INTERNATIONAL STANDARD

ISO/IEC 19075-4

First edition
2021-08

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

Part 4: Routines and types using the Java™ programming language

Technologies de l'information — Recommandations pour l'utilisation du langage de base de données SQL —

Partie 4: Routines et types utilisant le langage de programmation Java™

Reference number
ISO/IEC 19075-4:2021(E)

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Published in Switzerland

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Foreword

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

This first edition of ISO/IEC 19075-4 cancels and replaces ISO/IEC TR 19075-4:2015.

This document is intended to be used in conjunction with the following editions of the parts of the ISO/IEC 9075 series:

— ISO/IEC 9075-1, sixth edition or later;

— ISO/IEC 9075-2, sixth edition or later;

— ISO/IEC 9075-3, sixth edition or later;

— ISO/IEC 9075-4, seventh edition or later;

— ISO/IEC 9075-9, fifth edition or later;

— ISO/IEC 9075-10, fifth edition or later;

— ISO/IEC 9075-11, fifth edition or later;

— ISO/IEC 9075-13, fifth edition or later;

— ISO/IEC 9075-14, sixth edition or later;

— ISO/IEC 9075-15, second edition or later;

— ISO/IEC 9075-16, first edition or later.

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

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 and www.iec.ch/-national-committees.

Introduction

The organization of this document is as follows:

1) Clause 1, "Scope", specifies the scope of this document.
2) Clause 2, "Normative references", identifies additional standards that, through reference in this document, constitute provisions of this document.
3) Clause 3, "Terms and definitions", defines the terms and definitions used in this document.
4) Clause 4, "Routines tutorial", provides a tutorial on the use of routines written in the Java™[1] programming language within SQL expressions and statements.
5) Clause 5, "Types tutorial", provides a tutorial on the use of user-defined types written in the Java programming language within SQL expressions and statements.

Java™ is the trademark of a product supplied by Oracle. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC of the product named.

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

Part 4:
Routines and types using the Java™ programming language

1 Scope

This document provides a tutorial of SQL routines and types using the Java™ programming language.

This document discusses the following features of the SQL Language:

— The use of routines written in the Java programming language within SQL expressions and statements.

— The use of user-defined types written in the Java programming language within SQL expressions and statements.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 9075-2, *Information technology — Database languages — SQL — Part 2: Foundation (SQL/Foundation)*

ISO/IEC 9075-13, *Information technology — Database languages — SQL — Part 13: SQL Routines and Types Using the Java™ Programming Language (SQL/JRT)*

Java Community Process. *The Java™ Language Specification* [online]. Java SE 13 Edition. Redwood Shores, California, USA: Oracle, Available at `https://docs.oracle.com/javase/specs/jls/-se13/jls13.pdf`

Java Community Process. *JDBC™ 4.3 Specification* [online]. Edition 4.3. Redwood Shores, California, USA: Oracle, Available at `https://download.oracle.com/otn-pub/jcp/-jdbc-4_3-mrel3-eval-spec/jdbc4.3-fr-spec.pdf`

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 9075-1 apply.

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

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

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

4 Routines tutorial

4.1 Context of routines

The requirements for the material discussed in this document shall be as specified in ISO/IEC 9075-1, ISO/IEC 9075-13, Java, and JDBC.

4.2 Technical components

ISO/IEC 9075-13 includes the following:

— New built-in procedures.

- `SQLJ.INSTALL_JAR` — to load a set of Java classes in an SQL system.
- `SQLJ.REPLACE_JAR` — to supersede a set of Java classes in an SQL system.
- `SQLJ.REMOVE_JAR` — to delete a previously installed set of Java classes.
- `SQLJ.ALTER_JAVA_PATH` — to specify a path for name resolution within Java classes.

— New built-in schema.

The built-in schema named `SQLJ` is assumed to be in all catalogs of an SQL system that implements the SQL/JRT facility, and to contain all of the built-in procedures of the SQL/JRT facility.

— Extensions of the following SQL statements:

- CREATE PROCEDURE/FUNCTION — to specify an SQL name for a Java method.
- DROP PROCEDURE/FUNCTION — to delete the SQL name of a Java method.
- CREATE TYPE — to specify an SQL name for a Java class.
- DROP TYPE — to delete the SQL name of a Java class.
- GRANT — to grant the USAGE privilege on Java JARs.
- REVOKE — to revoke the USAGE privilege on Java JARs.

— Conventions for returning values of OUT and INOUT parameters, and for returning SQL result sets.

— New forms of reference: Qualified references to the fields and methods of columns whose data types are defined on Java classes.

— Additional views and columns in the Information Schema.

4.3 Overview

This tutorial shows a series of example Java classes, indicates how they can be installed, and shows how their static, public methods can be referenced with SQL/JRT facilities in an SQL-environment.

The example Java methods assume an SQL table named EMPS, with the following columns:

— NAME — the employee's name.

— ID — the employee's identification.

— STATE — the state in which the employee is located.

— SALES — the amount of the employee's sales.

— JOBCODE — the job code of the employee.

The table definition is:

```
CREATE TABLE emps (
    name    VARCHAR(50),
    id      CHARACTER(5),
    state   CHARACTER(20),
    sales   DECIMAL (6,2),
    jobcode INTEGER );
```


The example classes and methods are:

— `Routines1.region` — A Java method that maps a US state code to a region number. This method does not use SQL internally.

— `Routines1.correctStates` — A Java method that performs an SQL UPDATE statement to correct the spelling of *state* codes. The old and new spellings are specified by input-mode parameters.

— `Routines2.bestTwoEmps` — A Java method that determines the top two employees by their sales, and returns the columns of those two employee rows as output-mode parameter values. This method creates an SQL result set and processes it internally.

— `Routines3.orderedEmps` — A Java method that creates an SQL result set consisting of selected employee rows ordered by the sales column, and returns that result set to the client.

— `Over1.isOdd` and `Over2.isOdd` — Contrived Java methods to illustrate overloading rules.

— `Routines4.job1` and `Routines5.job2` — Java methods that return a string value corresponding to an integer jobcode value. These methods illustrate the treatment of null arguments.

— `Routines6.job3` — Another Java method that returns a string value corresponding to an integer jobcode value. This method illustrates the behavior of static Java variables.

Unless otherwise noted, the methods that invoke SQL use JDBC. One of the methods is shown in both aversion using JDBC and a version using SQL/OLB. The others could also be coded with SQL/OLB.

It is assumed that the import statements `import java.sql.*;` and `java.math.*;` have been included in all classes.

4.4 Example Java methods: region and correctStates

This clause shows an example Java class, `Routines1`, with two simple methods.

— The `int`-valued static method `region` categorizes 9 states into 3 geographic regions, returning an integer indicating the region associated with a valid state or throwing an exception for invalid states. This method will be called as a function in SQL.

— The `void` method `correctStates` updates the EMPS table to correct spelling errors in the state column. This method will be called as a procedure in SQL.

```
public class Routines1 {
  //An int method that will be called as a function
  public static int region(String s) throws SQLException {
    if (s.equals("MN") || s.equals("VT") || s.equals("NH")) return 1;
      else if (s.equals("FL") || s.equals("GA") || s.equals("AL")) return 2;
      else if (s.equals("CA") || s.equals("AZ") || s.equals("NV")) return 3;
      else throw new SQLException("Invalid state code", "38001");
  }
  //A void method that will be called as a stored procedure
  public static void correctStates (String oldSpelling, String newSpelling)
      throws SQLException {
    Connection conn = DriverManager.getConnection ("jdbc:default:connection");
    PreparedStatement stmt = conn.prepareStatement
        ("UPDATE emps SET state = ? WHERE state = ?");
    stmt.setString(1, newSpelling);
    stmt.setString(2, oldSpelling);
    stmt.executeUpdate();
    stmt.close();
    conn.close();
    return;
  }
}
```


4.5 Installing region and correctStates in SQL

The source code for Java classes such as `Routines1` will normally be in one or more Java files (i.e.,, files with file-type “java”). When they are compiled (using the `javac` compile command), the resulting code will be in one or more class files (i.e.,, files with file-type “class”). A set of class files is then collected into a Java JAR, which is a ZIP-coded collection of files.

To use Java classes in SQL, a JAR containing them is loaded into the SQL system by calling the SQL `SQLJ.INSTALL_JAR` procedure. The `SQLJ.INSTALL_JAR` procedure is a new built-in SQL procedure that makes the collection ofJava classes contained in a specified JAR available for use in the current SQL catalog. For example, assume that the above `Routines1` class has been assembled into a JAR with local file name “`~/classes/Routines1.jar`”:

```
SQLJ.INSTALL_JAR('file:~/classes/Routines1.jar', 'routines1_jar', 0)
```

— The first parameter of the `SQLJ.INSTALL_JAR` procedure is a character string specifying the URL of the given JAR. This parameter is never folded to upper case.

— The second parameter of the `SQLJ.INSTALL_JAR` procedure is a character string that will be used as the name of the JAR in the SQL system. The JAR name is an SQL qualified name, and follows SQL conventions for qualified names.

  The JAR name specified as the second parameter of the `SQLJ.INSTALL_JAR` procedure identifies the JAR within the SQL system. That is, the JAR name specified is used only in SQL, and has nothing to do with the contents of the JAR itself. The JAR name is used in the following contexts, which are described in later clauses:

  - As a parameter of the `SQLJ.REMOVE_JAR` and `SQLJ.REPLACE_JAR` procedures.

- As a qualifier of Java class names in SQL CREATE PROCEDURE/FUNCTION statements.
- As an operand of the extended SQL GRANT and REVOKE statements.
- As a qualifier of Java class names in SQL CREATE TYPE statements.

The JAR name may also be used in follow-on facilities for downloading JARs from the SQL system.

— JARs can also contain *deployment descriptors*, which specify implicit actions to be taken by the `SQLJ.INSTALL_JAR` and `SQLJ.REMOVE_JAR` procedures. The third parameter of the `SQLJ.INSTALL_JAR` procedure is an integer that specifies whether or not (indicated by non-zero or zero values, respectively) the `SQLJ.INSTALL_JAR` procedure is expected to execute the actions specified by a deployment descriptor in the JAR.

The name of the INSTALL_JAR procedure is qualified with the schema name SQLJ. All built-in procedures of the SQL/JRT facility are defined to be contained in that built-in schema. The SQLJ schema is assumed to be present in each catalog of an SQL system that implements the SQL/JRT facility.

The first two parameters of `SQLJ.INSTALL_JAR` are character strings, so if they are specified as literals, single quotes are used, not the double quotes used for SQL delimited identifiers.

The actions of the `SQLJ.INSTALL_JAR` procedure are as follows:

— Obtain the JAR designated by the first parameter.

— Extract the class files that it contains and install them into the current SQL schema.

— Retain a copy of the JAR itself, and associate it with the value of the second parameter.

— If the third parameter is non-zero, then perform the actions specified by the deployment descriptor of the JAR.

After a JAR has been installed with the `SQLJ.INSTALL_JAR` procedure, the static methods of the classes contained in that JAR can be referenced in the CREATE PROCEDURE/FUNCTION statement, as described in the next Subclause.

4.6 Defining SQL names for region and correctStates

Before a Java method can be called in SQL, that method must have an SQL name. This is done with new options on the SQL CREATE PROCEDURE/FUNCTION statement. For example:

```
CREATE PROCEDURE correct_states(old CHARACTER(20), new CHARACTER(20))
  MODIFIES SQL DATA
  LANGUAGE JAVA PARAMETER STYLE JAVA
  EXTERNAL NAME 'routines1_jar:Routines1.correctStates';
CREATE FUNCTION region_of(state CHARACTER(20)) RETURNS INTEGER
  NO SQL
  LANGUAGE JAVA PARAMETER STYLE JAVA
  EXTERNAL NAME 'routines1_jar:Routines1.region';
```

The CREATE PROCEDURE and CREATE FUNCTION statements specify SQL names and Java method signatures for the Java methods specified in the EXTERNAL NAME clauses. The format of the method names in the external name clause consists of the JAR name that was specified in the `SQLJ.INSTALL_JAR` procedure followed by the Java method name, fully qualified with the package name(s) (if any) and class name.

The CREATE PROCEDURE for `correct_states` specifies the clause MODIFIES SQL DATA. This indicates that the specified Java method modifies (via INSERT, UPDATE, or DELETE) data in SQL tables. The CREATE FUNCTION for `region_of` specifies NO SQL. This indicates that the specified Java method performs no SQL operations.