BKM_DATS: Databázové systémy
4. Advanced SQL

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Advanced Aggregate Functions

- General functions
  - array_agg(expression)
    - packs all input values into one array
- Statistical functions
  - stddev_samp(expression)
    - calculates the (sample) standard deviation over the values
  - var_samp(expression)
    - calculates the (sample) variance over the values
  - corr(a,b)
    - correlation coefficient between the two sets of values
  - regr_slope(y,x)
    - slope of the least-squares-fit linear function determined by the (x, y) pairs
  - regr_intercept(y, x)
    - y-intercept of the least-squares-fit linear equation determined by the (x, y) pairs

Advanced Aggregate Functions

- (Inverse) Distribution functions
  - mode() WITHIN GROUP (ORDER BY expression)
    - returns the most frequent input value
      - choosing the first one arbitrarily if there are multiple equally-frequent results
  - percentile_cont(fraction) WITHIN GROUP (ORDER BY expression)
    - *continuous* percentile: returns a value corresponding to the specified fraction in the ordering,
    - interpolating between adjacent input items if needed
  - percentile_disc(fraction) WITHIN GROUP (ORDER BY expression)
    - *discrete* percentile: returns the first input value whose position in the ordering equals or exceeds the specified fraction

fraction $\in$ <0;1>

Advanced Aggregate Functions

- Hypothetical-set functions
  - rank(value) WITHIN GROUP (ORDER BY expr)
    - rank of the hypothetical value, with gaps for duplicate rows, over all values of expr.
  - dense_rank(value) WITHIN GROUP (ORDER BY expr)
    - rank of the hypothetical value, without gaps
  - percent_rank(value) WITHIN GROUP (ORDER BY expr)
    - relative rank of the hypothetical value, ranging from 0 to 1
  - cume_dist(value) WITHIN GROUP (ORDER BY expr)
    - relative rank of the hypothetical value, ranging from 1/N to 1

Analytic Functions

- provide the ability to perform calculations across sets of rows that are related to the current query row
- generally called *Window functions*
- <aggregate function>
  OVER ([PARTITION BY <column list>]
  ORDER BY <sort column list>
  [<aggregation grouping>])
- E.g.,
  SELECT … ,
  AVG(sales) OVER (PARTITION BY region
  ORDER BY month ASC ROWS 2 PRECEDING), …
  FROM …
  - moving/rolling average over 3 rows

Analytic Functions

- Ranking operators
  - Row numbering is the most basic ranking function
    - E.g.,

```
SELECT SalesOrderID , CustomerID ,
        ROW_NUMBER() OVER (ORDER BY SalesOrderID )
                as RunningCount
FROM Sales WHERE SalesOrderID > 10000
ORDER BY SalesOrderID
```

SalesOrderID	CustomerID	RunningCount
43659	543	1
43660	234	2
43661	143	3
43662	213	4
43663	312	5

Analytic Functions

- ROW_NUMBER doesn't consider tied values
  - Each 2 equal values get 2 different row numbers

SalesOrderID	RunningCount
43659	1
43659	2
43660	3
43661	4

  - The behavior is nondeterministic
    - Each tied value could have its number switched!
- We need something deterministic
  - RANK() and DENSE_RANK()

Analytic Functions

- RANK and DENSE_RANK functions
  - Allow ranking items in a group
  - Syntax:
    - RANK ( ) OVER ([query_partition_clause] order_by_clause)
    - DENSE_RANK ( ) OVER ([query_partition_clause] order_by_clause)
  - DENSE_RANK
    - leaves no gaps in ranking sequence when there are ties
  - PERCENT_RANK ←→ (rank - 1) / (total rows - 1)
  - CUME_DIST - the cumulative distribution
    - the number of partition rows preceding (or peers with) the current row / total partition rows
    - The value ranges from 1/N to 1

Analytic Functions

- Example

```
SELECT channel, calendar,
  TO_CHAR(TRUNC(SUM(amount_sold), -6), '9,999,999') AS sales,
  RANK() OVER (ORDER BY TRUNC(amount_sold, -6)) DESC) AS rank,
  DENSE_RANK() OVER (ORDER BY TRUNC(SUM(amount_sold), -6)) DESC) AS
dense_rank
FROM sales, products
… GROUP BY channel, calendar ORDER BY sales DESC
```

CHANNEL	CALENDAR	SALES	RANK	DENSE_RANK
Direct sales	02.2015	10,000	1	1
Direct sales	03.2015	9,000	2	2
Internet	02.2015	6,000	3	3
Internet	03.2015	6,000	3	3
Partners	03.2015	4,000	5	4

Analytic Functions

- Group ranking - RANK function can operate within groups: the rank gets reset whenever the group changes
  - A single query can contain more than one ranking function, each partitioning the data into different groups.
  - PARTITION BY clause

SELECT … RANK() OVER (PARTITION BY channel ORDER BY SUM(amount_sold) DESC) AS rank_by_channel

CHANNEL	CALENDAR	SALES	RANK _BY_CHANNEL
Direct sales	02.2016	10,000	1
Direct sales	03.2016	9,000	2
Internet	02.2016	6,000	1
Internet	03.2016	6,000	1
Partners	03.2016	4,000	1

Analytic Functions

- NTILE splits a set into equal-sized groups
  - It divides an ordered partition into buckets and assigns a bucket number to each row in the partition
  - Buckets are calculated so that each bucket has exactly the same number of rows assigned to it or at most 1 row more than the others

SELECT … NTILE(3) OVER (ORDER BY sales) NT_3 FROM …

CHANNEL	CALENDAR	SALES	NT_3
Direct sales	02.2016	10,000	1
Direct sales	03.2016	9,000	1
Internet	02.2016	6,000	2
Internet	03.2016	6,000	2
Partners	03.2016	4,000	3

  - NTILE(4) - quartile
  - NTILE(100) - percentage
- Not a part of the SQL99 standard, but adopted by major vendors

Analytic Functions

- Obtain a value of a particular row of a *window frame* defined by window clause (PARTITION BY…)
  - `first_value(expression)`
  - `last_value(expression)`
  - `nth_value (expression)`

CHANNEL	CALENDAR	SALES	LOWEST_SALE
Direst sales	02.2016	10,000	4,000
Direst sales	03.2016	9,000	4,000
Internet	02.2016	6,000	4,000
Internet	03.2016	6,000	4,000
Partners	03.2016	4,000	4,000

SELECT … FIRST_VALUE(sales) OVER (ORDER BY sales) AS lowest_sale

SELECT … FIRST_VALUE(sales) OVER (PARTITION BY channel ORDER BY sales) AS lowest_sales

Analytic Functions

- Access to a row that comes before the current row at a specified physical offset with the current window frame (partition)
  - LAG(expression [,offset [,default_value]])
- … after the current row
  - LEAD(expression [,offset [,default_value]]

CHANNEL	CALENDAR	SALES	PREV_SALE
Direst sales	02.2016	10,000	NULL
Direst sales	03.2016	9,000	10,000
Internet	02.2016	6,000	NULL
Internet	03.2016	6,000	6,000
Partners	03.2016	4,000	NULL

SELECT … LAG(sales, 1) OVER (PARTITION BY channel ORDER BY calendar) AS prev_sales

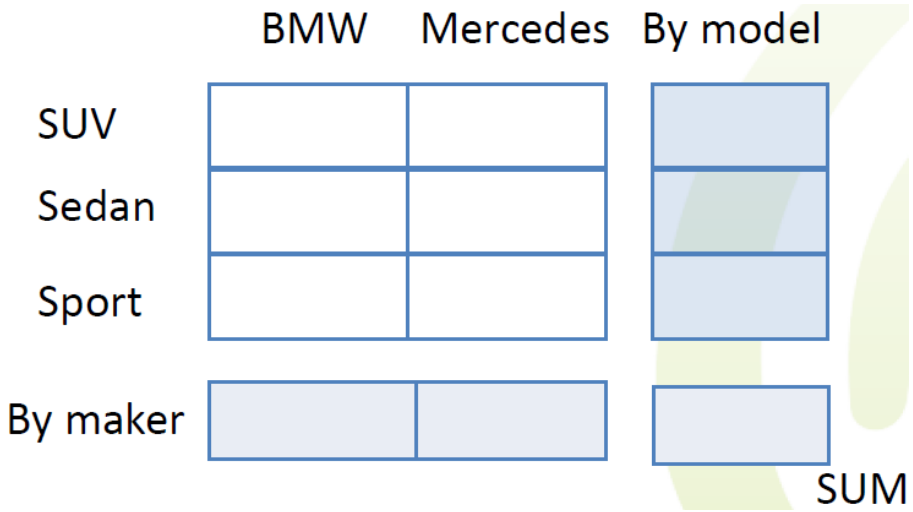
Data Aggregations

- Used in GROUP BY clause instead of mere list of attributes
- ROLLUP (e1, e2, e3, …)
  - represents the given list of expressions and all prefixes of the list including the empty list
- CUBE (e1, e2, e3, …)
  - represents the given list and all of its possible subsets (i.e., the power set)
- GROUPING SETS ((e1,e2), (e4,e5), (e6), () …)
  - rows are grouped separately by each specified grouping set

- Function to obtain which “GROUP BY” takes place
  - GROUPING(args...)
    - Integer bit mask indicating which arguments are not being included in the current grouping set

Data Aggregations

- Pivoting table for make and model over sales data
  - SELECT make, model, sum(amount) FROM sales GROUP BY CUBE (make, model)



Data Aggregations

- Example of CUBE on table of car sales (year, make, model, amount)
  - GROUP BY CUBE (year, make, model) calculates: