TECHNICAL REPORT

ISO/IEC TR 19075-8

Information technology database languages — SQL technical reports —

Part 8:
Multi-dimensional arrays (SQL/MDA)

Langages de base de données IT — SQL rapport techniques —

Partie 8: Tableaux multidimensionnels

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 32, *Data management and interchange*.

A list of all parts in the ISO/IEC 19075 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

NOTE 1 — The individual parts of multi-part standards are not necessarily published together. New editions of one or more parts may be published without publication of new editions of other parts.

Introduction

This Technical Report describes the definition and use of multi-dimensional arrays in SQL. Multidimensional arrays represent a core underlying structure of manifold science and engineering data. It is generally recognized today, therefore, that arrays have an essential role in Big Data and should become an integral part of the overall data type orchestration in information systems. This Technical Report discusses the syntax and semantics of operations on the MD-array data type defined in ISO/IEC 9075-15.

The organization of this Technical Report is as follows:

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

2) Clause 2, "Normative references", identifies standards that are referenced by this Technical Report.

3) Clause 4, "Multidimensional Arrays (MDA) concepts", introduces the concept of Multidimensional Arrays.

4) Clause 5, "SQL/MDA data model", introduces the data model.

5) Clause 6, "SQL/MDA operations", covers the supported operations on MD-arrays..

6) Clause 7, "Remote sensing example", illustrates the supported functionality through realistic examples.

Information technology database languages — SQL technical reports —

Part 8:
Multi-dimensional arrays (SQL/MDA)

1   Scope

This Technical Report describes the support in SQL for Multi-Dimensional Arrays (MDA) as defined in ISO/IEC 9075-15.

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2 Normative references

There are no normative references in this document.

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

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

— IEC Electropedia: available at `http://www.electropedia.org/`.

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3   Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1   **coordinate**
non-empty ordered list of integers

3.2   **cardinality**
number of elements in an MD-array

3.3   **MD-array**
ordered collection of elements of the same type associated with an MD-extent where each element is 1:1 associated with some coordinate within its MD-extent.

> NOTE 2 — A coordinate is within an MD-extent if every coordinate value from the integer list is greater than or equal to the lower limit, and less than or equal to the upper limit of the MD-interval of the MD-axis at the position in the MD-extent as the coordinate value has within the coordinate

3.4   **MD-axis**
named MD-interval

3.5   **MD-dimension**
number of MD-axes in the MD-extent of an MD-array

> NOTE 3 — Also known as "rank" outside of SQL/MDA

3.6   **MD-extent**
non-empty ordered collection of MD-axes with no duplicate names

3.7   **MD-interval**
integer interval given by a pair of lower and upper integer limits such that the lower limit is less than or equal to the upper limit; the interval is closed, *i.e.*, both limits are contained in it

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4 Multidimensional Arrays (MDA) concepts

4.1 Concept

The phrase "(Multidimensional) array, raster data" is used to refer to arrays generally, in contrast to the MD-array term confined to the realm of SQL/MDA. It is not to be confused with the term "array" in ISO/IEC 9075-2:2016. This document uses the term ARRAY for the original SQL array collection type.

The array concept is a simple and efficient data representation that finds its use in a wide array of fields, business-related as well as scientific and engineering. Many sensors, images, image timeseries, simulation processes, statistical models, and so on, produce raw data that can immediately be classified as array data. These data may be naturally arranged along more than one axis: position and time, for example.

A *multidimensional array* (MDA) is a set of elements ordered in a multidimensional space. The space considered here is discretized (also called rasterized or gridded), that is, only integer coordinates are admitted as positions of the individual array elements. The number of integers needed to refer a particular position in this space is the array's dimension (sometimes also referred to as its dimensionality).

An element can be a single value (such as an intensity value in case of grayscale images) or a composite value (such as integer triples for the red, green, and blue components of a true-color image). All elements of an array share the same structure, referred to as the array's element type.

4.2 Why consider support for MDA in SQL?

Large multidimensional arrays in particular represent a prevalent data type across most scientific domains, with examples including 1-D sensor data, 2-D satellite images and microscope scans, 3-D x/y/t image timeseries and x/y/z voxel models, as well as 4-D and 5-D climate models.