SQL Language: news from the 2003 standard

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SQL:2003

- a lot of corrections and bug fixes
- several new features
  - data types
    - operations
    - predicates
  - operation MERGE
  - OLAP: TABLESAMPLE
  - generated columns
  - the identity columns and generators
- part 14 SQL/XML

New data types

- BIGINT
- MULTISET

Rejected types (from 1999)

- BIT
- BIT VARYING

BIGINT

- Precision of BIGINT ≥ precision of INTEGER ≥ precision of SMALLINT
- based on INT and SMALLINT
- the same operators like SMALLINT and INTEGER

MULTISET

- types of collections:
  - MULTISET
  - ARRAY
- multiset is a non-sorted, variable-length collection whose elements have a specified type
  - MULTISET - no maximal cardinality is specified
  - ARRAY - max. cardinality is not mandatory

MULTISET - definition

- A INTEGER MULTISET
- B ROW(F1 BIGINT, F2 VARCHAR(4000)) MULTISET
- C INTEGER MULTISET()
  - empty multiset of integers (*not* NULL!)
- D INTEGER MULTISET(2, 3, 5, 7)
  - non-empty multiset with several integers
- E INTEGER MULTISET(SELECT A
  FROM R WHERE A > 10)
  multiset of integers given by a SELECT

MULTISET – ops. and functions

/* *multi* stands for a multiset */

- CARDINALITY(*multi*)
  - returns the number of elements in *multi*
- SET(*multi*)
  - returns content of *multi* without duplicities
- ELEMENT(*multi*)
  - the cardinality must by 1
  - returns the element (singleton)

MULTISET - ops. and functions

- UNNEST(*multi*) AS *name*
  - returns the individual elements of *multi* as rows of a virtual table *name*

    UNNEST MULTISET (2, 3, 5, 7) AS P

P
2
3
5
7

MULTISET – ops. and functions

- *multi1* MULTISET *op* [*quantifier*] *multi2*

  op — UNION, EXCEPT, INTERSECT

  quantifier — ALL or DISTINCT

Note: similar to the set operators

UNION, EXCEPT a INTERSECT

Note: quantifier ALL is implicit

MULTISET – ops. and functions

```
SELECT
   A MULTISET INTERSECT DISTINCT B
FROM R
WHERE CARDINALITY(B) > 50
```

MULTISET – ops. and functions

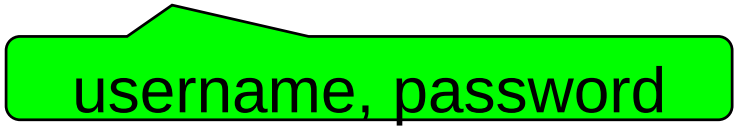
New aggregation functions for multisets

Assumption: a group is given by GROUP BY or by a collumn

- COLLECT — transforms values in a group into the multiset
- FUSION — creates a *union* of all multisests in a group — amount of duplicities of a value = sum of duplicities of the value in each multiset in a group
- INTERSECTION — *intersects* all multisets in a group — amount of duplicities on a value in the result = minimum of duplicities on the value in all multisets in given groups

MULTISET – ops. and functions

```
CREATE TABLE Logins(
    session_id      INT NOT NULL PRIMARY KEY,
    successful      BOOLEAN NOT NULL,
    user_id         INT,
    attempts        ROW(VARCHAR(128), VARCHAR(128))
                    MULTISET);
```




```
SELECT user_id,
            COLLECT (session_id) AS s_ids,
            FUSION (attempts) AS all_attempts,
            INTERSECTION (attempts) AS common_attempts
FROM Logins
WHERE Successful
GROUP BY user_id;
```

MULTISET – ops. and functions

A part of Logins for the user with Id = 8 and his/her successful attempts

Logins:	session_Id	user_Id	attempts
	a	8	multiset[(1,x),(2,y)]
	b	8	multiset[(1,x)]
	c	8	multiset[(1,x),(3,h)]

Result (1 row for the user with Id = 8)

s_ids	all_attempts	common_attempts
multiset[a,b,c]	multiset[(1,x), (1,x), (1,x), (2,y), (3,h)]	multiset[(1,x)]

New predicates

- comparison (multiset!) operators = and <>
- [NOT] MEMBER
- [NOT] SUBMULTISET
- IS A SET, IS NOT A SET

Predicate MEMBER

h [NOT] MEMBER [OF] *multi*

- *h* must be compatible with the type of elements in *multi*
- FALSE if *h* is not in *multi* or *h* is empty
- TRUE if *h* is equals to any element in *multi*
- UNKNOWN if any element in *multi* is NULL

Predicate SUBMULTISET

multi1 [NOT] SUBMULTISET [OF] *multi2*

…element types from multisets have to be compatible

- relation „be a submultiset“
- TRUE if $|$*multi1*$|$ = $|$*multi2*$|$ and each value in *multi1* has a correspondent value in *multi2*

Predicate SET

multi IS [NOT] A SET

- *multi* is a multiset
- TRUE if there are no duplicities in *multi*
- max 1 NULL value in the set

MERGE

- combines INSERT and UPDATE statements
- rows of input (reference) table are divided into two groups according to predicate P:

  insert source table (IST) if P is FALSE or UNKNOWN

  update source table (UST), if P is TRUE.

MERGE

- IST rows are inserted into result table R.
- each row in R which equals to a row in UST is updated.
  - if there are more equal rows in R for one row from UST, an error is raised
- Syntax is done by MATCHED and NOT MATCHED keywords

MERGE

```
MERGE INTO table [AS name]
   USING reference_table
   ON condition
   WHEN MATCHED THEN
        SET column = value
```

```
MERGE INTO table [AS name]
   USING reference_table
   ON condition
   WHEN NOT MATCHED THEN
                INSERT [(a_list_of_columns)]
                VALUES (a_list_of_values)
```

store(prod_id, description, amount)
import(prod_id, description, amount, price)

MERGE

```
MERGE INTO store AS ST
   USING (SELECT prod_id, description, amount
             FROM import) AS IM
   ON (ST.prod_id = IM.prod_id)
WHEN MATCHED THEN
    UPDATE SET amount = ST.amount + IM.amount
WHEN NOT MATCHED THEN
    INSERT (prod_id, description, amount)
    VALUES (IM.prod_id, IM.descr, IM.amount)
```

TABLESAMPLE

- new feature for OLAP
- evaluation of aggregation functions in samples derived from DB data
- faster application development in the case of a big DB
- two different sampling methods: BERNOULLI and SYSTEM

TABLESAMPLE

```
TABLESAMPLE {BERNOULLI | SYSTEM}
(%amount) [REPEATABLE(amount_op)]
```

- BERNOULLI: sample table consists of appr. %amount of original table; probability of appearance a given row in the sample is %amount independently of every other row.
- SYSTEM: sample table consists of appr. %amount of original table; probability of appearance a given row in the sample can depend on rows already inserted into the sample
- REPEATABLE: amount of repeated operation calls (amount_op) generates the same sample for the same source.

TABLESAMPLE

Q.: Guess appr. estimation of the total salary for each department

```
SELECT dept, SUM(salary) * 10
FROM employees
    TABLESAMPLE BERNOULLI (10)
REPEATABLE (5)
GROUP BY dept
```

Generated columns

- original columns of table: *base columns*
- *generated columns* - their value is computed from 0 or more base columns of the same row

```
CREATE TABLE employees (
emp_ID          INTEGER,
dept            string(6)
salary          DECIMAL(7,2),
addition        DECIMAL(7,2),
total_salary    GENERATED ALWAYS AS
                (salary + addition),
user            GENERATED ALWAYS AS
                (CURRENT_USER ))
```

- Values of generated columns are calculated automatically with INSERT into the table.

Identity columns & generators

- *identity column*: mechanism for automatic key population
- *generator*: used for generation of the next value of a sequence
- together provides the mechanism for automatic key generation for identity columns

Sequence generators

Parameters:

- data type (numeric)
- start value
- increment (positive or negative, 1 by default)
- minimal and maximal values
- cycle (when the maximum value is reached, it starts from the beginning)
- external (explicit object of the schema) or internal (part of another schema object, column for example)

External generators

```
CREATE SEQUENCE s_name AS type
    START WITH value
    INCREMENT BY value
    MAXVALUE value
    CYCLE
```

} generator options

- possibilities:
  - NO CYCLE
  - NO MAXVALUE, MINVALUE, NO MINVALUE

Sequence generators

- is initialized to a base value Z
- generation of the next value:

  NEXT VALUE FOR s_name
- returns $Z + N * incremental\_value$, *for* $N \geq 0$
  - if computed value > MAXVALUE (or < MINVALUE) and NO CYCLE, then raise exception

Sequence generators

Examples:

Order(order_id, prod, amount)

```
INSERT INTO Order
    VALUES (NEXT VALUE FOR order_id, 'prod1', 2 );

CALL myproc(NEXT VALUE FOR order_id);

SET J = J + NEXT VALUE FOR order_id ;
```

Sequence generators

- value of start, max, min, increment, and cycle/nocycle can be changed by alter statement

```
ALTER SEQUENCE s_name
RESTART WITH new_base_value
```

- removing of sequence

```
DROP SEQUENCE s_name
```

Internal sequence generators

- GENERATED ALWAYS or GENERATED BY DEFAULT
  - ALWAYS — means UPDATE on column is not allowed;

    INSERT requires OVERRIDING SYSTEM VALUE (privilege)
  - BY DEFAULT — INSERT or UPDATE allowed; the value is generated during INSERT, if it is not specified in statement

Internal sequence generators

```
CREATE TABLE Employees (
    em_id   INTEGER
        GENERATED ALWAYS AS IDENTITY
        START WITH 100
        INCREMENT 1
        MINVALUE 100
        NO MAXVALUE
        NO CYCLE,
    salary DECIMAL(7,2), ...,
  )
```

Conclusion

- These extensions support creating analytical functions in SQL, i.e., they are usable for OLAP and now for so called Big Analytics.