, DENSE_RANK() OVER w
FROM generate_1_to_5_x2
WINDOW w AS (ROWS BETWEEN
              UNBOUNDED PRECEDING AND CURRENT ROW);
```

x	rank	dense_rank
1	1	1
1	1	1
2	1	1
2	1	1
3	1	1
3	1	1
4	1	1
4	1	1
5	1	1
5	1	1

Operates on Peers, so Needs ORDER BY

```
SELECT x, RANK() OVER w, DENSE_RANK() OVER w
FROM generate_1_to_5_x2
WINDOW w AS (ORDER BY x);
```

x	rank	dense_rank
1	1	1
1	1	1
2	3	2
2	3	2
3	5	3
3	5	3
4	7	4
4	7	4
5	9	5
5	9	5

PERCENT_RANK, CUME_DIST, NTILE

```
SELECT x, (PERCENT_RANK() OVER w)::numeric(10, 2),  
        (CUME_DIST() OVER w)::numeric(10, 2), NTILE(3) OVER w  
FROM generate_1_to_5_x2  
WINDOW w AS (ORDER BY x);
```

x	percent_rank	cume_dist	ntile
1	0.00	0.20	1
1	0.00	0.20	1
2	0.22	0.40	1
2	0.22	0.40	1
3	0.44	0.60	2
3	0.44	0.60	2
4	0.67	0.80	2
4	0.67	0.80	3
5	0.89	1.00	3
5	0.89	1.00	3

PERCENT_RANK is ratio of rows less than current row, excluding current row. CUME_DIST is ratio of rows \leq current row.

PARTITION BY

```
SELECT int4(x >= 3), x, RANK() OVER w, DENSE_RANK() OVER w
FROM generate_1_to_5_x2
WINDOW w AS (PARTITION BY x >= 3 ORDER BY x)
ORDER BY 1,2;
```

int4	x	rank	dense_rank
0	1	1	1
0	1	1	1
0	2	3	2
0	2	3	2
1	3	1	1
1	3	1	1
1	4	3	2
1	4	3	2
1	5	5	3
1	5	5	3

PARTITION BY and Other Rank Functions

```
SELECT int4(x >= 3), x, (PERCENT_RANK() OVER w)::numeric(10,2),  
       (CUME_DIST() OVER w)::numeric(10,2), NTILE(3) OVER w  
FROM generate_1_to_5_x2  
WINDOW w AS (PARTITION BY x >= 3 ORDER BY x)  
ORDER BY 1,2;
```

int4	x	percent_rank	cume_dist	ntile
0	1	0.00	0.50	1
0	1	0.00	0.50	1
0	2	0.67	1.00	2
0	2	0.67	1.00	3
1	3	0.00	0.33	1
1	3	0.00	0.33	1
1	4	0.40	0.67	2
1	4	0.40	0.67	2
1	5	0.80	1.00	3
1	5	0.80	1.00	3

5. Window Function Examples



<https://www.flickr.com/photos/fishywang/>

Create *emp* Table and Populate

```
CREATE TABLE emp (  
    id SERIAL,  
    name TEXT NOT NULL,  
    department TEXT,  
    salary NUMERIC(10, 2)  
);
```

```
INSERT INTO emp (name, department, salary) VALUES  
    ('Andy', 'Shipping', 5400),  
    ('Betty', 'Marketing', 6300),  
    ('Tracy', 'Shipping', 4800),  
    ('Mike', 'Marketing', 7100),  
    ('Sandy', 'Sales', 5400),  
    ('James', 'Shipping', 6600),  
    ('Carol', 'Sales', 4600);
```

<https://www.postgresql.org/docs/current/tutorial-window.html>

Emp Table

```
SELECT * FROM emp ORDER BY id;
```

id	name	department	salary
1	Andy	Shipping	5400.00
2	Betty	Marketing	6300.00
3	Tracy	Shipping	4800.00
4	Mike	Marketing	7100.00
5	Sandy	Sales	5400.00
6	James	Shipping	6600.00
7	Carol	Sales	4600.00

Generic Aggregates

```
SELECT COUNT(*), SUM(salary),  
       round(AVG(salary), 2) AS avg  
FROM emp;
```

count	sum	avg
7	40200.00	5742.86

GROUP BY

```
SELECT department, COUNT(*), SUM(salary),  
       round(AVG(salary), 2) AS avg  
FROM emp  
GROUP BY department  
ORDER BY department;
```

department	count	sum	avg
Marketing	2	13400.00	6700.00
Sales	2	10000.00	5000.00
Shipping	3	16800.00	5600.00

ROLLUP

```
SELECT department, COUNT(*), SUM(salary),  
       round(AVG(salary), 2) AS avg  
FROM emp  
GROUP BY ROLLUP(department)  
ORDER BY department;
```

department	count	sum	avg
Marketing	2	13400.00	6700.00
Sales	2	10000.00	5000.00
Shipping	3	16800.00	5600.00
(null)	7	40200.00	5742.86

Emp.name and *Salary*

```
SELECT name, salary  
FROM emp  
ORDER BY salary DESC;
```

name	salary
Mike	7100.00
James	6600.00
Betty	6300.00
Andy	5400.00
Sandy	5400.00
Tracy	4800.00
Carol	4600.00

OVER

```
SELECT name, salary, SUM(salary) OVER ()  
FROM emp  
ORDER BY salary DESC;
```

name	salary	sum
Mike	7100.00	40200.00
James	6600.00	40200.00
Betty	6300.00	40200.00
Andy	5400.00	40200.00
Sandy	5400.00	40200.00
Tracy	4800.00	40200.00
Carol	4600.00	40200.00

Percentages

```
SELECT name, salary,  
       round(salary / SUM(salary) OVER () * 100, 2) AS pct  
FROM emp  
ORDER BY salary DESC;
```

name	salary	pct
Mike	7100.00	17.66
James	6600.00	16.42
Betty	6300.00	15.67
Andy	5400.00	13.43
Sandy	5400.00	13.43
Tracy	4800.00	11.94
Carol	4600.00	11.44

Cumulative Totals Using ORDER BY

```
SELECT name, salary,  
       SUM(salary) OVER (ORDER BY salary DESC ROWS BETWEEN  
                          UNBOUNDED PRECEDING AND CURRENT ROW)  
FROM emp  
ORDER BY salary DESC;
```

name	salary	sum
Mike	7100.00	7100.00
James	6600.00	13700.00
Betty	6300.00	20000.00
Andy	5400.00	25400.00
Sandy	5400.00	30800.00
Tracy	4800.00	35600.00
Carol	4600.00	40200.00

Cumulative totals are often useful for time-series rows.

Window AVG

```
SELECT name, salary,  
       round(AVG(salary) OVER (), 2) AS avg  
FROM emp  
ORDER BY salary DESC;
```

name	salary	avg
Mike	7100.00	5742.86
James	6600.00	5742.86
Betty	6300.00	5742.86
Andy	5400.00	5742.86
Sandy	5400.00	5742.86
Tracy	4800.00	5742.86
Carol	4600.00	5742.86

Difference Compared to Average

```
SELECT name, salary,  
       round(AVG(salary) OVER (), 2) AS avg,  
       round(salary - AVG(salary) OVER (), 2) AS diff_avg  
FROM emp  
ORDER BY salary DESC;
```

name	salary	avg	diff_avg
Mike	7100.00	5742.86	1357.14
James	6600.00	5742.86	857.14
Betty	6300.00	5742.86	557.14
Andy	5400.00	5742.86	-342.86
Sandy	5400.00	5742.86	-342.86
Tracy	4800.00	5742.86	-942.86
Carol	4600.00	5742.86	-1142.86

Compared to the Next Value

```
SELECT name, salary,  
       salary - LEAD(salary, 1) OVER  
           (ORDER BY salary DESC) AS diff_next  
FROM emp  
ORDER BY salary DESC;
```

name	salary	diff_next
Mike	7100.00	500.00
James	6600.00	300.00
Betty	6300.00	900.00
Sandy	5400.00	0.00
Andy	5400.00	600.00
Tracy	4800.00	200.00
Carol	4600.00	(null)

Compared to Lowest-Paid Employee

```
SELECT name, salary,  
       salary - LAST_VALUE(salary) OVER w AS more,  
       round((salary - LAST_VALUE(salary) OVER w) /  
             LAST_VALUE(salary) OVER w * 100) AS pct_more  
FROM emp  
WINDOW w AS (ORDER BY salary DESC ROWS BETWEEN  
             UNBOUNDED PRECEDING AND UNBOUNDED FOLLOWING)  
ORDER BY salary DESC;
```

name	salary	more	pct_more
Mike	7100.00	2500.00	54
James	6600.00	2000.00	43
Betty	6300.00	1700.00	37
Andy	5400.00	800.00	17
Sandy	5400.00	800.00	17
Tracy	4800.00	200.00	4
Carol	4600.00	0.00	0

RANK and DENSE_RANK

```
SELECT name, salary, RANK() OVER s, DENSE_RANK() OVER s
FROM emp
WINDOW s AS (ORDER BY salary DESC)
ORDER BY salary DESC;
```

name	salary	rank	dense_rank
Mike	7100.00	1	1
James	6600.00	2	2
Betty	6300.00	3	3
Andy	5400.00	4	4
Sandy	5400.00	4	4
Tracy	4800.00	6	5
Carol	4600.00	7	6

Departmental Average

```
SELECT name, department, salary,  
       round(AVG(salary) OVER  
             (PARTITION BY department), 2) AS avg,  
       round(salary - AVG(salary) OVER  
             (PARTITION BY department), 2) AS diff_avg  
FROM emp  
ORDER BY department, salary DESC;
```

name	department	salary	avg	diff_avg
Mike	Marketing	7100.00	6700.00	400.00
Betty	Marketing	6300.00	6700.00	-400.00
Sandy	Sales	5400.00	5000.00	400.00
Carol	Sales	4600.00	5000.00	-400.00
James	Shipping	6600.00	5600.00	1000.00
Andy	Shipping	5400.00	5600.00	-200.00
Tracy	Shipping	4800.00	5600.00	-800.00

WINDOW Clause

```
SELECT name, department, salary,  
       round(AVG(salary) OVER d, 2) AS avg,  
       round(salary - AVG(salary) OVER d, 2) AS diff_avg  
FROM emp  
WINDOW d AS (PARTITION BY department)  
ORDER BY department, salary DESC;
```

name	department	salary	avg	diff_avg
Mike	Marketing	7100.00	6700.00	400.00
Betty	Marketing	6300.00	6700.00	-400.00
Sandy	Sales	5400.00	5000.00	400.00
Carol	Sales	4600.00	5000.00	-400.00
James	Shipping	6600.00	5600.00	1000.00
Andy	Shipping	5400.00	5600.00	-200.00
Tracy	Shipping	4800.00	5600.00	-800.00

Compared to Next Department Salary

```
SELECT name, department, salary,  
       salary - LEAD(salary, 1) OVER  
         (PARTITION BY department  
          ORDER BY salary DESC) AS diff_next  
FROM emp  
ORDER BY department, salary DESC;
```

name	department	salary	diff_next
Mike	Marketing	7100.00	800.00
Betty	Marketing	6300.00	(null)
Sandy	Sales	5400.00	800.00
Carol	Sales	4600.00	(null)
James	Shipping	6600.00	1200.00
Andy	Shipping	5400.00	600.00
Tracy	Shipping	4800.00	(null)

Departmental and Global Ranks

```
SELECT name, department, salary, RANK() OVER s AS dept_rank,  
       RANK() OVER (ORDER BY salary DESC) AS global_rank  
FROM emp  
WINDOW s AS (PARTITION BY department ORDER BY salary DESC)  
ORDER BY department, salary DESC;
```

name	department	salary	dept_rank	global_rank
Mike	Marketing	7100.00	1	1
Betty	Marketing	6300.00	2	3
Sandy	Sales	5400.00	1	4
Carol	Sales	4600.00	2	7
James	Shipping	6600.00	1	2
Andy	Shipping	5400.00	2	4
Tracy	Shipping	4800.00	3	6

6. Considerations



<https://www.flickr.com/photos/10413717@N08/>

Tips

- ▶ Do you want to split the set? (`PARTITION BY` creates multiple partitions)
- ▶ Do you want an order in the partition? (use `ORDER BY`)
- ▶ How do you want to handle rows with the same `ORDER BY` values?
 - ▶ `RANGE` vs `ROW`
 - ▶ `RANK` vs `DENSE_RANK`
- ▶ Do you need to define a window frame?
- ▶ Window functions can define their own partitions, ordering, and window frames.
- ▶ Multiple window names can be defined in the `WINDOW` clause.
- ▶ Pay attention to whether window functions operate on frames or partitions.

Window Function Summary

Scope	Type	Function	Description
frame	computation	<i>generic aggs.</i>	e.g., SUM, AVG
	row access	FIRST_VALUE	first frame value
		LAST_VALUE	last frame value
NTH_VALUE		<i>n</i> th frame value	
partition	row access	LAG	row before current
		LEAD	row after current
		ROW_NUMBER	current row number
	ranking	CUME_DIST	cumulative distribution
		DENSE_RANK	rank without gaps
		NTILE	rank in <i>n</i> partitions
PERCENT_RANK	percent rank		
RANK	rank with gaps		

Window functions never process rows outside their partitions. However, without PARTITION BY the partition is the entire set.

Postgres 11 Improvements: RANGE AND GROUPS

- ▶ Allow RANGE window frames to specify peer groups whose values are plus or minus the specified PRECEDING/FOLLOWING offset
- ▶ Add GROUPS window frames which specify the number of peer groups PRECEDING/FOLLOWING the current peer group:

```
WINDOW (  
    [PARTITION BY ...]  
    [ORDER BY ...]  
    [  
        { RANGE | ROW | GROUPS }  
        { frame_start | BETWEEN frame_start AND frame_end }  
    ]  
)
```

Postgres 11 Improvements: Frame Exclusion

- ▶ New *frame_exclusion* clause:

```
WINDOW (  
    [PARTITION BY ...]  
    [ORDER BY ...]  
    [  
        { RANGE | ROW | GROUPS }  
        { frame_start | BETWEEN frame_start AND frame_end }  
        frame_exclusion  
    ]  
)
```

where *frame_exclusion* can be:

- ▶ EXCLUDE CURRENT ROW
- ▶ EXCLUDE GROUP (exclude peer group)
- ▶ EXCLUDE TIES (exclude other peers)
- ▶ EXCLUDE NO OTHERS

Conclusion



<http://momjian.us/presentations>

<https://www.flickr.com/photos/10318765@N03/>