PUBLIC

SAP HANA Platform SPS 11
Document Version: 1.0 – 2015-11-25

SAP HANA Spatial Reference

Content

1 Introduction

Column-oriented data structures and in-memory computing have developed into powerful components of today's enterprise applications. While the focus of these developments has primarily been on analyzing sales data, the potential for using these technologies to analyze geographic information is significant. Support for the processing of spatial data represents a key evolution in SAP HANA.

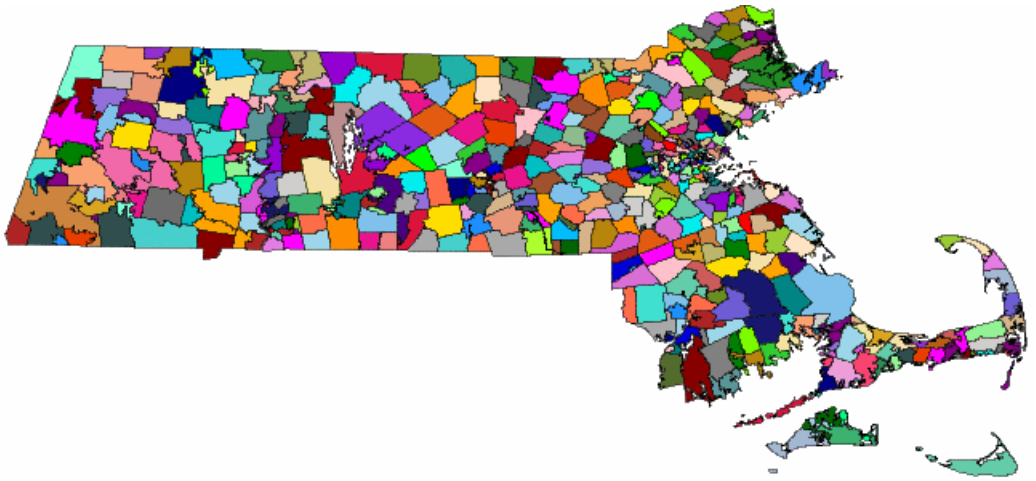
To deliver vastly improved performance and results in everything from modeling and storage to analysis and presentation of your spatial data, SAP HANA includes a multilayered spatial engine and supports spatial columns, spatial access methods, and spatial reference systems. With these enhanced GIS features, SAP HANA now provides a common database for both your business and spatial data.

SAP HANA spatial is an SAP HANA optional component.

> ⚠ Caution
>
> SAP HANA server software and tools can be used for several SAP HANA platform and options scenarios as well as the respective capabilities used in these scenarios. The availability of these is based on the available SAP HANA licenses and the SAP HANA landscape, including the type and version of the back-end systems the SAP HANA administration and development tools are connected to. There are several types of licenses available for SAP HANA. Depending on your SAP HANA installation license type, some of the features and tools described in the SAP HANA platform documentation may only be available in the SAP HANA options and capabilities, which may be released independently of an SAP HANA Platform Support Package Stack (SPS). Although various features included in SAP HANA options and capabilities are cited in the SAP HANA platform documentation, each SAP HANA edition governs the options and capabilities available. Based on this, customers do not necessarily have the right to use features included in SAP HANA options and capabilities. For customers to whom these license restrictions apply, the use of features included in SAP HANA options and capabilities in a production system requires purchasing the corresponding software license(s) from SAP. The documentation for the SAP HANA optional components is available in SAP Help Portal at http://help.sap.com/hana_options. If you have additional questions about what your particular license provides, or wish to discuss licensing features available in SAP HANA options, please contact your SAP account team representative.

2 Spatial Data

Spatial data is data that describes the position, shape, and orientation of objects in a defined space. Spatial data is represented as 2D geometries in the form of points, line strings, and polygons. For example, the following image shows the state of Massachusetts, representing the union of polygons representing zip code regions.



Two common operations performed on spatial data are calculating the distance between geometries, and determining the union or intersection of multiple objects. These calculations are performed using predicates such as intersects, contains, and crosses.

The spatial data documentation assumes you already have some familiarity with spatial reference systems and with the spatial data you intend to work with.

The software provides storage and data management features for spatial data, allowing you to store information such as geographic locations, routing information, and shape data.

These information pieces are stored as points and various forms of polygons and lines in columns defined with a corresponding **spatial data type** (such as ST_Point and ST_Polygon). You use methods and constructors to access and manipulate the spatial data. The software also provides a set of SQL spatial functions designed for compatibility with other products.

Example

How spatial data might be used

Spatial data support lets application developers´ associate spatial information with their data. For example, a table representing companies could store the location of the company as a point, or store the delivery area for the company as a polygon. This could be represented in SQL as (returns 1):

```
SELECT NEW ST_Polygon('Polygon((0 0, 0 1, 1 1, 1 0, 0 0 ))').ST_Contains( NEW
ST_POINT('Point(0.5 0.5)') ) FROM dummy;
```

> **Note**
>
> ST_POINT is composed of longitude and latitude:
>
> ```
> NEW ST_Point( <longitude> , <latitude> )
> NEW ST_Point('POINT ( <longitude> <latitude> )')
> ```

2.1 Spatial Reference Systems (SRS) and Spatial Reference Identifiers (SRID)

In the context of spatial databases, the defined space in which geometries are described is called a **spatial reference system (SRS)**. A spatial reference system defines, at minimum:

- Units of measure of the underlying coordinate system (degrees, meters, and so on)
- Maximum and minimum coordinates (also referred to as the bounds)
- Default linear unit of measure
- Whether the data is planar or spheroid data
- Projection information for transforming the data to other SRSs

Every spatial reference system has an identifier called a **Spatial Reference Identifier (SRID)**. When the database server performs operations like finding out if a geometry touches another geometry, it uses the SRID to look up the spatial reference system definition so that it can perform the calculations properly for that spatial reference system. Each SRID must be unique in a database.

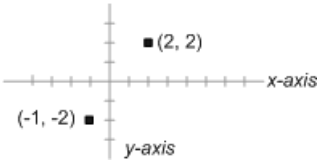
Spatial reference system information is stored in the ST_SPATIAL_REFERENCE_SYSTEMS system view.

By default, the database server adds the following spatial reference systems to a new database:

Default - SRID 0

This is the default spatial reference system used when constructing a geometry and the SRID is not specified in the SQL and is not present in the value being loaded.

Default is a Cartesian spatial reference system that works with data on a flat, two dimensional plane. Any point on the plane can be defined using a single pair of x, y coordinates where x and y have the bounds -1,000,000 to 1,000,000. Distances are measured using perpendicular coordinate axis. This spatial reference system is assigned SRID of **0**.



Cartesian is a planar type of spatial reference system.

WGS84 - SRID 4326

The WGS84 standard provides a spheroidal reference surface for the Earth. It is the spatial reference system used by the Global Positioning System (GPS). The

	coordinate origin of WGS 84 is the Earth's center, and is considered accurate up to ±1 meter. WGS stands for World Geodetic System. WGS 84 Coordinates are in degrees, where the first coordinate is longitude with bounds -180 to 180, and the second coordinate is latitude with bounds -90 to 90. The default unit of measure for WGS 84 is METRE, and it is a round-Earth type of spatial reference system.
WGS 84 (planar) - SRID 1000004326	WGS 84 (planar) is similar to WGS 84 except that it uses equirectangular projection, which distorts length, area and other computations. For example, at the equator in both WGS 84 and WGS 84 (planar), 1 degree longitude is approximately 111 km. At 80 degrees north, 1 degree of longitude is approximately 19 km in WGS 84, but WGS 84 (planar) treats 1 degree of longitude as approximately 111 km at *all* latitudes. The amount of distortion of lengths in the WGS 84 (planar) is considerable—off by a factor of 10 or more—the distortion factor varies depending on the location of the geometries relative to the equator. Consequently, WGS 84 (planar) should not be used for distance and area calculations. It should only be used for relationship predicates such as ST_Contains, ST_Touches, ST_Covers, and so on. The default unit of measure for WGS 84 (planar) is planar DEGREE, and it is a flat-Earth type of spatial reference system.
sa_planar_unbounded (unbounded (planar)) - SRID 2147483646	For internal use only.

2.2 Units of Measure

Geographic features can be measured in degrees of latitude, radians, or other angular units of measure. Every spatial reference system must explicitly state the name of the unit in which geographic coordinates are measured, and must include the conversion from the specified unit to a radian.

If you are using a projected coordinate system, the individual coordinate values represent a linear distance along the surface of the Earth to a point. Coordinate values can be measured by the meter, foot, mile, or yard. The projected coordinate system must explicitly state the linear unit of measure in which the coordinate values are expressed.

The following units of measure are automatically installed in any new database:

meter	A linear unit of measure. Also known as International metre. SI standard unit. Defined by ISO 1000.
metre	A linear unit of measure. An alias for meter. SI standard unit. Defined by ISO 1000.
radian	An angular unit of measure. SI standard unit. Defined by ISO 1000:1992.
degree	An angular unit of measure (pi()/180.0 radians).

planar degree	A linear unit of measure. Defined as 60 nautical miles. A linear unit of measure used for geographic spatial reference systems with PLANAR line interpretation.

Unit of measure information is stored in the ST_UNITS_OF_MEASURE system view.

2.3 Support for Spatial Data

The following sections describe the SAP HANA support for spatial data.

2.3.1 Supported Spatial Data Types and Their Hierarchy

Spatial support follows the SQL Multimedia (SQL/MM) standard for storing and accessing geospatial data.

A key component of this standard is the use of the ST_Geometry type hierarchy to define how geospatial data is created. Within the hierarchy, the prefix ST is used for all data types (also referred to as classes or types). When a column is identified as a specific type, the values of the type and its subtypes can be stored in the column. For example, a column identified as ST_Geometry can also store the ST_LineString and ST_MultiLineString values.

Descriptions of supported spatial data types

The following spatial data types are supported:

Geometries	The term geometry means the overarching type for objects such as points, linestrings, and polygons. The geometry type is the supertype for all supported spatial data types.
Points	A point defines a single location in space. A point geometry does not have length or area. A point always has an X and Y coordinate. ST_Dimension returns 0 for non-empty points. In GIS data, points are typically used to represent locations such as addresses, or geographic features such as a mountain.
Multipoints	A multipoint is a collection of individual points. In GIS data, multipoints are typically used to represent a set of locations.
Linestrings	A linestring is geometry with a length, but without any area. ST_Dimension returns 1 for non-empty linestrings. Linestrings can be characterized by whether they are simple or not simple, closed or not closed. **Simple** means a linestring that does not cross itself. **Closed** means a linestring that starts and ends at the same point. For example, a ring is an example of simple, closed linestring.

In GIS data, linestrings are typically used to represent rivers, roads, or delivery routes.

Multilinestrings

A multilinestring is a collection of linestrings.

In GIS data, multilinestrings are often used to represent geographic features like rivers or a highway network.

Polygons

A polygon defines a region of space. A polygon is constructed from one exterior bounding ring that defines the outside of the region and zero or more interior rings which define holes in the region. A polygon has an associated area but no length.

ST_Dimension returns 2 for non-empty polygons.

In GIS data, polygons are typically used to represent territories (counties, towns, states, and so on), lakes, and large geographic features such as parks.

Multipolygons

A multipolygon is a collection of zero or more polygons.

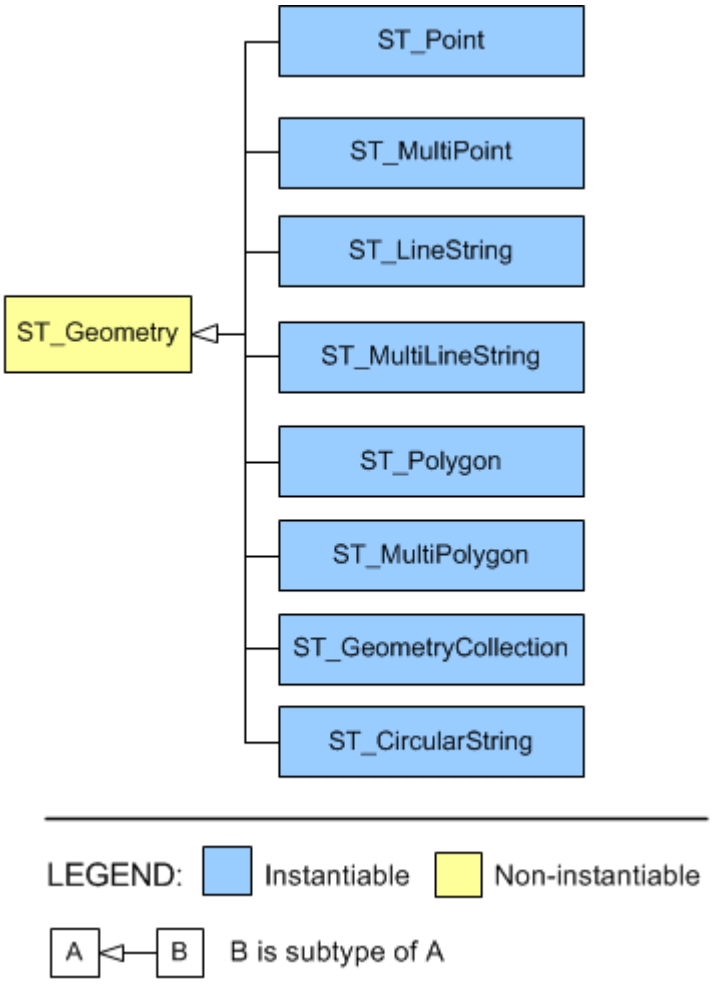
In GIS data, multipolygons are often used to represent territories made up of multiple regions (for example a state with islands), or geographic features such as a system of lakes.

Circularstrings

A circularstring is a connected sequence of circular arc segments; much like a linestring with circular arcs between points.

Spatial type hierarchy

The following diagram illustrates the hierarchy of the ST_Geometry data types:



Object-oriented properties of spatial data types

- A subtype (or derived type) is more specific than its supertype (or base type). For example, ST_LineString is a more specific type of ST_Curve.
- A subtype inherits all methods from all supertypes. For example, ST_Polygon values can call methods from the ST_Geometry.
- A value of a subtype can be automatically converted to any of its supertypes. For example, an ST_Point value can be used where a ST_Geometry parameter is required, as in `point1.ST_Distance( point2 )`.
- A column or variable can store a values of any subtype. For example, a column of type ST_Geometry can store spatial values of any type.
- A column, variable, or expression with a declared type can be treated as, or cast to a subtype. For example, you can use the TREAT expression to change a ST_Polygon value in a ST_Geometry column

named geom to have declared type ST_Surface so you can call the ST_Area method on it with `TREAT( geom AS ST_Surface ).ST_Area()`.

2.3.1.1 Supported Spatial Predicates

A predicate is a conditional expression that, combined with the logical operators AND and OR, makes up the set of conditions in a WHERE, HAVING, or ON clause, or in an IF or CASE expression, or in a CHECK constraint. In SQL, a predicate may evaluate to TRUE, FALSE. In many contexts, a predicate that evaluates to UNKNOWN is interpreted as FALSE.

Spatial predicates are implemented as member functions that return 0 or 1. To test a spatial predicate, your query should compare the result of the function to 1 or 0 using the = or <> operator. For example:

```
SELECT * FROM SpatialShapes WHERE shape.ST_IsEmpty() = 0;
```

You use predicates when querying spatial data to answer such questions as: how close together are two or more geometries? Do they intersect or overlap? Is one geometry contained within another? If you are a delivery company, for example, you may use predicates to determine if a customer is within a specific delivery area.

Related Information

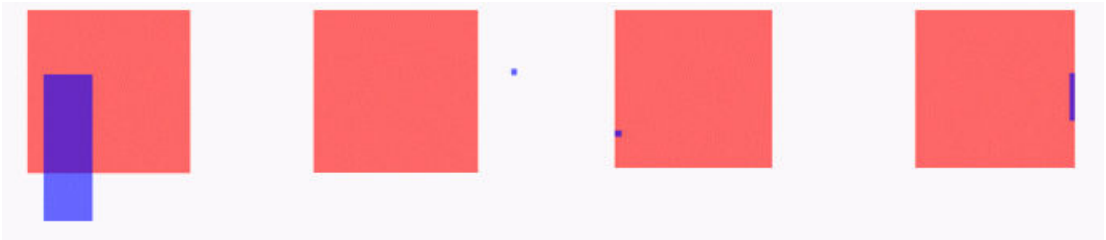
SpatialShapes Table [page 32]

2.3.1.1.1 Intuitiveness of Spatial Predicates

Sometimes the outcome of a predicate is not intuitive.

Test special cases to make sure you are getting the results you want. For example, in order for a geometry to contain another geometry (`a.ST_Contains(b)=1`), or for a geometry to be within another geometry (`b.ST_Within(a)=1`), the interior of a and the interior of b must intersect, and no part of b can intersect the exterior of a. However, there are some cases where you would expect a geometry to be considered contained or within another geometry, but it is not.

For example, the following return 0 (a is red) for `a.ST_Contains(b)` and `b.ST_Within(a)`:



Case one and two are obvious; the purple geometries are not completely within the red squares. Case three and four, however, are not as obvious. In both of these cases, the purple geometries are only on the boundary

of the red squares. ST_Contains does not consider the purple geometries to be within the red squares, even though they appear to be within them.

ST_Covers and ST_CoveredBy are similar predicates to ST_Contains and ST_Within. The difference is that ST_Covers and ST_CoveredBy do not require the interiors of the two geometries to intersect. Also, ST_Covers and ST_CoveredBy often have more intuitive results than ST_Contains and ST_Within.

If your predicate tests return a different result for cases than desired, consider using the ST_Relate method to specify the exact relationship you are testing for.

2.3.2 Supported Import and Export Formats for Spatial Data

The following table lists the data and file formats supported for importing and exporting spatial data:

Table 1:

Data format	Import	Export	Description
Well Known Text (WKT)	Yes	Yes	Geographic data expressed in ASCII text. This format is maintained by the Open Geospatial Consortium (OGC) as part of the Simple Features defined for the OpenGIS Implementation Specification for Geographic Information. See http://www.opengeospatial.org/standards/sfa . Here is an example of how a point might be represented in WKT: `'POINT(1 1)'`
Well Known Binary (WKB)	Yes	Yes	Geographic data expressed as binary streams. This format is maintained by the OGC as part of the Simple Features defined for the OpenGIS Implementation Specification for Geographic Information. See http://www.opengeospatial.org/standards/sfa . Here is an example of how a point might be represented in WKB: `'01010000000000000000F03F000000000000F03F'`
Extended Well Known Text (EWKT)	Yes	Yes	WKT format, but with SRID information embedded. This format is maintained as part of PostGIS, the spatial database extension for PostgreSQL. See post-gis.refractions.net/ . `'srid=101;POINT (1 1)'`

Data format	Import	Export	Description
Extended Well Known Binary (EWKB)	Yes	Yes	WKB format, but with SRID information embedded. This format is maintained as part of PostGIS, the spatial database extension for PostgreSQL. See post-gis.refractions.net/ . Here is an example of how a point might be represented in EWKB: `'01010000020040 000000000000000 0F03F0000000000 00F03F'`
ESRI shapefiles	Yes	No	A popular geospatial vector data format for representing spatial objects in the form of shapefiles (several files that are used together to define the shape).
GeoJSON	No	Yes	Text format that uses name/value pairs, ordered lists of values, and conventions similar to those used in common programming languages such as C, C++, C#, Java, JavaScript, Perl, and Python. GeoJSON is a subset of the JSON standard and is used to encode geographic information. The GeoJSON standard is supported and the software provides the ST_AsGeoJSON method for converting SQL output to the GeoJSON format. Here is an example of how a point might be represented in GeoJSON: `{"x" : 1, "y" : 1, "spatialReference" : {"wkid" : 4326}}` For more information about the GeoJSON specification, see http://geojson.org/geojson-spec.html .
Scalable Vector Graphic (SVG) files	No	Yes	XML-based format used to represent twodimensional geometries. The SVG format is maintained by the World Wide Web Consortium (W3C). See www.w3.org/Graphics/ SVG/ . Here is an example of how a point might be represented in SVG: `<rect width="1" height="1" fill="deepskyblue" stroke="black" strokewidth=" 1" x="1" y="-1"/>`

2.3.3 Support for ESRI Shapefiles

The Environmental System Research Institute, Inc. (ESRI) shapefile format is supported. ESRI shapefiles are used to store geometry data and attribute information for the spatial features in a data set.

An ESRI shapefile includes at least three different files: `.shp`, `.shx`, and `.dbf`. The suffix for the main file is `.shp`, the suffix for the index file is `.shx`, and the suffix for the attribute columns is `.dbf`. All files share the same base name and are frequently combined in a single compressed file. The software can read all ESRI shapefiles with all shape types except MultiPatch. This includes shape types that include Z and M data.

The data in an ESRI shapefile usually contains multiple rows and columns. For example, the spatial tutorial loads a shapefile that contains zip code regions for Massachusetts. The shapefile contains one row for each zip code region, including the polygon information for the region. It also contains additional attributes (columns) for each zip code region, including the zip code name (for example, the string '02633') and other attributes.

Related Information

http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf
Import ESRI Shapefiles Using Menu Functions [page 18]
Import ESRI Shapefiles Using SQL Commands [page 17]

2.3.3.1 Import ESRI Shapefiles Using SQL Commands

You can import ESRI shapefiles using SQL commands.

To load ESRI shapefiles to a SAP HANA system perform these steps:

1. Create or acquire ESRI shapefiles.
2. Create a zip file containing the ESRI shapefiles.
3. Copy the zip file containing the ESRI shapefiles to the host on which the SAP HANA system runs.
4. Unzip the zip file which contains the ESRI shapefiles.
5. Make the files accessible to the <sid>adm user.
6. Call a SAP HANA studio, and log on to the SAP HANA System.
7. Open an SQL console.
8. Enter the SQL command to import the ESRI shapefiles.
   To load a shapefile into a table, simply use the standard import statement with `AS SHAPEFILE` as follows:

```
IMPORT [<schema_name>.]<identifier> AS SHAPEFILE FROM <path>  [WITH
<shapefile-option-list> ]
<schema_name>           ::= <identifier>
<path>                  ::= <string_literal>
<shapefile_option_list> ::= <shapefile_option> [{, <shapefile_option_list>}]
<shapefile-option>      ::= CATALOG ONLY | REPLACE | SRID <srs-id> |
                                THREADS <number_of_threads>
<srs-id>                ::= <unsigned_integer>
<number_of_threads>     ::= <unsigned_integer>
```

   (**prefix:** filename without extension, **abs-path:** absolute path)

If the schema does not exist, it will be created before the import statement is performed.

Example

The following SQL commands could be used to import an ESRI shapefile:

```
IMPORT "My"."Table" AS SHAPEFILE FROM '/tmp/shapefile';
IMPORT "My"."Table" AS SHAPEFILE FROM '/tmp/shapefile' WITH REPLACE;
IMPORT "My"."Table" AS SHAPEFILE FROM '/tmp/shapefile' WITH SRID 4326;
IMPORT "My"."Table" AS SHAPEFILE FROM '/tmp/shapefile' WITH REPLACE SRID 4326;
IMPORT "My"."Table" AS SHAPEFILE FROM '/tmp/shapefile' WITH SRID 0 THREADS 4;
```

In the directory `/tmp` there are the following files: `shapefile.shp`, `shapefile.shx`, `shapefile.dbf`.

2.3.3.2 Import ESRI Shapefiles Using Menu Functions

You can import ESRI shapefiles using menu functions.

To load ESRI shapefiles to a SAP HANA system perform these steps:

1. Copy the ESRI shapefiles (for example `shapefile.shp`, `shapefile.shx`, `shapefile.dbf`) to the directory you have chosen, according to the import location (server, current client), you want to use, and provide the necessary access rights to the files.
2. Call a SAP HANA studio and log on to the SAP HANA system.
3. In the *File* menu, choose *Import*.
4. Expand the *SAP HANA* node.
5. Choose *ESRI Shapefiles*, and choose *Next*.
6. Choose the *Import Location*:
   - *Import ESRI shapefiles on server*
     You can choose the default directory on the server or enter a different directory, where the shapefiles are located on the server.
   - *Import ESRI shapefiles from current client*
     Enter the directory, where the shapefiles are located on the current client.
7. Choose *Next*.
8. Select the ESRI shapefiles you want to import, and choose *Next*.
9. Enter the name of the schema you want to import the ESRI shapefiles into, and choose the additional import options.
10. Choose *Finish*.

2.3.4 Multidimensional Support

SAP HANA Spatial supports multidimensional spatial data.

Note

SAP HANA spatial supports multidimensional spatial data for the column type ST_GEOMETRY.

The following dimension types are supported:

- 2D dimension (X, Y)
- 2D dimension with measure (X, Y, M)
- 3D dimension (X, Y, Z)
- 3D dimension with measure (X, Y, Z, M)

Multidimensional support is available for the following spatial data types (examples in WKT format):

- ST_Point
  - `'Point (10 20)'`
  - `'Point M(10 30 40)'`
  - `'Point Z(10 30 60)'`
  - `'Point ZM(10 20 30 50)'`
- ST_LineString
  - `'LineString (0 0, 5 10)'`
  - `'LineString M(0 0 4, 5 10 6)'`
  - `'LineString Z(0 0 7, 5 10 4)'`
  - `'LineString ZM(0 0 3 6, 5 10 4 8)'`
- ST_Polygon
  - `'Polygon ((-5 -5, 5 -5, 0 5, -5 -5), (-2 -2, -2 0, 2 0, 2 -2, -2 -2))'`
  - `'Polygon Z((-5 -5 6, 5 -5 6, 0 5 6, -5 -5 6), (-2 -2 1, -2 0 1, 2 0 1, 2 -2 1, -2 -2 1))'`
  - `'Polygon M((-5 -5 6, 5 -5 6, 0 5 6, -5 -5 6), (-2 -2 1, -2 0 1, 2 0 1, 2 -2 1, -2 -2 1))'`
  - `'Polygon ZM((-5 -5 6 4, 5 -5 6 4, 0 5 6 4, -5 -5 6 4), (-2 -2 1 4, -2 0 1 4, 2 0 1 4, 2 -2 1 4, -2 -2 1 4))'`
- ST_MultiPoint
  - `'MultiPoint ((10 10), (12 12), (14 10))'`
  - `'MultiPoint Z((10 10 12), (12 12 14), (14 10 10))'`
  - `'MultiPoint ZM((10 10 12 1), (12 12 14 1), (14 10 10 1))'`
- ST_MultiLineString
  - `'MultiLineString ((10 10, 12 12), (14 10, 16 12))'`
  - `'MultiLineString Z((10 10 10, 12 12 12), (14 10 10, 16 12 12))'`
  - `'MultiLineString ZM((10 10 10 10, 12 12 12 10), (14 10 12 13, 16 12 13 14))'`
- ST_MultiPolygon
  - `'MultiPolygon (((-5 -5, 5 -5, 0 5, -5 -5), (-2 -2, -2 0, 2 0, 2 -2, -2 -2)), ((10 -5, 15 5, 5 5, 10 -5)))'`
  - `'MultiPolygon M(((-5 -5 3, 5 -5 3, 0 5 3, -5 -5 3), (-2 -2 3, -2 0 3, 2 0 3, 2 -2 3, -2 -2 3)), ((10 -5 3, 15 5 3, 5 5 3, 10 -5 3)))'`
  - `'MultiPolygon ZM(((-5 -5 4 1, 5 -5 7 1, 0 5 1 1, -5 -5 4 1), (-2 -2 9 1, -2 0 4 1, 2 0 4 1, 2 -2 1 1, -2 -2 9 1)), ((10 -5 2 1, 15 5 2 1, 5 5 3 1, 10 -5 2 1)))'`
- ST_GeometryCollection
  - `'GeometryCollection (LineString (5 10, 10 12, 15 10), Polygon ((10 -5, 15 5, 5 5, 10 -5)))'`

- 'GeometryCollection Z(LineString Z(5 10 20, 10 12 25, 15 10 13), Polygon Z((10 -5 4, 15 5 6, 5 5 7, 10 -5 4)), Point Z(10 15 12))'

2.4 Recommended Reading on Spatial Topics

Various recommended readings on spatial topics are available.

- A brief overview of coordinates and their reference systems: http://www.iogp.org/geomatics -> Geodetic awareness (http://www.iogp.org/pubs/373-01.pdf)
- OGC OpenGIS Implementation Specification for Geographic information - Simple feature access: http://www.opengeospatial.org/standards/sfs
- International Standard ISO/IEC 13249-3:2006: http://www.iso.org/iso/catalogue_detail.htm?csnumber=38651
- Scalable Vector Graphics (SVG) 1.1 Specification: http://www.w3.org/Graphics/SVG/
- JavaScript Object Notation (JSON): http://json.org
- GeoJSON specification: http://geojson.org/geojson-spec.html

2.5 Create Spatial Columns (SQL)

You can add spatial data to any table by adding a column that supports spatial data.

Prerequisites

You must be the owner of the table, or have ALTER privilege on the table, or have the ALTER ANY TABLE or ALTER ANY OBJECT system privilege.

> **Note**
>
> The following column types are supported:
>
> - ST_POINT
>   The column type ST_POINT supports 2D spatial data (X, Y).
> - ST_GEOMETRY
>   The column type ST_GEOMETRY supports multidimensional spatial data.

Procedure

1. Connect to the database.

2. Execute an ALTER TABLE statement.

Results

A spatial column is added to the existing table.

Example

The following statement adds a spatial column named Location to the SpatialShapes table. The new column is of spatial data type ST_Point, and has a declared SRID of 1000004326, which is a flat-Earth spatial reference system.

```
ALTER TABLE SpatialShapes ADD (location ST_POINT(1000004326));
```

Next Steps

You can place SRID constraints on the column to place restrictions on the values that can be stored in a spatial column.

2.6 Create a Table with Spatial Columns (SQL)

You create a table with columns which support spatial data.

You must have the privilege to create a TABLE in a database schema.

Note

The following column types are supported:

- ST_POINT
  The column type ST_POINT supports only 2D spatial data (X,Y).
- ST_GEOMETRY
  The column type ST_GEOMETRY supports multidimensional spatial data.

1. Connect to the database.
2. Execute a CREATE TABLE statement.

Example

The following statement creates the table `SpatialShapes_POINTS` which contains the column SHAPE with column type ST_POINT:

```
CREATE COLUMN TABLE MYSCHEMA.SpatialShapes_POINTS
```

```
(
ShapeID integer,
SHAPE ST_Point
);
```

Example

The following statement creates the table `SpatialShapes_GEOMETRIES` which contains the column SHAPE1 with column type ST_POINT and column SHAPE2 with column type ST_GEOMETRY:

```
CREATE COLUMN TABLE MYSCHEMA.SpatialShapes_GEOMETRIES
(
ShapeID integer,
SHAPE1 ST_Point,
SHAPE2 ST_GEOMETRY
);
```

2.7 Spatial Data Type Syntax

The SQL/MM standard defines spatial data support in terms of user-defined extended types (UDTs) built on the ANSI/SQL CREATE TYPE statement. Although user-defined types are not supported, the spatial data support has been implemented as though they are supported.

Instantiating instances of a UDT

You can instantiate a value of a user-defined type by calling a constructor as follows:

```
NEW <type-name>( <argument-list>)
```

For example, a query could contain the following to instantiate two ST_Point values:

```
SELECT NEW ST_Point(), NEW ST_Point(3,4) FROM dummy;
```

The database server matches `<argument-list>` against defined constructors using the normal overload resolution rules. An error is returned in the following situations:

- If NEW is used with a type that is not a user-defined type
- If the user-defined type is not instantiable (for example, ST_Geometry is not an instantiable type).
- If there is no overload that matches the supplied argument types

Using instance methods

User defined types can have instance methods defined. Instance methods are invoked on a value of the type as follows:

```
<value-expression>.<method-name>( <argument-list> )
```

For example, the following fictitious example selects the X coordinate:

```
SELECT NEW ST_Point(2.25, 3.41).ST_X() FROM dummy;
```

If there was a user ID called CenterPoint, the database server would consider `CenterPoint.ST_X()` to be **ambiguous**. This is because the statement could mean "call the user-defined function ST_X owned by user CenterPoint" (the incorrect intention of the statement), or it could mean "call the ST_X method on the Massdata.CenterPoint column" (the correct meaning). The database server resolves the ambiguity by first performing a case-insensitive search for a user named CenterPoint. If one is found, the database server proceeds as though a user-defined function called ST_X and owned by user CenterPoint is being called. If no user is found, the database server treats the construct as a method call and calls the ST_X method on the Massdata.CenterPoint column.

An instance method invocation gives an error in the following cases:

- If the declared type of the `<value-expression>` is not a user-defined type
- If the named method is not defined in the declared type of `<value-expression>` or one of its supertypes
- If `<argument-list>` does not match one of the defined overloads for the named method.

2.8 Advanced Spatial Topics

This section contains advanced spatial topics.

2.8.1 How Flat-Earth and Round-Earth Representations Work

SAP HANA supports both flat-Earth and round-Earth representations.

Flat-Earth reference systems project all or a portion of the surface of the Earth to a flat, two dimensional plane (planar), and use a simple 2D Euclidean geometry. Lines between points are straight (except for circularstrings), and geometries cannot wrap over the edge (cross the dateline).

Round-Earth spatial reference systems use an ellipsoid to represent the Earth. Points are mapped to the ellipsoid for computations, all lines follow the shortest path and arc toward the pole, and geometries can cross the date line.

Both flat-Earth and round-Earth representations have their limitations. There is not a single ideal map projection that best represents all features of the Earth, and depending on the location of an object on the Earth, distortions may affect its area, shape, distance, or direction.

Limitations of round-Earth spatial reference systems

When working with a round-Earth spatial reference system such as WGS84, many operations are not available. For example, computing distance is restricted to points or collections of points.

Some predicates and set operations are also not available.

Circularstrings are not allowed in round-Earth spatial reference systems.

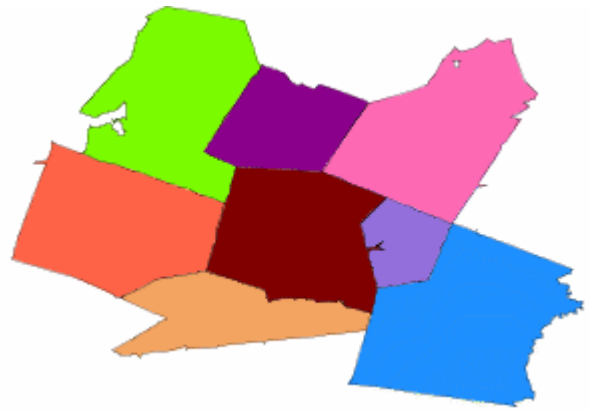
Computations in round-Earth spatial reference systems are more expensive than the corresponding computation in a flat-Earth spatial reference system.

Limitations of flat-Earth spatial reference systems

A flat-Earth spatial reference system is a planar spatial reference system that has a projection defined for it. Projection resolves distortion issues that occur when using a flat-Earth spatial reference system to operate on round-Earth data. For example of the distortion that occurs if projection is not used, the next two images show the same group of zip code regions in Massachusetts. The first image shows the data in a SRID 3586, which is a projected planar spatial reference system specifically for Massachusetts data. The second image shows the data in a planar spatial reference system without projection (SRID 1000004326). The distortion manifests itself in the second image as larger-than-actual distances, lengths, and areas that cause the image to appear horizontally stretched.

Projected planar spatial reference system (SRID 3586)

Planar spatial reference system without projection (SRID 1000004326)



While more calculations are possible in flat-Earth spatial reference systems, calculations are only accurate for areas of bounded size, due to the effect of projection.

You can project round-Earth data to a flat-Earth spatial reference system to perform distance computations with reasonable accuracy provided you are working within distances of a few hundred kilometers. To project the data to a planar projected spatial reference system, you use the ST_Transform method.

2.8.2 How Snap-to-Grid and Tolerance Impact Spatial Calculations

Spatial calculations are impacted by **Snap-to-grid** and **Tolerance**.

Snap-to-grid is the action of positioning the points in a geometry so they align with intersection points on a grid. When aligning a point with the **grid**, the X and Y values may be shifted by a small amount - similar to rounding. In the context of spatial data, a grid is a framework of lines that is laid down over a two-dimensional representation of a spatial reference system. The database server uses a square grid.

As a simplistic example of snap-to-grid, if the grid size is 0.2, then the line from Point(14.2321, 28.3262) to Point(15.3721, 27.1128) would be snapped to the line from Point(14.2, 28.4) to Point(15.4, 27.2). Grid size is typically much smaller than this simplistic example, however, so the loss of precision is much less.

By default, the database server automatically sets the grid size so that 12 significant digits can be stored for every point within the X and Y bounds of a spatial reference system. For example, if the range of X values is from -180 to 180, and the range of Y values is from -90 to 90, the database server sets the grid size to 1e-9 (0.000000001). That is, the distance between both horizontal and vertical grid lines is 1e-9. The intersection points of the grid line represents all the points that can be represented in the spatial reference system. When a geometry is created or loaded, each point's X and Y coordinates are snapped to the nearest points on the grid.

Tolerance defines the distance within which two points or parts of geometries are considered equal. This can be thought of as all geometries being represented by points and lines drawn by a marker with a thick tip, where the thickness is equal to the tolerance. Any parts that touch when drawn by this thick marker are considered equal within tolerance. If two points are exactly equal to tolerance apart, they are considered not equal within tolerance.

As a simplistic example of tolerance, if the tolerance is 0.5, then Point(14.2, 28.4) and Point(14.4, 28.2) are considered equal. This is because the distance between the two points (in the same units as X and Y) is about 0.283, which is less than the tolerance. Tolerance is typically much smaller than this simplistic example, however.

Tolerance can cause extremely small geometries to become invalid. Lines which have length less than tolerance are invalid (because the points are equivalent), and similarly polygons where all points are equal within tolerance are considered invalid.

Snap-to-grid and tolerance are set on the spatial reference system and are always specified in same units as the X and Y (or Longitude and Latitude) coordinates. Snap-to-grid and tolerance work together to overcome issues with inexact arithmetic and imprecise data. However, be aware of how their behavior can impact the results of spatial operations.

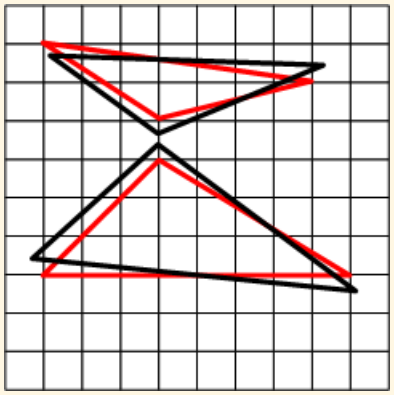
> **Note**
>
> For planar spatial reference systems, setting grid size to 0 is never recommended as it can result in incorrect results from spatial operations.

The following examples illustrate the impact of grid size and tolerance settings on spatial calculations.

Example

Example 1: Snap-to-grid impacts intersection results

Two triangles (shown in black) are loaded into a spatial reference system where tolerance is set to grid size, and the grid in the diagram is based on the grid size. The red triangles represent the black triangles after the triangle vertexes are snapped to the grid. Notice how the original triangles (black) are well within tolerance of each other, whereas the snapped versions in red do not. ST_Intersects returns 0 for these two geometries. If tolerance was larger than the grid size, ST_Intersects would return 1 for these two geometries.



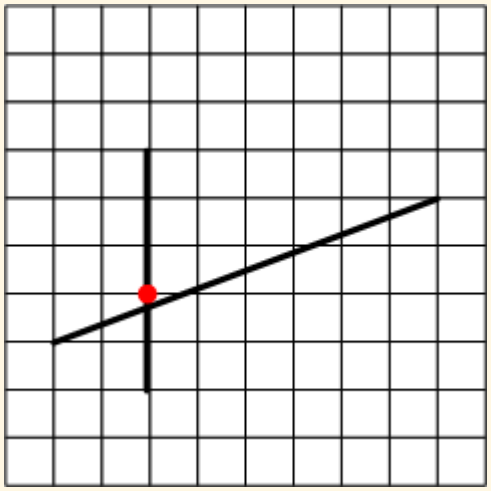
Example

Example 2: Tolerance impacts intersection results

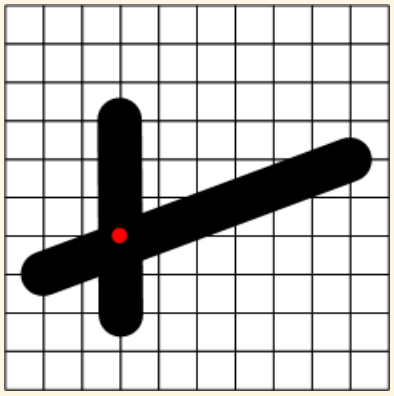
In the following example, two lines lie in a spatial reference system where tolerance is set to 0. The intersection point of the two lines is snapped to the nearest vertex in the grid. Since tolerance is set to 0, a test to determine if the intersection point of the two lines intersects the diagonal line returns false.

In other words, the following expression returns 0 when tolerance is 0:

```
vertical_line.ST_Intersection( diagonal_line ).ST_Intersects( diagonal_line )
```



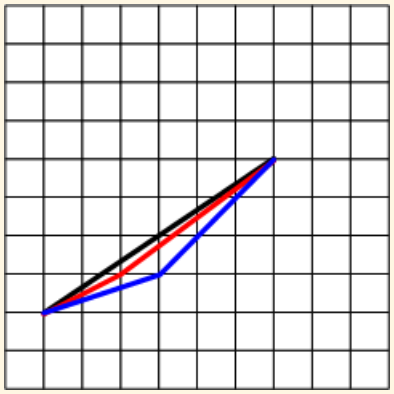
Setting the tolerance to grid size (the default), however, causes the intersection point to be inside the thick diagonal line. So a test of whether the intersection point intersects the diagonal line within tolerance would pass:



Example

Example 3: Tolerance and transitivity

In spatial calculations when tolerance is in use, transitivity does not necessary hold. For example, suppose you have the following three lines in a spatial reference system where the tolerance is equal to the grid size:



The ST_Equals method considers the black and red lines to be equivalent within tolerance, and the red and blue lines to be equivalent within tolerance but black line and the blue line are not equivalent within tolerance. ST_Equals is not transitive.

ST_OrderingEquals considers each of these lines to be different, and ST_OrderingEquals is transitive.

Example

Example 4: Impact of grid and tolerance settings on imprecise data

Suppose you have data in a projected planar spatial reference system which is mostly accurate to within 10 centimeters, and always accurate to within 10 meters. You have three choices:

1. Use the default grid size and tolerance that the database server selects, which is normally greater than the precision of your data. Although this provides maximum precision, predicates such as ST_Intersects, ST_Touches, and ST_Equals may give results that are different than expected for some geometries, depending on the accuracy of the geometry values. For example, two adjacent polygons

that share a border with each other may not return true for ST_Intersects if the leftmost polygon has border data a few meters to the left of the rightmost polygon.

2. Set the grid size to be small enough to represent the most accuracy in any of your data (10 centimeters, in this case) and at least four times smaller than the tolerance, and set tolerance to represent the distance to which your data is always accurate to (10 meters, in this case). This strategy means your data is stored without losing any precision, and that predicates will give the expected result even though the data is only accurate within 10 meters.
3. Set grid size and tolerance to the precision of your data (10 meters, in this case). This way your data is snapped to within the precision of your data, but for data that is more accurate than 10 meters the additional accuracy is lost.
   In many cases predicates will give the expected results but in some cases they will not. For example, if two points are within 10 centimeters of each other but near the midway point of the grid intersections, one point will snap one way and the other point will snap the other way, resulting in the points being about 10 meters apart. For this reason, setting grid size and tolerance to match the precision of your data is not recommended in this case.

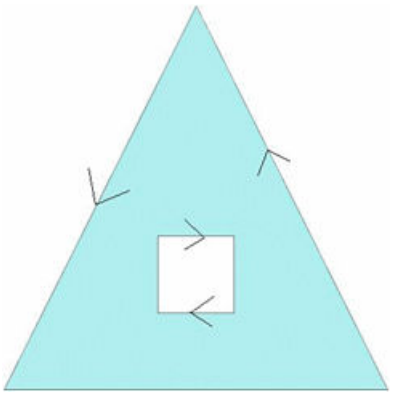
2.8.3 How Polygon Ring Orientation Works

Internally, the database server interprets polygons by looking at the orientation of the constituent rings.

As one travels a ring in the order of the defined points, the inside of the polygon is on the left side of the ring. The same rules are applied in PLANAR and ROUND EARTH spatial reference systems. In most cases, outer rings are in counter-clockwise orientation and interior rings are in the opposite (clockwise) orientation. The exception is for rings that contain the north or south pole in ROUND EARTH.

By default, polygons are automatically reoriented if they are created with a different ring orientation than the internal ring orientation.

For example, if you create a polygon and specify the points in a clockwise order `Polygon((0 0, 5 10, 10 0, 0 0), (4 2, 4 4, 6 4, 6 2, 4 2))`, the database server automatically rearranges the points to be in counter-clockwise rotation, as follows: `Polygon((0 0, 10 0, 5 10, 0 0), (4 2, 4 4, 6 4, 6 2, 4 2))`.



If the inner ring was specified before the outer ring, the outer ring would appear as the first ring

In order for polygon reorientation to work in round-Earth spatial reference systems, polygons are limited to 160° in diameter.

2.8.4 How Geometry Interiors, Exteriors, and Boundaries Work

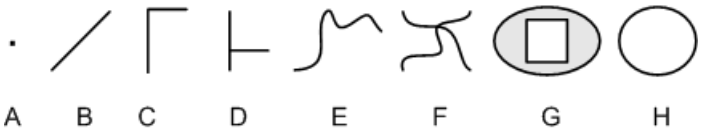
The **interior** of a geometry is all points that are part of the geometry except the boundary.

The **exterior** of a geometry is all points that are not part of the geometry. This can include the space inside an interior ring, for example in the case of a polygon with a hole. Similarly, the space both inside and outside a linestring ring is considered the exterior.

The **boundary** of a geometry is what is returned by the ST_Boundary method.

Knowing the boundary of a geometry helps when comparing to another geometry to determine how the two geometries are related. However, while all geometries have an interior and an exterior, not all geometries have a boundary, nor are their boundaries always intuitive.

Here are some cases of geometries where the boundary may not be intuitive:



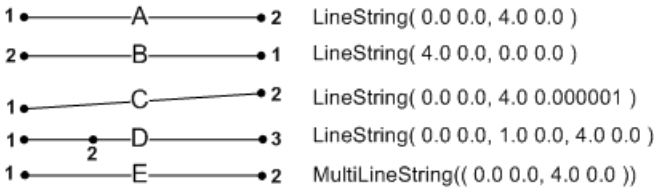
Point	A point (such as A) has no boundary.
Lines and linestrings	The boundary for lines and linestrings (B, C, D, E, F) are their endpoints. Geometries B, C, and E have two end points for a boundary. Geometry D has four end points for a boundary, and geometry F has four.
Polygon	The boundary for a polygon (such as G) is its outer ring and any inner rings.
Rings	A ring—a curve where the start point is the same as the end point and there are no self-intersections (such as H)—has no boundary.

2.8.5 How Spatial Comparisons Work

There are two methods you can use to test whether a geometry is equal to another geometry: ST_Equals, and ST_OrderingEquals. These methods perform the comparison differently, and return a different result.

ST_Equals	The order in which points are specified does not matter, and point comparison takes tolerance into account. Geometries are considered equal if they occupy the same space, within tolerance. For example, if two linestrings occupy the same space, yet one is defined with more points, they are still considered equal.
ST_OrderingEquals	With ST_OrderingEquals, the two geometries must contain the same hierarchy of objects with the exact same points in the same order to be considered equal under ST_OrderingEquals. That is, the two geometries must be exactly the same.

To illustrate the difference in results when comparisons are made using ST_Equals versus ST_OrderingEquals, consider the following lines. ST_Equals considers them all equal (assuming line C is within tolerance). However, ST_OrderingEquals does not consider any of them equal.



2.8.6 How Spatial Relationships Work

For best performance, use methods like ST_Within, or ST_Touches to test single, specific relationships between geometries. However, if you have more than one relationship to test, ST_Relate can be a better method, since you can test for several relationships at once. ST_Relate is also good when you want to test for a different interpretation of a predicate.

The most common use of ST_Relate is as a predicate, where you specify the exact relationship(s) to test for. However, you can also use ST_Relate to determine all possible relationships between two geometries.

Predicate use of ST_Relate

ST_Relate assesses how geometries are related by performing intersection tests of their interiors, boundaries, and exteriors. The relationship between the geometries is then described in a 9-character string in DE-9IM (Dimensionally Extended 9 Intersection Model) format, where each character of the string represents the dimension of the result of an intersection test.

When you use ST_Relate as a predicate, you pass a DE-9IM string reflecting intersection results to test for. If the geometries satisfy the conditions in the DE-9IM string you specified, then ST_Relate returns a 1. If the conditions are not satisfied, then 0 is returned. If either or both of the geometries is NULL, then NULL is returned.

The 9-character DE-9IM string is a flattened representation of a pair-wise matrix of the intersection tests between interiors, boundaries, and exteriors. The next table shows the 9 intersection tests in the order they are performed: left to right, top to bottom:

Table 2:

	g2 interior	**g2 boundary**	**g2 exterior**
g1 interior	`Interior(g1) ∩ Interior( g2)`	`Interior(g1) ∩ Boundary( g2)`	`Interior(g1) ∩ Exterior( g2)`
g1 boundary	`Boundary(g1) ∩ Interior( g2)`	`Boundary(g1) ∩ Boundary( g2)`	`Boundary(g1) ∩ Exterior( g2)`
g1 exterior	`Exterior(g1) ∩ Interior( g2)`	`Exterior(g1) ∩ Boundary( g2)`	`Exterior(g1) ∩ Exterior( g2)`

When you specify the DE-9IM string, you can specify *, 0, 1, 2, T, or F for any of the 9 characters. These values refer to the number of dimensions of the geometry created by the intersection.

Table 3:

When you specify:	The intersection test result must return:
T	one of: 0, 1, 2 (an intersection of any dimension)

When you specify:	The intersection test result must return:
F	-1
*	-1, 0, 1, 2 (any value)
0	0
1	1
2	2

Suppose you want to test whether a geometry is within another geometry using ST_Relate and a custom DE-9IM string for the within predicate:

```
SELECT NEW ST_Polygon('Polygon(( 2 3, 8 3, 4 8, 2 3 ))').
ST_Relate(NEW ST_Polygon('Polygon((-3 3, 3 3, 3 6, -3 6, -3 3))'), 'T*F**F***' )
FROM dummy;
```

This is equivalent to asking ST_Relate to look for the following conditions when performing the intersection tests:

Table 4:

	g2 interior	g2 boundary	g2 exterior
g1 interior	**one of: 0, 1, 2**	one of: 0, 1, 2, -1	**-1**
g1 boundary	one of: 0, 1, 2, -1	one of: 0, 1, 2, -1	**-1**
g1 exterior	one of: 0, 1, 2, -1	one of: 0, 1, 2, -1	one of: 0, 1, 2, -1

When you execute the query, however, ST_Relate returns 0 indicating that the first geometry is not within the second geometry.

Non-predicate use of ST_Relate

The non-predicate use of ST_Relate returns the full relationship between two geometries.

For example, suppose you have the same two geometries used in the previous example and you want to know how they are related. You would execute the following statement in Interactive SQL to return the DE-9IM string defining their relationship.

```
SELECT NEW ST_Polygon('Polygon(( 2 3, 8 3, 4 8, 2 3 ))').
ST_Relate(NEW ST_Polygon('Polygon((-3 3, 3 3, 3 6, -3 6, -3 3))')) FROM dummy;
```

ST_Relate returns the DE-9IM string, `212111212`.

The matrix view of this value shows that there are many points of intersection:

Table 5:

	g2 interior	g2 boundary	g2 exterior
g1 interior	2	1	2
g1 boundary	1	1	1
g1 exterior	2	1	2

2.8.7 How Spatial Dimensions Work

As well as having distinct properties of its own, each of the geometry subtypes inherits properties from the ST_Geometry supertype.

A geometry subtype has one of the following dimensional values:

- -1 – A value of -1 indicates that the geometry is empty (it does not contain any points).
- 0 – A value of 0 indicates the geometry has no length or area. The subtypes ST_Point and ST_MultiPoint have dimensional values of 0. A point represents a geometric feature that can be represented by a single pair of coordinates, and a cluster of unconnected points represents a multipoint feature.
- 1 – A value of 1 indicates the geometry has length but no area. The set of subtypes that have a dimension of 1 is ST_LineString, or collection types containing this type. In GIS data, these geometries of dimension 1 are used to define linear features such as streams, branching river systems, and road segments.
- 2 – A value of 2 indicates the geometry has area. The set of subtypes that have a dimension of 2 are subtypes of ST_Surface (ST_Polygon), or collection types containing these types. Polygons and multipolygons represent geometric features with perimeters that enclose a defined area such as lakes or parks.

The dimension of a geometry is not related to the number of coordinate dimensions of each point in a geometry.

A single ST_GeometryCollection can contain geometries of different dimensions, and the highest dimension geometry is returned.

2.9 SpatialShapes Table

Several examples in this documentation refer to spatial shapes. The following table is used in those examples to further explain some functions.

You can use the following syntax to create a test table:

```
CREATE COLUMN TABLE SpatialShapes
(
  ShapeID integer,
   shape ST_GEOMETRY
);
-- a set of points
INSERT INTO SpatialShapes VALUES(1,  NEW ST_POINT('POINT(2.5 3.0)'));
INSERT INTO SpatialShapes VALUES(2,  NEW ST_POINT('POINT(3.0 4.5)'));
INSERT INTO SpatialShapes VALUES(3,  NEW ST_POINT('POINT(3.0 6.0)'));
INSERT INTO SpatialShapes VALUES(4,  NEW ST_POINT('POINT(4.0 6.0)'));
INSERT INTO SpatialShapes VALUES(5,  NEW ST_POINT());
-- a set of linestrings
INSERT INTO SpatialShapes VALUES(6,  NEW ST_LINESTRING('LINESTRING(3.0 3.0, 5.0
4.0, 6.0 3.0)'));
INSERT INTO SpatialShapes VALUES(7,  NEW ST_LINESTRING('LINESTRING(4.0 4.0, 6.0
5.0, 7.0 4.0)'));
INSERT INTO SpatialShapes VALUES(8,  NEW ST_LINESTRING('LINESTRING(7.0 5.0, 9.0
7.0)'));
INSERT INTO SpatialShapes VALUES(9,  NEW ST_LINESTRING('LINESTRING(7.0 3.0, 8.0
5.0)'));
INSERT INTO SpatialShapes VALUES(10,  NEW ST_LINESTRING());
-- a set of polygons
```

```
INSERT INTO SpatialShapes VALUES(11, NEW ST_POLYGON('POLYGON((6.0 7.0, 10.0 3.0,
10.0 10.0, 6.0 7.0))'));
INSERT INTO SpatialShapes VALUES(12, NEW ST_POLYGON('POLYGON((4.0 5.0, 5.0 3.0,
6.0 5.0, 4.0 5.0))'));
INSERT INTO SpatialShapes VALUES(13, NEW ST_POLYGON('POLYGON((1.0 1.0, 1.0 6.0,
6.0 6.0, 6.0 1.0, 1.0 1.0))'));
INSERT INTO SpatialShapes VALUES(14, NEW ST_POLYGON('POLYGON((1.0 3.0, 1.0 4.0,
5.0 4.0, 5.0 3.0, 1.0 3.0))'));
INSERT INTO SpatialShapes VALUES(15, NEW ST_POLYGON());
```

Note

The ST_Geometry/ST_Point column is using the default spatial reference system 0 (Euclidean space). If you want to use a different spatial reference system (for instance 1000004326) you have to specify it explicitly at table creation time:

```
CREATE COLUMN TABLE SpatialShapes
(
  id integer,
   shape ST_GEOMETRY(1000004326)
);
```

3 Accessing and Manipulating Spatial Data

This section describes the types, methods, and constructors you can use to access, manipulate, and analyze spatial data. The spatial data types can be considered like data types or classes. Each spatial data type has associated methods and constructors you use to access the data.

3.1 ST_Geometry Type

The ST_Geometry type is the maximal supertype of the geometry type hierarchy.

Direct subtypes

ST_LineString type
ST_MultiLineString type
ST_MultiPoint type
ST_MultiPolygon type
ST_Point type
ST_Polygon type
ST_GeometryCollection type
ST_CircularString type

Methods

- Methods of ST_Geometry:

  Table 6:

ST_AsBinary	ST_AsEWKB	ST_AsEWKT	ST_AsGeoJSON
ST_AsText	ST_AsWKB	ST_AsWKT	ST_AsSVG
ST_AsSVGAggr	ST_Boundary	ST_Buffer	ST_Contains
ST_CoveredBy	ST_Covers	ST_ConvexHull	ST_Crosses
ST_Difference	ST_Dimension	ST_Disjoint	ST_Distance
ST_Envelope	ST_Equals	ST_GeomFromEWKB	ST_GeomFromEWKT
ST_GeomFromText	ST_GeomFromWKB	ST_GeomFromWKT	ST_GeometryType

ST_Intersection	ST_Intersects	ST_IntersectsFilter	ST_IntersectsRect
ST_Is3D	ST_IsEmpty	ST_IsMeasured	ST_IsSimple
ST_IsValid	ST_MMax	ST_MMin	ST_NumInteriorRings
ST_NumInteriorRing	ST_OrderingEquals	ST_Overlaps	ST_PointOnSurface
ST_Relate	ST_SRID	ST_SnapToGrid	ST_SymDifference
ST_Touches	ST_Transform	ST_UnionAggr	ST_WithinDistance
ST_Within	ST_XMax	ST_XMin	ST_YMax
ST_YMin	ST_ZMax	ST_ZMin	

Remarks

The ST_Geometry type is the maximal supertype of the geometry type hierarchy. The ST_Geometry type supports methods that can be applied to any spatial value. The ST_Geometry type cannot be instantiated; instead, a subtype should be instantiated. When working with original formats (WKT or WKB), you can use methods such as ST_GeomFromText/ST_GeomFromWKB to instantiate the appropriate concrete type representing the value in the original format.

All of the values in an ST_Geometry value are in the same spatial reference system. The ST_SRID method can be used to retrieve the spatial reference system associated with the value.

Columns of type ST_Geometry or any of its subtypes cannot be included in a primary key, unique index, or unique constraint.

Related Information

ST_SRID Method [page 84]

3.1.1 ST_AsBinary Method

Returns the WKB representation of an ST_Geometry value.

Syntax

```
<geometry-expression>.ST_AsBinary()
```

Returns

BLOB (Binary Large Object)	Returns the WKB representation of the <geometry-expression>.

Remarks

The ST_AsBinary method returns a binary string representing the geometry in WKB format.

Example

The following returns the result 0101000000000000000000F03F0000000000000040.

```
SELECT NEW ST_Point( 1.0, 2.0 ).ST_AsBinary() FROM dummy;
```

Related Information

ST_AsWKB Method [page 39]

3.1.2 ST_AsEWKB Method

Returns the extended WKB representation of an ST_Geometry value.

Syntax

```
<geometry-expression>.ST_AsEWKB()
```

Returns

BLOB (Binary Large Object)	Returns a binary string containing the extended WKB representation of the <geometry-expression>.

Remarks

The ST_AsEWKB method returns a binary string representing the geometry in extended WKB format.

Example

The following example returns the result `0101000020000000000000000000000000000000000000000000000000`.

```
SELECT NEW ST_Point(0.0,0.0).ST_AsEWKB() FROM dummy;
```

3.1.3 ST_AsEWKT Method

Returns the extended WKT representation of an ST_Geometry value.

Syntax

```
<geometry-expression>.ST_AsEWKT()
```

Returns

CLOB (Character Large Object)	Returns a string containing the extended WKT representation of the `<geometry-expression>`.

Remarks

The ST_AsEWKT method returns a string representing the geometry in extended WKT format.

Example

The following example returns the result `SRID=0;POINT (2 4)`.

```
SELECT NEW ST_Point(2.0,4.0).ST_AsEWKT() FROM dummy;
```

3.1.4 ST_AsGeoJSON Method

Returns a string representing a geometry in JSON format.

Syntax

```
<geometry-expression>.ST_AsGeoJSON()
```

Returns

CLOB (Character Large Object)	Returns the GeoJSON representation of the `<geometry-expression>`.

Remarks

The GeoJSON standard defines a geospatial interchange format based on the JavaScript Object Notation (JSON). This format is suited to web-based applications and it can provide a format that is more concise and easier to interpret than WKT or WKB. See http://geojson.org/geojson-spec.html .

The ST_AsGeoJSON method returns a text string representing the geometry.

Example

The following returns the result `{"type": "Point", "coordinates": [1.000000000000000,2.000000000000000]}`.

```
SELECT NEW ST_Point( 1.0, 2.0 ).ST_AsGeoJSON() FROM dummy;
```

3.1.5 ST_AsText Method

Returns the text representation of an ST_Geometry value.

Syntax

```
<geometry-expression>.ST_AsText()
```

Returns

CLOB (Character Large Object)	Returns the text representation of the <geometry-expression>.

Remarks

The ST_AsText method returns a text string representing the geometry in well known text format (WKT).

Example

The following returns the result `POINT (1 2)`.

```
SELECT NEW ST_Point( 1.0, 2.0 ).ST_AsText() FROM dummy;
```

Related Information

ST_AsWKT Method [page 40]

3.1.6 ST_AsWKB Method

Returns the WKB representation of an ST_Geometry value.

Syntax

```
<geometry-expression>.ST_AsWKB()
```

Returns

BLOB (Binary Large Object)	Returns the WKB representation of the <geometry-expression>.

Remarks

The ST_AsWKB method returns a binary string representing the geometry in WKB format.

Example

The following returns the result `0101000000000000000000F03F0000000000000040`.

```
SELECT NEW ST_Point( 1.0, 2.0 ).ST_AsWKB() FROM dummy;
```

Related Information

ST_AsBinary Method [page 35]

3.1.7 ST_AsWKT Method

Returns the WKT representation of an ST_Geometry value.

Syntax

```
<geometry-expression>.ST_AsWKT()
```

Returns

CLOB (Character Large Object)	Returns the WKT representation of the `<geometry-expression>`.

Remarks

The ST_AsWKT method returns a text string representing the geometry in well known text format (WKT).

Example

The following returns the result `POINT (1 2)`.

```
SELECT NEW ST_Point( 1.0, 2.0 ).ST_AsWKT() FROM dummy;
```

Related Information

ST_AsText Method [page 38]

3.1.8 ST_AsSVG Method

Returns an SVG figure representing a geometry value.

Syntax

```
<geometry-expression>.ST_AsSVG([<parameter>[,...])
```

Parameters

Table 7:

Name	Type	Description
parameter	VARCHAR(128)	A key value pair defining the parameters to use when converting the geometry-expression to an SVG representation.

The following parameters can be specified:

Table 8:

Parameter	Values	Description
`Approximate`	`<yes|no>`	Defines, if the geometry should have reduced details
`Attribute`	`<text>`	Additional SVG attributes
`DecimalDigits`	`<integer>`	Precision of coordinate
`PathDataOnly`	`<yes|no>`	Only paths are created
`RandomFill`	`<yes|no>`	Randomly assign fill color
`Relative`	`<yes|no>`	Start point of the plot

Returns

CLOB (Character Large Object)	Returns an SVG rendering of the <geometry-expression>.

Example

The following returns a complete SVG document with polygons filled with random colors.

```
SELECT NEW ST_Polygon( 'Polygon(( 0 0, 0 20, 60 10, 0 0 ))' ).ST_AsSVG() FROM
dummy;
```

The following returns a complete SVG document with polygons with no fill and precision 3.

```
SELECT NEW ST_Polygon( 'Polygon(( 0 0, 0 20, 60 10, 0
0 ))' ).ST_AsSVG(RandomFill=>'no',DecimalDigits=>3) FROM dummy;
```

The following returns a complete SVG document with polygons filled with random colors and precision 3.

```
SELECT NEW ST_Polygon( 'Polygon(( 0 0, 0 20, 60 10, 0
0 ))' ).ST_AsSVG(RandomFill=>'yes',DecimalDigits=>3) FROM dummy;
```

3.1.9 ST_AsSVGAggr Method

Returns a complete or partial SVG document which renders the geometries in a group.

Syntax

```
ST_AsSVGAggr(<geometry_column>)
```

Parameters

Table 9:

Name	Type	Description
geometry_column	ST_Geometry	The geometry value to contribute to the SVG figure. Typically this is a column.

Returns

LONG VARCHAR Returns a complete or partial SVG document which renders the geometries in a group.

Example

The following returns a complete SVG document with polygons filled with random colors.

```
SELECT ST_AsSVGAggr(Shape) FROM SpatialShapes;
```

3.1.10 ST_Boundary Method

Returns the boundary of the geometry value.

Syntax

```
<geometry-expression>.ST_Boundary()
```

Returns

ST_Geometry Returns a geometry value representing the boundary of the <geometry-expression>.

Example

The following example constructs a geometry collection containing a polygon and a linestring and returns the boundary for the collection: GEOMETRYCOLLECTION (LINESTRING (0 0,3 0,3 3,0 3,0 0),POINT (0 7),POINT (4 4)).

```
SELECT NEW ST_GeometryCollection('GeometryCollection (Polygon ((0 0, 3 0, 3 3,
0 3, 0 0)), LineString (0 7, 0 4, 4 4))').ST_Boundary().ST_AsText() FROM dummy;
```

3.1.11 ST_Buffer Method

Returns the ST_Geometry value that represents all points whose distance from any point of an ST_Geometry value is less than or equal to a specified distance in the given units.

Syntax

```
<geometry-expression>.ST_Buffer(<distance>[, <unit_name>])
```

Parameters

Table 10:

Name	Type	Description
distance	DOUBLE	The distance the buffer should be from the geometry value.
unit_name	VARCHAR(128)	The units in which the distance parameter should be interpreted. Defaults to the unit of the spatial reference system. The unit name must match the UNIT_NAME column of a row in the ST_UNITS_OF_MEASURE view where UNIT_TYPE is 'LINEAR'.

Returns

ST_Geometry

Returns the ST_Geometry value representing all points within the specified distance of the `<geometry-expression>`.

The spatial reference system identifier of the result is the same as the spatial reference system of the `<geometry-expression>`.

Remarks

The ST_Buffer method generates a geometry that expands a geometry by the specified distance. This method can be used, for example, to find all points in geometry A that are within a specified distance of geometry B. The distance parameter must be a positive value. This method will return an error if distance is negative. If the

distance parameter is equal to 0, the original geometry is returned. The ST_Buffer method is best used only when the actual buffer geometry is required. Determining whether two geometries are within a specified distance of each other should be done using ST_WithinDistance instead.

Note

If the <geometry-expression> is an empty geometry (ST_IsEmpty()=1), then this method returns NULL.

Note

This method cannot be used with geometries in round-Earth spatial reference systems.

Example

The following example shows the buffer of radius 1 computed on a polygon with 2 rings.

```
SELECT NEW ST_Polygon('Polygon((1 2, 10 2, 10 10, 1 2),(9 3, 5 3, 9 9, 9
3))').ST_Buffer( 1.0 ) FROM dummy;
```

The following example returns the buffer of radius 1 around a single point (1, 2). The buffer of a single point is a polygon which is an approximation of a circle.

```
SELECT NEW ST_Point(1,2).ST_Buffer(1.0).ST_AsText() FROM dummy;
```

The following examples returns the buffer of a straight line in well known binary format:

```
SELECT NEW ST_LineString('LineString(1 2, 2 2)').ST_Buffer(1.0) FROM dummy;
```

The following example determines which part of the line from (0, 2) to (4, 2) is within 1 unit of the point (2, 2.5). The result is `LINESTRING (1.137272 2,2.863421 2)`.

```
SELECT NEW ST_Point(2, 2.5).ST_Buffer(1.0).ST_Intersection( NEW
ST_LineString('Linestring(0 2, 4 2)')).ST_AsText() FROM dummy;
```

3.1.12 ST_Contains Method

Tests if a geometry value spatially contains another geometry value.

Syntax

```
<geometry-expression>.ST_Contains(<geo2>)
```

Parameters

Table 11:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be compared to the <geometry-expression>.

Returns

BIT Returns 1 if the <geometry-expression> contains <geo2>, otherwise 0.

Remarks

The ST_Contains method tests if the <geometry-expression> completely contains <geo2> and there is one or more interior points of <geo2> that lies in the interior of the <geometry-expression>.

<geometry-expression>.ST_Contains(<geo2>) is equivalent to <geo2>.ST_Within(<geometry-expression>).

The ST_Contains and ST_Covers methods are similar. The difference is that ST_Covers does not require intersecting interior points.

Example

The following example tests if a polygon contains a point. The polygon completely contains the point, and the interior of the point (the point itself) intersects the interior of the polygon, so the example returns 1.

```
SELECT NEW ST_Polygon( 'Polygon(( 0 0, 2 0, 1 2, 0 0 ))' ).ST_Contains( NEW
ST_Point( 1, 1 ) ) FROM dummy;
```

The following example tests if a polygon contains a line. The polygon completely contains the line, but the interior of the line and the interior of the polygon do not intersect (the line only intersects the polygon on the polygon's boundary, and the boundary is not part of the interior), so the example returns 0. If ST_Covers was used in place of ST_Contains, ST_Covers would return 1.

```
SELECT NEW ST_Polygon( 'Polygon(( 0 0, 2 0, 1 2, 0 0 ))' ).ST_Contains( NEW
ST_LineString( 'LineString( 0 0, 1 0 )' ) ) FROM dummy;
```

3.1.13 ST_CoveredBy Method

Tests if a geometry value is spatially covered by another geometry value.

Syntax

```
<geometry-expression>.ST_CoveredBy(<geo2>)
```

Parameters

Table 12:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be compared to the <geometry-expression>.

Returns

BIT Returns 1 if the <geometry-expression> covers <geo2>, otherwise 0.

Remarks

The ST_CoveredBy method tests if the <geometry-expression> is completely covered by <geo2>.

<geometry-expression>.ST_CoveredBy(<geo2>) is equivalent to <geo2>.ST_Covers(<geometry-expression>).

This predicate is similar to ST_Within except for one subtle difference. The ST_Within predicate requires that one or more interior points of the <geometry-expression> lie in the interior of <geo2>. For ST_CoveredBy(), the method returns 1 if no point of the <geometry-expression> lies outside of <geo2>, regardless of whether interior points of the two geometries intersect. ST_CoveredBy can be used with geometries in round-Earth spatial reference systems.

Example

The following example tests if a point is covered by a polygon. The point is completely covered by the polygon so the example returns 1.

```
SELECT NEW ST_Point( 1, 1 ).ST_CoveredBy( NEW
ST_Polygon( 'Polygon(( 0 0, 2 0, 1 2, 0 0 ))' ) ) FROM dummy;
```

The following example tests if a line is covered by a polygon. The line is completely covered by the polygon so the example returns 1. If ST_Within was used in place of ST_CoveredBy, ST_Within would return 0.

```
SELECT NEW ST_LineString( 'LineString( 0 0, 1 0 )' ).ST_CoveredBy( NEW
ST_Polygon( 'Polygon(( 0 0, 2 0, 1 2, 0 0 ))' ) ) FROM dummy;
```

The following example lists the ShapeIDs where the given point is within the Shape geometry. The following example lists the ShapeIDs where the given point is within the Shape geometry. This example returns the result 7.

```
SELECT ShapeID FROM SpatialShapes WHERE NEW ST_Point( 4,
4 ).ST_CoveredBy( Shape ) = 1 ORDER BY ShapeID;
```

3.1.14 ST_Covers Method

Tests if a geometry value spatially covers another geometry value.

Syntax

```
<geometry-expression>.ST_Covers(<geo2>)
```

Parameters

Table 13:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be compared to the <geometry-expression>.

Returns

BIT	Returns 1 if the <geometry-expression> covers <geo2>, otherwise 0.

Remarks

The ST_Covers method tests if the <geometry-expression> completely covers <geo2>. <geometry-expression>.ST_Covers(<geo2>) is equivalent to <geo2>.ST_CoveredBy(<geometry-expression>).

This predicate is similar to ST_Contains except for one subtle difference. The ST_Contains predicate requires that one or more interior points of <geo2> lie in the interior of the geometry-expression. For ST_Covers(), the method returns 1 if no point of <geo2> lies outside of the geometry-expression. Also, ST_Covers can be used with geometries in round-Earth spatial reference systems, while ST_Contains cannot.

Note

If the <geometry-expression> contains circularstrings, then these are interpolated to line strings.

Example

The following example tests if a polygon covers a point. The polygon completely covers the point so the example returns 1.

```
SELECT NEW ST_Polygon( 'Polygon(( 0 0, 2 0, 1 2, 0 0 ))' )
.ST_Covers( NEW ST_Point( 1, 1 ) ) FROM dummy;
```

The following example tests if a polygon covers a line. The polygon completely covers the line so the example returns 1. If ST_Contains was used in place of ST_Covers, ST_Contains would return 0.

```
SELECT NEW ST_Polygon( 'Polygon(( 0 0, 2 0, 1 2, 0 0 ))' )
.ST_Covers( NEW ST_LineString( 'LineString( 0 0, 1 0 )' ) ) FROM dummy;
```

The following example lists the ShapeIDs where the given polygon covers each Shape geometry. The following example lists the ShapeIDs where the given polygon covers each Shape geometry. This example returns the result 1.

```
SELECT ShapeID FROM SpatialShapes WHERE NEW ST_Polygon('Polygon ((-9 -9, 9 -9,
0 9, -9 -9), (-2 -2, -2 -1, -1 -1, -1 -2, -2 -2))').ST_Covers( Shape ) = 1
ORDER BY ShapeID;
```

3.1.15 ST_ConvexHull Method

Returns the convex hull of the geometry value.

Syntax

```
<geometry-expression>.ST_ConvexHull()
```

Returns

ST_Geometry If the geometry value is NULL or an empty value, then NULL is returned. Otherwise, the convex hull of the geometry value is returned.

The spatial reference system identifier of the result is the same as the spatial reference system of the `<geometry-expression>`.

Remarks

The convex hull of a geometry is the smallest convex geometry that contains all of the points in the geometry.

The convex hull may be visualized by imagining an elastic band stretched to enclose all of the points in the geometry. When released, the elastic band takes the shape of the convex hull.

If the geometry consists of a single point, the point is returned. If all of the points of the geometry lie on a single straight line segment, a linestring is returned. Otherwise, a convex polygon is returned.

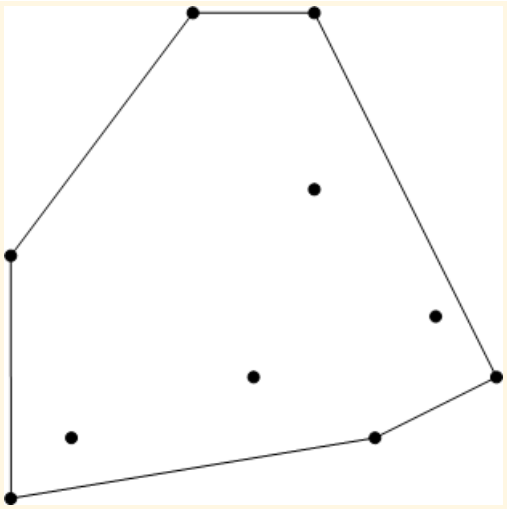
The convex hull can serve as an approximation of the original geometry. When testing a spatial relationship, the convex hull can serve as a quick pre-filter because if there is no spatial intersection with the convex hull then there can be no intersection with the original geometry.

Note

If the `<geometry-expression>` is an empty geometry (ST_IsEmpty()=1), then this method returns NULL.

Example

The following example shows the convex hull computed from 10 points. The resulting hull is the result `Polygon ((1 1, 7 2, 9 3, 6 9, 4 9, 1 5, 1 1))`.



```
SELECT NEW ST_MultiPoint('MultiPoint( (1 1), (2 2), (5 3), (7 2), (9 3), (8
4), (6 6), (6 9), (4 9), (1 5) )').ST_ConvexHull().ST_ASTEXT() FROM dummy;
```

The following example returns the single point (0,0). The convex hull of a single point is a point.

```
SELECT NEW ST_Point(0,0).ST_ConvexHull().ST_ASTEXT() FROM dummy;
```

The following example returns the result `LineString (0 0, 3 3)`. The convex hull of a single straight line is a linestring with a single segment.

```
SELECT NEW ST_LineString('LineString(0 0,1 1,2 2,3
3)').ST_ConvexHull().ST_ASTEXT() FROM dummy;
```

3.1.16 ST_ConvexHullAggr Method

Returns the convex hull for all of the geometries in a group.

Syntax

```
ST_ConvexHullAggr(<geometry_column>)
```

Parameters

Table 14:

Name	Type	Description
geometry_column	ST_Geometry	The geometry values to generate the convex hull. This is normally a column.

Returns

ST_Geometry	Returns the convex hull for all the geometries in a group.

Example

The following example returns: `POLYGON ((10 3,10 10,6 7,4 5,5 3,10 3))`.

```
SELECT ST_ConvexHullAggr( Shape ).ST_AsText() FROM SpatialShapes WHERE ShapeID
in (11, 12);
```

3.1.17 ST_Crosses Method

Tests if a geometry value crosses another geometry value.

Syntax

```
<geometry-expression>.ST_Crosses(<geo2>)
```

Parameters

Table 15:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be compared to the `<geometry-expression>`.

Returns

BIT Returns 1 if the <geometry-expression> crosses <geo2>, otherwise 0. Returns NULL if <geometry-expression> is a polygon or multipolygon, or if <geo2> is a point or multipoint.

Remarks

Tests if a geometry value crosses another geometry value.

When both <geometry-expression> and <geo2> are linestrings or multilinestrings, they cross each other if their interiors intersect at one or more points. If the intersection results in a linestring or multilinestring, the geometries do not cross. If all of the intersecting points are boundary points, the geometries do not cross.

When <geometry-expression> has lower dimension than <geo2>, then <geometry-expression> crosses <geo2> if part of <geometry-expression> is on the interior of <geo2> and part of <geometry-expression> is on the exterior of <geo2>.

More precisely, <geometry-expression>.ST_Crosses(<geo2>) returns 1 when the following is TRUE:

```
( <geometry-expression>.ST_Dimension() = 1 AND <geo2>.ST_Dimension() = 1 AND
<geometry-expression>.ST_Relate( <geo2>, '0********' ) = 1 ) OR( <geometry-
expression>.ST_Dimension() < <geo2>.ST_Dimension() AND <geometry-
expression>.ST_Relate( <geo2>, 'T*T******' ) = 1 )
```

Example

The following example returns the result 1.

```
SELECT NEW ST_LineString( 'LineString( 0 0, 2 2 )' ).ST_Crosses( NEW
ST_LineString( 'LineString( 0 2, 2 0 )' ) ) FROM dummy;
```

The following examples returns the result 0 because the interiors of the two lines do not intersect (the only intersection is at the first linestring boundary).

```
SELECT NEW ST_LineString( 'LineString( 0 1, 2 1 )' ).ST_Crosses( NEW
ST_LineString( 'LineString( 0 0, 2 0 )' ) ) FROM dummy;
```

The following example returns NULL because the first geometry is a polygon.

```
SELECT NEW ST_Polygon( 'Polygon(( 0 0, 0 1, 1 0, 0 0))' ).ST_Crosses( NEW
ST_LineString( 'LineString( 0 0, 2 0 )' ) ) FROM dummy;
```

3.1.18 ST_Difference Method

Returns the geometry value that represents the point set difference of two geometries.

Syntax

```
<geometry-expression>.ST_Difference(<geo2>)
```

Parameters

Table 16:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be subtracted from the <geometry-expression>.

Returns

ST_Geometry Returns the geometry value that represents the point set difference of two geometries.

The spatial reference system identifier of the result is the same as the spatial reference system of the <geometry-expression>.

Remarks

The ST_Difference method finds the spatial difference of two geometries. A point is included in the result if it is present in the geometry-expression but not present in <geo2>.

Unlike other spatial set operations (ST_Union, ST_Intersection, ST_SymDifference), the ST_Difference method is not symmetric: the method can give a different answer for `A.ST_Difference( B )` and `B.ST_Difference( A )`.

Example

The following example shows the difference between the two objects.

```
SELECT NEW ST_Polygon( 'Polygon( (-1 -0.25, 1 -0.25, 1 2.25, -1 2.25, -1
-0.25) )' ).ST_Difference(NEW ST_Polygon('Polygon ((-5 -5, 5 -5, 0 5, -5 -5),
(-2 -2, -2 0, 2 0, 2 -2, -2 -2))')) from dummy;
```

3.1.19 ST_Dimension Method

Returns the dimension of the ST_Geometry value. Points have dimension 0, lines have dimension 1, and polygons have dimension 2. Any empty geometry has dimension -1.

Syntax

```
<geometry-expression>.ST_Dimension()
```

Returns

SMALLINT Returns the dimension of the `<geometry-expression>` as a SMALLINT between -1 and 2.

Remarks

The ST_Dimension method returns the spatial dimension occupied by a geometry. The following values may be returned:

-1 The geometry corresponds to the empty set.

0 The geometry consists only of individual points (for example, an ST_Point or ST_MultiPoint).

1 The geometry contains at least one linestring and no polygons (for example, an ST_LineString).

2 The geometry consists of at least one polygon (for example, an ST_Polygon or ST_MultiPolygon).

When computing the dimension of a collection, the largest dimension of any element is returned. For example, if a geometry collection contains a linestring and a point, ST_Dimension returns 1 for the collection.

Example

The following example returns the result `0`.

```
SELECT NEW ST_Point(1.0,1.0).ST_Dimension() FROM dummy;
```

The following example returns the result `1`.

```
SELECT NEW ST_LineString('LineString( 0 0, 1 1)' ).ST_Dimension() FROM dummy;
```

3.1.20 ST_Disjoint Method

Test if a geometry value is spatially disjoint from another value.

Syntax

```
<geometry-expression>.ST_Disjoint(<geo2>)
```

Parameters

Table 17:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be compared to the <geometry-expression>.

Returns

BIT Returns 1 if the geometry-expression is spatially disjoint from <geo2>, otherwise 0.

Remarks

Tests if a geometry value is spatially disjoint from another value. Two geometries are disjoint if their intersection is empty. In other words, they are disjoint if there is no point anywhere in geometry-expression that is also in <geo2>."

<geometry-expression>.ST_Disjoint(<geo2>) = 1 is equivalent to <geometry-expression>.ST_Intersects(<geo2>) = 0.

> **Note**
>
> If the <geometry-expression> contains circularstrings, then these are interpolated to line strings.

Example

The following example returns a result with one row for each shape that has no points in common with the specified triangle.

```
SELECT ShapeID FROM SpatialShapes WHERE
NEW ST_Polygon( 'Polygon((0 0, 5 0, 0 5, 0 0))' ).ST_Disjoint( Shape ) = 1
ORDER BY ShapeID;
```

The example returns the following SHAPEIDs: `1, 2, 3, 4, 6, 7, 8, 9, 11, 12.`

3.1.21 ST_Distance Method

Returns the smallest distance between the `<geometry-expression>` and the specified geometry value.

Syntax

```
<geometry-expression>.ST_Distance(<geo2>,<unit_name>)
```

Parameters

Table 18:

Name	Type	Description
geo2	ST_Geometry	The other geometry value whose distance is to be measured from the `<geometry-expression>`.
unit_name	VARCHAR(128)	The units in which the distance parameter should be interpreted. Defaults to the unit of the spatial reference system. The unit name must match the UNIT_NAME column of a row in the ST_UNITS_OF_MEASURE view where UNIT_TYPE is 'LINEAR'.

Returns

DOUBLE Returns the smallest distance between the <geometry-expression> and <geo2>. If either <geometry-expression> or <geo2> is empty, then NULL is returned.

Remarks

The ST_Distance method computes the shortest distance between two geometries. For planar spatial reference systems, the distance is calculated as the Cartesian distance within the plane, computed in the linear units of measure for the associated spatial reference system. For round-Earth spatial reference systems, the distance is computed taking the curvature of the Earth's surface into account using the ellipsoid parameters in the spatial reference system definition.

Example

The following returns the result 5.

```
SELECT NEW ST_Point(0, 0).ST_Distance( NEW ST_Point(5, 0) ) FROM dummy;
```

The following returns the result 5.

```
SELECT NEW ST_LineString('LineString(0 0, 10 0)').ST_Distance( NEW ST_Point(0,
5) ) FROM dummy;
```

The following returns the result 44,5533390045166.

```
SELECT NEW ST_Polygon('Polygon((-3 3, 3 3, 3 6, -3 6, -3
3))').ST_Distance( NEW ST_Point(10, 50) ) FROM dummy;
```

The following returns the distance between SAP headquarter to the Kalipeh (SRS 4326): 352,6532242777006 (meter).

```
SELECT NEW ST_Point('POINT (8.641612 49.293703)', 4326).ST_Distance(NEW
ST_Point('POINT (8.645850 49.295243)', 4326), 'meter') FROM dummy;
```

The following returns the distance between SAP headquarter to the Kalipeh (SRS 4326): 385,66625577176353 (yard).

```
SELECT NEW ST_Point('POINT (8.641612 49.293703)', 4326).ST_Distance(NEW
ST_Point('POINT (8.645850 49.295243)', 4326), 'yard') FROM dummy;
```

The following returns the distance between SAP headquarter to the Kalipeh (SRS 1000004326): 501,05437338352203 (meter).

```
SELECT NEW ST_Point('POINT (8.641612 49.293703)', 1000004326).ST_Distance(NEW
ST_Point('POINT (8.645850 49.295243)', 1000004326), 'meter') FROM dummy;
```

The following returns the distance between SAP headquarter to the Kalipeh (SRS 1000004326): 547,9597259224869 (yard).

```
SELECT NEW ST_Point('POINT (8.641612 49.293703)', 1000004326).ST_Distance(NEW
ST_Point('POINT (8.645850 49.295243)', 1000004326), 'yard') FROM dummy;
```

3.1.22 ST_Envelope Method

Returns the bounding rectangle for the geometry value.

Syntax

```
<geometry-expression>.ST_Envelope()
```

Returns

ST_Polygon — Returns a polygon that is the bounding rectangle for the `<geometry-expression>`.

The spatial reference system identifier of the result is the same as the spatial reference system of the `<geometry-expression>`.

Remarks

The ST_Envelope method constructs a polygon that is an axis-aligned bounding rectangle for the `<geometry-expression>`. The envelope covers the entire geometry, and it can be used as a simple approximation for the geometry.

Note

If the `<geometry-expression>` is an empty geometry (ST_IsEmpty()=1), then this method returns NULL.

Example

The following returns the result `Polygon ((0 0, 1 0, 1 1, 0 1, 0 0))`.

```
SELECT NEW ST_LineString('LineString(0 0, 1 1)').ST_Envelope() FROM dummy;
```

3.1.23 ST_EnvelopeAggr Method

Returns the bounding rectangle for all of the geometries in a group.

Syntax

```
ST_EnvelopeAggr(<geometry_column>)
```

Parameters

Table 19:

Name	Type	Description
geometry_column	ST_Geometry	The geometry values to generate the bounding rectangle. This is normally a column.

Returns

ST_Polygon Returns a polygon that is the bounding rectangle for all the geometries in a group.

Example

The following example returns: `POLYGON ((2.5 3,9 3,9 7,2.5 7,2.5 3))`.

```
SELECT ST_EnvelopeAggr( Shape ).ST_AsText() FROM SpatialShapes WHERE ShapeID
=< 10;
```

3.1.24 ST_Equals Method

Tests if an ST_Geometry value is spatially equal to another ST_Geometry value.

Syntax

```
<geometry-expression>.ST_Equals(<geo2>)
```

Parameters

Table 20:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be compared to the <geometry-expression>.

Returns

BIT Returns 1 if the two geometry values are spatially equal, otherwise 0.

Remarks

Tests if an ST_Geometry value is equal to another ST_Geometry value.

The test for spatial equality is performed by first comparing the bounding rectangles of the two geometries. If they are not equal within tolerance, the two geometries are considered not to be equal, and 0 is returned. Otherwise, the database server returns 1 if <geometry-expression>.ST_SymDifference(geo2) is the empty set, otherwise it returns 0.

The SQL/MM standard defines ST_Equals only in terms of ST_SymDifference, without an additional bounding box comparison. There are some geometries that generate an empty result with ST_SymDifference while their bounding boxes are not equal. These geometries would be considered equal by the SQL/MM standard but are not considered equal in the software. This difference can arise if one or both geometries contain spikes or punctures.

Two geometry values can be considered equal even though they have different representations. For example, two linestrings may have opposite orientations but contain the same set of points in space. These two linestrings are considered equal by ST_Equals but not by ST_OrderingEquals.

ST_Equals may be limited by the resolution of the spatial reference system or the accuracy of the data.

Example

The following example returns the result 1, indicating that the two linestrings are equal even though they contain a different number of points specified in a different order, and the intermediate point is not exactly on the line. The intermediate point is about 3.33e-7 away from the line with only two points, but that distance less than the tolerance 1e-6 for the "Default" spatial reference system (SRID 0).

```
SELECT NEW ST_LineString( 'LineString( 0 0, 0.333333 1, 1
3 )' ).ST_Equals( NEW ST_LineString( 'LineString( 1 3, 0 0 )' ) ) FROM dummy;
```

3.1.25 ST_GeomFromEWKB Method

Constructs a geometry from a string representation.

Syntax

```
ST_GeomFromEWKB(<ewkb>)
```

Parameters

Table 21:

Name	Type	Description
ewkb	VARBINARY	A string containing the extended WKB representation of a geometry.

Returns

ST_Geometry	Returns a geometry value of the appropriate type based on the source string.

Remarks

Parses a string containing an extended WKB representation of a geometry and creates a geometry value of the appropriate type. This method is used by the server when evaluating a cast from a hexadecimal character string to a geometry type.

Example

The following example returns the result `POINT (0 0)`.

```
SELECT
ST_GeomFromEWKB(x'0101000020000000000000000000000000000000000000000000000000').ST_AsTex
t() FROM dummy;
```

3.1.26 ST_GeomFromEWKT Method

Constructs a geometry from a string representation.

Syntax

```
ST_GeomFromEWKT(<wkt>)
```

Parameters

Table 22:

Name	Type	Description
wkt	VARCHAR	A string containing the extended WKT representation of a geometry value.

Returns

ST_Geometry — Returns a geometry value of the appropriate type based on the source string.

Remarks

Parses a string containing an extended WKT representation of a geometry and creates a geometry value of the appropriate type. This method is used by the server when evaluating a cast from a character string to a geometry type.

Example

The following example returns the point `POINT (2 4)` in binary format.

```
SELECT ST_GeomFromEWKT('SRID=0;POINT (2.0 4.0)').ST_AsText() FROM dummy;
```

3.1.27 ST_GeomFromText Method

Constructs a geometry from a character string representation.

Syntax

```
ST_GeomFromText(<character-string>[, <srid>])
```

Parameters

Table 23:

Name	Type	Description
character-string	LONG VARCHAR	A string containing the text representation of a geometry.
srid	INT	The SRID of the result. If not specified and the input string does not contain a SRID, the default is 0.

Returns

ST_Geometry

Returns a geometry value of the appropriate type based on the source string.

The spatial reference system identifier of the result is given by parameter `<srid>`.

Remarks

Parses a text string representing a geometry and creates a geometry value of the appropriate type. This method is used by the server when evaluating a cast from a character string to a geometry type.

The server detects the format of the input string. Some input formats contain a SRID definition. If provided, the `<srid>` parameter must match any value taken from the input string.

Example

The following example returns the result `LineString (1 2, 5 7)`.

```
SELECT ST_GeomFromText( 'LineString( 1 2, 5 7 )', 4326 ).ST_AsText() FROM
dummy;
```

Related Information

ST_GeomFromText Method [page 64]
ST_GeomFromWKT Method [page 66]

3.1.28 ST_GeomFromWKB Method

Constructs a geometry from a string representation.

Syntax

```
ST_GeomFromWKB(<wkb>[, <srid>])
```

Parameters

Table 24:

Name	Type	Description
wkb	VARBINARY	A string containing the WKB representation of a geometry value.
srid	INTEGER	The SRID of the result. If not specified, the default is 0.

Returns

ST_Geometry Returns a geometry value of the appropriate type based on the source string.

The spatial reference system identifier of the result is given by parameter `<srid>`.

Remarks

Parses a string containing a WKB representation of a geometry and creates a geometry value of the appropriate type. This method is used by the server when evaluating a cast from a hexadecimal character string to a geometry type. Some input formats contain an SRID definition.

Example

The following example returns the result `POINT (2 4)`.

```
SELECT
ST_GeomFromWKB(x'0101000000000000000000004000000000000001040').ST_AsText() FROM
dummy;
```

3.1.29 ST_GeomFromWKT Method

Constructs a geometry from a string representation.

Syntax

```
ST_GeomFromWKT(<wkt>[, <srid>])
```

Parameters

Table 25:

Name	Type	Description
wkt	VARCHAR	A string containing the WKT representation of a geometry value.
srid	INTEGER	The SRID of the result. If not specified, the default is 0.

Returns

ST_Geometry Returns a geometry value of the appropriate type based on the source string.

The spatial reference system identifier of the result is given by parameter `<srid>`.

Remarks

Parses a string containing a WKT representation of a geometry and creates a geometry value of the appropriate type. This method is used by the server when evaluating a cast from a character string to a geometry type. Some input formats contain an SRID definition.

Example

The following example returns the result `POINT (2 4)`.

```
SELECT ST_GeomFromWKT('POINT (2.0 4.0)').ST_AsText() FROM dummy;
```

Related Information

ST_GeomFromText Method [page 64]

3.1.30 ST_GeometryType Method

Returns the name of the type of the ST_Geometry value.

Syntax

```
<geometry-expression>.ST_GeometryType()
```

Returns

VARCHAR(128) Returns the data type of the geometry value as a text string. This method can be used to determine the dynamic type of a value.

Remarks

The ST_GeometryType method returns a string containing the specific type name of `<geometry-expression>`.

Example

The following returns the string the result `ST_Point`.

```
SELECT NEW ST_Point( 1, 2 ).ST_GeometryType() FROM dummy;
```

3.1.31 ST_Intersection Method

Returns the geometry value that represents the point set intersection of two geometries.

Syntax

```
<geometry-expression>.ST_Intersection(<geo2>)
```

Parameters

Table 26:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be intersected with the `<geometry-expression>`.

Returns

ST_Geometry Returns the geometry value that represents the point set intersection of two geometries.

The spatial reference system identifier of the result is the same as the spatial reference system of the `<geometry-expression>`.

Remarks

The ST_Intersection method finds the spatial intersection of two geometries. A point is included in the intersection if it is present in both of the input geometries. If the two geometries don't share any common points, the result is an empty geometry.

Example

The following intersection between a triangle and a square returns the result `POLYGON ((1 1,3 1,3 2,2.5 3,1.5 3,1 2,1 1)`, a six-sided polygon.

```
SELECT NEW ST_Polygon('Polygon ((0 0, 4 0, 2 4, 0 0))').ST_Intersection( NEW ST_Polygon('Polygon ((1 1, 3 1, 3 3, 1 3, 1 1))') ).ST_AsText() FROM dummy;
```

3.1.32 ST_Intersects Method

Test if a geometry value spatially intersects another value.

Syntax

```
<geometry-expression>.ST_Intersects(<geo2>)
```

Parameters

Table 27:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be compared to the `<geometry-expression>`.

Returns

BIT Returns 1 if the `<geometry-expression>` spatially intersects with `<geo2>`, otherwise 0.

Remarks

Tests if a geometry value spatially intersects another value. Two geometries intersect if they share one or more common points.

Example

The following returns the result `1` because the two linestrings intersect.

```
SELECT NEW ST_LineString('LineString(0 0,2 0)').ST_Intersects( NEW
ST_LineString('LineString(1 -1,1 1)') ) FROM dummy;
```

The following returns the result `0` because the two linestrings do not intersect.

```
SELECT NEW ST_LineString('LineString(0 0,2 0)').ST_Intersects( NEW
ST_LineString('LineString(1 1,1 2)') ) FROM dummy;
```

3.1.33 ST_IntersectionAggr Method

Returns the spatial intersection of all of the geometries in a group.

Syntax

```
ST_IntersectionAggr(<geometry_column>)
```

Parameters

Table 28:

Name	Type	Description
geometry_column	ST_Geometry	The geometry values to generate the spatial intersection. This is normally a column.

Returns

ST_Geometry Returns a geometry that is the spatial intersection for all the geometries in a group.

Example

The following example returns an empty geometry collection, because there is no spatial intersection for all the geometries in the selected group.

```
SELECT ST_IntersectionAggr( Shape ).ST_AsText() FROM SpatialShapes WHERE
ShapeID IN ( 11, 12 );
```

The following example returns: `POLYGON ((1 4,1 3,5 3,5 4,1 4))`.

```
SELECT ST_IntersectionAggr( Shape ).ST_AsText() FROM SpatialShapes WHERE
ShapeID IN ( 13, 14 );
```

3.1.34 ST_IntersectsFilter Method

A quick test if the two geometries intersect.

Syntax

```
<geometry-expression>.ST_IntersectsFilter(<geo2>)
```

Parameters

Table 29:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be compared to the <geometry-expression>.

Returns

BIT Returns 1 if the <geometry-expression> spatially intersects with <geo2>, otherwise 0.

3.1.35 ST_IntersectsRect Method

Test if a geometry intersects a rectangle.

Syntax

```
<geometry-expression>.ST_IntersectsRect(<pmin>,<pmax>)
```

Parameters

Table 30:

Name	Type	Description
pmin	ST_Point	The minimum point value that is to be compared to the <geometry-expression>.
pmax	ST_Point	The maximum point value that is to be compared to the <geometry-expression>.

Returns

BIT Returns 1 if the <geometry-expression> intersects with the specified rectangle, otherwise 0.

Remarks

The ST_IntersectsRect method tests if a geometry intersects with a specified axis-aligned bounding rectangle.

Therefore, this method can be useful for writing window queries to find all geometries that intersect a given axis-aligned rectangle.

Example

The following returns the result 0 because the linestring does not intersect the provided window.

```
SELECT NEW ST_LineString( 'LineString( 0 0, 10 0, 10
10 )' ).ST_IntersectsRect( NEW ST_Point( 4, 4 ), NEW ST_Point( 6, 6 ) ) FROM
dummy;
```

The following returns the result 1 because the linestring does intersect the provided window.

```
SELECT NEW ST_LineString( 'LineString( 0 4, 10 4, 10
10 )' ).ST_IntersectsRect( NEW ST_Point( 4, 4 ), NEW ST_Point( 6, 6 ) ) FROM
dummy;
```

3.1.36 ST_Is3D Method

Determines if the geometry value has Z coordinate values.

Syntax

```
<geometry-expression>.ST_Is3D()
```

Returns

BIT Returns 1 if the geometry value has Z coordinate values, otherwise 0.

Example

The following returns the result `0` because the point does not contain a Z value.

```
SELECT NEW ST_POINT('POINT(0 0)').ST_Is3D() FROM dummy;
```

The following returns the result `1` .

```
SELECT NEW ST_POINT('POINT Z(0 0 0)').ST_Is3D() FROM dummy;
```

The following returns the result `0` because the point does not contain a Z value.

```
SELECT NEW ST_POINT('POINT M(0 0 0)').ST_Is3D() FROM dummy;
```

The following returns the result `1`.

```
SELECT NEW ST_POINT('POINT ZM(0 0 0 0)').ST_Is3D() FROM dummy;
```

3.1.37 ST_IsEmpty Method

Determines whether the geometry value represents an empty set.

Syntax

```
<geometry-expression>.ST_IsEmpty()
```

Returns

BIT Returns 1 if the geometry value is empty, otherwise 0.

Example

The following example returns the result `1`.

```
SELECT NEW ST_LineString().ST_IsEmpty() FROM dummy;
```

3.1.38 ST_IsMeasured Method

Determines if the geometry value has associated measure values.

Syntax

```
<geometry-expression>.ST_IsMeasured()
```

Returns

BIT Returns 1 if the geometry value has measure values, otherwise 0.

Example

The following example returns the result `1`.

```
SELECT ST_GeomFromText( 'LineString M( 1 2 4, 5 7 3 )' ).ST_IsMeasured() FROM
dummy;
```

The following example returns the result `0`.

```
SELECT ST_GeomFromText( 'LineString Z( 1 2 4, 5 7 3 )' ).ST_IsMeasured() FROM
dummy;
```

The following example returns the result `0`.

```
SELECT count(*) FROM SpatialShapes WHERE Shape.ST_IsMeasured() = 1;
```

3.1.39 ST_IsSimple Method

Determines whether the geometry value is simple (containing no self-intersections or other irregularities).

Syntax

```
<geometry-expression>.ST_IsSimple(<>)
```

Returns

BIT Returns 1 if the geometry value is simple, otherwise 0.

Example

The following returns the result `1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13.`

```
SELECT Shape.ST_IsSimple() FROM SpatialShapes;
```

3.1.40 ST_IsValid Method

Determines whether the geometry is a valid spatial object.

Syntax

```
<geometry-expression>.ST_IsValid()
```

Returns

BIT Returns 1 if the geometry value is valid, otherwise 0.

Remarks

By default, the server does not validate spatial data as it is created or imported from other formats. The ST_IsValid method can be used to verify that the imported data represents a geometry that is valid. Operations on invalid geometries return undefined results.

Example

The following returns the result `0` because the polygon contains a bow tie (the ring has a self-intersection).

```
SELECT NEW ST_Polygon( 'Polygon(( 0 0, 4 0, 4 5, 0 -1, 0 0 ))' ).ST_IsValid()
FROM dummy;
```

The following returns the result `0` because the polygons within the geometry self-intersect at a polygon. Self-intersections of a geometry collection at finite number of points is considered valid.

```
SELECT NEW ST_MultiPolygon( 'MultiPolygon((( 0 0, 2 0, 1 2, 0 0 )),((0 2, 1 0,
2 2, 0 2)))' ).ST_IsValid() FROM dummy;
```

3.1.41 ST_MMax Method

Retrieves the maximum M coordinate value of a geometry.

Syntax

```
<geometry-expression>.ST_MMax()
```

Returns

DOUBLE Returns the maximum M coordinate value of the `<geometry-expression>`.

Example

The following example returns the result `8`.

```
SELECT NEW ST_LineString( 'LineString ZM( 1 2 3 4, 5 6 7 8 )' ).ST_MMax() FROM
dummy;
```

3.1.42 ST_MMin Method

Retrieves the minimum M coordinate value of a geometry.

Syntax

```
<geometry-expression>.ST_MMin()
```

Returns

DOUBLE Returns the minimum M coordinate value of the <geometry-expression>.

Example

The following example returns the result 4.

```
SELECT NEW ST_LineString( 'LineString ZM( 1 2 3 4, 5 6 7 8 )' ).ST_MMin() FROM
dummy;
```

3.1.43 ST_NumInteriorRings Method

Returns the number of interior rings in the polygon.

Syntax

```
<polygon-expression>.ST_NumInteriorRings()
```

Returns

INT Returns the number of interior rings in the polygon.

Example

The following example returns the result `1`.

```
SELECT NEW ST_Polygon('Polygon ((0 0, 3 0, 3 3, 0 3, 0 0), (1 1, 2 1, 2 2, 1
1))').ST_NumInteriorRings() FROM dummy;
```

Related Information

ST_NumInteriorRing Method [page 78]

3.1.44 ST_NumInteriorRing Method

Returns the number of interior rings in the polygon.

Syntax

```
<polygon-expression>.ST_NumInteriorRing()
```

Returns

INT	Returns the number of interior rings in the polygon.

Example

The following example returns the result `1`.

```
SELECT NEW ST_Polygon('Polygon ((0 0, 3 0, 3 3, 0 3, 0 0), (1 1, 2 1, 2 2, 1
1))').ST_NumInteriorRing() FROM dummy;
```

Related Information

ST_NumInteriorRings Method [page 77]

3.1.45 ST_OrderingEquals Method

Tests if a geometry is identical to another geometry.

Syntax

```
<geometry-expression>.ST_OrderingEquals(<geo2>)
```

Parameters

Table 31:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be compared to the <geometry-expression>.

Returns

BIT Returns 1 if the two geometry values are exactly equal, otherwise 0.

Remarks

Tests if an ST_Geometry value is identical to another ST_Geometry value. The two geometries must contain the same hierarchy of objects with the exact same points in the same order to be considered equal under ST_OrderingEquals.

The ST_OrderingEquals method differs from ST_Equals in that it considers the orientation of linestrings. Two linestrings can contain exactly the same points but in opposite orders. These two linestrings are considered equal with ST_Equals but unequal with ST_OrderingEquals. Additionally, ST_OrderingEquals requires that each point in both geometries is exactly equal, not just equal within the tolerance-distance specified by the spatial reference system.

The ST_OrderingEquals method defines the semantics used for comparison predicates (= and <>), IN list predicates, DISTINCT, and GROUP BY. If you wish to compare if two spatial values are spatially equal (contain the same set of points in set), you can use the ST_Equals method.

Note

The SQL/MM standard defines ST_OrderingEquals to return a relative ordering, with 0 returned if two geometries are spatially equal (according to ST_Equals) and 1 if they are not equal. The software follows industry practice and differs from SQL/MM in that it returns a Boolean with 1 indicating the geometries are equal and 0 indicating they are different. Further, the ST_OrderingEquals implementation differs from SQL/MM because it tests that values are identical (same hierarchy of objects in the same order) instead of spatially equal (same set of points in space).

Example

The following returns the result `1` because the two linestrings contain exactly the same points in the same order.

```
SELECT NEW ST_LineString('LineString(0 0, 1 0)').ST_OrderingEquals(NEW
ST_LineString('LineString(0 0, 1 0)')) FROM dummy;
```

The following returns the result `0` because the two linestrings are defined in different orders (even though the two linestrings are spatially equal (ST_Equals is 1)).

```
SELECT NEW ST_LineString('LineString(0 0, 1 0)').ST_OrderingEquals(NEW
ST_LineString('LineString(1 0, 0 0)')) FROM dummy;
```

3.1.46 ST_Overlaps Method

Tests if a geometry value overlaps another geometry value.

Syntax

```
<geometry-expression>.ST_Overlaps(<geo2>)
```

Parameters

Table 32:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be compared to the `<geometry-expression>`.

Returns

BIT Returns 1 if the <geometry-expression> overlaps <geo2>, otherwise 0. Returns NULL if geometry-expression and <geo2> have different dimensions.

Remarks

Two geometries overlap if the following conditions are all true:

- Both geometries have the same dimension.
- The intersection of <geometry-expression> and <geo2> geometries has the same dimension as <geometry-expression>.
- Neither of the original geometries is a subset of the other.

More precisely, <geometry-expression>.ST_Overlaps(<geo2>) returns 1 when the following is TRUE:

```
<geometry-expression>.ST_Dimension() = <geo2>.ST_Dimension()
AND <geometry-expression>.ST_Intersection( <geo2> ).ST_Dimension() =
<geometry-expression>.ST_Dimension()
AND <geometry-expression>.ST_Covers( <geo2> ) = 0
AND <geo2>.ST_Covers( <geometry-expression> ) = 0
```

Note

If the <geometry-expression> contains circularstrings, then these are interpolated to line strings.

Note

This method cannot be used with geometries in round-Earth spatial reference system.

Example

The following returns the result 1 since the intersection of the two linestrings is also a linestring, and neither geometry is a subset of the other.

```
SELECT NEW ST_LineString( 'LineString( 0 0, 5 0 )' ).ST_Overlaps( NEW
ST_LineString( 'LineString( 2 0, 3 0, 3 3 )' ) ) FROM dummy;
```

The following returns the result NULL since the linestring and point have different dimension.

```
SELECT NEW ST_LineString( 'LineString( 0 0, 5 0 )' ).ST_Overlaps( NEW
ST_Point( 1, 0 ) ) FROM dummy;
```

The following returns the result 0 since the point is a subset of the multipoint.

```
SELECT NEW ST_MultiPoint( 'MultiPoint(( 2 3 ), ( 1 0 ))' ).ST_Overlaps( NEW
ST_Point( 1, 0 ) ) FROM dummy;
```

The following returns the result 12.

```
SELECT ShapeID FROM SpatialShapes WHERE NEW ST_Polygon('Polygon(( 3 3, 3 6, 6
6, 3 3 ))').ST_Overlaps ( Shape ) = 1 ORDER BY ShapeID;
```

3.1.47 ST_PointOnSurface Method

Returns an ST_Point value that is guaranteed to spatially intersect the ST_Surface value.

Syntax

```
<surface-expression>.ST_PointOnSurface()
```

Returns

ST_Point If the surface is the empty set, returns NULL. Otherwise, returns an `ST_Point` value guaranteed to spatially intersect the surface.

Example

The following returns a point that intersects the polygon.

```
SELECT NEW ST_Polygon('POLYGON((0 0, 0 1.25, 1.25 1.25, 0
0))').ST_PointOnSurface().ST_AsText() FROM dummy;
```

3.1.48 ST_Relate Method

Tests if a geometry value is spatially related to another geometry value as specified by the intersection matrix.

The ST_Relate method uses a 9-character string from the Dimensionally Extended 9 Intersection Model (DE-9IM) to describe the pair-wise relationship between two spatial data items. For example, the ST_Relate method determines if an intersection occurs between the geometries, and the geometry of the resulting intersection, if it exists.

Syntax

```
<geometry-expression>.ST_Relate(<geo2>)
```

Parameters

Table 33:

Name	Type	Description
geo2	ST_Geometry	The second geometry value that is to be compared to the <geometry-expression>.

Returns

BIT Returns a 9-character string representing a matrix in the dimensionally extended 9 intersection model. Each character in the 9-character string represents the type of intersection at one of the nine possible intersections between the interior, boundary, and exterior of the two geometries.

Remarks

Tests if a geometry value is spatially related to another geometry value by testing for intersection between the interior, boundary, and exterior of two geometries, as specified by the intersection matrix.

The intersection matrix is returned as a string. While it is possible to use this method variant to test a spatial relationship by examining the returned string, it is more efficient to test relationships by passing a pattern string as second parameter or by using specific spatial predicates such as ST_Contains or ST_Intersects.

Note

If the <geometry-expression> contains circularstrings, then these are interpolated to line strings.

Note

This method cannot be used with geometries in round-Earth spatial reference system.

Example

The following example returns the result 1F2001102.

```
SELECT NEW ST_Polygon( 'Polygon(( 0 0, 2 0, 0 2, 0 0 ))' )
```

```
.ST_Relate( NEW ST_LineString( 'LineString( 0 1, 5 1 )' ) ) from dummy;
```

Related Information

How Spatial Relationships Work [page 30]

3.1.49 ST_SRID Method

Returns the SRID of the geometry.

Syntax

```
<geometry-expression>.ST_SRID()
```

Returns

INT	Returns the SRID of the geometry.

Remarks

Returns the SRID of the geometry. Every geometry is associated with a spatial reference system.

Example

The following returns the result `0`, indicating the point has the SRID 0, corresponding to the 'Default' spatial reference system.

```
SELECT NEW ST_Point().ST_SRID() FROM dummy;
```

3.1.50 ST_SnapToGrid Method

Returns a copy of the geometry with all points snapped to the specified grid.

Syntax

```
<geometry-expression>.ST_SnapToGrid(<cell-size>)
```

Parameters

Table 34:

Name	Type	Description
cell-size	DOUBLE	The cell size for the grid.

Returns

ST_Geometry

Returns the geometry with all points snapped to the grid.

The spatial reference system identifier of the result is the same as the spatial reference system of the <geometry-expression>.

Remarks

The ST_SnapToGrid method can be used to reduce the precision of data by snapping all points in a geometry to a grid defined by the origin and cell size.

The X and Y coordinates are snapped to the grid; any Z and M values are unchanged.

> **Note**
>
> Reducing precision may cause the resulting geometry to have different properties. For example, it may cause a simple linestring to cross itself, or it may generate an invalid geometry.

> **Note**
>
> Each spatial reference system defines a grid that all geometries are automatically snapped to. You cannot store more precision than this predefined grid.

Example

The following example returns the result `LineString (1.536133 6.439453, 2.173828 6.100586)`.

```
SELECT NEW ST_LineString( 'LineString( 1.5358 6.4391, 2.17401
6.10018 )' ).ST_SnapToGrid( 0.001 ).ST_AsText() FROM dummy;
```

Each X and Y coordinate is shifted to the closest grid point using a grid size of approximately 0.001. The actual grid size used is not exactly the grid size specified.

3.1.51 ST_SymDifference Method

Returns the geometry value that represents the point set symmetric difference of two geometries.

Syntax

```
<geometry-expression>.ST_SymDifference(<geo2>)
```

Parameters

Table 35:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be subtracted from the `<geometry-expression>` to find the symmetric difference.

Returns

ST_Geometry Returns the geometry value that represents the point set symmetric difference of two geometries.

The spatial reference system identifier of the result is the same as the spatial reference system of the `<geometry-expression>`.

Remarks

The ST_SymDifference method finds the symmetric difference of two geometries. The symmetric difference consists of all of those points that are in only one of the two geometries. If the two geometry values consist of the same points, the ST_SymDifference method returns an empty geometry.

Example

The following example shows the difference between the two objects.

```
SELECT NEW ST_Polygon( 'Polygon( (-1 -0.25, 1 -0.25, 1 2.25, -1 2.25, -1
-0.25) )' ).ST_SymDifference(NEW ST_Polygon('Polygon ((-5 -5, 5 -5, 0 5, -5
-5), (-2 -2, -2 0, 2 0, 2 -2, -2 -2))')) from dummy;
```

3.1.52 ST_Touches Method

Tests if a geometry value spatially touches another geometry value.

Syntax

```
<geometry-expression>.ST_Touches(<geo2>)
```

Parameters

Table 36:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be compared to the <geometry-expression>.

Returns

BIT Returns 1 if the <geometry-expression> touches <geo2>, otherwise 0. Returns NULL if both <geometry-expression> and <geo2> have dimension 0.

Remarks

Tests if a geometry value spatially touches another geometry value. Two geometries spatially touch if their interiors do not intersect but one or more boundary points from one value intersects the interior or boundary of the other value.

> **Note**
>
> This method cannot be used with geometries in round-Earth spatial reference system.

> **Example**
>
> The following example returns 1.

```
SELECT NEW ST_LINESTRING('LINESTRING(7.0 5.0, 9.0 7.0)')
.ST_Touches( NEW ST_LINESTRING('LINESTRING(7.0 5.0, 8.0 5.0)') ) FROM dummy;
```

3.1.53 ST_Transform Method

Creates a copy of the geometry value transformed into the specified spatial reference system.

Syntax

```
<geometry-expression>.ST_Transform(<srid>)
```

Parameters

Table 37:

Name	Type	Description
srid	INT	The SRID of the result.

Returns

ST_Geometry — Returns a copy of the geometry value transformed into the specified spatial reference system.

Remarks

The ST_Transform method transforms `<geometry-expression>` from its spatial reference system to the specified spatial reference system using the transform definition of both spatial reference systems.

A transformation only takes place, if both spatial reference systems exist and if both spatial reference systems have a transform defintion.

For spatial reference systems 0 a transformation does not take place, because spatial reference systems 0 does not have a transform definition.

Example

The following example returns the result `Point (10, 30)` in binary format.

```
SELECT new ST_Point('POINT(-86 36)',4326).ST_Transform(1000026980) from dummy;
```

3.1.54 ST_UnionAggr Method

Returns the spatial union of all of the geometries in a group.

Syntax

```
ST_UnionAggr(<geometry_column>)
```

Parameters

Table 38:

Name	Type	Description
geometry_column	ST_Geometry	The geometry values to generate the spatial union. Typically this is a column.

Returns

ST_Geometry	Returns a geometry that is the spatial union for all the geometries in a group.

Example

The following example returns the result `MULTIPOINT ((2.5 3),(3 4.5))`.

```
SELECT ST_UnionAggr( Shape ).ST_AsText() FROM SpatialShapes WHERE ShapeID in
(1,2);
```

3.1.55 ST_WithinDistance Method

Test if two geometries are within a specified distance of each other.

Syntax

```
<geometry-expression>.ST_WithinDistance(<geo2>,<distance>,<unit_name>)
```

Parameters

Table 39:

Name	Type	Description
geo2	ST_Geometry	The other geometry value whose distance is to be measured from the `<geometry-expression>`.
distance	DOUBLE	The distance the two geometries should be within.
unit_name	VARCHAR(128)	The units in which the distance parameter should be interpreted. Defaults to the unit of the spatial reference system. The unit name must match the UNIT_NAME column of a row in the ST_UNITS_OF_MEASURE view where UNIT_TYPE is 'LINEAR'.

Returns

BIT Returns 1 if <geometry-expression> and <geo2> are within the specified distance of each other, otherwise 0.

Remarks

The ST_WithinDistance method tests if the smallest distance between two geometries does not exceed a specified distance, taking tolerance into consideration.

More precisely, let <d> denote the smallest distance between <geometry-expression> and <geo2>. The expression <geometry-expression>.ST_WithinDistance(<geo2>, <distance>) evaluates to 1 if either <d> <= <distance> or if <d> exceeds <distance> by a length that is less than the tolerance of the associated spatial reference system.

Example

The following example returns 1 because the two points are within 1 unit of distance.

```
SELECT NEW ST_Point(0,0).ST_WithinDistance( NEW ST_Point(1,0), 1 ) FROM dummy;
```

The following example returns 0 because the two points are not within 1 unit of distance.

```
SELECT NEW ST_Point(0,0).ST_WithinDistance( NEW ST_Point(1,1), 1 ) FROM dummy;
```

The following example returns 0 because the two points are not within 4 units of distance.

```
SELECT NEW ST_Point( 'Point(0 0)' ).ST_WithinDistance(NEW ST_Point( 'Point(3.1
4.1)' ), 4) FROM dummy;
```

The following example returns 0 because the two points are not within 6 units of distance.

```
SELECT NEW ST_Point( 'Point(0 0)' ).ST_WithinDistance(NEW ST_Point( 'Point(3.1
4.1)' ), 6) FROM dummy;
```

The following example returns 0 because the distance between Walldorf and Heidelberg is not less or equal 25 meters.

```
SELECT NEW ST_Point('Point(8.641493 49.293679)', 4326).ST_WithinDistance(new
ST_Point('Point(8.682241 49.407571)', 4326), 25, 'meter') FROM
dummy;
```

The following example returns 1 because the distance between Walldorf and Heidelberg is less or equal 25 kilometers.

```
SELECT NEW ST_Point('Point(8.641493 49.293679)', 4326).ST_WithinDistance(new
ST_Point('Point(8.682241 49.407571)', 4326), 25, 'kilometer')
FROM dummy;
```

3.1.56 ST_Within Method

Tests if a geometry value is spatially contained within another geometry value.

Syntax

```
<geometry-expression>.ST_Within(<geo2>)
```

Parameters

Table 40:

Name	Type	Description
geo2	ST_Geometry	The other geometry value that is to be compared to the <geometry-expression>.

Returns

BIT Returns 1 if <geometry-expression> is within <geo2>, otherwise 0.

Remarks

The ST_Within method tests if the <geometry-expression> is completely within <geo2> and there is one or more interior points of <geo2> that lies in the interior of the <geometry-expression>.

<geometry-expression>. ST_Within(<geo2>) is equivalent to <geo2>.ST_Contains(<geometry-expression>).

The ST_Within and ST_CoveredBy methods are similar. The difference is that ST_CoveredBy does not require intersecting interior points.

> **Note**
>
> If the <geometry-expression> contains circularstrings, then these are interpolated to line strings.

> **Note**
>
> This method cannot be used with geometries in round-Earth spatial reference system.

Example

The following example tests if a point is within a polygon. The point is completely within the polygon, and the interior of the point (the point itself) intersects the interior of the polygon, so the example returns 1.

```
SELECT NEW ST_Point(1, 1).ST_Within( NEW ST_Polygon( 'Polygon(( 0 0, 2 0, 1 2,
0 0 ))' ) ) FROM dummy;
```

The following example tests if a line is within a polygon. The line is completely within the polygon, but the interior of the line and the interior of the polygon do not intersect (the line only intersects the polygon on the polygon's boundary, and the boundary is not part of the interior), so the example returns 0. If ST_CoveredBy was used in place of ST_Within, ST_CoveredBy would return 1.

```
SELECT NEW ST_LineString( 'LineString( 0 0, 1 0 )' ).ST_Within( NEW
ST_Polygon( 'Polygon(( 0 0, 2 0, 1 2, 0 0 ))' ) ) FROM dummy;
```

3.1.57 ST_XMax Method

Retrieves the maximum X coordinate value of a geometry.

Syntax

```
<geometry-expression>.ST_XMax()
```

Returns

DOUBLE Returns the maximum X coordinate value of the <geometry-expression>.

Remarks

Returns the maximum X coordinate value of the <geometry-expression>. This is computed by comparing the X attribute of all points in the geometry.

Note

If the <geometry-expression> is an empty geometry (ST_IsEmpty()=1), then this method returns NULL.

Example

The following returns the result `3`.

```
SELECT NEW ST_LineString('LineString(1 2, 3 4)').ST_XMax() FROM dummy;
```

3.1.58 ST_XMin Method

Retrieves the minimum X coordinate value of a geometry.

Syntax

```
<geometry-expression>.ST_XMin()
```

Returns

DOUBLE	Returns the minimum X coordinate value of the `<geometry-expression>`.

Remarks

Returns the minimum X coordinate value of the `<geometry-expression>`. This is computed by comparing the X attribute of all points in the geometry.

Note

If the `<geometry-expression>` is an empty geometry (ST_IsEmpty()=1), then this method returns NULL.

Example

The following returns the result `1`.

```
SELECT NEW ST_LineString('LineString(1 2, 3 4)').ST_XMin() FROM dummy;
```

3.1.59 ST_YMax Method

Retrieves the maximum Y coordinate value of a geometry.

Syntax

```
<geometry-expression>.ST_YMax()
```

Returns

DOUBLE	Returns the maximum Y coordinate value of the <geometry-expression>.

Remarks

Returns the maximum Y coordinate value of the <geometry-expression>. This is computed by comparing the Y attribute of all points in the geometry.

> **Note**
>
> If the <geometry-expression> is an empty geometry (ST_IsEmpty()=1), then this method returns NULL.

> **Example**
>
> The following returns the result 4.
>
> ```
> SELECT NEW ST_LineString('LineString(1 2, 3 4)').ST_YMax() FROM dummy;
> ```

3.1.60 ST_YMin Method

Retrieves the minimum Y coordinate value of a geometry.

Syntax

```
<geometry-expression>.ST_YMin()
```

Returns

DOUBLE	Returns the minimum Y coordinate value of the <geometry-expression>.

Remarks

Returns the minimum Y coordinate value of the <geometry-expression>. This is computed by comparing the Y attribute of all points in the geometry.

> **Note**
>
> If the <geometry-expression> is an empty geometry (ST_IsEmpty()=1), then this method returns NULL.

> **Example**
>
> The following returns the result 2.

```
SELECT NEW ST_LineString('LineString(1 2, 3 4)').ST_YMin() FROM dummy;
```

3.1.61 ST_ZMax Method

Retrieves the maximum Z coordinate value of a geometry.

Syntax

```
<geometry-expression>.ST_ZMax()
```

Returns

DOUBLE	Returns the maximum Z coordinate value of the <geometry-expression>.

Remarks

Returns the maximum Z coordinate value of the <geometry-expression>. This is computed by comparing the Z attribute of all points in the geometry.

> **Note**
>
> If the <geometry-expression> is an empty geometry (ST_IsEmpty()=1), then this method returns NULL.

> **Example**
>
> **Example**
>
> The following returns the result 10.

```
SELECT NEW ST_LineString('LineString Z(1 2 10, 3 4 7, 5 6 9.9)').ST_ZMax()
FROM dummy;
```

3.1.62 ST_ZMin Method

Retrieves the minimum Z coordinate value of a geometry.

Syntax

```
<geometry-expression>.ST_ZMin()
```

Returns

DOUBLE	Returns the minimum Z coordinate value of the <geometry-expression>.

Remarks

Returns the minimum Z coordinate value of the <geometry-expression>. This is computed by comparing the Z attribute of all points in the geometry.

> **Note**
>
> If the <geometry-expression> is an empty geometry (ST_IsEmpty()=1), then this method returns NULL.

Example

Example

The following returns the result `7`.

```
SELECT NEW ST_LineString('LineString Z(1 2 10, 3 4 7, 5 6 9.9)').ST_ZMin()
FROM dummy;
```

3.2 ST_GeometryCollection Type

An ST_GeometryCollection is a collection of zero or more ST_Geometry values.

Direct supertype

ST_Geometry class

Constructor

ST_GeometryCollection constructor

Methods

Methods of ST_GeometryCollection

Table 41:

ST_NumGeometries	ST_GeometryN

Remarks

An ST_GeometryCollection is a collection of zero or more ST_Geometry values. All of the values are in the same spatial reference system as the collection value. The ST_GeometryCollection type can contain a heterogeneous collection of objects (for example, points, lines, and polygons). Sub-types of ST_GeometryCollection can be used to restrict the collection to certain geometry types. The dimension of the geometry collection value is the largest dimension of its constituents. A geometry collection is simple if all of the constituents are simple and no two constituent geometries intersect except possibly at their boundaries.

3.2.1 ST_GeometryCollection Constructor

Constructs a geometry collection.

Overload list

Table 42:

Name	Description
ST_GeometryCollection()	Constructs a geometry collection representing the empty set.
ST_GeometryCollection(LONG VARCHAR [,INT])	Constructs a geometry collection from a text representation.
ST_GeometryCollection(LONG BINARY)	Constructs a geometry collection from Well Known Binary (WKB).

3.2.1.1 ST_GeometryCollection() Constructor

Constructs a geometry collection representing the empty set.

Syntax

```
NEW ST_GeometryCollection()
```

Example

The following returns 1, indicating the value is empty.

```
SELECT NEW ST_GeometryCollection().ST_IsEmpty() FROM dummy;
```

3.2.1.2 ST_GeometryCollection(LONG VARCHAR [,INT]) Constructor

Constructs a geometry collection from a text representation.

Syntax

```
NEW ST_GeometryCollection(<text-representation> [,INT <srid>])
```

Parameters

Table 43:

Name	Type	Description
text-representation	LONG VARCHAR	A string containing the text representation of a multi linestring in Well Known Text (WKT) format.
srid	INT	The SRID of the result. If not specified and the input string does not contain a SRID, the default is 0.

Remarks

Constructs a multi linestring from a character string representation.

Example

The following returns `GeometryCollection (LineString(5 10, 10 12, 15 10), Polygon ((10 -5, 15 5, 5 5, 10 -5)))` in binary format.

```
SELECT New ST_GeometryCollection( 'GeometryCollection (LineString(5 10, 10 12,
15 10), Polygon ((10 -5, 15 5, 5 5, 10 -5)))') FROM dummy;
```

The following returns the geometry collection in binary format.

```
SELECT New ST_GeometryCollection( 'GeometryCollection Z(LineString Z(5 10 20,
10 12 25, 15 10 13), Polygon Z((10 -5 4, 15 5 6, 5 5 7, 10 -5 4)), Point Z(10
15 12))') FROM dummy;
```

The following returns `GeometryCollection (LineString(5 10, 10 12, 15 10), Polygon ((10 -5, 15 5, 5 5, 10 -5)))` in binary format.

```
SELECT New ST_GeometryCollection( 'GeometryCollection (LineString(5 10, 10 12,
15 10), Polygon ((10 -5, 15 5, 5 5, 10 -5)))', 4326) FROM dummy;
```

3.2.1.3 ST_GeometryCollection(LONG BINARY) Constructor

Constructs a geometry collection from Well Known Binary (WKB).

Syntax

```
NEW ST_GeometryCollection(<wkb>)
```

Parameters

Table 44:

Name	Type	Description
wkb	LONG BINARY	A string containing the binary representation of a multi linestring in Well Known Binary (WKB) format.

Remarks

Constructs an ST_GeometryCollection value from a binary string representation.

Example

The following returns GeometryCollection (Point (10 20)).

```
SELECT NEW
ST_GeometryCollection(x'01070000000100000001010000000000000000002440000000000000
03440') FROM dummy;
```

3.2.2 ST_GeometryN Method

Returns the nth geometry in the geometry collection.

Syntax

```
<geometrycollection-expression>.ST_GeometryN(<n>)
```

Parameters

Table 45:

Name	Type	Description
n	INT	The position of the element to return, from 1 to `geometrycollectionexpression. ST_NumGeometries()`.

Returns

ST_Geometry	Returns the nth geometry in the geometry collection.

Example

The following example returns the result `POLYGON ((10.000000000000000 -5.000000000000000,15.000000000000000 5.000000000000000,5.000000000000000 5.000000000000000,10.000000000000000 -5.000000000000000))`.

```
SELECT NEW ST_GeometryCollection('GeometryCollection (LineString(5 10, 10 12,
15 10), Polygon ((10 -5, 15 5, 5 5, 10 -5)))').ST_GeometryN( 2 ).ST_AsText()
FROM dummy;
```

The following example returns the result `POLYGON ((10.000000000000000 -5.000000000000000,15.000000000000000 5.000000000000000,5.000000000000000 5.000000000000000,10.000000000000000 -5.000000000000000))`.

```
SELECT NEW ST_GeometryCollection('GeometryCollection (LineString(5 10, 10 12,
15 10), Polygon ((10 -5, 15 5, 5 5, 10 -5)))',
1000004326).ST_GeometryN( 2 ).ST_AsText() FROM dummy;
```

3.2.3 ST_NumGeometries Method

Returns the number of geometries contained in the geometry collection.

Syntax

```
<geometrycollection-expression>.ST_NumGeometries()
```

Returns

INT Returns the number of geometries stored in this collection.

Example

The following example returns the result 3.

```
SELECT NEW ST_MultiPoint('MultiPoint ((10 10), (12 12), (14
10))').ST_NumGeometries() FROM dummy;
```

The following example returns the result 3.

```
SELECT NEW ST_MultiPoint('MultiPoint ((10 10), (12 12), (14 10))',
1000004326).ST_NumGeometries() FROM dummy;
```

3.3 ST_CircularString Type

The ST_CircularString type is a subtype of ST_Geometry that uses circular line segments between control points.

The first three points define a segment as follows. The first point is the start point of the segment. The second point is any point on the segment other than the start and end point. The third point is the end point of the segment. Subsequent segments are defined by two points only (intermediate and end point). The start point is taken to be the end point of the preceding segment.

A circularstring can be a complete circle with three points, if the start and end points are coincident. In this case, the intermediate point is the midpoint of the segment. If the start, intermediate and end points are collinear, the segment is a straight line segment between the start and end point. A circularstring with exactly three points is a circular arc. A circular ring is a circularstring that is both closed and simple.

Circularstrings are not allowed in round-Earth spatial reference systems. Attempting to create one for SRID 4326 for example returns an error.

Direct supertype

ST_Geometry class

Constructor

ST_CircularString constructor

3.3.1 ST_CircularString Constructor

Constructs a circularstring.

Overload list

Table 46:

Name	Description
ST_CircularString()	Constructs a circularstring representing the empty set.
ST_CircularString(BLOB [,INT]) Constructor	Constructs a circularstring from Well Known Binary (WKB).
ST_CircularString(CLOB [,INT]) Constructor	Constructs a circularstring from Well Known Text (WKT).

3.3.1.1 ST_CircularString() Constructor

Constructs a circularstring representing the empty set.

Syntax

```
NEW ST_CircularString()
```

Example

Constructs a circularstring representing the empty set.

```
SELECT NEW ST_CircularString() FROM dummy;
```

3.3.1.2 ST_CircularString(BLOB) Constructor

Constructs a circularstring from Well Known Binary (WKB).

Syntax

```
NEW ST_CircularString(BLOB <wkb>)
```

Parameters

Table 47:

Name	Type	Description
wkb	BLOB	A string containing the text representation of a circularstring in Well Known Text (WKT) format.

Example

The following returns `CircularString (5 10, 10 12, 15 10)`.

```
SELECT NEW
ST_CircularString(x'01080000000300000000000000000014400000000000002440000000000
00024400000000000000284000000000000002e400000000000002440') FROM dummy;
```

3.3.1.3 ST_CircularString(CLOB [,INT]) Constructor

Constructs a circularstring from Well Known Text (WKT).

Syntax

```
NEW ST_CircularString(CLOB <wkt> [,INT <srid>])
```

Parameters

Table 48:

Name	Type	Description
wkt	CLOB	A string containing the text representation of a circularstring in Well Known Text (WKT) format.
srid	INT	The SRID of the result. If not specified and the input string does not contain a SRID, the default is 0.

Example

The following returns CircularString (0 0, 1 1, 0 2).

```
SELECT NEW ST_CircularString('CIRCULARSTRING(0 0, 1 1, 0 2)') FROM dummy;
```

The following returns CircularString (0 0, 1 1, 0 2).

```
SELECT NEW ST_CircularString('CIRCULARSTRING(0 0, 1 1, 0 2)', 1000004326) FROM
dummy;
```

3.4 ST_LineString Type

The ST_LineString type is used to represent a multi-segment line using straight line segments between control points.

Direct supertype

ST_Geometry class

Constructor

ST_LineString constructor

Methods

- Methods of ST_LineString:

  Table 49:

ST_EndPoint	ST_IsClosed	ST_IsRing	ST_Length
ST_NumPoints	ST_PointN	ST_StartPoint	

- All methods of ST_Geometry can also be called on a ST_LineString type:

  Table 50:

ST_AsBinary	ST_AsGeoJSON	ST_AsText	ST_AsWKB
ST_AsWKT	ST_Contains	ST_ConvexHull	ST_Crosses
ST_Dimension	ST_Distance	ST_Envelope	ST_Equals
ST_GeomFromText	ST_GeometryType	ST_Intersection	ST_Intersects
ST_IntersectsRect	ST_Is3D	ST_IsEmpty	ST_IsValid
ST_OrderingEquals	ST_SRID	ST_SnapToGrid	ST_WithinDistance
ST_XMax	ST_XMin	ST_YMax	ST_YMin

Remarks

The ST_LineString type is used to represent a multi-segment line using straight line segments between control points. Each consecutive pair of points is joined with a straight line segment.

A line is an ST_LineString value with exactly two points. A linear ring is an ST_LineString value which is closed and simple.

3.4.1 ST_LineString Constructor

Constructs a linestring.

Overload list

Table 51:

Name	Description
ST_LineString()	Constructs a linestring representing the empty set.
ST_LineString(LONG VARCHAR)	Constructs a linestring from a text representation.

Name	Description
ST_LineString(LONG BINARY)	Constructs a linestring from Well Known Binary (WKB).

3.4.1.1 ST_LineString() Constructor

Constructs a linestring representing the empty set.

Syntax

```
NEW ST_LineString()
```

Example

The following returns 1, indicating the value is empty.

```
SELECT NEW ST_LineString().ST_IsEmpty() FROM dummy;
```

3.4.1.2 ST_LineString(LONG VARCHAR [,INT]) Constructor

Constructs a linestring from a text representation.

Syntax

```
NEW ST_LineString(<text-representation> [,INT <srid>])
```

Parameters

Table 52:

Name	Type	Description
text-representation	LONG VARCHAR	A string containing the text representation of a linestring in Well Known Text (WKT) format.

Name	Type	Description
srid	INT	The SRID of the result. If not specified and the input string does not contain a SRID, the default is 0.

Remarks

Constructs a linestring from a character string representation.

Example

The following returns `LineString (0 0, 5 10)` in binary format.

```
SELECT NEW ST_LineString('LineString (0 0, 5 10)') FROM dummy;
```

The following returns `01D20700000200000000000000000000000000000000000000000000000000000000000104000000000000001440000000000000024400000000000001840`.

```
SELECT NEW ST_LineString('LineString M(0 0 4, 5 10 6)') FROM dummy;
```

The following returns `01EA03000002000000000000000000000000000000000000000000000000000000000001C4000000000000001440000000000000024400000000000001040`.

```
SELECT NEW ST_LineString('LineString Z(0 0 7, 5 10 4)') FROM dummy;
```

The following returns `01BA0B0000020000000000000000000000000000000000000000000000000000000000084000000000000018400000000000000144000000000000002440000000000000104000000000000002040`.

```
SELECT NEW ST_LineString('LineString ZM(0 0 3 6, 5 10 4 8)') FROM dummy;
```

The following returns `0102000000020000000000000000000000000000000000000000000000000000000001440000000000000024400`.

```
SELECT NEW ST_LineString('LineString (0 0, 5 10)', 4326) FROM dummy;
```

3.4.1.3 ST_LineString(LONG BINARY) Constructor

Constructs a linestring from Well Known Binary (WKB).

Syntax

```
NEW ST_LineString(<wkb>)
```

Parameters

Table 53:

Name	Type	Description
wkb	LONG BINARY	A string containing the binary representation of a linestring in Well Known Binary (WKB) format.

Remarks

Constructs a linestring from a binary string representation.

Example

The following returns LineString (0 0, 5 10).

```
SELECT NEW
ST_LineString(x'0102000000020000000000000000000000000000000000000000000000000000000000000001
4400000000000002440') FROM dummy;
```

3.4.2 ST_EndPoint Method

Returns an ST_Point value that is the end point.

Syntax

```
<linestring-expression>.ST_EndPoint()
```

Returns

ST_Point If the linestring is an empty set, returns NULL. Otherwise, returns the end point of the linestring.

The spatial reference system identifier of the result is the same as the spatial reference system of the `<linestring-expression>`.

Example

The following example returns the result `Point (5 10)`.

```
SELECT NEW ST_LineString( 'LineString(0 0, 5 5, 5 10)' ).ST_EndPoint() FROM
dummy;
```

The following example returns the result `Point (5 10)`.

```
SELECT NEW ST_LineString( 'LineString(0 0, 5 5, 5 10)', 4326).ST_EndPoint()
FROM dummy;
```

3.4.3 ST_IsClosed Method

Test if the linestring is closed. A linestring is closed if the start and end points are coincident.

Syntax

```
<linestring-expression>.ST_IsClosed()
```

Returns

BIT Returns 1 if the linestring is closed (and non-empty). Otherwise, returns 0.

Example

The following returns "1" because the linestring is closed.

```
SELECT NEW ST_LineString( 'LineString(0 0, 5 5, 5 0, 0 0)' ).ST_IsClosed()
FROM dummy;
```

The following returns "1" because the linestring is closed.

```
SELECT NEW ST_LineString( 'LineString(0 0, 5 5, 5 0, 0 0)',
4326).ST_IsClosed() FROM dummy;
```

3.4.4 ST_IsRing Method

Tests if the linestring is a ring. A linestring is a ring if it is closed and simple (no self-intersections).

Syntax

```
<linestring-expression>.ST_IsRing()
```

Returns

BIT Returns 1 if the linestring is a ring (and non-empty). Otherwise, returns 0.

Example

The following returns "1" because the linestring is a ring.

```
SELECT NEW ST_LineString( 'LineString(0 0, 5 5, 5 0, 0 0)' ).ST_IsRing() FROM
dummy;
```

The following returns "1" because the linestring is a ring.

```
SELECT NEW ST_LineString( 'LineString(0 0, 5 5, 5 0, 0 0)', 4326).ST_IsRing()
FROM dummy;
```

3.4.5 ST_Length Method

Returns the length of the linestring.

Syntax

```
<linestring-expression>.ST_Length(<unit_name>)
```

Parameters

Table 54:

Name	Type	Description
unit_name	VARCHAR(128)	The units in which the distance parameter should be interpreted. Defaults to the unit of the spatial reference system. The unit name must match the UNIT_NAME column of a row in the ST_UNITS_OF_MEASURE view where UNIT_TYPE is 'LINEAR'.

Returns

DOUBLE If the linestring is an empty set, returns NULL. Otherwise, returns the length of the linestring.

Remarks

The ST_Length method returns the length of a linestring. If the linestring is empty, then NULL is returned.

If the linestring contains Z values, these are not considered when computing the length of the geometry.

Note

If the `<linestring-expression>` is an empty geometry (ST_IsEmpty()=1), then this method returns NULL.

Example

The following example returns the result `2`.

```
SELECT NEW ST_LineString( 'LineString(1 0, 1 1, 2 1)' ).ST_Length() FROM dummy;
```

The following example returns the result `2`.

```
SELECT NEW ST_LineString( 'LineString(1 0, 1 1, 2 1)', 4326).ST_Length() FROM
dummy;
```

3.4.6 ST_NumPoints Method

Returns the number of points defining the linestring.

Syntax

```
<linestring-expression>.ST_NumPoints()
```

Returns

INT Returns NULL if the linestring value is empty, otherwise the number of points in the value.

Example

The following returns the result 5.

```
SELECT NEW ST_LineString('LineString(0 0, 1 0, 1 1, 0 1, 0
0 )').ST_NumPoints() FROM dummy;
```

The following returns the result 5.

```
SELECT NEW ST_LineString('LineString(0 0, 1 0, 1 1, 0 1, 0 0 )',
4326).ST_NumPoints() FROM dummy;
```

3.4.7 ST_PointN Method

Returns the <n>th point in the linestring.

Syntax

```
<linestring-expression>.ST_PointN(<n>)
```

Parameters

Table 55:

Name	Type	Description
n	INT	The position of the element to return, from 1 to <linestring-expression>.ST_NumPoints().

Returns

ST_Point If the value of <linestring-expression> is the empty set, returns NULL. If the specified position <n> is less than 1 or greater than the number of points, returns NULL. Otherwise, returns the ST_Point value at position n.

The spatial reference system identifier of the result is the same as the spatial reference system of the <linestring-expression>.

Example

The following returns the result `Point (1 0)`.

```
SELECT NEW ST_LineString('LineString(0 0, 1 0, 1 1, 0 1, 0 0 )').ST_PointN(2)
FROM dummy;
```

The following returns the result `Point (1 0)`.

```
SELECT NEW ST_LineString('LineString(0 0, 1 0, 1 1, 0 1, 0 0 )',
4326).ST_PointN(2) FROM dummy;
```

3.4.8 ST_StartPoint Method

Returns an ST_Point value that is the starting point.

Syntax

```
<linestring-expression>.ST_StartPoint()
```

Returns

ST_Point If the linestring is an empty set, returns NULL. Otherwise, returns the start point of the linestring.

The spatial reference system identifier of the result is the same as the spatial reference system of the `<linestring-expression>`.

Example

The following example returns the result `Point (0 0)`.

```
SELECT NEW ST_LineString( 'LineString(0 0, 5 5, 5 10)').ST_StartPoint() FROM
dummy;
```

The following example returns the result `Point (0 0)`.

```
SELECT NEW ST_LineString( 'LineString(0 0, 5 5, 5 10)', 4326).ST_StartPoint()
FROM dummy;
```

3.5 ST_MultiLineString Type

An ST_MultiLineString is a collection of zero or more ST_LineString values, and all of the linestrings are within the spatial reference system.

Direct supertype

ST_Geometry class

Constructor

ST_MultiLineString constructor

Methods

- Methods of ST_MultiLineString:

  Table 56:

ST_IsClosed	ST_Length

- All methods of ST_Geometry can also be called on a ST_MultiLineString type:

  Table 57:

ST_AsBinary	ST_AsGeoJSON	ST_AsText	ST_AsWKB
ST_AsWKT	ST_Contains	ST_ConvexHull	ST_Crosses
ST_Dimension	ST_Distance	ST_Envelope	ST_Equals
ST_GeomFromText	ST_GeometryType	ST_Intersection	ST_Intersects
ST_IntersectsRect	ST_Is3D	ST_IsEmpty	ST_IsValid
ST_OrderingEquals	ST_SRID	ST_SnapToGrid	ST_WithinDistance
ST_XMax	ST_XMin	ST_YMax	ST_YMin

3.5.1 ST_MultiLineString Constructor

Constructs a multi linestring.

Overload list

Table 58:

Name	Description
ST_MultiLineString()	Constructs a multi linestring representing the empty set.
ST_MultiLineString(LONG VARCHAR)	Constructs a multi linestring from a text representation.
ST_MultiLineString(LONG BINARY)	Constructs a multi linestring from Well Known Binary (WKB).

3.5.1.1 ST_MultiLineString() Constructor

Constructs a multi linestring representing the empty set.

Syntax

```
NEW ST_MultiLineString()
```

Example

The following returns 1, indicating the value is empty.

```
SELECT NEW ST_MultiLineString().ST_IsEmpty() FROM dummy;
```

3.5.1.2 ST_MultiLineString(LONG VARCHAR [,INT]) Constructor

Constructs a multi linestring from a text representation.

Syntax

```
NEW ST_MultiLineString(<text-representation> [,INT <srid>])
```

Parameters

Table 59:

Name	Type	Description
text-representation	LONG VARCHAR	A string containing the text representation of a multi linestring in Well Known Text (WKT) format.
srid	INT	The SRID of the result. If not specified and the input string does not contain a SRID, the default is 0.

Remarks

Constructs a multi linestring from a character string representation.

Example

The following returns `MultiLineString ((10 10, 12 12), (14 10, 16 12))` in binary format.

```
SELECT NEW ST_MultiLineString('MultiLineString ((10 10, 12 12), (14 10, 16
12))') FROM dummy;
```

The following returns the multi linestring in binary format.

```
SELECT NEW ST_MultiLineString('MultiLineString Z((10 10 10, 12 12 12), (14 10
10, 16 12 12))') FROM dummy;
```

The following returns the multi linestring in binary format.

```
SELECT NEW ST_MultiLineString('MultiLineString ZM((10 10 10 10, 12 12 12 10),
(14 10 12 13, 16 12 13 14))') FROM dummy;
```

The following returns `MultiLineString ((10 10, 12 12), (14 10, 16 12))` in binary format.

```
SELECT NEW ST_MultiLineString('MultiLineString ((10 10, 12 12), (14 10, 16
12))', 4326) FROM dummy;
```

3.5.1.3 ST_MultiLineString(LONG BINARY) Constructor

Constructs a multi linestring from Well Known Binary (WKB).

Syntax

```
NEW ST_MultiLineString(<wkb>)
```

Parameters

Table 60:

Name	Type	Description
wkb	LONG BINARY	A string containing the binary representation of a multi linestring in Well Known Binary (WKB) format.

Remarks

Constructs a multi linestring from a binary string representation.

Example

The following returns MultiLineString ((10 10, 12 12)).

```
SELECT NEW
ST_MultiLineString(x'01050000000100000001020000000200000000000000000002440000000000000244000000000000028400000000000002840') FROM dummy;
```

3.5.2 ST_IsClosed Method

Tests if the value is closed. A linestring is closed if the start and end points are coincident. A multilinestring is closed if it is non-empty and has an empty boundary.

Syntax

```
<multilinestring-expression>.ST_IsClosed()
```

Returns

BIT	Returns 1 if the multilinestring is closed, otherwise 0.

Example

The following returns the result `0` because the `LineString` has two points and therefore is not closed.

```
SELECT NEW ST_LineString('LineString(0 0, 1 0)').ST_IsClosed() FROM dummy;
```

The following returns the result `0` because the `LineString` has two points and therefore is not closed.

```
SELECT NEW ST_LineString('LineString(0 0, 1 0)', 4326).ST_IsClosed() FROM
dummy;
```

The following returns the result `1` because the `LineString` is closed.

```
SELECT NEW ST_LineString('LineString(0 0, 1 0, 1 1, 0 0)').ST_IsClosed() FROM
dummy;
```

The following returns the result `1` because the `LineString` is closed.

```
SELECT NEW ST_LineString('LineString(0 0, 1 0, 1 1, 0 0)', 4326).ST_IsClosed()
FROM dummy;
```

3.5.3 ST_Length Method

Returns the length measurement of all the linestrings in the multilinestring.

Syntax

```
<multilinestring-expression>.ST_Length(<unit_name>)
```

Parameters

Table 61:

Name	Type	Description
unit_name	VARCHAR(128)	The units in which the distance parameter should be interpreted. Defaults to the unit of the spatial reference system. The unit name must match the UNIT_NAME column of a row in the ST_UNITS_OF_MEASURE view where UNIT_TYPE is 'LINEAR'.

Returns

DOUBLE Returns the length measurement of the ST_LineString ST_MultiLineString value.

Remarks

The ST_Length method returns the length of a multilinestring. The length of a multilinestring is the sum of the lengths of the contained linestrings. If the multilinestring is empty, then NULL is returned.

If the multilinestring contains Z values, these are not considered when computing the length of the geometry.

> **Note**
>
> If the `<multilinestring-expression>` is an empty geometry (ST_IsEmpty()=1), then this method returns NULL.

Example

The following example creates a multilinestring with two elements and uses ST_Length to find the length of the geometry, returning the value the result 2.

```
SELECT NEW ST_MultiLineString('MultiLineString ((0 0, 1 0), (0 1, 1
1))').ST_Length() FROM dummy;
```

The following example creates a multilinestring with two elements and uses ST_Length to find the length of the geometry, returning the value the result 2.

```
SELECT NEW ST_MultiLineString('MultiLineString ((0 0, 1 0), (0 1, 1 1))',
4326).ST_Length() FROM dummy;
```

3.6 ST_MultiPoint Type

An ST_MultiPoint is a collection of zero or more ST_Point values, and all of the points are within the spatial reference system.

Direct supertype

ST_Geometry class

Constructor

ST_MultiPoint constructor

3.6.1 ST_MultiPoint Constructor

Constructs a multi-point.

Overload list

Table 62:

Name	Description
ST_MultiPoint()	Constructs a multi-point representing the empty set.
ST_MultiPoint(LONG VARCHAR)	Constructs a multi-point from a text representation.
ST_MultiPoint(LONG BINARY)	Constructs a multi-point from Well Known Binary (WKB).

3.6.1.1 ST_MultiPoint() Constructor

Constructs a multi-point representing the empty set.

Syntax

```
NEW ST_MultiPoint()
```

Example

The following returns 1, indicating the value is empty.

```
SELECT NEW ST_MultiPoint().ST_IsEmpty() FROM dummy;
```

3.6.1.2 ST_MultiPoint(LONG VARCHAR [,INT]) Constructor

Constructs a multi-point from a text representation.

Syntax

```
NEW ST_MultiPoint(<text-representation> [,INT <srid>])
```

Parameters

Table 63:

Name	Type	Description
text-representation	LONG VARCHAR	A string containing the text representation of a multi-point in Well Known Text (WKT) format.
srid	INT	The SRID of the result. If not specified and the input string does not contain a SRID, the default is 0.

Remarks

Constructs a multi-point from a character string representation.

Example

The following returns `MultiPoint ((10 10), (12 12), (14 10))` in binary format.

```
SELECT NEW ST_MultiPoint('MultiPoint ((10 10), (12 12), (14 10))') FROM dummy;
```

The following returns the multi-point in binary format.

```
SELECT NEW ST_MultiPoint('MultiPoint Z((10 10 12), (12 12 14), (14 10 10))')
FROM dummy;
```

The following returns the multi-point in binary format.

```
SELECT NEW ST_MultiPoint('MultiPoint ZM((10 10 12 1), (12 12 14 1), (14 10 10
1))') FROM dummy;
```

The following returns multi-point in binary format.

```
SELECT NEW ST_MultiPoint('MultiPoint ((10 10), (12 12), (14 10))', 4326) FROM
dummy;
```

3.6.1.3 ST_MultiPoint(LONG BINARY) Constructor

Constructs a multi-point from Well Known Binary (WKB).

Syntax

```
NEW ST_MultiPoint(<wkb>)
```

Parameters

Table 64:

Name	Type	Description
wkb	LONG BINARY	A string containing the binary representation of a multi-point in Well Known Binary (WKB) format.

Remarks

Constructs a multi-point from a binary string representation.

Example

The following returns MultiPoint ((10 10), (12 12), (14 10)).

```
SELECT NEW
ST_MultiPoint(x'0104000000030000000101000000000000000024400000000000002440010
100000000000000000028400000000000002840010100000000000000002c4000000000000024
40') FROM dummy;
```

3.7 ST_MultiPolygon Type

An ST_MultiPolygon is a collection of zero or more ST_Polygon values, and all of the polygons are within the same spatial reference system.

Direct supertype

ST_Geometry class

Constructor

ST_MultiPolygon constructor

Methods

- Methods of ST_MultiPolygon:

  Table 65:

ST_Area

- All methods of ST_Geometry can also be called on a ST_MultiPolygon type:

  Table 66:

ST_AsBinary	ST_AsGeoJSON	ST_AsText	ST_AsWKB
ST_AsWKT	ST_Contains	ST_ConvexHull	ST_Crosses
ST_Dimension	ST_Distance	ST_Envelope	ST_Equals
ST_GeomFromText	ST_GeometryType	ST_Intersection	ST_Intersects
ST_IntersectsRect	ST_Is3D	ST_IsEmpty	ST_IsValid
ST_OrderingEquals	ST_SRID	ST_SnapToGrid	ST_WithinDistance
ST_XMax	ST_XMin	ST_YMax	ST_YMin

3.7.1 ST_MultiPolygon Constructor

Constructs a multi polygon.

Overload list

Table 67:

Name	Description
ST_MultiPolygon()	Constructs a multi polygon representing the empty set.
ST_MultiPolygon(LONG VARCHAR)	Constructs a multi polygon from a text representation.
ST_MultiPolygon(LONG BINARY)	Constructs a multi polygon from Well Known Binary (WKB).

3.7.1.1 ST_MultiPolygon() Constructor

Constructs a multi polygon representing the empty set.

Syntax

```
NEW ST_MultiPolygon()
```

Example

The following returns 1, indicating the value is empty.

```
SELECT NEW ST_MultiPolygon().ST_IsEmpty() FROM dummy;
```

3.7.1.2 ST_MultiPolygon(LONG VARCHAR [,INT]) Constructor

Constructs a multi polygon from a text representation.

Syntax

```
NEW ST_MultiPolygon(<text-representation> [,INT <srid>])
```

Parameters

Table 68:

Name	Type	Description
text-representation	LONG VARCHAR	A string containing the text representation of a multi polygon in Well Known Text (WKT) format.
srid	INT	The SRID of the result. If not specified and the input string does not contain a SRID, the default is 0.

Remarks

Constructs a multi polygon from a character string representation.

Example

The following returns `MultiPolygon (((-5 -5, 5 -5, 0 5, -5 -5), (-2 -2, -2 0, 2 0, 2 -2, -2 -2)), ((10 -5, 15 5, 5 5, 10 -5)))` in binary format.

```
SELECT NEW ST_MultiPolygon('MultiPolygon (((-5 -5, 5 -5, 0 5, -5 -5), (-2 -2,
-2 0, 2 0, 2 -2, -2 -2)), ((10 -5, 15 5, 5 5, 10 -5)))') FROM dummy;
```

The following returns multipolygon in binary format.

```
SELECT NEW ST_MultiPolygon('MultiPolygon M(((-5 -5 3, 5 -5 3, 0 5 3, -5 -5 3),
(-2 -2 3, -2 0 3, 2 0 3, 2 -2 3, -2 -2 3)), ((10 -5 3, 15 5 3, 5 5 3, 10 -5
3)))') FROM dummy;
```

The following returns multipolygon in binary format.

```
SELECT NEW ST_MultiPolygon('MultiPolygon Z(((-5 -5 4, 5 -5 7, 0 5 1, -5 -5 4),
(-2 -2 9, -2 0 4, 2 0 4, 2 -2 1, -2 -2 9)), ((10 -5 2, 15 5 2, 5 5 3, 10 -5
2)))') FROM dummy;
```

The following returns multipolygon in binary format.

```
SELECT NEW ST_MultiPolygon('MultiPolygon ZM(((-5 -5 4 1, 5 -5 7 1, 0 5 1 1, -5
-5 4 1), (-2 -2 9 1, -2 0 4 1, 2 0 4 1, 2 -2 1 1, -2 -2 9 1)), ((10 -5 2 1, 15
5 2 1, 5 5 3 1, 10 -5 2 1)))') FROM dummy;
```

The following returns `MultiPolygon (((-5 -5, 5 -5, 0 5, -5 -5), (-2 -2, -2 0, 2 0, 2 -2, -2 -2)), ((10 -5, 15 5, 5 5, 10 -5)))`.

```
SELECT NEW ST_MultiPolygon('MultiPolygon (((-5 -5, 5 -5, 0 5, -5 -5), (-2 -2,
-2 0, 2 0, 2 -2, -2 -2)), ((10 -5, 15 5, 5 5, 10 -5)))', 4326) FROM dummy;
```

3.7.1.3 ST_MultiPolygon(LONG BINARY) Constructor

Constructs a multi polygon from Well Known Binary (WKB).

Syntax

```
NEW ST_MultiPolygon(<wkb>)
```

Parameters

Table 69:

Name	Type	Description
wkb	LONG BINARY	A string containing the binary representation of a multi polygon in Well Known Binary (WKB) format.

Remarks

Constructs a multi polygon from a binary string representation.

Example

The following returns MultiPolygon (((10 -5, 15 5, 5 5, 10 -5))).

```
SELECT NEW
ST_MultiPolygon(x'0106000000010000000103000000010000000400000000000000000024400
0000000000014c00000000000002e400000000000000144000000000000014400000000000001440
000000000000244000000000000014c0') FROM dummy;
```

3.7.2 ST_Area Method

Computes the area of the multipolygon.

Syntax

```
<multipolygon-expression>.ST_Area(<unit_name>)
```

Parameters

Table 70:

Name	Type	Description
unit_name	VARCHAR(128)	The units in which the distance parameter should be interpreted. Defaults to the unit of the spatial reference system. The unit name must match the UNIT_NAME column of a row in the ST_UNITS_OF_MEASURE view where UNIT_TYPE is 'LINEAR'.

Returns

DOUBLE	Returns the area of the multipolygon.

Remarks

Computes the area of the multipolygon. The area of the multipolygon is the sum of the areas of the contained polygons.

Example

The following returns the result `4`.

```
SELECT NEW ST_MultiPolygon( 'MultiPolygon((( 0 0, 2 0, 1 2, 0 0 )),((10 2, 11
0, 12 2, 10 2)))' )
.ST_Area() FROM dummy;
```

The following returns the result `4`.

```
SELECT NEW ST_MultiPolygon( 'MultiPolygon((( 0 0, 2 0, 1 2, 0 0 )),((10 2, 11
0, 12 2, 10 2)))', 1000004326).ST_Area() FROM dummy;
```

3.8 ST_Point Type

The ST_Point type is a 0-dimensional geometry and represents a single location.

Direct supertype

ST_Geometry class

Constructor

ST_Point constructor

Methods

- Methods of ST_Point:

  Table 71:

ST_M	ST_X	ST_Y	ST_Z

- All methods of ST_Geometry can also be called on a ST_Point type:

Table 72:

ST_AsBinary	ST_AsGeoJSON	ST_AsText	ST_AsWKB
ST_AsWKT	ST_Contains	ST_ConvexHull	ST_Crosses
ST_Dimension	ST_Distance	ST_Envelope	ST_Equals
ST_GeomFromText	ST_GeometryType	ST_Intersection	ST_Intersects
ST_IntersectsRect	ST_Is3D	ST_IsEmpty	ST_IsValid
ST_OrderingEquals	ST_SRID	ST_SnapToGrid	ST_WithinDistance
ST_XMax	ST_XMin	ST_YMax	ST_YMin

3.8.1 ST_Point Constructor

Constructs a point.

Overload list

Table 73:

Name	Description
ST_Point()	Constructs a point representing the empty set.
ST_Point(LONG VARCHAR)	Constructs a point from a text representation.
ST_Point(LONG BINARY)	Constructs a point from Well Known Binary (WKB).
ST_Point(DOUBLE,DOUBLE)	Constructs a 2D point from X,Y coordinates.

3.8.1.1 ST_Point() Constructor

Constructs a point representing the empty set.

Syntax

```
NEW ST_Point()
```

Example

The following returns 1, indicating the value is empty.

```
SELECT NEW ST_Point().ST_IsEmpty() FROM dummy;
```

3.8.1.2 ST_Point(LONG VARCHAR [,INT]) Constructor

Constructs a point from a text representation.

Syntax

```
NEW ST_Point(<wkt> [,INT <srid>])
```

Parameters

Table 74:

Name	Type	Description
<wkt>	LONG VARCHAR	A string containing the text representation of a point in Well Known Text (WKT) format which is composed of x/longitude and y/latitude.
srid	INT	The SRID of the result. If not specified and the input string does not contain a SRID, the default is 0.

Remarks

Constructs a point from a character string representation.

Example

The following returns `0101000000000000000000244000000000000034 40`.

```
SELECT NEW ST_Point('Point (10 20)') FROM dummy;
```

The following returns `01E9030000000000000002440000000000000344000000000000003E40`.

```
SELECT NEW ST_Point('Point Z(10 20 30)') FROM dummy;
```

The following returns `01D1070000000000000002440000000000000003E400000000000004440`.

```
SELECT NEW ST_Point('Point M(10 30 40)') FROM dummy;
```

The following returns `01B90B0000000000000002440000000000000344000000000000003E400000000000004940`.

```
SELECT NEW ST_Point('Point ZM(10 20 30 50)') FROM dummy;
```

The following returns `0101000000000000000000244000000000000003440`.

```
SELECT NEW ST_Point('Point (10 20)', 4326) FROM dummy;
```

3.8.1.3 ST_Point(LONG BINARY) Constructor

Constructs a point from Well Known Binary (WKB).

Syntax

```
NEW ST_Point(<wkb>)
```

Parameters

Table 75:

Name	Type	Description
wkb	LONG BINARY	A string containing the binary representation of a point in Well Known Binary (WKB) format.

Remarks

Constructs a point from a binary string representation.

Example

The following returns `0101000000000000000000244000000000000003440`.

```
SELECT NEW ST_Point(x'0101000000000000000000244000000000000003440') FROM dummy;
```

3.8.1.4 ST_Point(DOUBLE,DOUBLE) Constructor

Constructs a 2D point from X,Y coordinates.

Syntax

```
NEW ST_Point(<x>,<y>)
```

Parameters

Table 76:

Name	Type	Description
<x>	DOUBLE	The x/longitude coordinate value.
<y>	DOUBLE	The y/latitude coordinate value.

Example

The following returns the result `0101000000000000000000244000000000000003440`.

```
SELECT NEW ST_Point(10.0,20.0) FROM dummy;
```

3.8.2 ST_M Method

Returns the measure value of the ST_POINT value.

Syntax

```
<point-expression>.ST_M()
```

Returns

DOUBLE	Returns the measure value of the ST_Point value.

Example

Example

The following example returns `70`.

```
SELECT NEW ST_Point('Point M(10 40 70)').ST_M() FROM dummy;
```

3.8.3 ST_X Method

Returns the X coordinate of the ST_Point value.

Note

If the `<point-expression>` is an empty geometry (ST_IsEmpty()=1), then this method returns NULL.

Syntax

```
<point-expression>.ST_X()
```

Returns

DOUBLE	Returns the X coordinate of the ST_Point value.

Example

The following example returns the result `1`.

```
SELECT NEW ST_Point( 'Point (1 2)').ST_X() FROM dummy;
```

3.8.4 ST_Y Method

Returns the Y coordinate of the ST_Point value.

Note

If the `<point-expression>` is an empty geometry (ST_IsEmpty()=1), then this method returns NULL.

Syntax

```
<point-expression>.ST_Y()
```

Returns

DOUBLE	Returns the Y coordinate of the ST_Point value.

Example

The following example returns the result `2`.

```
SELECT NEW ST_Point( 'Point (1 2)').ST_Y() FROM dummy;
```

3.8.5 ST_Z Method

Returns the Z coordinate of the ST_Point value.

> **Note**
>
> If the `<point-expression>` is an empty geometry `(ST_IsEmpty()=1)`, then this method returns NULL.

Syntax

```
<point-expression>.ST_Z()
```

Returns

DOUBLE	Returns the Z coordinate of the ST_Point value.

> **Example**
>
> **Example**
>
> The following example returns the result `3`.
>
> ```
> SELECT NEW ST_Point( 'Point Z(1 2 3)').ST_Z() FROM dummy;
> ```

3.9 ST_Polygon Type

An ST_Polygon defines an area of space using an exterior ring and one or more interior rings, all defined using ST_LineString.

Direct supertype

ST_Geometry class

Constructor

ST_Polygon constructor

Methods

- Methods of ST_Polygon:

  Table 77:

ST_Area	ST_Centroid	ST_ExteriorRing	ST_InteriorRingN

- All methods of ST_Geometry can also be called on a ST_Polygon type:

  Table 78:

ST_AsBinary	ST_AsGeoJSON	ST_AsText	ST_AsWKB
ST_AsWKT	ST_Contains	ST_ConvexHull	ST_Crosses
ST_Dimension	ST_Distance	ST_Envelope	ST_Equals
ST_GeomFromText	ST_GeometryType	ST_Intersection	ST_Intersects
ST_IntersectsRect	ST_Is3D	ST_IsEmpty	ST_IsValid
ST_OrderingEquals	ST_SRID	ST_SnapToGrid	ST_WithinDistance
ST_XMax	ST_XMin	ST_YMax	ST_YMin

3.9.1 ST_Polygon Constructor

Constructs a polygon.

Overload list

Table 79:

Name	Description
ST_Polygon()	Constructs a polygon representing the empty set.
ST_Polygon(LONG VARCHAR)	Constructs a polygon from a text representation.
ST_Polygon(LONG BINARY)	Constructs a polygon from Well Known Binary (WKB).

3.9.1.1 ST_Polygon() Constructor

Constructs a polygon representing the empty set.

Syntax

```
NEW ST_Polygon()
```

Example

The following returns 1, indicating the value is empty.

```
SELECT NEW ST_Polygon().ST_IsEmpty() FROM dummy;
```

3.9.1.2 ST_Polygon(LONG VARCHAR [,INT]) Constructor

Constructs a polygon from a text representation.

Syntax

```
NEW ST_Polygon(<text-representation> [,INT <srid>])
```

Parameters

Table 80:

Name	Type	Description
text-representation	LONG VARCHAR	A string containing the text representation of a polygon in Well Known Text (WKT) format.
srid	INT	The SRID of the result. If not specified and the input string does not contain a SRID, the default is 0.

Remarks

Constructs a polygon from a character string representation.

Example

The following returns `Polygon ((-5 -5, 5 -5, 0 5, -5 -5), (-2 -2, -2 0, 2 0, 2 -2, -2 -2))` in binary format.

```
SELECT NEW ST_Polygon('Polygon ((-5 -5, 5 -5, 0 5, -5 -5), (-2 -2, -2 0, 2 0,
2 -2, -2 -2))') FROM dummy;
```

The following returns the polygon in binary format.

```
SELECT NEW ST_Polygon('Polygon Z((-5 -5 6, 5 -5 6, 0 5 6, -5 -5 6), (-2 -2 1,
-2 0 1, 2 0 1, 2 -2 1, -2 -2 1))') FROM dummy;
```

The following returns the polygon in binary format.

```
SELECT NEW ST_Polygon('Polygon M((-5 -5 6, 5 -5 6, 0 5 6, -5 -5 6), (-2 -2 1,
-2 0 1, 2 0 1, 2 -2 1, -2 -2 1))') FROM dummy;
```

The following returns the polygon in binary format.

```
SELECT NEW ST_Polygon('Polygon ZM((-5 -5 6 4, 5 -5 6 4, 0 5 6 4, -5 -5 6 4),
(-2 -2 1 4, -2 0 1 4, 2 0 1 4, 2 -2 1 4, -2 -2 1 4))') FROM dummy;
```

The following returns the polygon in binary format.

```
SELECT NEW ST_Polygon('Polygon ((-5 -5, 5 -5, 0 5, -5 -5), (-2 -2, -2 0, 2 0,
2 -2, -2 -2))', 4326) FROM dummy;
```

The following returns the polygon in binary format.

```
SELECT NEW ST_Polygon('Polygon ((-5 -5, 5 -5, 0 5, -5 -5), (-2 -2, -2 0, 2 0,
2 -2, -2 -2))', 1000004326) FROM dummy;
```

3.9.1.3 ST_Polygon(LONG BINARY) Constructor

Constructs a polygon from Well Known Binary (WKB).

Syntax

```
NEW ST_Polygon(<wkb>)
```

Parameters

Table 81:

Name	Type	Description
wkb	LONG BINARY	A string containing the binary representation of a polygon in Well Known Binary (WKB) format.

Remarks

Constructs a polygon from a binary string representation.

Example

The following returns Polygon ((10 -5, 15 5, 5 5, 10 -5)).

```
SELECT NEW
ST_Polygon(x'0103000000010000000400000000000000000024400000000000000014c000000000
00002e4000000000000001440000000000000014400000000000000144000000000000002440000000
0000014c0') FROM dummy;
```

3.9.2 ST_Area Method

Calculates the area of a polygon.

Syntax

```
<polygon-expression>.ST_Area(<unit_name>)
```

Parameters

Table 82:

Name	Type	Description
unit_name	VARCHAR(128)	The units in which the distance parameter should be interpreted. Defaults to the unit of the spatial reference system. The unit name must match the UNIT_NAME column of a row in the ST_UNITS_OF_MEASURE view where UNIT_TYPE is 'LINEAR'.

Returns

DOUBLE	Returns the area of the polygon.

Remarks

The ST_Area method computes the area of a polygon.

Example

The following returns the result `1` as the area of the unit square.

```
SELECT NEW ST_Polygon('Polygon((0 0, 1 0, 1 1, 0 1, 0 0))').ST_Area() FROM
dummy;
```

The following returns the result `1` as the area of the unit square.

```
SELECT NEW ST_Polygon('Polygon((0 0, 1 0, 1 1, 0 1, 0 0))',
1000004326).ST_Area() FROM dummy;
```

3.9.3 ST_Centroid Method

Returns the ST_Point value that is the mathematical centroid of the polygon value.

Syntax

```
<polygon-expression>.ST_Centroid()
```

Returns

ST_Point If the polygon is the empty set, returns NULL. Otherwise, returns the mathematical centroid of the polygon.

The spatial reference system identifier of the result is the same as the spatial reference system of the `<polygon-expression>`.

Remarks

Returns the ST_Point value that is the mathematical centroid of the polygon value. This point will not necessarily be a point on the polygon.

Example

The following returns the result `0101000000000000000000001440ABAAAAAAAAAA1240`.

```
SELECT NEW ST_Polygon('Polygon ((3 3, 8 3, 4 8, 3 3))').ST_Centroid() FROM
dummy;
```

The following returns the result `0101000000000000000000001440ABAAAAAAAAAA1240`.

```
SELECT NEW ST_Polygon('Polygon ((3 3, 8 3, 4 8, 3 3))',
1000004326).ST_Centroid() FROM dummy;
```

3.9.4 ST_ExteriorRing Method

Returns the exterior ring of the polygon.

Syntax

```
<polygon-expression>.ST_ExteriorRing()
```

Returns

ST_LineString	Returns a line string representing the exterior ring of the `POLYGON` geometry.

Example

The following example returns the polygon with the specified external ring.

```
SELECT NEW ST_Polygon('Polygon ((0 0, 3 0, 3 3, 0 3, 0 0), (1 1, 2 1, 2 2, 1
1))').ST_ExteriorRing() FROM dummy;
```

3.9.5 ST_InteriorRingN Method

Returns the nth interior ring in the polygon.

Syntax

```
<polygon-expression>.ST_InteriorRingN(<n>)
```

Parameters

Table 83:

Name	Type	Description
n	INT	The position of the element to return, from 1 to `polygonexpression.ST_NumInteriorRing()`.

Returns

ST_LineString	Returns the nth interior ring in the polygon.

Example

The following example returns the inner ring as `LINESTRING (1 1,2 2,2 1,1 1)`.

```
SELECT NEW ST_Polygon('Polygon ((0 0, 3 0, 3 3, 0 3, 0 0), (1 1, 2 1, 2 2, 1
1))').ST_InteriorRingN( 1 ).ST_AsText() FROM dummy;
```

3.10 List of All Supported Methods

The following is a list of all supported spatial methods.

Table 84:

Method	Type	Description
ST_Area	ST_MultiPolygon	Computes the area of the multipolygon.
ST_Area	ST_Polygon	Calculates the area of a polygon.
ST_AsBinary	ST_Geometry	Returns the WKB representation of an ST_Geometry value.
ST_AsEWKB	ST_Geometry	Returns the extended WKB representation of an ST_Geometry value.
ST_AsEWKT	ST_Geometry	Returns the extended WKT representation of an ST_Geometry value.

Method	Type	Description
ST_AsGeoJSON	ST_Geometry	Returns a string representing a geometry in JSON format.
ST_AsSVG	ST_Geometry	Returns an SVG figure representing a geometry value.
ST_AsSVGAggr	ST_Geometry	Returns a complete or partial SVG document which renders the geometries in a group.
ST_AsText	ST_Geometry	Returns the text representation of an ST_Geometry value.
ST_AsWKB	ST_Geometry	Returns the WKB representation of an ST_Geometry value.
ST_AsWKT	ST_Geometry	Returns the WKT representation of an ST_Geometry value.
ST_Boundary	ST_Geometry	Returns the boundary of the geometry value.
ST_Buffer	ST_Geometry	Returns the ST_Geometry value that represents all points whose distance from any point of an ST_Geometry value is less than or equal to a specified distance in the given units.
ST_Centroid	ST_Polygon	Returns the ST_Point value that is the mathematical centroid of the polygon value.
ST_Contains	ST_Geometry	Tests if a geometry value spatially contains another geometry value.
ST_CoveredBy	ST_Geometry	Tests if a geometry value is spatially covered by another geometry value.
ST_Covers	ST_Geometry	Tests if a geometry value spatially covers another geometry value.
ST_ConvexHull	ST_Geometry	Returns the convex hull of the geometry value.
ST_Crosses	ST_Geometry	Tests if a geometry value crosses another geometry value.
ST_Difference	ST_Geometry	Returns the geometry value that represents the point set difference of two geometries.

Method	Type	Description
ST_Dimension	ST_Geometry	Returns the dimension of the ST_Geometry value. Points have dimension 0, lines have dimension 1, and polygons have dimension 2. Any empty geometry has dimension -1.
ST_Disjoint	ST_Geometry	Test if a geometry value is spatially disjoint from another value.
ST_Distance	ST_Geometry	Returns the smallest distance between the `<geometry-expression>` and the specified geometry value.
ST_EndPoint	ST_LineString	Returns an ST_Point value that is the end point.
ST_Envelope	ST_Geometry	Returns the bounding rectangle for the geometry value.
ST_Equals	ST_Geometry	Tests if an ST_Geometry value is spatially equal to another ST_Geometry value.
ST_ExteriorRing	ST_Geometry	Returns the exterior ring of the polygon.
ST_GeomFromEWKB	ST_Geometry	Constructs a geometry from a string representation.
ST_GeomFromEWKT	ST_Geometry	Constructs a geometry from a string representation.
ST_GeomFromText	ST_Geometry	Constructs a geometry from a character string representation.
ST_GeomFromWKB	ST_Geometry	Constructs a geometry from a string representation.
ST_GeomFromWKT	ST_Geometry	Constructs a geometry from a string representation.
ST_GeometryN	ST_GeometryCollection	Returns the nth geometry in the geometry collection.
ST_GeometryType	ST_Geometry	Returns the name of the type of the ST_Geometry value.
ST_InteriorRingN	ST_Geometry	Returns the nth interior ring in the polygon.

Method	Type	Description
ST_Intersection	ST_Geometry	Returns the geometry value that represents the point set intersection of two geometries.
ST_Intersects	ST_Geometry	Test if a geometry value spatially intersects another value.
ST_IntersectsFilter	ST_Geometry	An inexpensive test if the two geometries might intersect.
ST_IntersectsRect	ST_Geometry	Test if a geometry intersects a rectangle.
ST_Is3D	ST_Geometry	Determines if the geometry value has Z coordinate values.
ST_IsClosed	ST_LineString	Test if the linestring is closed. A linestring is closed if the start and end points are coincident.
ST_IsClosed	ST_MultiLineString	Tests if the value is closed. A linestring is closed if the start and end points are coincident. A multilinestring is closed if it is non-empty and has an empty boundary.
ST_IsEmpty	ST_Geometry	Determines whether the geometry value represents an empty set.
ST_IsMeasured	ST_Geometry	Determines if the geometry value has associated measure values.
ST_IsRing	ST_LineString	Tests if the linestring is a ring. A linestring is a ring if it is closed and simple (no self intersections).
ST_IsSimple	ST_Geometry	Determines whether the geometry value is simple (containing no self intersections or other irregularities).
ST_IsValid	ST_Geometry	Determines whether the geometry is a valid spatial object.
ST_Length	ST_LineString	Retrieves the length measurement.
ST_Length	ST_MultiLineString	Returns the length measurement of all the linestrings in the multilinestring.
ST_M	ST_Point	Retrieves or modifies the M coordinate value of a point.

Method	Type	Description
ST_MMax	ST_Geometry	Retrieves the maximum M coordinate value of a geometry.
ST_MMin	ST_Geometry	Retrieves the minimum M coordinate value of a geometry.
ST_NumGeometries	ST_GeometryCollection	Returns the number of geometries contained in the geometry collection.
ST_NumInteriorRing	ST_Geometry	Returns the number of interior rings in the polygon.
ST_NumInteriorRings	ST_Geometry	Returns the number of interior rings in the polygon.
ST_NumPoints	ST_LineString	Returns the number of points defining the linestring.
ST_OrderingEquals	ST_Geometry	Tests if a geometry is identical to another geometry.
ST_Overlaps	ST_Geometry	Tests if a geometry value overlaps another geometry value.
ST_PointN	ST_LineString	Returns the <n>th point in the linestring.
ST_Relate	ST_Geometry	Tests if a geometry value is spatially related to another geometry value as specified by the intersection matrix.
ST_SRID	ST_Geometry	Retrieves or modifies the spatial reference system associated with the geometry value.
ST_SnapToGrid	ST_Geometry	Returns a copy of the geometry with all points snapped to the specified grid.
ST_SymDifference	ST_Geometry	Returns the geometry value that represents the point set symmetric difference of two geometries.
ST_Touches	ST_Geometry	Tests if a geometry value spatially touches another geometry value.
ST_Transform	ST_Geometry	Creates a copy of the geometry value transformed into the specified spatial reference system.
ST_UnionAggr	ST_Geometry	Returns the spatial union of all of the geometries in a group.

Method	Type	Description
ST_StartPoint	ST_LineString	Returns an ST_Point value that is the starting point.
ST_WithinDistance	ST_Geometry	Test if two geometries are within a specified distance of each other.
ST_Within	ST_Geometry	Tests if a geometry value is spatially contained within another geometry value.
ST_X	ST_Point	Retrieves or modifies the X coordinate value of a point.
ST_XMax	ST_Geometry	Retrieves the maximum X coordinate value of a geometry.
ST_XMin	ST_Geometry	Retrieves the minimum X coordinate value of a geometry.
ST_Y	ST_Point	Retrieves or modifies the Y coordinate value of a point.
ST_YMax	ST_Geometry	Retrieves the maximum Y coordinate value of a geometry.
ST_YMin	ST_Geometry	Retrieves the minimum Y coordinate value of a geometry.
ST_Z	ST_Point	Retrieves or modifies the Z coordinate value of a point.
ST_ZMax	ST_Geometry	Retrieves the maximum Z coordinate value of a geometry.
ST_ZMin	ST_Geometry	Retrieves the minimum Z coordinate value of a geometry.

3.11 List of All Supported Constructors

The following is a list of all supported spatial constructors.

Table 85:

Constructor	Description
ST_CircularString	Constructs a circularstring.

Constructor	Description
ST_GeometryCollection	Constructs a geometry collection.
ST_LineString	Constructs a linestring.
ST_MultiLineString	Constructs a multi linestring.
ST_MultiPoint	Constructs a multi point.
ST_MultiPolygon	Constructs a multi polygon.
ST_Point	Constructs a point.
ST_Polygon	Constructs a polygon.

3.12 List of Set Operation Methods

The following is a list of set operation methods available for use with spatial data.

Table 86:

Method	Type	Description
ST_Difference	ST_Geometry	Returns the geometry value that represents the point set difference of two geometries.
ST_Intersection	ST_Geometry	Returns the geometry value that represents the point set intersection of two geometries.
ST_SymDifference	ST_Geometry	Returns the geometry value that represents the point set symmetric difference of two geometries.

3.13 List of Spatial Predicates

The following is a list of predicate methods available for use with spatial data.

Table 87:

Method	Type	Description
ST_Contains	ST_Geometry	Tests if a geometry value spatially contains another geometry value.

Method	Type	Description
ST_CoveredBy	ST_Geometry	Tests if a geometry value is spatially covered by another geometry value.
ST_Covers	ST_Geometry	Tests if a geometry value spatially covers another geometry value.
ST_Crosses	ST_Geometry	Tests if a geometry value crosses another geometry value.
ST_Disjoint	ST_Geometry	Test if a geometry value is spatially disjoint from another value.
ST_Equals	ST_Geometry	Tests if an ST_Geometry value is spatially equal to another ST_Geometry value.
ST_Intersects	ST_Geometry	Test if a geometry value spatially intersects another value.
ST_IntersectsRect	ST_Geometry	Test if a geometry intersects a rectangle.
ST_OrderingEquals	ST_Geometry	Tests if a geometry is identical to another geometry.
ST_Overlaps	ST_Geometry	Tests if a geometry value overlaps another geometry value.
ST_Relate	ST_Geometry	Tests if a geometry value is spatially related to another geometry value as specified by the intersection matrix. The ST_Relate method uses a 9-character string from the Dimensionally Extended 9 Intersection Model (DE-9IM) to describe the pair-wise relationship between two spatial data items. For example, the ST_Relate method determines if an intersection occurs between the geometries, and the geometry of the resulting intersection, if it exists.
ST_Touches	ST_Geometry	Tests if a geometry value spatially touches another geometry value.
ST_Within	ST_Geometry	Tests if a geometry value is spatially contained within another geometry value.

4 Spatial Clustering

SAP HANA spatial provides spatial clustering using the algorithms grid, k-means, and DBSCAN. Spatial clustering can be performed on a set of geospatial points (referred to hereafter as the original data set) in the SAP HANA system.

4.1 Introduction to Spatial Clustering

Spatial clustering groups a set of points with regard to certain criteria into clusters. A cluster is a partition of the original point set.

> **Note**
>
> Spatial clustering for SAP HANA spatial is available for two-dimensional points in flat-earth spatial reference systems (for example WGS 84 (planar) - SRID 1000004326).

The grouping criteria depend on the clustering algorithm that is applied on the points and on the parameterization of the cluster algorithm. SAP spatial provides the following algorithms:

- Grid
- K-means
- DBSCAN

Clustering provides many insights into the data set. Most of the time operators are interested in the following:

- Association of each data point to a cluster (identified by a cluster ID)
- Characteristics of each cluster, for example:
  - Centroid
  - Envelope
- Aggregates on data associated with the points located in a cluster:
  - Number of points
  - Average measurement (average household income level for example)
  - Aggregation functions (ST_ConvexHullAggr, ST_EnvelopeAggr, ST_Intersection_Aggr)

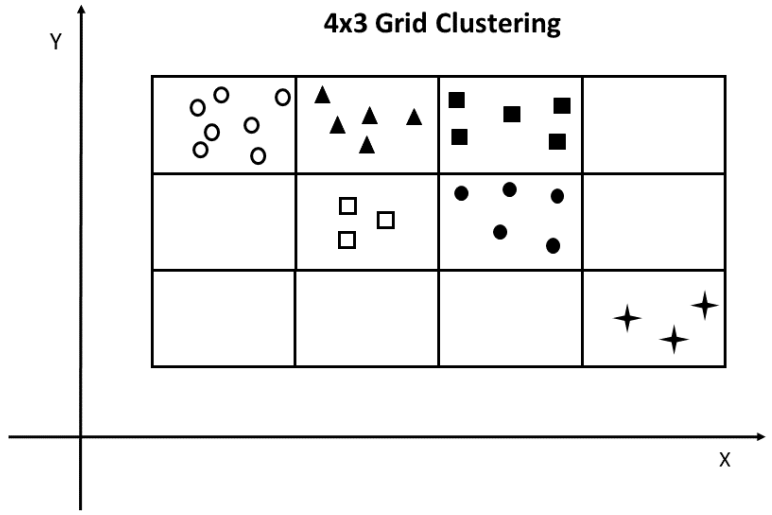
4.2 Cluster Algorithms

SAP HANA spatial supports several cluster algorithms.

4.2.1 Grid

SAP HANA spatial supports a grid-based aggregation. The following methods are available for the grid algorithm: ST_ClusterID(), ST_ClusterEnvelope().

Grid clustering provides a quick and easy way to use clustering. It is useful for providing a first impression. For deeper analysis, you can use the other algorithms.



The mapping for the grid clustering is defined with respect to the grid. A grid is a rectangle that can be further divided into a set of inner rectangles (cells). Rather than intersecting the grid, these cells tessellate it. Every cell has a unique cluster identifier. You can specify the number of grid cells in the X and Y direction. You can also specify the location of the grid.

SAP HANA spatial grid clustering uses the following parameters:

- **X CELLS <int> Y CELLS <int>** (mandatory)
  The number of cells is X times Y
  The number of clusters can be less than X times Y, because cells without points do not count as clusters.
  For X = 10 and Y = 10, the situation could be:
  - 100 = number of cells
  - 81 = number of clusters (19 cells do not contain points)

  The boundary of the overall grid rectangle is determined by the points to be investigated.
- **BETWEEN <left-point> AND <right-point>** (optional, X values)

Determines the X values of the overall grid rectangle regardless of the points to be investigated

- **BETWEEN <lower-point> AND <upper-point>** (optional, Y values)
  Determines the Y values of the overall grid rectangle regardless of the points to be investigated

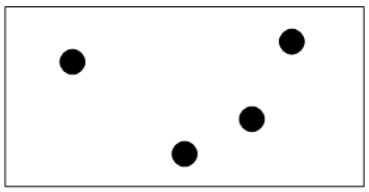
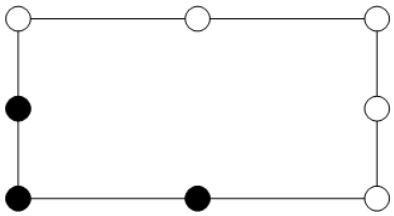
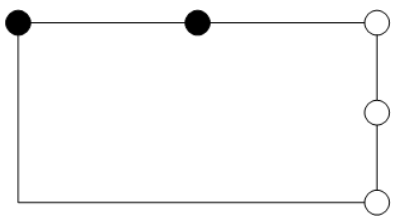
The following combinations of the mandatory and optional parameters are possible:

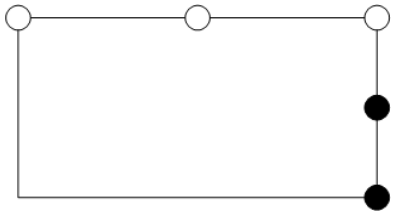
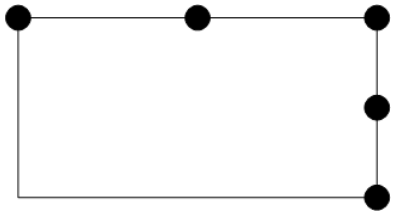
- **X CELLS <int> Y CELLS <int>**
  (example: *X CELLS 50 Y CELLS 50*)
- **X BETWEEN <left-point> AND <right-point> CELLS <int> Y CELLS <int>**
  (example: *X BETWEEN 0 AND 100 CELLS 50 Y CELLS 50*)
- **X CELLS <int> Y BETWEEN <lower-point> AND <upper-point> CELLS <int>**
  (example: *X CELLS 50 Y BETWEEN 0 AND 200 CELLS 50*)
- **X BETWEEN <left-point> AND <right-point> CELLS <int> Y BETWEEN <lower-point> AND <upper-point> CELLS <int>**
  (example: *X BETWEEN 0 AND 100 CELLS 50 Y BETWEEN 0 AND 200 CELLS 50*)

Assignment rules for cluster points

Points which are inside a cell and not at a boundary are assigned to this cell. The assignment of points on the boundary need to be defined. The assignment of points is made according to the following rules (points with black fill belong to cell; points with white fill do not belong to the cell):

Table 88:

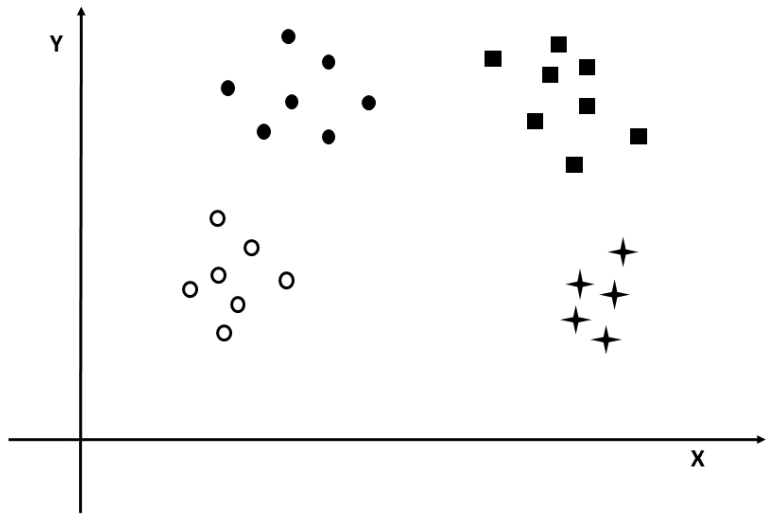
Position	Rule	Graphic
Points inside a cell	All points inside a cell belong to the cell.	
Boundary points of any cell	All points on the left boundary of the cell except the point with the highest Y value belong to the cell. The point with the highest Y value belongs to the neighbor above. All points on the lower boundary of the cell except the point with the highest X value belong to the cell. The point with the highest X value belongs to the neighbor to the right.	
Boundary points of all cells of the upper boundary of the overall grid rectangle (no neighbor above) except the upper right cell (see last rule)	All points on the upper boundary except the point with the highest X value belong to the cell.	

Position	Rule	Graphic
Boundary points of all cells of the right-hand boundary of the overall grid rectangle (no neighbor to the right) except the upper right cell (see last rule)	All points on the right-hand boundary of a cell belong to the cell, except the one with the highest Y value.	
Boundary points of the upper right cell (no neighbor above and no neighbor to the right)	All boundary points belong to the cell.	

4.2.2 K-Means

SAP HANA spatial supports k-means clustering. The following methods are available for the k-means algorithm: ST_ClusterID(), ST_ClusterCentroid().

K-means is a clustering algorithm. It is best suited for spherical clusters. K-means is centroid based. The higher complexity of the algorithm provides better insights.



K-means tries to find an assignment of points to clusters, so that the sum of squared distances of the points to the center of the cluster they belong to is minimal. The initialization is performed randomly. RANDOM

PARTITION starts by assigning every point to one of the random k clusters. FORGY starts with the random choice of k cluster centers.

The iterations now start. They try to find a better solution according to the sum of the squared distances. The iterations stops when MAXITERATIONS is reached, or the change of the sum of squared distances between two iterations is below the THRESHOLD.

Note

K-means is not deterministic. k-means might therefore produce different results with the same parameters on the same data set.

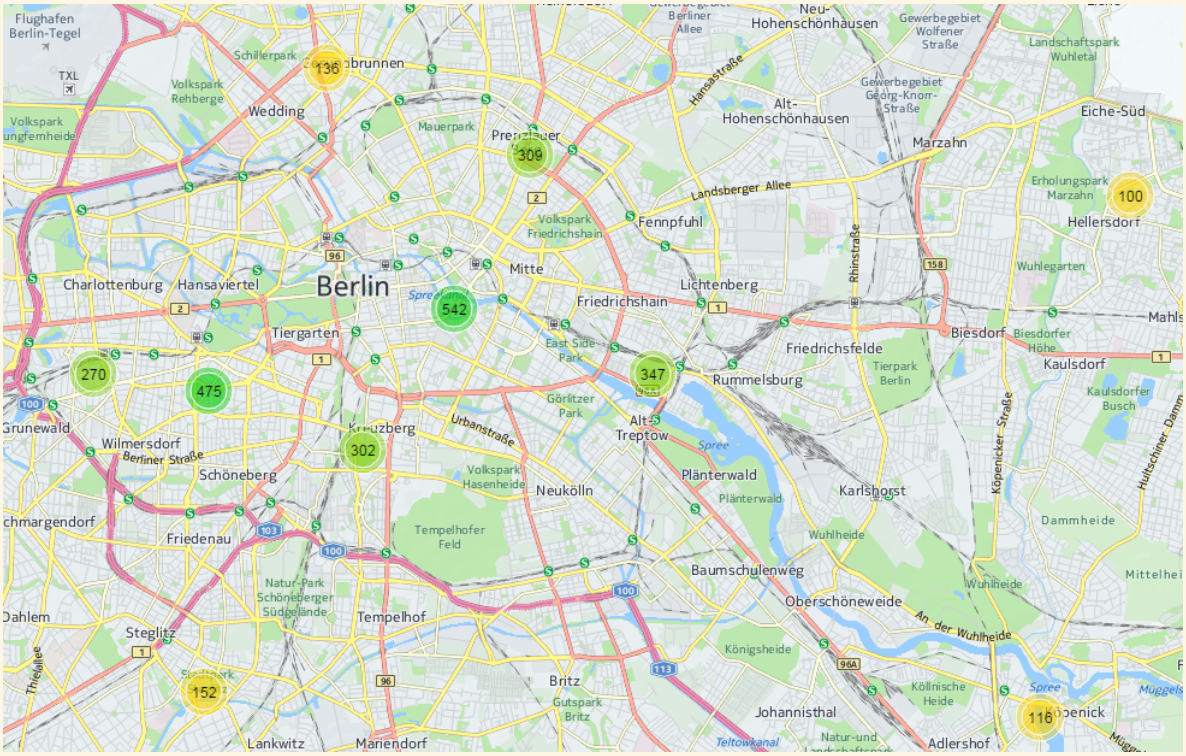
In SAP HANA spatial k-means uses the following parameters:

- **CLUSTERS <int>** (mandatory)
  Number of clusters to be created
- **MAXITERATIONS <int>** (optional, default 128)
  Maximum number of iterations to be performed
- **THRESHOLD <int>** (optional, default 0)
  Threshold for the change of the sum of the squared distances between two iterations
- **INIT RANDOM PARTITION** or **INIT FORGY** (optional, default FORGY)
  Initialization method; FORGY is the recommended method

For more information about k-means, see k-means clustering

Example

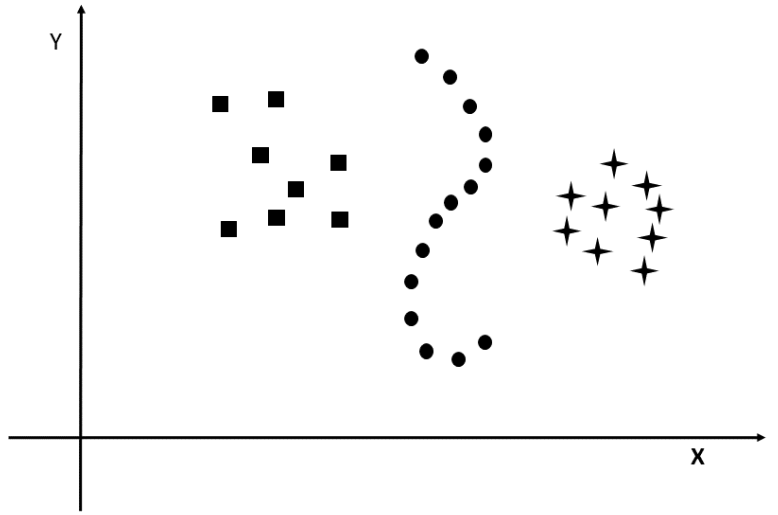
The following example shows clusters of restaurants in Berlin:



4.2.3 DBSCAN

SAP HANA spatial supports DBSCAN clustering. The following method is available for the DBSCAN algorithm: ST_ClusterID().

Density-based spatial clustering of applications with noise (DBSCAN) is a data clustering algorithm. DBSCAN is best suited for non-spherical clusters. The higher complexity of the algorithm provides better insights.



The set of points with a distance of less than or equal to EPS are called the **neighborhood** of this point. There are the following classes of points:

- If a data point has at least MINPTS data points in its neighborhood, including itself, it is called a **core point**.
- If a data point is within the neighborhood of a core point, but not a core point itself, it is called a **border point**.
- All other points, i.e. points that are not within the neighborhood of a core point, are called **outliers** or **noise**.

The points are grouped into clusters according to these rules:

- Two core points x and y belong to the same cluster if - and only if - there is a sequence of core points x = x_1, x_2, ..., x_n = y, such that the distance of x_(n-1) and x_n is less than or equal to EPS; i.e. every point is in the neighborhood of its successor and predecessor.
- Border points are assigned to the same cluster that a core point in their neighborhood is assigned to. Note that this might not be uniquely defined; there might be more than one core point in the border points neighborhood.
- Outliers are assigned to the outlier cluster with ST_ClusterID 0.

In SAP HANA, spatial DBSCAN uses the following parameters:

- **EPS <int>** (mandatory)
  Neighborhood radius
- **MINPTS <int>** (mandatory)

The number of data points that must be contained in the neighborhood of a point in order to make it a core point

For more information about DBSCAN, see DBSCAN

4.3 SQL Syntax for Spatial Clustering

For spatial clustering, special clauses are provided in a SELECT statement.

4.3.1 Window Functions

Clustering functions are supported as SQL window functions.

Syntax

```
<spatial_window_function> ::= <spatial_window_func_type>
OVER ( <window_cluster_by_clause> [<window_order_by_clause>] )
```

The spatial window function clause is part of the select clause of a subquery. Example:

```
SELECT <spatial_window_function> <from_clause> ...
```

The spatial window function clause consists of:

- Spatial window function type
- Window cluster by clause
- Window order by clause

Spatial window function type

```
<spatial_window_func_type> ::= <window_func>            |
                               <aggregate_func>         |
                               <cluster_metadata_func>
```

There are the following spatial window function types:

- Window functions
- Aggregate functions
- Cluster metadata functions

```
<window_func> ::= all existing window_function_types
```

```
                (for example ROW_NUMBER, RANK, FIRST_VALUE, NTH_VALUE, …)
```

For a complete list of supported window functions, see *Window Functions* in *SAP HANA SQL and System Views Reference*.

```
<aggregate_func> ::= COUNT(*) | <agg_name> ( <expression> )
<agg_name> ::= COUNT | MIN | MAX | SUM | AVG | STDDEV | VAR
```

The spatial aggregation functions are also supported (for example ST_AsSVGAggr). For information about the spatial aggregation functions, see the *SAP HANA Spatial Reference*.

```
<cluster_metadata_func> ::= ST_ClusterId() |
                            ST_ClusterCentroid() |
                            ST_ClusterEnvelope()
```

Window cluster by clause

```
<cluster_by_clause> ::= GROUP CLUSTER BY <spatial_column_name>
                    USING <cluster_algorithm>
```

The <spatial_column_name> is a table column of type ST_POINT, or of type ST_GEOMETRY containing only points.

```
<cluster_algorithm> ::= <dbscan> | <grid> | <kmeans>
<dbscan> ::= DBSCAN
             EPS <double>
             MINPTS <integer>
<grid>   ::= GRID
             X [BETWEEN <left-point> AND <right-point>] CELLS <integer>
             Y [BETWEEN <lower-point> AND <upper-point>] CELLS <integer>
<kmeans> ::= KMEANS
             CLUSTERS <integer>
             [MAXITERATIONS <integer>]
             [THRESHOLD <integer>]
             [INIT RANDOM PARTITION | INIT FORGY]
```

Window order by clause

```
<window_order_by_clause> ::= ORDER BY {<window_order_by_expression>}
```

```
<window_order_by_expression> ::= <expression> [ASC | DESC]
                                 [NULLS FIRST | NULLS LAST]
                                 [, <window_order_by_expression>]
```

4.3.2 GROUP CLUSTER BY

Clustering functions are supported as a GROUP CLUSTER BY clause.

Syntax

```
<subquery> ::= <select_clause>
               <from_clause>
               [<where_clause>]
               [<group_by_clause> | <cluster_by_clause>]
               [<having_clause>]
               [<set_operator> <subquery> [{, <set_operator> <subquery>}...]]
               [<order_by_clause>]
               [<limit>]
```

For spatial clustering, the CLUSTER BY clause has been added.

For more information, see *Select* in the *SAP HANA SQL and System Views Reference*.

SELECT clause

In the select clause, you can use the methods for spatial clustering (ST_ClusterID(), ST_ClusterCentroid(), ST_ClusterEnvelope()) that can be used to investigate the data provided by the cluster algorithms.

Cluster by clause

```
<cluster_by_clause> ::= GROUP CLUSTER BY <spatial_column_name>
                        USING <cluster_algorithm>
```

The <spatial_column_name> is a table column of type ST_POINT, or of type ST_GEOMETRY containing only points.

Cluster algorithm

```
<cluster_algorithm> ::= <dbscan> | <grid> | <kmeans>
<dbscan> ::= DBSCAN
             EPS <double>
             MINPTS <integer>
<grid>   ::= GRID
             X [BETWEEN <left-point> AND <right-point>] CELLS <integer>
             Y [BETWEEN <lower-point> AND <upper-point>] CELLS <integer>
<kmeans> ::= KMEANS
             CLUSTERS <integer>
             [MAXITERATIONS <integer>]
```

```
              [THRESHOLD <integer>]
              [INIT RANDOM PARTITION | INIT FORGY]
```

SAP HANA spatial provides spatial clustering using the algorithms grid, k-means, and DBSCAN.

4.4 Methods for Spatial Clustering

SAP HANA spatial provides methods to perform spatial clustering.

The following methods are provided:

- ST_ClusterID() - cluster algorithms Grid, K-Means, DBSCAN
- ST_ClusterCentroid() - cluster algorithm K-Means
- ST_ClusterEnvelope() - cluster algorithm Grid

4.4.1 ST_ClusterID Method

Returns the cluster ID of a given point. This method works for all cluster algorithms (Grid, K-Means, DBSCAN).

Syntax

```
ST_ClusterID()
```

Parameters

Table 89:

Name	Type	Description
Table column	ST_Point	Method ST_ClusterID operates on table columns of type ST_Point.

Returns

Metadata	Returns the cluster ID for a given point.

Example

The following example returns cluster IDs and the number of points for each cluster:

```
SELECT ST_ClusterID() AS cluster_id, COUNT(*) AS counter
FROM CLUSTER.VENDING_MACHINES
GROUP CLUSTER BY LOCATION
USING GRID X CELLS 10 Y CELLS 10;
```

4.4.2 ST_ClusterCentroid Method

Computes the ST_Point. This is the mathematical centroid of a cluster. This method works for the following cluster algorithm: K-Means.

Syntax

```
ST_ClusterCentroid()
```

Parameters

Table 90:

Name	Type	Description
Table column	ST_Point	Method ST_ClusterCentroid operates on table columns of type ST_Point.

Returns

Metadata	Returns the centroid of a cluster.

Example

The following example returns cluster centroids and the number of points per cluster:

```
SELECT ST_ClusterCentroid() AS centroidcluster,
COUNT(*) AS counter
FROM CLUSTER.VENDING_MACHINES
GROUP CLUSTER BY LOCATION
USING KMEANS
      CLUSTERS 5
      MAXITERATIONS 10
```

```
        THRESHOLD 0.01
        INIT RANDOM PARTITION;
```

4.4.3 ST_ClusterEnvelope Method

Returns the geometry of a cell (inner rectangle). This method works for the following cluster algorithm: Grid.

Syntax

```
ST_ClusterEnvelope()
```

Parameters

Table 91:

Name	Type	Description
Table column	ST_Point	The method ST_Envelope operates on table columns of type ST_Point.

Returns

Metadata Returns the envelope of a cluster.

Example

The following example returns the cluster IDs and the cluster envelopes:

```
SELECT ST_ClusterID() AS cluster_id,
ST_ClusterEnvelope() AS clusterenvelope
FROM CLUSTER.VENDING_MACHINES
GROUP CLUSTER BY LOCATION
USING GRID X CELLS 10 Y CELLS 10;
```

4.5 Use Cases for Spatial Clustering

Spatial clustering provides metadata, so that geographical information can be used to group data.

You can investigate and group data by many different attributes. You can investigate the income of households or the revenue of vending machines for example. Columns containing attributes (for example CITY, STATE, COUNTRY) used for grouping data (GROUP BY/PARTITION BY) provide basic information, but this might not be sufficient.

With spatial clustering (GROUP CLUSTER BY, CLUSTER BY) you can use geographical information together with other attributes (income and revenue for example) to cluster data.

Finding clusters with high or low household income

A company wants to establish a new chain of luxury stores and a new chain of discounters in the United States. To find suitable locations for their luxury stores, the company would like to identify areas with a preponderance of high-income households. For their discounters, they would like to find areas with a preponderance of low-income households.

The company has the data for a total of 120 million households in the United States, including their location and income. The management team wants to visualize areas with a preponderance of high-income households and areas with a preponderance of low-income households on a map.

A simplified table containing the household data could be defined as following:

```
CREATE COLUMN TABLE HOUSEHOLDS (
    HHID      INT PRIMARY KEY,
    STATE     CHAR(2),
    LOCATION  ST_POINT,
    INCOME    DECIMAL(11,2));
```

The following statements show examples of how the necessary information can be retrieved using GROUP BY or CLUSTER BY.

GROUP BY

A grouping on a pre-defined area (in this case state) could be defined as:

```
SELECT
    STATE,
    COUNT(*)    AS number_of_households,
    AVG(INCOME) AS household_income
FROM HOUSEHOLDS
WHERE INCOME > 120000
GROUP BY STATE
HAVING COUNT(*) >= 1000;
```

This query finds the number of households with an income of more than $120,000 per state and the average income of these households with more than $120,000 income as long as there are at least 1,000 of these households in the state. The STATE is the key to further information of this area. The shape and the centroid of the state could be located in an extra table accessed via the state abbreviation.

GROUP CLUSTER BY

With spatial clustering, you investigate the information about the household income in conjunction with a cluster algorithm. The following query provides information about the cluster centroids, which can give you a first impression of the situation:

```
SELECT
    ST_ClusterId()       AS cluster_id,
    ST_ClusterCentroid() AS centroid,
    COUNT(*)             AS number_of_households,
    AVG(INCOME)          AS average_cluster_income
FROM HOUSEHOLDS
WHERE INCOME > 120000
GROUP CLUSTER BY LOCATION USING KMEANS CLUSTERS 100
HAVING COUNT(*) >= 300;
```

With the following statement, you can combine all centroids to one scalable vector graphic:

```
SELECT ST_AsSVGAggr(centroid) from
(SELECT
    ST_ClusterId()       AS cluster_id,
    ST_ClusterCentroid() AS centroid,
    COUNT(*)             AS number_of_households,
    AVG(INCOME)          AS average_cluster_income
FROM HOUSEHOLDS
WHERE INCOME > 120000
GROUP CLUSTER BY LOCATION USING KMEANS CLUSTERS 100
HAVING COUNT(*) >= 300);
```

Finding clusters with high or low vending machine revenue

A vending machine supplier has its vending machines distributed and operating across the United States. The company knows the location of each vending machine and its revenue from the past year.

It would like to identify lucrative areas where the vending machines produced higher revenue and non-lucrative areas where its machines produced low revenue. It wants to visualize these areas on a map. It also wants to be able to zoom into these areas, and be able to retrieve detailed information, such as the ID and revenue of each vending machine.

A simplified table containing the vending machine data could be defined as:

```
CREATE COLUMN TABLE VENDING_MACHINES (
    VM_ID     INT PRIMARY KEY,
    STATE     CHAR(2),
    LOCATION  ST_POINT,
    REVENUE   DECIMAL(11,2));
```

The following statements show examples of how the required information can be retrieved using GROUP BY/ PARTITION BY or CLUSTER BY in a window function.

GROUP BY/PARTITION BY

With GROUP BY/PARTITION BY, you can investigate the data on a pre-defined group (in this case state).

The following query finds the number and average revenue of vending machines per state, which have less than $60,000 revenue.

```
SELECT
```

```
    STATE,
    COUNT(*)     AS number_of_vending_machines,
    AVG(REVENUE) AS average_revenue
FROM VENDING_MACHINES
WHERE REVENUE < 60000
GROUP BY STATE;
```

The following query finds the rank of vending machines per state, which have less than $60,000 revenue, and ranks them by revenue in ascending order.

```
SELECT
    STATE,
    RANK() OVER (PARTITION BY STATE ORDER BY REVENUE ASC) AS RANK,
    REVENUE,
    VM_ID
FROM VENDING_MACHINES
WHERE REVENUE < 60000;
```

CLUSTER BY (window functions)

You can perform the spatial clustering as a window function. The cluster by clause is located in the select clause.

In the following query, the clusters for vending machines with less than $60,000 are determined:

```
SELECT
  ST_ClusterID() OVER (CLUSTER BY LOCATION USING DBSCAN EPS 100 MINPTS 5)
  AS cluster_id,
  REVENUE, VM_ID, LOCATION
FROM VENDING_MACHINES
WHERE REVENUE < 60000
ORDER BY cluster_id;
```

In the following query, ST_ClusterID() and RANK() are combined. In the query in brackets, ST_ClusterID() is performed as a window function, while in the surrounding query RANK() is performed on cluster_id. The vending machines are grouped by cluster and ranked inside the clusters by revenue:

```
SELECT cluster_id, REVENUE, VM_ID,
       RANK() OVER (PARTITION BY cluster_id order by REVENUE ASC) AS rank,
LOCATION
FROM (SELECT ST_ClusterID() OVER (CLUSTER BY LOCATION USING DBSCAN EPS 100
MINPTS 5)
     AS cluster_id,
     REVENUE, VM_ID, LOCATION
     FROM VENDING_MACHINES
     WHERE REVENUE < 60000)
ORDER BY cluster_id;
```

In the following query ST_ClusterID() and RANK() are combined in the select clause. ST_ClusterID() (CLUSTER BY LOCATION ...) and RANK() (CLUSTER BY LOCATION ... ORDER BY REVENUE) are performed as window functions. The vending machines are grouped by cluster and ranked inside the clusters by revenue:

```
SELECT
  ST_CLusterID()
    OVER (CLUSTER BY LOCATION USING DBSCAN EPS 100 MINPTS 5) AS cluster_id,
  RANK()
    OVER (CLUSTER BY LOCATION USING DBSCAN EPS 100 MINPTS 5
    ORDER BY REVENUE ASC) AS rank,
  REVENUE, VM_ID, LOCATION
FROM VENDING_MACHINES
WHERE REVENUE < 60000;
```

Comparison of GROUP BY and CLUSTER BY

The way spatial clustering and window functions are used is similar. This is a comparison using the examples above:

1. You group your data set by a column (for example STATE) or you determine geographical clusters using an algorithm on a column containing geospatial points.
2. Within the group or the cluster, you order the data by a column (for example REVENUE).
3. Within the group or the cluster, you rank the data (starting with 1 for the highest REVENUE for example).

> **Note**
>
> The main difference between the two methods is:
>
> - GROUP BY groups the data set using information contained in the column(s).
> - CLUSTER BY splits the data set into clusters, which are determined by geospatial point data using an algorithm.
>
> Further investigations on the data set are similar. Using spatial clustering provides a benefit however, because it helps to investigate data from a geospatial point of view as well.

5 Appendix

The appendix provides additional information.

5.1 SQL Statements

Reference material for SQL statements mentioned in this document.

5.1.1 CREATE SPATIAL REFERENCE SYSTEM Statement

Creates a spatial reference system.

Syntax

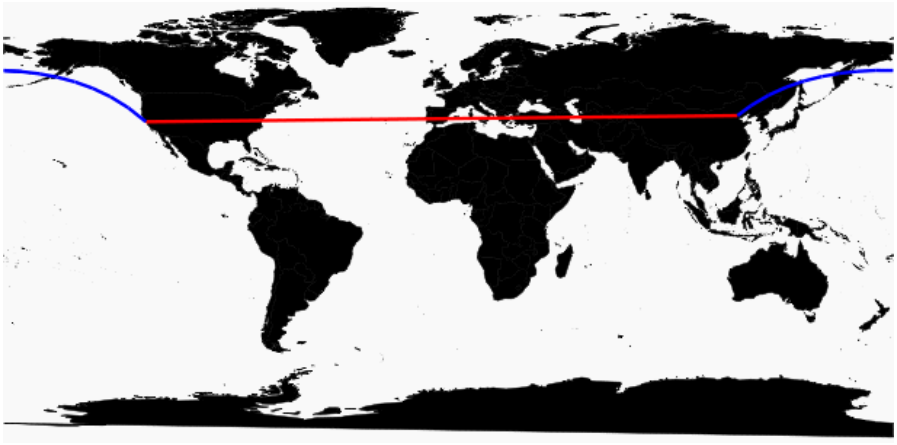
```
CREATE SPATIAL REFERENCE SYSTEM <srs-name>
[ srs-attribute ] [ srs-attribute ... ]
srs-attribute - (back to Syntax)
SRID <srs-id>
  | DEFINITION { <definition-string> | NULL }
  | ORGANIZATION
    { <organization-name> IDENTIFIED BY <organization-srs-id> | NULL }
  | TRANSFORM DEFINITION { <transform-definition-string> | NULL }
  | LINEAR UNIT OF MEASURE <linear-unit-name>
  | ANGULAR UNIT OF MEASURE { <angular-unit-name> | NULL }
  | TYPE { ROUND EARTH | PLANAR }
  | COORDINATE <coordinate-name>
    { UNBOUNDED | BETWEEN <low-number> AND <high-number> }
  | ELLIPSOID SEMI MAJOR AXIS <semi-major-axis-length>
    { SEMI MINOR AXIS <semi-minor-axis-length> |
      INVERSE FLATTENING <inverse-flattening-ratio> }
  | TOLERANCE { <tolerance-distance> | DEFAULT }
  | SNAP TO GRID { grid-size | DEFAULT }
  | AXIS ORDER axis-order
  | POLYGON FORMAT polygon-format
  | STORAGE FORMAT storage-format
grid-size - (back to srs-attribute)
DOUBLE : usually between 0 and 1
axis-order - (back to srs-attribute)
{ 'x/y/z/m' | 'long/lat/z/m' | 'lat/long/z/m' }
polygon-format - (back to srs-attribute)
     { 'CounterClockWise' | 'Clockwise' | 'EvenOdd' }
storage-format - (back to srs-attribute)
{ 'Internal' | 'Original' | 'Mixed' }
```

Parameters

Table 92:

Name	Description
IDENTIFIED BY	The SRID (srs-id) for the spatial reference system. If the spatial reference system is defined by an organization with an organization-srs-id, then srs-id should be set to that value. If the IDENTIFIED BY clause is not specified, then the SRID defaults to the organization srs-id defined by either the ORGANIZATION clause or the DEFINITION clause. If neither clause defines an organization-srs-id that could be used as a default SRID, an error is returned. When the spatial reference system is based on a well known coordinate system, but has a different geodesic interpretation, set the srs-id value to be 1000000000 (one billion) plus the well known value. For example, the SRID for a planar interpretation of the geodetic spatial reference system WGS 84 (ID 4326) would be 1000004326. With the exception of SRID 0, spatial reference systems provided by SAP IQ that are not based on well known systems are given a SRID of 2000000000 (two billion) and above. The range of SRID values from 2000000000 to 2147483647 is reserved by SAP IQ and you should not create SRIDs in this range. To reduce the possibility of choosing a SRID that is reserved by a defining authority such as OGC or by other vendors, you should not choose a SRID in the range 0 - 32767 (reserved by EPSG), or in the range 2147483547 - 2147483647. Also, since the SRID is stored as a signed 32-bit integer, the number cannot exceed (2^31)-1 or 2147483647.
DEFINITION	Set, or override, default coordinate system settings. If any attribute is set in a clause other than the DEFINITION clause, it takes the value specified in the other clause regardless of what is specified in the DEFINITION clause. `<definition-string>` is a string in the Spatial Reference System Well Known Text syntax as defined by SQL/MM and OGC. In Interactive SQL, if you double-click the value returned, an easier to read version of the value appears. When the DEFINITION clause is specified, definition-string is parsed and used to choose default values for attributes. For example, definition-string may contain an AUTHORITY element that defines the organization-name and `<organization-srs-id>`. Parameter values in definition-string are overridden by values explicitly set using the SQL statement clauses. For example, if the ORGANIZATION clause is specified, it overrides the value for ORGANIZATION in `<definition-string>`.
ORGANIZATION	Information about the organization that created the spatial reference system that the spatial reference system is based on.

Name	Description
TRANSFORM DEFINITION	A description of the transform to use for the spatial reference system. Currently, only the PROJ.4 transform is supported. The transform definition is used by the ST_Transform method when transforming data between spatial reference systems. Some transforms may still be possible even if there is no transform definition-string defined.
LINEAR UNIT OF MEASURE	The linear unit of measure for the spatial reference system. The value you specify must match a linear unit of measure defined in the ST_UNITS_OF_MEASURE system view. If this clause is not specified, and is not defined in the DEFINITION clause, the default is METRE. To add predefined units of measure to the database, use the sa_install_feature system procedure. To add custom units of measure to the database, use the CREATE SPATIAL UNIT OF MEASURE statement. **Note** While both METRE and METER are accepted spellings, METRE is preferred as it conforms to the SQL/MM standard.
ANGULAR UNIT OF MEASURE	The angular unit of measure for the spatial reference system. The value you specify must match an angular unit of measure defined in the ST_UNITS_OF_MEASURE system table. If this clause is not specified, and is not defined in the DEFINITION clause, the default is DEGREE for geographic spatial reference systems and NULL for non-geographic spatial reference systems. The angular unit of measure must be non-NULL for geographic spatial reference systems and it must be NULL for non-geographic spatial reference systems. To add custom units of measure to the database, use the CREATE SPATIAL UNIT OF MEASURE statement.

Name	Description
TYPE	Control how the SRS interprets lines between points. For geographic spatial reference systems, the TYPE clause can specify either ROUND EARTH (the default) or PLANAR. The ROUND EARTH model interprets lines between points as great elliptic arcs. Given two points on the surface of the Earth, a plane is selected that intersects the two points and the center of the Earth. This plane intersects the Earth, and the line between the two points is the shortest distance along this intersection. For two points that lie directly opposite each other, there is not a single unique plane that intersects the two points and the center of the Earth. Line segments connecting these anti-podal points are not valid and give an error in the ROUND EARTH model. The ROUNDEARTH model treats the Earth as a spheroid and selects lines that follow the curvature of the Earth. In some cases, it may be necessary to use a planar model where a line between two points is interpreted as a straight line in the equirectangular projection where x=long, y=lat. In the following example, the blue line shows the line interpretation used in the ROUND EARTH model and the red line shows the corresponding PLANAR model.  The PLANAR model may be used to match the interpretation used by other products. The PLANAR model may also be useful because there are some limitations for methods that are not supported in the ROUND EARTH model (such as ST_Area, ST_ConvexHull) and some are partially supported (ST_Distance only supported between point geometries). Geometries based on circularstrings are not supported in ROUND EARTH spatial reference systems. For non-geographic SRSs, the type must be PLANAR (and that is the default if the TYPE clause is not specified and either the DEFINITION clause is not specified or it uses a non-geographic definition).

Name	Description
COORDINATE	The bounds on the spatial reference system's dimensions. Coordinate name is the name of the coordinate system used by the spatial reference system. For nongeographic coordinate systems, coordinate-name can be x, y, or m. For geographic coordinate systems, coordinate-name can be LATITUDE, LONGITUDE, z, or m. Specify UNBOUNDED to place no bounds on the dimensions. Use the BETWEEN clause to set low and high bounds. The X and Y coordinates must have associated bounds. For geographic spatial reference systems, the longitude coordinate is bounded between -180 and 180 degrees and the latitude coordinate is bounded between -90 and 90 degrees by default unless the COORDINATE clause overrides these settings. For non-geographic spatial reference systems, the CREATE statement must specify bounds for both X and Y coordinates. LATITUDE and LONGITUDE are used for geographic coordinate systems. The bounds for LATITUDE and LONGITUDE default to the entire Earth, if not specified.
ELLIPSOID	The values to use for representing the Earth as an ellipsoid for spatial reference systems of type ROUND EARTH. If the DEFINITION clause is present, it can specify ellipsoid definition. If the ELLIPSOID clause is specified, it overrides this default ellipsoid. The Earth is not a perfect sphere because the rotation of the Earth causes a flattening so that the distance from the center of the Earth to the North or South pole is less than the distance from the center to the equator. For this reason, the Earth is modeled as an ellipsoid with different values for the semi-major axis (distance from center to equator) and semi-minor axis (distance from center to the pole). It is most common to define an ellipsoid using the semi-major axis and the inverse flattening, but it can instead be specified using the semi-minor axis (for example, this approach must be used when a perfect sphere is used to approximate the Earth). The semi-major and semi-minor axes are defined in the linear units of the spatial reference system, and the inverse flattening (1/f) is a ratio: `1/f = (semi-major-axis) / (semi-major-axis - semi-minor-axis)` product-name uses the ellipsoid definition when computing distance in geographic spatial reference systems.
SNAP TO GRID	Flat-Earth (planar) spatial reference systems, use the SNAP TO GRID clause to define the size of the grid SAP IQ uses when performing calculations. By default, SAP IQ selects a grid size so that 12 significant digits can be stored at all points in the space bounds for X and Y. For example, if a spatial reference system bounds X between -180 and 180 and Y between -90 and 90, then a grid size of 0.000000001 (1E-9) is selected.

Name	Description
TOLERANCE	Flat-Earth (planar) spatial reference systems, use the TOLERANCE clause to specify the precision to use when comparing points. If the distance between two points is less than tolerance-distance, the two points are considered equal. Setting tolerance-distance allows you to control the tolerance for imprecision in the input data or limited internal precision. By default, tolerance-distance is set to be equal to grid-size. When set to 0, two points must be exactly equal to be considered equal. For round-Earth spatial reference systems, TOLERANCE must be set to 0.
POLYGON FORMAT	Internally, SAP IQ interprets polygons by looking at the orientation of the constituent rings. As one travels a ring in the order of the defined points, the inside of the polygon is on the left side of the ring. The same rules are applied in PLANAR and ROUND EARTH spatial reference systems. The interpretation used by SAP IQ is a common but not universal interpretation. Some products use the exact opposite orientation, and some products do not rely on ring orientation to interpret polygons. The POLYGONFORMAT clause can be used to select a polygon interpretation that matches the input data, as needed. The following values are supported: • **CounterClockwise** – Input follows SAP IQ's internal interpretation: the inside of the polygon is on the left side while following ring orientation. • **Clockwise** – Input follows the opposite of SAP IQ's approach: the inside of the polygon is on the right side while following ring orientation. • **EvenOdd** – (default) The orientation of rings is ignored and the inside of the polygon is instead determined by looking at the nesting of the rings, with the exterior ring being the largest ring and interior rings being smaller rings inside this ring. A ray is traced from a point within the rings and radiating outward crossing all rings. If the number the ring being crossed is an even number, it is an outer ring. If it is odd, it is an inner ring.
STORAGE FORMAT	STORAGE FORMAT – control what is stored when spatial data is loaded into the database. Possible values are: • **Internal** – SAP IQ stores only the normalized representation. Specify this when the original input characteristics do not need to be reproduced. This is the default for planar spatial reference systems (TYPE PLANAR). • **Original** – SAP IQ stores only the original representation. The original input characteristics can be reproduced, but all operations on the stored values must repeat normalization steps, possibly slowing down operations on the data. • **Mixed** – SAP IQ stores the internal version and, if it is different from the original version, SAP SQL Anywhere® stores the original version as well. By storing both versions, the original representation characteristics can be reproduced and Appendix – SQL Statements 274 SAP IQ operations on stored values do not need to repeat normalization steps. However, storage requirements may increase significantly because potentially two representations are being stored for each geometry. Mixed is the default format for round-Earth spatial reference systems (TYPE ROUND EARTH).

Example

Creates a spatial reference system named <mySpatialRS>:

```
CREATE SPATIAL REFERENCE SYSTEM "mySpatialRS"
IDENTIFIED BY 1000026980
LINEAR UNIT OF MEASURE "meter"
TYPE PLANAR
COORDINATE X BETWEEN 171266.736269555 AND 831044.757769222
COORDINATE Y BETWEEN 524881.608973277 AND 691571.125115319
DEFINITION 'PROJCS["NAD83 / Kentucky South",
GEOGCS["NAD83",
DATUM["North_American_Datum_1983",
SPHEROID["GRS 1980",
6378137,298.257222101,AUTHORITY["EPSG","7019"]],
AUTHORITY["EPSG","6269"]],
PRIMEM["Greenwich",0,AUTHORITY["EPSG","8901"]],
UNIT["degree",0.01745329251994328,AUTHORITY["EPSG","9122"]],
AUTHORITY["EPSG","4269"]],
UNIT["metre",1,AUTHORITY["EPSG","9001"]],
PROJECTION["Lambert_Conformal_Conic_2SP"],
PARAMETER["standard_parallel_1",37.93333333333333],
PARAMETER["standard_parallel_2",36.73333333333333],
PARAMETER["latitude_of_origin",36.33333333333334],
PARAMETER["central_meridian",-85.75],
PARAMETER["false_easting",500000],
PARAMETER["false_northing",500000],
AUTHORITY["EPSG","26980"],
AXIS["X",EAST],
AXIS["Y",NORTH]]'
TRANSFORM DEFINITION '+proj=lcc
 +lat_1=37.93333333333333 +lat_2=36.73333333333333
 +lat_0=36.33333333333334 +lon_0=-85.75 +x_0=500000
 +y_0=500000 +ellps=GRS80 +datum=NAD83 +units=m +no_defs';
```

Usage

For a geographic spatial reference system, you can specify both a LINEAR and an ANGULAR unit of measure; otherwise for non-geographic, you specify only a LINEAR unit of measure. The LINEAR unit of measure is used for computing distance between points and areas. The ANGULAR unit of measure tells how the angular latitude/longitude are interpreted and is NULL for projected coordinate systems, non-NULL for geographic coordinate systems.

All derived geometries returned by operations are normalized.

When working with data that is being synchronized with a non-SQL Anywhere database, STORAGE FORMAT should be set to either 'Original' or 'Mixed' so that the original characteristics of the data can be preserved.

Permissions

Requires one of:

- MANAGE ANY SPATIAL OBJECT system privilege.

- CREATE ANY OBJECT system privilege.

5.1.2 CREATE SPATIAL UNIT OF MEASURE Statement

Creates a spatial unit of measurement.

Syntax

```
CREATE SPATIAL UNIT OF MEASURE <identifier>
TYPE { LINEAR | ANGULAR }
[ CONVERT USING <number> ]
```

Parameters

Table 93:

Name	Description
TYPE	Defines whether the unit of measure is used for angles (ANGULAR) or distances (LINEAR).
CONVERT USING	The conversion factor for the spatial unit relative to the base unit. For linear units, the base unit is METRE. For angular units, the base unit is RADIAN.

Example

The following examples create different types of spatial units of measure:

```
CREATE SPATIAL UNIT OF MEASURE "meter" TYPE LINEAR convert using 1;
```

```
CREATE SPATIAL UNIT OF MEASURE "radian" TYPE ANGULAR convert using 1;
```

```
CREATE SPATIAL UNIT OF MEASURE "degree" TYPE ANGULAR convert using 0.017453293;
```

```
CREATE SPATIAL UNIT OF MEASURE "planar degree" TYPE LINEAR convert using
111120;
```

```
CREATE SPATIAL UNIT OF MEASURE "kilometre" TYPE LINEAR convert using 1000;
```

```
CREATE SPATIAL UNIT OF MEASURE "yard" TYPE LINEAR convert using 0.9144;
DROP SPATIAL UNIT OF MEASURE "yard";
```

Example

Creates a spatial unit of measure named <Test>:

```
CREATE SPATIAL UNIT OF MEASURE Test
TYPE LINEAR
CONVERT USING 15;
```

Usage

The CONVERT USING clause is used to define how to convert a measurement in the defined unit of measure to the base unit of measure (radians or meters). The measurement is multiplied by the supplied conversion factor to get a value in the base unit of measure. For example, a measurement of 512 millimeters would be multiplied by a conversion factor of 0.001 to get a measurement of 0.512 metres.

Spatial reference systems always include a linear unit of measure to be used when calculating distances (ST_Distance or ST_Length), or area. For example, if the linear unit of measure for a spatial reference system is miles, then the area unit used is square miles. In some cases, spatial methods accept an optional parameter that specifies the linear unit of measure to use. For example, if the linear unit of measure for a spatial reference system is in miles, you could retrieve the distance between two geometries in meters by using the optional parameter 'metre'.

For projected coordinate systems, the X and Y coordinates are specified in the linear unit of the spatial reference system. For geographic coordinate systems, the latitude and longitude are specified in the angular units of measure associated with the spatial reference system. In many cases, this angular unit of measure is degrees but any valid angular unit of measure can be used.

You can use the sa_install_feature system procedure to add predefined units of measure to your database.

Permissions

Requires one of:

- MANAGE ANY SPATIAL OBJECT system privilege.
- CREATE ANY OBJECT system privilege.

5.1.3 DROP SPATIAL REFERENCE SYSTEM Statement

Drops a spatial reference system.

Syntax

```
DROP SPATIAL REFERENCE SYSTEM <srs-name>
```

Parameters

Table 94:

Name	Description
<srs-name>	Identifier of the spatial reference system that has to be dropped.

Remarks

You can only drop a spatial reference system, if it is not referenced by other objects.

Example

the following example drops a fictitious spatial reference system named <Test>.

```
DROP SPATIAL REFERENCE SYSTEM Test;
```

5.1.4 DROP SPATIAL UNIT OF MEASURE Statement

Drops a spatial unit of measurement.

Syntax

```
DROP SPATIAL UNIT OF MEASURE <identifier>
```

Parameters

Table 95:

Name	Description
`<identifier>`	Identifier of the unit of measurement that has to be dropped.

Remarks

You can only drop a spatial unit of measurement, if it is not referenced by other objects.

Example

The following example drops a fictitious spatial unit of measurement named `<Test>`.

```
DROP SPATIAL UNIT OF MEASURE Test;
```

5.2 Geocoding

Geocoding is the process of converting address information into geographic locations. Since current business data is associated with address information without location information, geocoding is crucial to enable geographic analysis of this data.

For geocoding, you use the index type `GEOCODE`, which is similar to the `FULLTEXT` index. To create, maintain and delete an index for geocoding, SQL statements are used.

The geocoding itself is provided by an external provider such as Nokia NAVTEQ or TOMTOM, while the outbound connectivity required is maintained and executed asynchronously in the XS engine. The index server provides jobs for geocoding, which are triggered by the table update. The geocoding processing is very similar to text processing, with the difference that multiple columns are used as an input, only asynchronous processing is supported, and the `geocode` column (the column which holds the converted addresses) is visible. The `GEOCODE` column is visible for searches, but must not be altered or dropped.

To specify which columns correspond semantically to an address, each individual part must be explicitly defined.

Note

SAP HANA smart data quality provides native geocoding and reverse geocoding capabilities in SAP HANA. You may need to license additional software options as well as a subscription to reference data from SAP, which is used by SAP HANA smart data quality to perform the geocoding and reverse geocoding operations. SAP HANA smart data quality also includes data cleansing capabilities which is able to cleanse and enhance address information to improve address geocoding capabilities natively in SAP HANA.

To find more information about how to use these capabilities natively in SAP HANA refer to the SAP HANA Enterprise Information Management Configuration Guide, and navigate to *Transforming Data* > *Geocode*.

5.2.1 Create Index

To create a geocoding index, you use the following SQL statement:

```
CREATE GEOCODE INDEX <name> ON <table_name> (
<column_name> COUNTRY,
<column_name> STATE,
<column_name> COUNTY,
<column_name> CITY,
<column_name> POSTAL_CODE,
<column_name> DISTRICT,
<column_name> STREET,
<column_name> HOUSE_NUMBER,
<column_name> ADDRESS_LINE,
<column_name> GEOCODE )
ASYNC[HRONOUS] [FLUSH [QUEUE] [EVERY <n> MINUTES] [[OR] AFTER <m> ROWS]]]
```

Note

At least one address column must be specified in addition to the `GEOCODE` column. Specifying any additional columns is optional.

Table 96:

Name	Description
COUNTRY	This column holds the country name of an address. The data type has to be character like (internally represented as string). If the column contains a value, it will be used for geocoding. If there is no value, or the value is null, the country is ignored.
STATE	This column holds the state name of an address. The data type has to be character like (internally represented as string). If the column contains a value, it will be used for geocoding. If there is no value, or the value is null, the state is ignored.
COUNTY	This column holds the county name of an address. The data type has to be character like (internally represented as string). If the column contains a value it will be used for geocoding. If there is no value, or the value is null, the county is ignored.
CITY	This column holds the city name of an address. The data type has to be character like (internally represented as string). If the column contains a value it will be used for geocoding. If there is no value, or the value is null, the city is ignored.
POSTAL_CODE	This column holds the postal code of an address. The data type has to be character like (internally represented as string). If the column contains a value it will be used for geocoding. If there is no value, or the value is null, the postal code is ignored.
DISTRICT	This column holds the district name of an address. The data type has to be character like (internally represented as string). If the column contains a value it will be used for geocoding. If there is no value, or the value is null, the district is ignored.

Name	Description
STREET	This column holds the street name of an address. The data type has to be character like (internally represented as string). If the column contains a value it will be used for geocoding. If there is no value, or the value is null, the street is ignored.
HOUSE_NUMBER	This column holds the house number of an address. The data type has to be character like (internally represented as string). If the column contains a value it will be used for geocoding. If there is no value, or the value is null, the house number is ignored.
ADDRESS_LINE	This column holds a several address parts in a single value. The data type has to be character like (internally represented as string). If the column contains a value it will be used for geocoding; in case of no or null value the address line is ignored. The ADDRESS_LINE is required as address data is not fully structured in most cases. In extreme cases, a single field stores the entire address information.
GEOCODE	The name of the generated point column that holds the geo-coded location. The data type of the GEOCODE column is ST_POINT.
ASYNC: EVERY <n> MINUTES	Preprocessing and insertion into geocode index does not take place immediately upon insert-call, but rather every n minutes.
ASYNC: AFTER <m> ROWS	Preprocessing and insertion into geocode index does not take place immediately upon insert-call, but rather after m new rows have been inserted.

5.2.2 Modify Index

Changing the criteria is only permitted for queue processing.

```
ALTER GEOCODE INDEX <name> ASYNC[HRONOUS] [FLUSH [QUEUE] [EVERY <n> MINUTES]
[[OR] AFTER <m> ROWS]]]
```

5.2.3 Drop Index

The SQL statement to drop a geocoding index is similar to the statement for the FULLTEXT index.

```
DROP GEOCODE INDEX <name>
```

5.2.4 Maintain the Queue

The SQL statements to maintain the geocoding queue are similar to the statements for the FULLTEXT index.

Stop queue processing:

```
ALTER GEOCODE INDEX <name> SUSPEND QUEUE
```

Continue processing of queue content:

```
ALTER GEOCODE INDEX <name> ACTIVATE QUEUE
```

Force processing of queue content:

```
ALTER GEOCODE INDEX <name> FLUSH QUEUE
```

Retry failed geocoding jobs:

```
call RETRY_DOCUMENT_INDEXING (<schema>,<name>,<error code>)
```

> **Note**
>
> Only error code 0 is allowed. If the `<error code>` is 0, any errors will be queued for retry.

5.2.5 System Tables and Monitoring View

Information about geocoding activities is stored in system tables and a monitoring view.

System Table INDEXES

A geocode index is registered in the `INDEXES` table with type `GEOCODE`.

System Table INDEX_COLUMNS

Columns that are part of a geocode index are registered in the `INDEX_COLUMNS` table and are distinguished by the constraint column.

Table 97:

Index part	Constraint
COUNTRY	GEOCODE COUNTRY
STATE	GEOCODE STATE
CITY	GEOCODE CITY
POSTAL_CODE	GEOCODE POSTAL_CODE
DISTRICT	GEOCODE DISTRICT
STREET	GEOCODE STREET
HOUSE_NUMBER	GEOCODE HOUSE_NUMBER
ADDRESS_LINE	GEOCODE ADDRESS_LINE
GEOCODE	GEOCODE

System Table GEOCODE_INDEXES

Detailed information about the geocode indexes in a system is registered in the `GEOCODE_INDEXES` table.

Table 98:

Columns name	Data type	Description
SCHEMA_NAME	NVARCHAR(256)	Schema name
TABLE_NAME	NVARCHAR(256)	Table name
TABLE_OID	BIGINT	Object ID of the table
INDEX_NAME	NVARCHAR(256)	Name of the geocode index
INDEX_OID	BIGINT	Object ID of the geocode index
FLUSH_AFTER_ROWS	INTEGER	Used to store change-tracking behavior of the geocode index
FLUSH_EVERY_MINUTES	INTEGER	Used to store change-tracking behavior of the geocode index

Monitoring View M_INDEXING_QUEUES

View M_INDEXING_QUEUES lists queues of all types. Queues related to geocoding are registered with type `GEOCODE`.

5.2.6 Geocode Provider

The geocoding function that is integrated in SAP HANA uses the XS engine.

A geocode provider is used to translate textual address data into geo locations. Geocode providers are supplied by delivery units and are written in JavaScript. To define the currently used provider, a configuration parameter is introduced:

```
ALTER SYSTEM ALTER CONFIGURATION ('xsengine.ini','SYSTEM') set
('geocoding','provider') = '<content_path>' WITH RECONFIGURE
```

> **Note**
>
> This parameter is not set by default in the case of newly imported and activated delivery units. It therefore has to be set manually. In general, `<content_path>` refers to an xsjs script provided by the delivery unit, for example `sap/hana/spatial/geocoding/<NameOfTheProvider>/geocodeindex.xsjs`.

5.2.7 User Defined Geocode Provider

A geocode provider can be created that can be used by SAP HANA, provided that a number of conditions are met.

The basic structure of a geocode provider script has to contain the following JavaScript code:

```
function doGeocoding(input) { // [1]
  var geocodes = [], errors = [];
  for( var i = 0; i < input.entries.length; ++i ) {
     // do the geocoding for entry at index i [2]
     // if no error for entry at index i {
     //   geocodes.push( "A valid WKT POINT" ); // [3]
     // } else {
     //   geocodes.push( null ) // [4]
     //   errors.push( 400 )
     // }
  }
  return { "geocodes" : geocodes, "errors" : errors}; // [5]
}
[6]
```

The following conditions have to be met:

1. The name of the function is fixed and has to be `doGeocoding` . It takes exactly one input argument. If the input object is valid, it contains a single array attribute, named `<entries>`.
2. The `<input.entries>` array contains a sequence of addresses that should be processed. The number of entries that have to be processed can vary per call. Each entry object has the same attributes as (and no more than) the column names that have been provided during the `create geocode index` statement. Possible attributes are: `<address_line>` , `<city>` , `<country>` , `<county>` , `<district>` , `<house_number>` , `<postal_code>` , `<state>` and `<street>` . For instance: `<input.entries[i].house_number>`.
3. Addresses that could be successfully geocoded have to be inserted in the `<geocodes>` array in the same order as they are extracted from the `<input.entries>` array. The type has to be a valid string WKT representation of point geometry.
4. If an address cannot be geocoded, or a different error occurs that is only related to this single entry, this can only be represented as an empty string or *null* in the `<geocodes>` array. The `<errors>` array must be filled with a meaningful error code for this case. Filling the `<errors>` array for valid geocodes is prohibited and will cause an error. Only integers are allowed as error codes. Tracing calls are still possible and can be used to give more details about the current state.
5. The return object has to have two attributes. The array called `<geocodes>` and the array called `<errors>`. Other attributes are ignored. If a general error occurs during execution, returning *null* is a valid option.
6. The whole script is interpreted before the `doGeocoding` function is called. If other instructions are present, make sure that they do not interfere with the geocoding task. Querying the database is disabled, and will result in a privileges error exception.

> **Note**
>
> Beside the xsjs-script with the doGeocoding function, there has to be at least one empty ".xsapp" file in the same folder, otherwise the script is unknown to the system.

5.2.8 Geocoding Errors and Messages

Geocoding errors and messages are handled as follows:

- If an address cannot be geocoded for any reason, this will be represented by the `POINT EMPTY` entity that is written into the geocode column for the failed row. This row will not be processed again until an address column in the geocode index is modified, the geocode column is updated to `null`, or the `RETRY_DOCUMENT_INDEXING` procedure is called.
- In case of any other errors related to the geocode provider or the queue processing of geocode indices, trace errors will be written, indicating the possible root cause. This can be recognized by the keyword `geocoding` available for the index server as well as the XS engine.

5.3 Additional Services for SAP HANA Spatial

Customers who have licensed SAP HANA (SAP HANA PLATFORM EDITION, SAP HANA ENTERPRISE EDITION, SAP HANA BASE EDITION with the SAP HANA SPATIAL OPTION, or derived licenses thereof) can use the voluntary map content and base map services (spatial map client, geo-content, spatial content viewer) provided by Nokia/HERE. These additional services and content are voluntarily provided by SAP and can be withdrawn, postponed, or suspended at any time. Customers who have licensed SAP HANA (SAP HANA PLATFORM EDITION, SAP HANA ENTERPRISE EDITION, SAP HANA BASE EDITION with the SAP HANA SPATIAL OPTION, or derived licenses thereof) can use this voluntary map content and base map services at no additional fee or license cost. Use of SAP HANA Spatial Engine is also governed by the Software Use Rights Agreement (Browse SAP agreements -> See agreements (your region) -> Access documents (Software Use Rights Agreements)). For more information about SAP HANA Spatial, see SAP Note 2091935 - SAP HANA Spatial.

The following additional services for SAP HANA Spatial are provided on SAP Support Portal:

- **Spatial map client**
  The spatial map client provides an interface to use `HERE` maps.
- **Spatial content viewer**
  The spatial content viewer is a simple web application that allows you to view geo-content in the predefined geo models (database schemas) called SAP_SPATIAL and SAP_SPATIAL_POSTAL. You need this to view the geo-content on HERE maps. To use the spatial content viewer, you need the spatial map client.
- **Geo-Content**
  The geo-content provides generalized administration boundaries (GAB) and postal codes (POC). The geo-content for GAB is provided in CSV files, whereas the geo-content for POC is provided in shapefiles.

> **Note**
>
> Some countries (for example China) do not allow use of all administration hierarchies. For these countries, only a subset of the geo-content is provided.

Related Information

SAP Note 1928222 - SAP HANA Spatial Delivery Units

5.3.1 Download Files for Additional Services from SAP Support Portal

In the SAP Software Download Center, you can access content for the additional services for SAP HANA Spatial.

1. Call a Web browser.
2. Open the SAP Software Download Center.
3. Choose *Search for Software*.
4. Search for and download the following objects:
   - "Map Client"
     Download the `HCOSPATIALMAPC00_0-<nnn>.ZIP` file and unpack it. Put the `HCOSPATIALMAPC.tgz` file on your client so that you can import it using the SAP HANA studio.
   - "Content Viewer"
     Download the `HCOSPATIALCV00_0-<nnn>.ZIP` file and unpack it. Put the `HCOSPATIALCV.tgz` file on your client so that you can import it using the SAP HANA studio.
   - "GAB" (Generalized Administration Boundaries)
     Download the .SAR files that you need and unpack them. Put the CSV files on the SAP HANA host, where you can import them into the SAP HANA database.
   - "POC" (Postal Codes)
     Download the .SAR files that you need and unpack them. Put the shapefiles on the SAP HANA host, where you can import them into the SAP HANA database.
     In addition to the unpacked shapefiles for POC, you will also find product guides and release notes for the unpacked shapefiles.

Related Information

SAP Software Download Center

5.3.2 Import the Map Client and the Spatial Content Viewer

Import the delivery units containing the map client and the content viewer.

1. Open the SAP HANA studio.
2. Choose *File* > *Import*.
3. Choose *SAP HANA Content* > *Delivery Unit*.

4. Select *Client*.
5. Import the delivery units:
   - Browse for file HCOSPATIALMAPC.tgz, select it and choose *Finish*.
   - Browse for file HCOSPATIALCV.tgz, select it and choose *Finish*.

For more information, see *Deploy a Delivery Unit Archive (*.tgz)* in the *SAP HANA Master Guide*.

> **Note**
>
> If you are using the `hdbalm` command to import the map client and the content viewer, you might encounter problems with the versions of the archives. An update might be rejected because `hdbalm` recognizes an older version in the archives you want to import. In this case you can enforce the update by using the hdbalm option `ALLOW_DU_DOWNGRADE`. The reason for this behavior is a change in the structuring of the version numbers.
>
> See also the attachment to *SAP Note 2165826 - SAP HANA Platform SPS 10 Release Note*.

Related Information

SAP HANA Master Guide
SAP Note 2165826 - SAP HANA Platform SPS 10 Release Note

5.3.3 Create Database Schemas and Tables

For the Generalized Administration Boundaries (GAB) and the Postal Codes (POC), you need to create different database schemas and tables.

5.3.3.1 Create Database Schema and Table (GAB)

The database schema for GAB is SAP_SPATIAL.

> **Note**
>
> The database schema can also be created by the content viewer. For more information, see *Use Content Viewer (GAB)*.

The database schema contains the following tables:

- AREA
- AREA_DESCRIPTION
- HIERARCHY
- HIERARCHY_DESCRIPTION

- SHAPE
- SHAPE_DISPLAY

1. Call the SAP HANA studio.
2. Open an SQL console.
3. Create the database schema and the tables with the following SQL commands:

```
create schema SAP_SPATIAL;
create column table SAP_SPATIAL.AREA (
 area_id bigint,
 spatial_hierarchy_id VARCHAR(15),
 package VARCHAR(3),
 name NVARCHAR(256),
 level TINYINT,
 parent_area_id bigint,
 PRIMARY KEY(area_id, spatial_hierarchy_id)
);
create column table SAP_SPATIAL.AREA_DESCRIPTION (
 area_id bigint,
 langu VARCHAR(3),
 description NVARCHAR(256),
 PRIMARY KEY(area_id, langu)
);
create column table SAP_SPATIAL.HIERARCHY (
 spatial_hierarchy_id VARCHAR(15),
 name NVARCHAR(256),
 PRIMARY KEY(spatial_hierarchy_id)
);
create column table SAP_SPATIAL.HIERARCHY_DESCRIPTION (
 spatial_hierarchy_id VARCHAR(15),
 langu VARCHAR(3),
 description NVARCHAR(256),
 PRIMARY KEY(spatial_hierarchy_id, langu)
);
create column table SAP_SPATIAL.SHAPE (
 area_id bigint,
 detail_level tinyint,
 external_id VARCHAR(20),
 shape ST_GEOMETRY(1000004326),
 PRIMARY KEY(area_id, detail_level)
);
create column table SAP_SPATIAL.SHAPE_DISPLAY (
 use_case_id VARCHAR(15),
 zoom_level tinyint,
 area_id bigint,
 display_detail_level tinyint,
 PRIMARY KEY(use_case_id, zoom_level, area_id)
);
```

Note

The field LEVEL in the table SAP_SPATIAL.AREA has the same meaning in every country, but not every country has entries on every leven:

- 1 - country
- 2 - state
- 3 - county
- 4 - city
- 5 - district

Related Information

Use the Content Viewer (GAB) [page 193]

5.3.3.2 Create Database Schema and Table (POC)

The database schema for POC is SAP_SPATIAL_POSTAL.

The database schema contains the GENERALIZED table.

1. Call the SAP HANA studio.
2. Open an SQL console.
3. Create the database schema and the table with the following SQL commands:

```
CREATE SCHEMA SAP_SPATIAL_POSTAL;
CREATE COLUMN TABLE "SAP_SPATIAL_POSTAL"."GENERALIZED" (
     "POSTCODE" VARCHAR(10),
     "ISO_CTRY" VARCHAR(3),
     "ADMIN1" VARCHAR(80),
     "ADMIN2" VARCHAR(80),
     "ADMIN3" VARCHAR(80),
     "ADMIN4" VARCHAR(80),
     "ADMIN5" VARCHAR(80),
     "AREA" DOUBLE CS_DOUBLE,
     "SHAPE" ST_GEOMETRY(0) CS_GEOMETRY) UNLOAD PRIORITY 5 AUTO MERGE;
```

> **Note**
>
> Some of the shapefiles contain the AREA column, while others do not. This difference has to be taken into account during the import into the SAP_SPATIAL_POSTAL.GENERALIZED table.

5.3.4 Import Geo-Content

Two different import methods are used depending on whether the geo-content is for Generalized Administration Boundaries (GAB) or for Postal Codes (POC).

5.3.4.1 Import Geo-Content (GAB)

The geo-content for Generalized Administration Boundaries (GAB) needs to be imported into the database tables.

The geo-content for GAB is contained in CSV files. To import the CSV files for GAB, perform the following steps:

1. Put the CSV files on the host.

2. Perform IMPORT commands like this:

```
IMPORT FROM CSV FILE '<path and filename>' INTO SAP_SPATIAL.<TABLE>
WITH THREADS 10
RECORD DELIMITED BY '\n'
FIELD DELIMITED BY ';'
OPTIONALLY ENCLOSED BY '\"'
ERROR LOG '<filepath and filename>';
```

Perform the import for all tables belonging to database schema SAP_SPATIAL and for all geo-content that you want to import. This is an example of importing for the table SAP_SPATIAL.AREA for EUROPE:

```
IMPORT FROM CSV FILE '/usr/sap/ABC/HDB50/work/GAB/EU_Q214/AREA.csv' INTO
SAP_SPATIAL.AREA
    WITH THREADS 10
    RECORD DELIMITED BY '\n'
    FIELD DELIMITED BY ';'
    OPTIONALLY ENCLOSED
    BY '\"'
    ERROR LOG '/usr/sap/ABC/HDB50/work/GAB/EU_Q214/AREA.err';
```

Caution

Choose the number of threads in accordance with your hardware.

Note

By default, the files have to be in the work folder of the SAP HANA system: `/usr/sap/<SID>/HDB<instance_number>/work/`. If configuration parameter `enable_csv_import_path_filter` (indexserver.ini, nameserver.ini) is set to `false`, the files can be located anywhere on the SAP HANA host.

5.3.4.2 Import Geo-Content (POC)

The geo-content for Postal Codes (POC) needs to be imported into the database table.

The geo-content for POC is contained in various kinds of shapefiles. Check the geo-content and choose the shapefiles you need. The following shapefiles are offered for Japan for example:

- JPN_2012Q1_PCB_PLY_GEN
- JPN_2012Q1_PCB_PLY_UNGEN
- JPN_2012Q1_PCB_PTS

Note

In addition to the unpacked shapefiles for POC, you will also find product guides and release notes for the unpacked shapefiles.

The following section describes how to import the shapefiles with the generalized content: `<country>_<year><quarter>_PCB_PLY_GEN` (for example `BEL_2013Q1_PCB_PLY_GEN`). The import is performed in the same way for the other types of shapefiles.

To import the shapefiles for POC, perform the following steps:

1. Put the shapefiles on the host.
2. Perform this step for all shapefiles you need.
   Perform IMPORT commands like this:

   ```
   IMPORT "SAP_SPATIAL_POSTAL"."<country>_GEN" AS SHAPEFILE FROM '<path and
   filename>';
   ```

   This is an example for importing shapefile BEL_2013Q1_PCB_PLY_GEN:

   ```
   IMPORT "SAP_SPATIAL_POSTAL"."BEL_GEN" AS SHAPEFILE FROM
   '/usr/sap/ABC/HDB507work/POC/BEL_2013Q1_PCB/shp/BEL_2013Q1_PCB_PLY_GEN';
   ```

   > **Note**
   >
   > By default, the files have to be in the work folder of the SAP HANA system: `/usr/sap/<SID>/HDB<instance_number>/work/`. If configuration parameter `enable_csv_import_path_filter` (indexserver.ini, nameserver.ini) is set to `false`, the files can be located anywhere on the SAP HANA host.

3. Insert the data from the tables you just imported into table SAP_SPATIAL_POSTAL.GENERALIZED.
   This is an example for inserting two tables that do not have the AREA column :

   ```
   insert into "SAP_SPATIAL_POSTAL"."GENERALIZED" (postcode, iso_ctry, admin1,
   admin2, admin3, admin4, admin5, shape) (
       select postcode, iso_ctry, admin1, admin2, admin3, admin4, admin5, shape
   from "SAP_SPATIAL_POSTAL"."BEL_GEN"
       union all
       select postcode, iso_ctry, admin1, admin2, admin3, admin4, admin5, shape
   from "SAP_SPATIAL_POSTAL"."NDL_GEN"
        );
   ```

   For tables that have the AREA column, the insert statement is:

   ```
   insert into "SAP_SPATIAL_POSTAL"."GENERALIZED" (postcode, iso_ctry, admin1,
   admin2, admin3, admin4, admin5, area, shape) (
       select postcode, iso_ctry, admin1, admin2, admin3, admin4, admin5, area,
   shape from "SAP_SPATIAL_POSTAL"."CAN_GEN"
       );
   ```

5.3.5 Create a User to View Geo-Content

To view the geo-content, you need a dedicated database user.

1. Call the SAP HANA studio.
2. In the *Systems* view, log on to the SAP HANA system.
3. In the *Systems* view, open the context menu for *Security* > *Users*.
4. Choose *New User* and make the required entries.
5. Grant the user Object Privileges for the following database schemas:
   - SAP_SPATIAL
   - SAP_SPATIAL_POSTAL

6. Choose *Deploy* to save the user.

5.3.6 Assign the User for the Content Viewer

Assign the user that you created to view the geo-content.

1. Open a Web browser.
2. Start the *SAP HANA XS Administration Tool*.
   The *SAP HANA XS Administration Tool* is available on the SAP HANA XS Web server at the following URL: `http://<host>:80<instance_number>/sap/hana/xs/admin/` (for example `http://myhost:8050/sap/hana/xs/admin/`).

   > **Note**
   >
   > You need XS Admin rights to assign the user.

3. Choose *XS Administration Tools*.
4. Choose *XS Artifact Administration*.
5. Choose *Application Objects* > *Packages* > *sap* > *hana* > *spatial* > *contentViewer*.
6. Select *query.xssqlcc*.
7. Choose *Edit*.
8. Enter user name and password of the user that you created to view the geo-content.
9. Choose *Save*.

Related Information

Create a User to View Geo-Content [page 192]

5.3.7 Use the Spatial Content Viewer

Different content viewers are provided for the Generalized Administration Boundaries (GAB) and for the Postal Codes (POC).

5.3.7.1 Use the Content Viewer (GAB)

Use the content viewer to view GAB geo content.

> **Note**
>
> If you have not created the database schema SAP_SPATIAL and imported the data yet, the viewer displays the message "SAP_SPATIAL not found. Please create it **now**!". If you choose "**now**", the content viewer

creates the database schema and the tables. You then have to import the data, as described in *Import Geo-Content (GAB)*. The object privileges are automatically granted to the user you have created to view the geo content.

1. Open a Web browser.
2. Start the *Geo Content Viewer*.
   The *Geo Content viewer* tool is available on the SAP HANA XS Web server at the following URL: `http://<host>:80<instance_number>/sap/hana/spatial/contentViewer/index.html`, (for example `http://myhost:8050/sap/hana/spatial/contentViewer/index.html`).
3. Choose *Geo Content Viewer*.
   You can make the following selections:
   - Country
   - Level
   - Area Name
   - Detail Level
   - Zoom Level
   - Jump to polygon (checked/not checked)
   - Clear map (checked/not checked)

   > **Note**
   >
   > If no database schema SAP_SPATIAL has been created, or if the database tables do not contain any data, the viewer displays an error message.
4. Choose *Submit* to perform your selection.

5.3.7.2 Use the Content Viewer (POC)

Use the content viewer to view GAB geo-content.

1. Open a Web browser.
2. Start the *Content Viewer*.
   The *Content Viewer* tool is available on the SAP HANA XS Web server at the following URL: `http://<host>:80<instance_number>/sap/hana/spatial/contentViewer/index.html`, (for example `http://myhost:8050/sap/hana/spatial/contentViewer/index.html`).
3. Choose *Postal Content Viewer*.
   You can make the following selections:
   - Country
   - Level
   - Area Name
   - Zoom Level
   - Jump to polygon (checked/not checked)
   - Clear map (checked/not checked)

> **Note**
>
> If no database schema SAP_SPATIAL_POSTAL has been created, or if the database table does not contain any data, the viewer displays an error message.

4. Choose *Submit* to perform your selection.

Important Disclaimers and Legal Information

Coding Samples

Any software coding and/or code lines / strings ("Code") included in this documentation are only examples and are not intended to be used in a productive system environment. The Code is only intended to better explain and visualize the syntax and phrasing rules of certain coding. SAP does not warrant the correctness and completeness of the Code given herein, and SAP shall not be liable for errors or damages caused by the usage of the Code, unless damages were caused by SAP intentionally or by SAP's gross negligence.

Accessibility

The information contained in the SAP documentation represents SAP's current view of accessibility criteria as of the date of publication; it is in no way intended to be a binding guideline on how to ensure accessibility of software products. SAP in particular disclaims any liability in relation to this document. This disclaimer, however, does not apply in cases of wilful misconduct or gross negligence of SAP. Furthermore, this document does not result in any direct or indirect contractual obligations of SAP.

Gender-Neutral Language

As far as possible, SAP documentation is gender neutral. Depending on the context, the reader is addressed directly with "you", or a gender-neutral noun (such as "sales person" or "working days") is used. If when referring to members of both sexes, however, the third-person singular cannot be avoided or a gender-neutral noun does not exist, SAP reserves the right to use the masculine form of the noun and pronoun. This is to ensure that the documentation remains comprehensible.

Internet Hyperlinks

The SAP documentation may contain hyperlinks to the Internet. These hyperlinks are intended to serve as a hint about where to find related information. SAP does not warrant the availability and correctness of this related information or the ability of this information to serve a particular purpose. SAP shall not be liable for any damages caused by the use of related information unless damages have been caused by SAP's gross negligence or willful misconduct. All links are categorized for transparency (see: http://help.sap.com/disclaimer).

www.sap.com/contactsap