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Information technology database languages — Guidance for the use of database language SQL

Part 9: Online analytic processing (OLAP) capabilities

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Foreword

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Introduction

This document discusses the syntax and semantics for including online analytic processing (OLAP) capabilities in SQL, as defined in ISO/IEC 9075-2.

The organization of this document is as follows:

1) Clause 1, "Scope", specifies the scope of this document.

2) Clause 2, "Normative references", identifies standards that are referenced as part of requirements by this document.

3) Clause 3, "Terms and definitions", defines the terms and definitions used in this document.

4) Clause 5, "Windows", discusses Feature T611, "Elementary OLAP operations" and Feature T612, "Advanced OLAP operations", introducing the concept of a window in an SQL query.

5) Clause 6, "Window functions", further discusses Feature T611, "Elementary OLAP operations" and Feature T612, "Advanced OLAP operations", as well as Feature T614, "NTILE function", Feature T615, "LEAD and LAG functions", Feature T616, "Null treatment option for LEAD and LAG functions", Feature T617, "FIRST_VALUE and LAST_VALUE functions", and Feature T618, "NTH_VALUE function".

6) Clause 7, "Nested window functions", discusses the additional window functionality in Feature T619, "Nested window functions".

7) Clause 8, "Enhanced aggregate functions", discusses Feature T621, "Enhanced numeric functions" and its introduction of enhanced aggregate functions in SQL.

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Information technology — Guidance for the use of database language SQL —

Part 9:
Online analytic processing (OLAP) capabilities

1 Scope

This document discusses the syntax and semantics for including online analytic processing (OLAP) capabilities in SQL, as defined in ISO/IEC 9075-2.

It discusses the following features regarding OLAP capabilities of the SQL language:

— Feature T611, “Elementary OLAP operations”,

— Feature T612, “Advanced OLAP operations”,

— Feature T614, “NTILE function”,

— Feature T615, “LEAD and LAG functions”,

— Feature T616, “Null treatment option for LEAD and LAG functions”,

— Feature T617, “FIRST_VALUE and LAST_VALUE functions”,

— Feature T618, “NTH_VALUE function”,

— Feature T619, “Nested window functions”,

— Feature T620, “WINDOW clause: GROUPS option”,

— Feature T621, “Enhanced numeric functions”.

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2 Normative references

There are no normative references in this document.

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3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

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4 Example data

4.1 Introduction to example data

The examples in this document are based on several tables.

The order in which the rows of all sample tables are displayed is immaterial.

4.2 Table sales history

Subclause 4.2, "Table sales history", contains information on a business spread over several territories with total sales accumulated monthly in each territory. Table 1, "Table sales_history ", shows sample data for Subclause 4.2, "Table sales history":

Table 1 — Table sales_history

Territory	Month	Sales
East	199812	11
West	199811	12
West	199901	11
East	199811	4
East	199810	10
West	199810	8
East	199902	10
East	199901	7
West	199812	7
West	199902	6

SQL to create and populate Subclause 4.2, "Table sales history".

```
CREATE TABLE Sales_History
(Territory CHARACTER (10),
 Month INTEGER,
 Sales INTEGER)

INSERT INTO Sales_History VALUES ('East', 199812, 11)
INSERT INTO Sales_History VALUES ('West', 199811, 12)
INSERT INTO Sales_History VALUES ('West', 199901, 11)
INSERT INTO Sales_History VALUES ('East', 199811, 4)
INSERT INTO Sales_History VALUES ('East', 199810, 10)
INSERT INTO Sales_History VALUES ('West', 199810, 8)
INSERT INTO Sales_History VALUES ('East', 199902, 10)
```


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```
INSERT INTO Sales_History VALUES ('East', 199901, 7)
INSERT INTO Sales_History VALUES ('West', 199812, 7)
INSERT INTO Sales_History VALUES ('West', 199902, 6)
```

4.3 Table stock1

The next examples are two variants of a stock table containing information on stock transactions for a particular account. Columns in Table 2, "Table stock1", include transaction ID, trade day, and type, as well as the share amount and ticker symbol. Subclause 4.4, "Table stocks", covers the columns ticker, tradeday, and price.

Table 2 — Table stock1

Acno	Tid	Tradeday	TType	Amount	Ticker
123	1	1	buy	1000	csco
123	2	1	buy	400	inpr
123	3	2	buy	2000	symc
123	4	2	buy	1200	csco
123	5	2	buy	500	inpr
123	6	4	buy	200	csco
123	7	4	buy	100	csco
123	9	5	buy	400	inpr
123	10	5	buy	200	goog
123	11	5	buy	1000	inpr
123	12	5	buy	4000	inpr
123	13	8	buy	2000	hpq

SQL to create and populate Table 2, "Table stock1".

```
CREATE TABLE Stock1
(Acno INTEGER,
 Tid INTEGER,
 Tradeday INTEGER,
 TType CHARACTER (10),
 Amount INTEGER,
 Ticker CHARACTER (10))

INSERT INTO Stock1 VALUES (123, 1, 1, 'buy', 1000, 'csco')
INSERT INTO Stock1 VALUES (123, 2, 1, 'buy', 400, 'inpr')
INSERT INTO Stock1 VALUES (123, 3, 2, 'buy', 2000, 'symc')
INSERT INTO Stock1 VALUES (123, 4, 2, 'buy', 1200, 'csco')
INSERT INTO Stock1 VALUES (123, 5, 2, 'buy', 500, 'inpr')
INSERT INTO Stock1 VALUES (123, 6, 4, 'buy', 200, 'csco')
```

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```
INSERT INTO Stock1 VALUES (123, 7, 4, 'buy', 100, 'csco')
INSERT INTO Stock1 VALUES (123, 9, 5, 'buy', 400, 'inpr')
INSERT INTO Stock1 VALUES (123, 10, 5, 'buy', 200, 'goog')
INSERT INTO Stock1 VALUES (123, 11, 5, 'buy', 1000, 'inpr')
INSERT INTO Stock1 VALUES (123, 12, 5, 'buy', 4000, 'inpr')
INSERT INTO Stock1 VALUES (123, 13, 8, 'buy', 2000, 'hpq')
```

4.4 Table stocks

Table 3 — Table stocks

Ticker	Tradeday	Price
ZYX	1	10
ZYX	2	11
ZYX	3	12
ZYX	4	12
ZYX	5	12
ZYX	6	11
ZYX	7	12
ZYX	8	12

SQL to create and populate Subclause 4.4, “Table stocks”.

```
CREATE TABLE Stocks
(Ticker CHARACTER (10),
 Tradeday INTEGER,
 Price INTEGER)

INSERT INTO Stocks VALUES ('ZYX', 1, 10)
INSERT INTO Stocks VALUES ('ZYX', 2, 11)
INSERT INTO Stocks VALUES ('ZYX', 3, 12)
INSERT INTO Stocks VALUES ('ZYX', 4, 12)
INSERT INTO Stocks VALUES ('ZYX', 5, 12)
INSERT INTO Stocks VALUES ('ZYX', 6, 11)
INSERT INTO Stocks VALUES ('ZYX', 7, 12)
INSERT INTO Stocks VALUES ('ZYX', 8, 12)
```

4.5 Table homes

The final example is Table 4, “Table homes”, containing data concerning house prices and locations.

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Table 4 — Table homes

Area	Address	Price
Uptown	15 Peekaboo St.	456,000
Uptown	27 Primrose Path	341,000
Uptown	44 Shady Lane	341,000
Uptown	23301 Highway 61	244,000
Uptown	34 Desolation Rd.	244,000
Uptown	77 Sunset Strip	102,000
Downtown	72 Easy St.	509,000
Downtown	29 Wong Way	201,000
Downtown	45 Diamond Lane	201,000
Downtown	76 Blind Alley	201,000
Downtown	15 Tern Pike	199,000
Downtown	444 Kanga Rua	102,000

SQL to create and populate Table 4, “Table homes”.

```
CREATE TABLE Homes
(Area CHARACTER (10),
 Address CHARACTER (20),
 Price INTEGER)

INSERT INTO Homes VALUES ('Uptown', '15 Peekaboo St.', 456000)
INSERT INTO Homes VALUES ('Uptown', '27 Primrose Path', 341000)
INSERT INTO Homes VALUES ('Uptown', '44 Shady Lane', 341000)
INSERT INTO Homes VALUES ('Uptown', '23301 Highway 61', 244000)
INSERT INTO Homes VALUES ('Uptown', '34 Desolation Rd.', 244000)
INSERT INTO Homes VALUES ('Uptown', '77 Sunset Strip', 102000)
INSERT INTO Homes VALUES ('Downtown', '72 Easy St.', 509000)
INSERT INTO Homes VALUES ('Downtown', '29 Wong Way', 201000)
INSERT INTO Homes VALUES ('Downtown', '45 Diamond Lane', 201000)
INSERT INTO Homes VALUES ('Downtown', '76 Blind Alley', 201000)
INSERT INTO Homes VALUES ('Downtown', '15 Tern Pike', 199000)
INSERT INTO Homes VALUES ('Downtown', '444 Kanga Rua', 102000)
```

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5 Windows

5.1 Introduction to windows

SQL in Feature T611, "Elementary OLAP operations" and Feature T612, "Advanced OLAP operations" of ISO/IEC 9075-2 adds support for online analytical processing (OLAP). The extensions are parts of the SELECT command.

OLAP is concerned with data aggregation across grouping criteria to generate values such as subtotals and totals on multiple levels. Grouping criteria are often called dimensions. OLAP is based on the concept of multiple dimensions and navigation across the aggregation levels as well as the accumulated data. OLAP is used in applications such as analytics and reporting. It can be used in iterative fashions trying out different grouping criteria and different subsets of the data to be analyzed.

To deal with these requirements, the features mentioned above introduce a "WINDOW" facility that can present aggregated content as a rolling window, ordered and grouped by the specified criteria. See the example in Subclause 5.2.2, "Window partitioning", Table 5, "Result of window clause".

The data can be treated like other result sets, and/or can be used for further processing.

A query contains a select list and a table expression. The table expression produces a result set; call it *RT*. The select list is evaluated by applying its expressions to each row in *RT*. Without the OLAP features, the select list expressions can only "see" that one current row, making it impossible to compute values that rely on values from other rows in *RT*. Such computations can be simulated only by arranging for the necessary values to be included as additional columns in *RT*, which may be inconvenient or impossible.

The concept of the windowed table alleviates this limitation by adding windows to the result of the table expression. One way to think of a window might be to imagine that it is a transient copy of *RT*, including an indication of the current row. (This is just a conceptual device; an implementation need not actually copy *RT*.) This transient copy can be logically re-arranged according to a sort ordering, a partitioning, or both; it can also be limited to a subset of rows, via window framing. These rearrangements of the window's rows take place without affecting *RT* itself. Multiple windows may exist, each with its own independently applied ordering, partitioning, and/or framing specifications. Windows may be defined either in the new window clause, or in-line in individual window function specifications in the select list.

Partitioning and/or ordering may be used to compute such results as ranking, Ntiles, and other analytic functions. The frame specifies which rows of a partition, relative to the current row, should participate in the calculation of an OLAP function. Through frames, windows support such important OLAP capabilities as cumulative sums and moving averages.

Ordering in windows is specified with the same sort specification list used by cursors and elsewhere in the SELECT statement, and with the same semantics. Ordering as enhanced for the OLAP capabilities of SQL also includes user specified control of the ordering of nulls. Although ordering of rows may be nondeterministic within a window, the same nondeterministic ordering is used in windows that have equivalent partitioning and ordering clauses specified.

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