Altibase Application Development

Spatial SQL Reference

Release 6.1.1

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ALTIBASE
PERFORMANCE SOLUTIONS

Altibase Application Development Spatial SQL Reference

Release 6.1.1

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Preface

About This Manual

This manual explains how to use spatial SQL statements and the spatial API with spatial data.

Audience

This manual has been prepared for the following ALTIBASE® HDB™ users:

- Database administrators
- Performance managers
- Database users
- Application developers
- Technical support workers

It is recommended that those reading this manual possess the following background knowledge:

- Basic knowledge in the use of computers, operating systems, and operating system utilities
- Experience in using relational databases and an understanding of database concepts
- Computer programming experience
- Experience in database server, operating system or network administration

Software Environment

This manual has been prepared assuming that ALTIBASE HDB 5.5.1 will be used as the database server.

Organization

This manual is organized as follows:

- Chapter1: Overview of Spatial Data

  This chapter explains fundamental spatial data concepts, defines some related terminology, and describes the features of spatial data that are particular to ALTIBASE HDB.

- Chapter2: Spatial SQL

  This chapter describes the spatial data types, spatial SQL statements, and spatial functions and operators that are supported in ALTIBASE HDB.

- Chapter3: Spatial Application Development

  This chapter describes the Spatial API, which can be used by application developers to access spatial data.

- Appendix A. Limitations on the Use of Spatial Data in ALTIBASE HDB

  This Appendix explains the current limitations on GEOMETRY type columns.

- Appendix B. Spatial Schema

  This Appendix provides a reference for the table schema and data used in the examples throughout this manual.

- Appendix C. Geometry Reference Tables

  This Appendix discusses how to install and use the SPATIAL_REF_SYS and GEOMETRY_COLUMNS meta tables.

Documentation Conventions

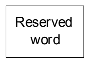
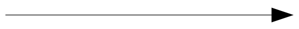
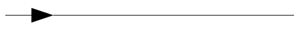
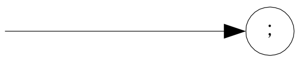
This section describes the conventions used in this manual. Understanding these conventions will make it easier to find information in this manual and in the other manuals in the series.

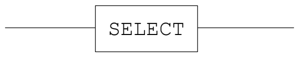
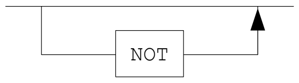
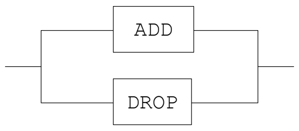
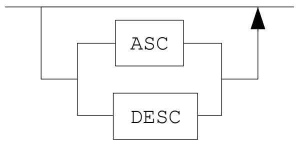
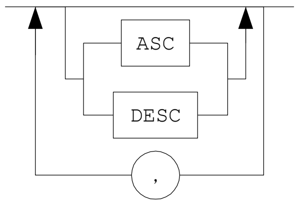
There are two sets of conventions:

- Syntax Diagram Conventions
- Sample Code Conventions

Syntax Diagram Conventions

In this manual, the syntax of commands is described using diagrams composed of the following elements:

Element	Description
	Indicates the start of a command. If a syntactic element starts with an arrow, it is not a complete command.
	Indicates that the command continues to the next line. If a syntactic element ends with this symbol, it is not a complete command.
	Indicates that the command continues from the previous line. If a syntactic element starts with this symbol, it is not a complete command.
	Indicates the end of a statement.

Element	Description
	Indicates a mandatory element.
	Indicates an optional element.
	Indicates a mandatory element comprised of options. One, and only one, option must be specified.
	Indicates an optional element comprised of options.
	Indicates an optional element in which multiple elements may be specified. A comma must precede all but the first element.

Sample Code Conventions

The code examples explain SQL statements, stored procedures, iSQL statements, and other command line syntax.

The following table describes the printing conventions used in the code examples.

Convention	Meaning	Example
[]	Indicates an optional item.	`VARCHAR [(size)] [[FIXED |] VARIABLE]`

Convention	Meaning	Example
`{}`	Indicates a mandatory field for which one or more items must be selected.	`{ ENABLE | DISABLE | COMPILE }`

|	A delimiter between optional or mandatory arguments.	`{ ENABLE | DISABLE | COMPILE }`
		`[ ENABLE | DISABLE | COMPILE ]`

.
.
.
	Indicates that the previous argument is repeated, or that sample code has been omitted.	`iSQL> select e_lastname from employees;`
		`E_LASTNAME`
		`------------------------`
		`Moon`
		`Davenport`
		`Kobain`
		`.`
		`.`
		`.`
		`20 rows selected.`

Other symbols	Symbols other than those shown above are part of the actual code.	`EXEC :p1 := 1;`
		`acc NUMBER(11,2);`

Italics	Statement elements in italics indicate variables and special values specified by the user.	`SELECT * FROM table_name;`
		`CONNECT` *`userID/password`*`;`

Lower Case Letters	Indicate program elements set by the user, such as table names, column names, file names, etc.	`SELECT e_lastname FROM employees;`
Upper Case Letters	Keywords and all elements provided by the system appear in upper case.	`DESC SYSTEM_.SYS_INDICES_;`

Related Reading

For additional technical information, please refer to the following manuals:

- ALTIBASE HDB Installation Guide
- ALTIBASE HDB Getting Started
- ALTIBASE HDB Administrator's Manual
- ALTIBASE HDB Replication Manual
- ALTIBASE HDB SQL Reference
- ALTIBASE HDB Stored Procedures Manual
- ALTIBASE HDB Precompiler User's Manual
- ALTIBASE HDB ODBC Reference
- ALTIBASE HDB Application Program Interface User's Manual

- ALTIBASE HDB iSQL User's Manual
- ALTIBASE HDB Error Message Reference

Online Manuals

Online versions of our manuals (PDF or HTML) are available from the Altibase Download Center (http://atc.altibase.com/).

Altibase Welcomes Your Comments

Please feel free to send us your comments and suggestions regarding this manual. Your comments and suggestions are important to us, and may be used to improve future versions of the manual.

When you send your feedback, please make sure to include the following information:

- The name and version of the manual that you are using
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- Your full name, address, and phone number

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We always appreciate your comments and suggestions.

1 Overview of Spatial Data

This chapter explains fundamental spatial data concepts, defines some related terminology, and describes the features of spatial data that are particular to ALTIBASE HDB.

1.1 The Concept of Spatial Data

1.1.1 Spatial Data

The term “spatial data” refers to the representation of multi-dimensional data, such as points, lines and surfaces, as a list of numbers using a particular coordinate system. A typical example of spatial data is electronic map data, which is used to represent the topography of the real world in a coordinate system.

There are two fundamentally different kinds of spatial data: raster data and vector data.

In a vector model, points define coordinates, and points and lines define the borders between different aspects of the real world. The location of each of these aspects on a map is specified and maintained using a consistent coordinate system. Points, lines and polygons are used to represent coordinates or geographical features that are irregularly distributed in the real world. Lines are used to represent one-dimensional features such as roads, and polygons are used to represent two-dimensional features such as forests and the like.

In a raster model, space is uniformly divided into units known as pixels or cells. The location of a geographical aspect or set of coordinates is defined as a matrix of the pixels and cells in which the aspect or set of coordinates exists. The level of detail that it is possible to represent using a raster model depends on the cell size. The area in each cell cannot be divided any further; that is, all of the attributes that apply to the cell apply uniformly to the entire area within the cell. All cells are identical in size. A raster model typically comprises millions of cells.

The basic units in a vector model are points, lines and polygons. Compared to a raster model, a vector model typically comprises far fewer basic units, and moreover they are not uniform in size. A vector file typically contains thousands of elements, the specific location of each element being defined by one or more consecutive coordinate values. Vector data are easier to manipulate on a computer than raster data because the number of data items is lower, and additionally because the model is easier to adjust for different scales, and yields more precise results when the scale is changed.

The advantages and disadvantages of vector and raster data are shown in the following table:

Table 1-1 Advantages and Disadvantages of Vector and Raster Data

Type	Advantages	Disadvantages
Vector data	• Easier to represent real-world phenomena using data structures • More space-efficient data storage • Easier construction of topological relationships • More precise graphical representation • Enables normalization of locations and attributes	• Complicated data structures • Difficulty overlapping map layers • Different topological form of respective units • Requires expensive equipment • Complicated spatial operations

Type	Advantages	Disadvantages
Raster data	• Makes spatial analysis easier • Simple and clear data structure • Consistent topological form of all units • Easy to overlap map layers • Low-cost technology and rapid development • Easier integration with remote sensing data	• Difficulty constructing topological relationships • Creating a projection is time-consuming • Large amounts of graphical data • Large amounts of data loss upon data compression • Quality of output can be low

1.1.2 The Characteristics of Spatial Data

Spatial data are generally characterized in that they have an indefinite form and are present in large quantities.

Spatial data are said to be indefinite because the content and structure of each spatial object are represented in different ways depending on the type of the spatial object. Further, even two objects of the same type can differ in the number of points, sub-objects, etc. that they comprise, and thus have different forms and lengths.

Spatial data are generally voluminous. The size of many kinds of spatial data can exceed the size of a DBMS data storage page. For example, it can take megabytes (MB) of storage space to store all of the data pertaining to the coastline of a single nation.

Because spatial data has these characteristics, in order to store and manipulate such data efficiently, it is necessary to take into account a number of considerations above and beyond those that apply when dealing with non-spatial data.

1.1.3 Spatial Data Models

There are two conventional spatial data models: the field-based model, in which a space is represented using a series of attributes, and the entity-based model, in which a space is represented as an object (or entity) made up of a set of points. In the field-based model, in which each point in space has one or more attributes, spaces are defined in a manner similar to the use of a continuous function in the Cartesian coordinate system.

However, the field-based model does not take the concept of objects, which is important to the entity-based model, into account. The objects that are usually the most important in the entity-based model include points, which indicate the locations of objects; lines, which indicate two connected points; polylines, which indicate a series of connected lines; and polygons.

The spatial data model that was put forth by the Open Geospatial Consortium (OGC) is a conceptual model. That is, the model was defined in terms of spatial schema, and is an abstract data model rather than one that was intended for use in a particular implementation. This spatial schema forms the basis for the ISO 19107 Spatial Schema standard, and is used in many other OGC specifications, including the OpenGIS Simple Features Specification and the GML Implementation Specification. Spatial schema comprise the geometry package, which is a geometric object model in which is proposed a quantitative technique for describing the spatial characteristics of features that are abstractions of real world features, and the topology package, which provides a model for describing the relationships between geometric objects.

Based on the data models in the abstract specification, the OGC proposed more concrete OpenGIS geometry models in specifications intended for use in practical implementation, such as the OpenGIS Simple Features Specification.

The so-called "Geometry Class" is a root class and an abstract class, and comprises subclasses such as Point, Curve, Surface and GeometryCollection. All geometric objects are defined in relation to the spatial reference system for a defined coordinate space. The actual classes that can be instantiated for use are the Point, LineString, Polygon, GeometryCollection, MultiPoint, MultiLineString and MultiPolygon classes. The rest of the classes are defined as abstract classes.

1.1.4 Spatial Database Systems

A spatial database contains both non-spatial data, typically represented using characters and numbers, and spatial data, which are represented as coordinate values for spatial objects. The geographic objects (usually spatial objects) that are managed in a spatial database have both general and geometric attributes, and include topological information, that is, information about the spatial relationships between objects.

In order to store and manage such spatial data efficiently, a spatial database system must be able to represent and control non-spatial and spatial data at the logical level, and save and manage the data efficiently at the physical level. Therefore, in a spatial database system, it must be possible to represent data logically, and to provide functions for performing spatial operations on spatial data. On the physical level, it must be possible to store data efficiently, and to provide spatial indexing so that spatial data can be accessed efficiently. In addition, it must be possible to efficiently store and manage the topological and general attributes of the spatial data that describe spatial objects.

Spatial data modeling is a technique that defines how spatial data are represented, and must support spatial data types, such as points, lines and surfaces, which can be used to describe real-world features. These spatial data types must be as simple and precise as possible, even when they are used to represent compound spatial objects. Additionally, the use of spatial operators must be supported with all spatial data types.

Spatial operators are those that are used to perform various kinds of spatial analysis, including the analysis of the topological relationships between spatial objects, so that spatial queries can be processed efficiently. For this reason, spatial database systems must support a variety of useful spatial operators.

1.1.5 Spatial Indexes

In general, complex and expensive operations on geometric figures are required in order to process spatial queries. Traditionally, point object operations involve sequential scanning and evaluation to determine which points are included in which objects, which requires frequent and repeated disk access and repetitive assessment of geometric conditions, thereby incurring high processing costs.

Therefore, efficient spatial access methods have been developed in order to reduce the number of objects that actually need to be processed in order to analyze large amounts of stored spatial data. A so-called "spatial access method" is a method in which a spatial index is used to reduce the number of objects that need to be to be processed when processing a spatial query. This method has a time complexity requirement, whereby it must be possible to conduct a search in sub-linear time, and a spatial complexity requirement, whereby the size of a spatial index must be smaller than the size of the indexed data. It also requires dynamic update, by which an object can be added to or removed from a spatial index without entailing a great reduction in performance. A typical spatial data access method that satisfies these requirements is one that uses an R-Tree.

The R-Tree, a height-balanced hierarchical multi-dimensional index structure that was originally designed for use with secondary storage, is a generalization of the B-tree for use with multi-dimensional data spaces. Like a B-tree, an R-Tree has a height-balanced tree structure, meaning that references to objects exist only at terminal nodes. The R-tree, which uses an MBR (Minimum Bounding Rectangle) to represent a spatial object, was designed to reduce the number of nodes that must be visited in order to locate a spatial object. In addition, because R-trees support the dynamic creation of tree structures, update and search operations can be performed on one R-tree at the same time, and there is no need to periodically rearrange the tree structure.

1.1.6 Spatial Reference Systems

In a spatial reference system, mutual associations are drawn between locations in real-world space and spatial objects that are defined on the basis of coordinates in mathematically expressed vector space. Spatial references can be realized using either spatial coordinates or identifiers.

A spatial reference system can be used to define a coordinate system for use with spatial data and the range of geographic area to which each data item refers.

1.1.7 Coordinate Systems

A coordinate system is used to specify the relative location of objects in a given area (for example, all or part of the earth's surface).

A reference system that is used to represent a location on the earth using longitude and latitude values is, together with an ellipsoid that represents the topology of the earth, called a geodetic reference system. In Korea, the Korean Geodetic System, which is based on the Bessel Ellipsoid and on longitude, latitudes and azimuth values determined through astronomical observations, is used. In the meantime, as GPS surveying has become more common, the demand for universal location reference systems that can be used around the world has grown, giving rise to international geodetic systems that can be used the same way all over the world. International survey systems can be classified as ITRF (International Terrestrial Reference Frame), WGS (World Geodetic System) and PZ (Parametry Zemli) systems, depending on the reference and ellipsoid on which they are based.

1.1.7.1 Reference Ellipsoids

A reference ellipsoid is a mathematical representation of the earth. It is a model of the earth that is obtained by rotating the earth around the major and minor axes of an earth-shaped ellipsoid. It is used as a reference model on which to base coordinate values. Various ellipsoids are used around the world, depending on the conditions in each country. One universal ellipsoid that is used around the world is WGS84.

1.1.7.2 Geoids

A geoid is a model of the earth's topology that is based on an imagined average sea level if the ocean were somehow able to penetrate the continents, in which all points are perpendicular to the direction of gravity. In other words, a geoid is an ellipsoid that represents the earth and throughout the surface of which the gravitational pull of the earth is the same, and represents a reference surface 0m above sea level, that is, the average seal level. Although the topology of a geoid is irregular due to differences in the gravitational pull of the earth in different locations, it can be approximated as an ellipsoid having a regular surface.

1.1.7.3 The Datum

A datum, meaning a parameter or a set of parameters that is either used unchanged or as the basis for the calculation of other parameters, is a value (i.e. a point, line, or surface) that is determined based on an observation, and is used as an arbitrary basis for calibrating other observations. A datum consists of longitudinal, latitudinal and azimuth values, and can also be referred to as a “horizontal datum” or “horizontal geodetic datum”. In addition, a datum defines an origin, scale and direction according to the axes of the terrestrial coordinate system, and can be a geodetic datum, a vertical datum or an engineering datum. When a datum is changed, the coordinates of its spatial data are also changed.

1.1.8 Projection

Projection is the process in which three-dimensional information about all or part of the earth is converted to a two-dimensional map by projecting it onto a two-dimensional planar surface, such as a cylinder, a cone, a disk, or the like. Everyday paper maps, as well as the numerical maps that are used for 2D GIS, are created using this projection process. Because shape, distance, direction, scale and area are inevitably distorted during the projection process, it is important to choose a projection method such that the distortion of the area to be projected is minimized.

In Korea, the Transverse Mercator (TM) projection method is used to create topographical maps. In TM projection, a geographic area is projected by bringing it into contact with a cylinder at its center meridian line (e.g. 127 ° East Longitude), which accurately projects the area close to the center meridian line. This projection method is thus frequently used when projecting areas that are extensive in the North-South direction. As one moves further from the center meridian, the distortion of distance, area, scale and direction becomes greater.

1.2 The Characteristics of Spatial Data in ALTIBASE HDB

The way that spatial data are processed in ALTIBASE HDB has the following characteristics:

- Since ALTIBASE HDB features high-performance memory database technology and includes a spatial data model, it is superior not only for existing GIS applications, but also for the next-generation high-speed spatial data processing systems that will be required in the ubiquitous data environment. Moreover, because the spatial model is integrated with a conventional SQL-based RDBMS model, existing DBMS development environments and expertise can be utilized, leading to increased productivity.
- In ALTIBASE HDB, spatial data (i.e. information about the location of a particular area) can be stored, managed and analyzed alongside traditional character and numeric data. This allows users to create, analyze and utilize spatial data such as, for example, information about the locations of office buildings or the size of flooded areas.
- The capability of ALTIBASE HDB has been expanded through the inclusion of a series of advanced spatial data types for representing geometric objects such as points, lines and polygons, as well as numerous functions and features for working with these data types. Because it is so easy to integrate business data and spatial data, users can readily increase the range of business logic in their database applications.

1.3 Spatial Data Terminology

1.3.1 Glossary of Spatial Data Terms

1.3.1.1 Closed

If the start and end points of a LINESTRING object are the same, the spatial object is said to be "closed". In order for a spatial object to be considered to be a closed object, all of the elements that the spatial object comprises must be closed. For a more detailed explanation of this concept, please refer to the description of the ISCLOSED function.

1.3.1.2 Compound Object

Compound objects are those spatial objects that are made up of two or more spatial objects.

1.3.1.3 Dimension

A dimension is the minimum number of real numbers needed to represent the location of any point within a figure, object or space. A point has zero (0) dimensions, a straight line has one dimension, a plane has two dimensions, and a body that has volume has 3 dimensions. Note however that it is also possible to conceive of n-dimensional space, even space with an infinite number of dimensions.

1.3.1.4 Element

An element is any of the common figures that comprise a spatial object. A single spatial object can be constructed from elements such as points, lines or surfaces.

1.3.1.5 Empty

A spatial object in which no elements exist is said to be "empty". Unlike NULL, which implies that the contents of an object are unknown, the empty state indicates definitively that the object contains nothing. For a more detailed explanation of this concept, please refer to the description of the ISEMPTY function.

1.3.1.6 Line

A line can be thought of as a trace of the continuous movement of a point. Next to the point, the line is the simplest figure. It has a location and a length, but no width or thickness. Lines can be straight or curved.

1.3.1.7 Multiple Object

Multiple objects are spatial objects that are made up of more than one spatial object having the same form, and comprise the MultiPoint, which consists only of points, the MultiLineString, which consists only of LineStrings, and the MultiPolygon, which consists only of Polygons.

1.3.1.8 Point

This is the simplest spatial object. It has a location, but no size.

1.3.1.9 Scale

Scale is the ratio between the distance shown in a map or picture and the actual distance in the real world. A scale value is typically expressed as a ratio, which enables the same units to be used for measurements on the map and in the real world. If, for example, the scale of a map is 1:25,000, one real-world unit of distance on the map represents 25,000 times that much distance in the real world. In other words, 1 cm on the map represents 25,000 cm in the real world. Note that the scale of a map describes horizontal distances only, and is not applicable to measurements of area or height.

1.3.1.10 Simple

If the elements of a spatial object do not have unusual points, such as intersections or points of tangency, the spatial object is considered to be "simple". For a more detailed explanation of this concept, please refer to the description of the ISSIMPLE function.

1.3.1.11 Spatial Object

A spatial object comprises both spatial data, which are used to represent the real world, and operations, such as procedures, methods and functions, related to those data.

1.3.1.12 Surface

A surface can be thought of as a trace of the continuous movement of a line, or as a planar form that cannot be described using a single point or line. Surfaces are classified as either planes or curved surfaces depending on whether their profile protrudes from a plane (i.e. a flat surface). Generally, the term "surface" is understood to refer to a planar surface, unless otherwise specified.

2 Spatial SQL

This chapter describes the spatial data types, spatial SQL statements, and spatial functions and operators that are supported in ALTIBASE HDB. Spatial SQL implementation of ALTIBASE HDB conforms with the ISO SQL/MM spatial standards and the Simple Features Specification for SQL proposed by the Open Geospatial Consortium (OGC). Because the Simple Features Specification for SQL is an extension of standard SQL, users who are familiar with SQL can continue to use queries in the way to which they are accustomed when dealing with spatial data.

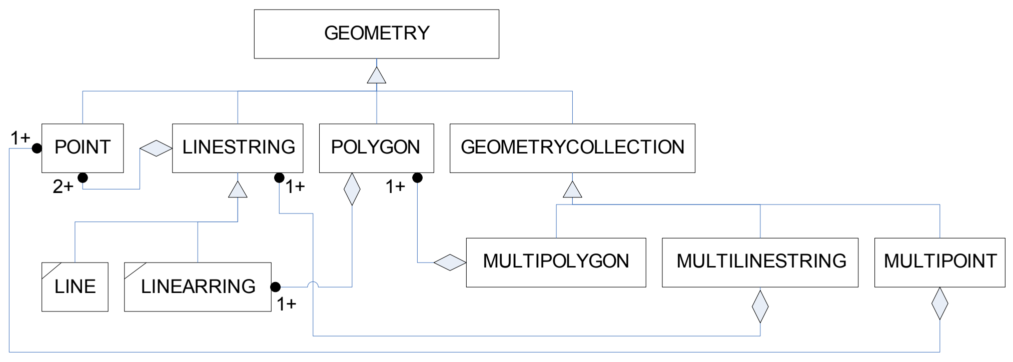
2.1 The GEOMETRY Data Type

An understanding of spatial data types is required in order to manipulate spatial data in a database using spatial SQL. In this section, the spatial data types will be described in detail.

The spatial data type that is currently supported for use with SQL is the GEOMETRY type. The GEOMETRY type comprises the following 7 subtypes:

- POINT
- LINESTRING
- POLYGON
- MULTIPOINT
- MULTILINESTRING
- MULTIPOLYGON
- GEOMETRYCOLLECTION

The following diagram illustrates the relationships between the GEOMETRY data type and the seven subtypes that it comprises.



The GEOMETRY data type, as supported in ALTIBASE HDB, uses X and Y coordinates to represent a POINT, which represents a single point in space, and uses two or more POINTS to represent a LINESTRING. Depending on whether or not it is closed (i.e. on whether the two terminal points are the same), a LINESTRING is referred to either as a LINE[1], which is unclosed, or as a LINEARRING[2], which is closed. The terms LINE and LINEARRING are used to indicate the shape of spatial objects, but do not denote mutually distinct data types.

A POLYGON comprises one or more LINEARRINGS. A MULTIPOINT comprises one or more POINTS, a MULTILINESTRING comprises one or more LINESTRINGS, and a MULTIPOLYGON comprises one or more POLYGONS. Finally, a GEOMETRYCOLLECTION can comprise any of the foregoing objects. In addition to the seven subtypes described above, ALTIBASE HDB also supports the EMPTY type. The EMPTY type can only be created by performing operations on spatial objects. The EMPTY type is returned by an operator whose return type is GEOMETRY when there is nothing to return as the

1. A LINE is an unclosed LINESTRING spatial object. It does not matter whether or not it is simple.
2. A LINEARRING is a closed simple LINESTRING spatial object.

result of an operation.

Classification of Subtypes

The criteria that are used to distinguish the 7 subtypes of the GEOMETRY data type from each other are described in the following [Table 2-1]:

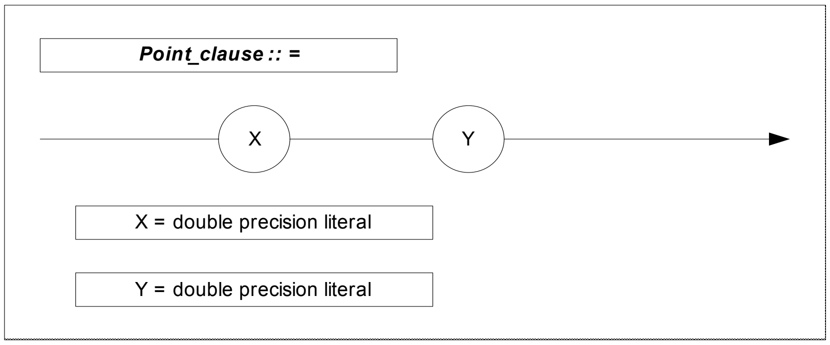
Table 2-1 Subtypes of the Geometry Data Type

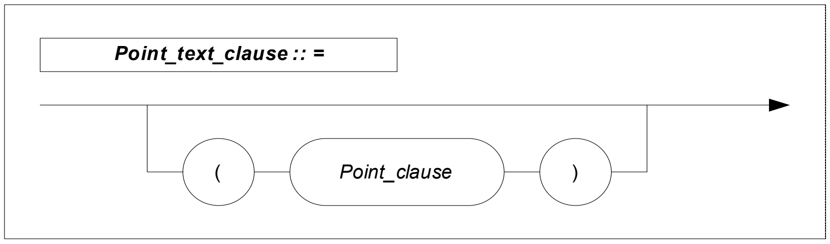
Subtype Name	Constituent Elements	Dimen sions	Simple ?	Closed ?	Interior	Boundary	Exterior
POINT	One POINT	0	O	X	Point	Ø[1]	Surface
LINES-TRING	Two or more POINTs	1	*[2]	*	Line	Ø when closed; both end points when not closed.	Surface
POLYGON	One or more simple closed LINESTRINGs	2	O[3]	O	Surface	A LINESTRING that includes all internal and external rings	Surface
MULTI-POINT	One or more POINTs	0	*	X	Point	Ø	Surface
MULTILIN-ESTRING	One or more LINESTRINGs	1	*	*	Line	Ø when closed; both end points when not closed.	Surface
MULTI-POLYGON	One or more POLYGONs	2	O	O	Surface	A LINESTRING that includes all internal and external rings in all spatial objects that it com-prises	Surface
GEOME-TRYCOL-LECTION	Two or more non-GEOME-TRYCOLLEC-TION type spatial objects	Maxi-mum of 2 dimen-sions	*	*	The inte-rior of all spatial objects	The boundar-ies of all spa-tial objects	Surface

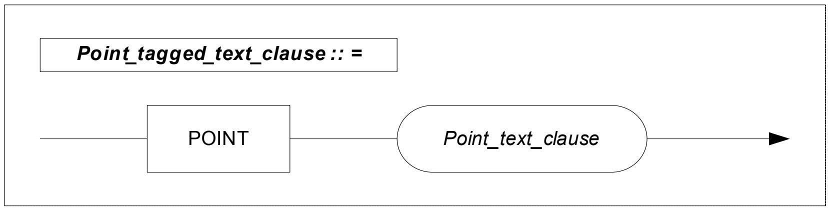
1. This symbol indicates an empty set that contains no results.
2. This symbol means that this subtype may or may not satisfy this condition.
3. A non-simple POLYGON violates the definition of a POLYGON, and thus cannot be inserted.

2.1.1 POINT

2.1.1.1 Syntax







```
POINT( x y )
```

x: The x-coordinate
y: The y-coordinate

2.1.1.2 Description

A POINT represents the location of a single point in a coordinate system. It is a zero-dimensional simple unclosed spatial object that has a single point as its only element. The interior of the spatial object is the POINT itself. It has no boundary. The exterior is the surrounding surface, not including the POINT itself.

2.1.1.3 Characteristics

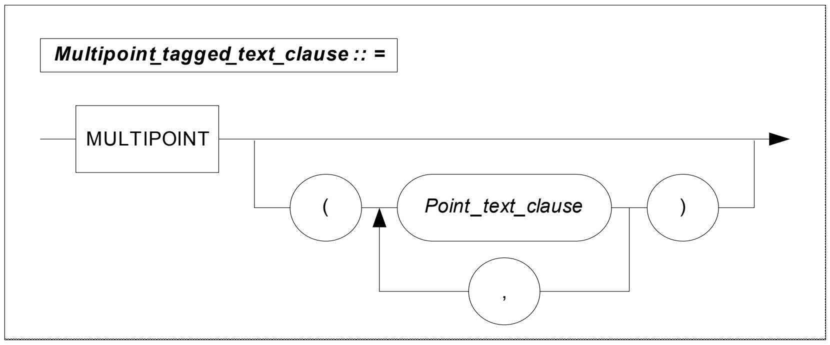
A POINT has x- and y-coordinate values.

2.1.1.4 Example

```
CREATE TABLE building ( id INTEGER, obj GEOMETRY );
INSERT INTO building VALUES (1, GEOMETRY'POINT( 10 10 ) ');
INSERT INTO building VALUES (2, GEOMFROMTEXT('POINT(20 20)'));
INSERT INTO building VALUES (3, POINTFROMTEXT('POINT( 100 100 )'));
```

2.1.2 MULTIPOINT

2.1.2.1 Syntax



MULTIPOINT(x1 y1 [, xn y_n])

x_n: The value of the x-coordinate for the nth point
y_n: The value of the y-coordinate for the nth point

2.1.2.2 Description

A MULTIPOINT is a zero-dimensional unclosed spatial object that has one or more POINTs as its elements. The interior of the spatial object is defined by the points that comprise the MULTIPOINT object. It has no boundary. The exterior is the surrounding surface, not including the POINTs themselves.

2.1.2.3 Characteristics

A MULTIPOINT is considered simple if no two of its points have the same coordinates.

2.1.2.4 Limitation

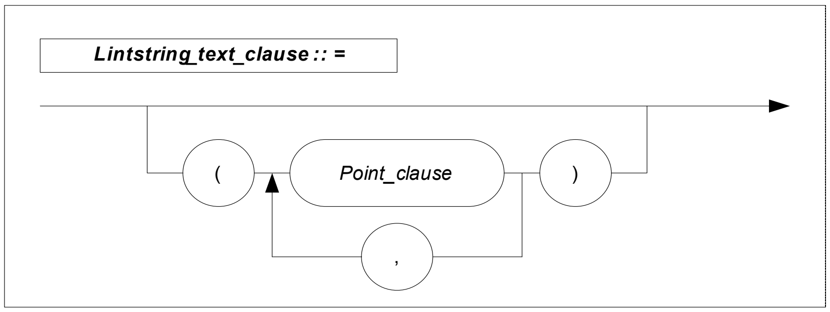
A MULTIPOINT only has points as its constituent elements. These points are not interconnected or ordered.

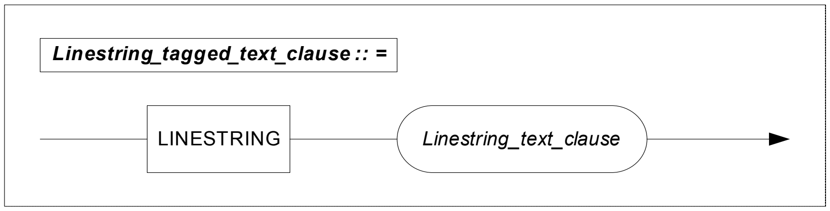
2.1.2.5 Example

```
CREATE TABLE building ( id INTEGER, obj GEOMETRY );
INSERT INTO building VALUES (1, GEOMETRY'MULTIPOINT( 10 10, 20 20 )');
INSERT INTO building VALUES (2, GEOMFROMTEXT('MULTIPOINT( 10 20, 20 30 ) '));
INSERT INTO building VALUES (3, MPOINTFROMTEXT('MULTIPOINT( 100 100, 150 150
)'));
```

2.1.3 LINESTRING

2.1.3.1 Syntax





`LINESTRING(` x_1 y_1 , x_2 y_2 [, x_n y_n])

x_n: The value of the x-coordinate for the nth point
y_n: The value of the y-coordinate for the nth point

2.1.3.2 Description

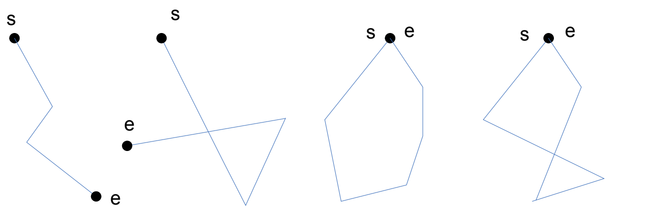
A LINESTRING is a one-dimensional spatial object that has two or more POINTs as its elements. These POINTs are connected with each other via straight lines. The interior of the spatial object is the actual segment that is the LINESTRING. If the segment is closed, the LINESTRING has no boundary, whereas if the segment is not closed, the LINESTRING has the two terminal POINTs as its boundary. The exterior is the surrounding surface, not including the LINESTRING itself.

2.1.3.3 Characteristics

If a LINESTRING is closed and simple, it is called a LINEARRING.

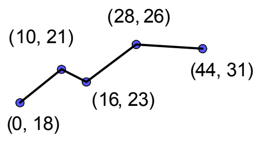
In the following figure, LINESTRING #3 is a LINEARRING, that is, it is a closed and simple LINESTRING, while LINESTRING #4 is not a LINEARRING, even though it is closed, because it is not simple.

Figure 2-1 Examples of LineString

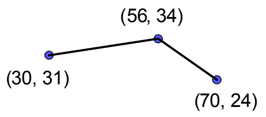


2.1.3.4 Examples

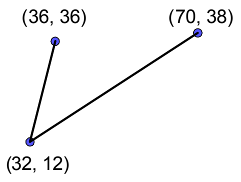
```
CREATE TABLE road ( id INTEGER, obj GEOMETRY );
INSERT INTO road VALUES (1, GEOMETRY'LINESTRING( 0 18, 10 21, 16 23, 28 26, 44
31 )');
```



```
INSERT INTO road VALUES (2, GEOMFROMTEXT('LINESTRING( 30 31, 56 34, 70 24
)'));
```

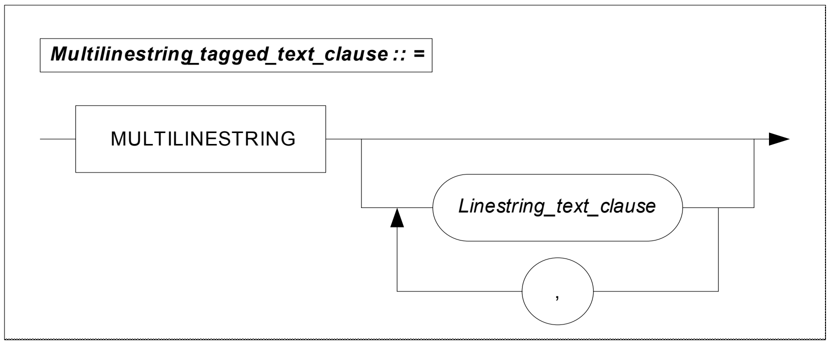


```
INSERT INTO road VALUES (3, LINEFROMTEXT('LINESTRING( 70 38, 32 12, 36 36
)'));
```



2.1.4 MULTILINESTRING

2.1.4.1 Syntax



```
MULTILINESTRING( (x1 y1, x2 y2 [, xn yn ] ) [, (x1 y1, x2 y2 [, xn yn ]
) ] )
```

x_n: The value of the x-coordinate for the nth point
y_n: The value of the y-coordinate for the nth point

2.1.4.2 Description

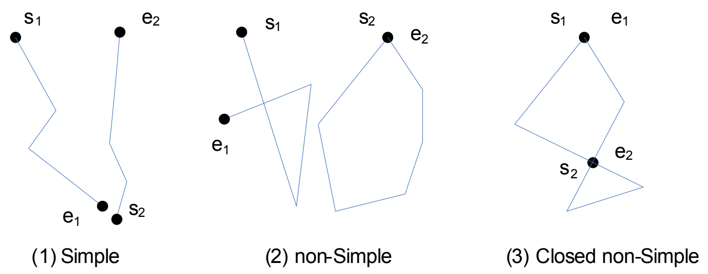
A MULTILINESTRING is a one-dimensional spatial object comprising one or more LINESTRINGS (segments) as its elements. The interior of the spatial object is defined by the segments that comprise the MULTILINESTRING. The boundary of the MULTILINESTRING comprises the two terminal POINTs of any constituent segments that are not closed. If all segments are closed, the MULTILINESTRING has no boundary. The exterior is the surrounding surface, not including the segments.

2.1.4.3 Characteristics

If all of the LINESTRINGs that a MULTILINESTRING comprises are closed, the MULTILINESTRING itself is closed, and has no boundary.

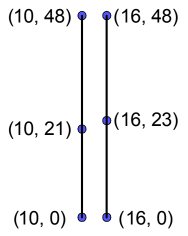
In the following figure, the boundaries of the MultiLineStrings are {s1, e2} for (1), {s1, e1} for (2) and ϕ (i.e. an empty set) for (3).

Figure 2-2 Examples of MultiLineString

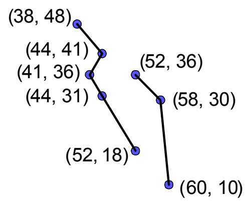


2.1.4.4 Example

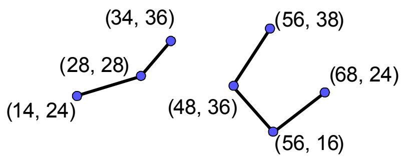
```
CREATE TABLE road ( id INTEGER, obj GEOMETRY );
INSERT INTO road VALUES (1, GEOMETRY'MULTILINESTRING(( 10 48, 10 21, 10 0 ),
(16 0, 16 23, 16 48) )');
```



```
INSERT INTO road VALUES (2, GEOMFROMTEXT('MULTILINESTRING(( 38 48, 44 41, 41
36, 44 31, 52 18 ), ( 60 10, 58 30, 52 36))'));
```

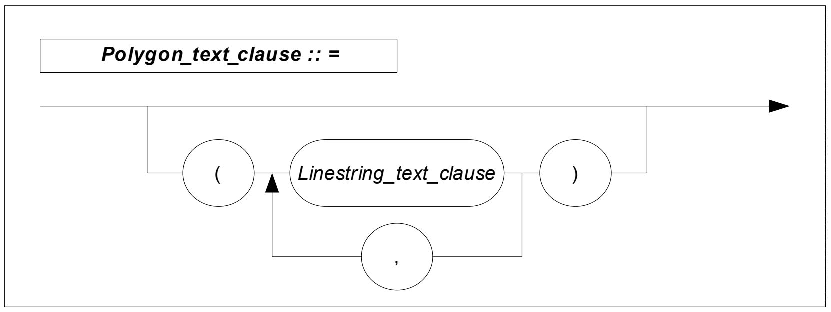


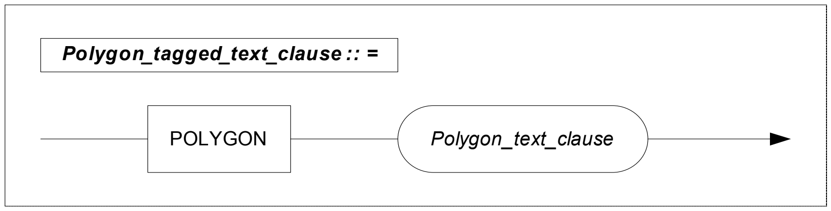
```
INSERT INTO road VALUES (3, MLINEFROMTEXT('MULTILINESTRING(( 14 24, 28 28, 34
36 ), ( 56 38, 48 36, 56 16, 68 24 ))'));
```



2.1.5 POLYGON

2.1.5.1 Syntax





POLYGON((x_1 y_1, x_2 y_2, x_3 y_3 [, x_n y_n])[, (x_1 y_1, x_2 y_2, x_3 y_3 [, x_n y_n])])

x_n: The value of the x-coordinate for the nth point
y_n: The value of the y-coordinate for the nth point

2.1.5.2 Description

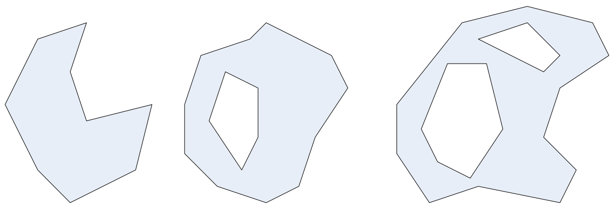
A POLYGON is a spatial object that represents a surface in a space. It is a two-dimensional spatial object comprising one or more simple closed LINESTRINGs. A POLYGON must also be simple and closed. The interior of the spatial object is the surface defined by the POLYGON. The exterior is the surrounding surface, not including the POLYGON itself. The boundary consists of any exterior rings that comprise the POLYGON. For example, the boundary of a POLYGON that comprises an exterior ring and an interior ring is the LINESTRINGs that respectively define the exterior ring and the interior ring.

2.1.5.3 Characteristics

- A POLYGON is defined as a surface that has one exterior boundary and 0 (zero) or more interior boundaries.
- A POLYGON is a simple closed spatial object.
- The boundary of a POLYGON consists of LINEARRINGs that form interior and exterior boundaries.

The following figure shows representative examples of POLYGONs.

Figure 2-3 Examples of Polygon



2.1.5.4 Requirements for a Polygon

No two closed LINESTRINGs that form the boundary of a POLYGON can intersect or be tangent to each other. They can only meet each other at a single point, and both LINESTRINGs must have POINTs defined where they meet.

```
∀ P ∈ Polygon, ∀ c1, c2 ∈ P.Boundary(), c1 ≠ c2, ∀p, q ∈ Point,
p, q ∈ c1, p ≠ q, [p ∈ c2 ⇒ q ∈ c2]
```

The interior ring must not be connected to the exterior of a Polygon.

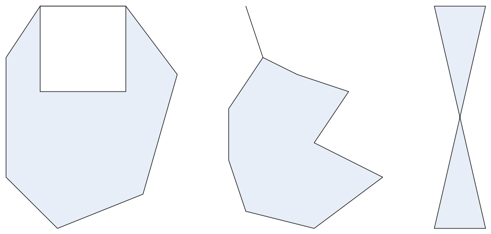
A Polygon cannot have a segment protruding from it, nor can it have within it a point that is not part of a closed LINESTRING.

```
∀ P ∈ Polygon, P = Closure(Interior(P))
```

The entire interior of a POLYGON must form a single interconnected surface.

The following figure shows objects that do not satisfy the above requirements, and thus cannot be represented as POLYGONS.

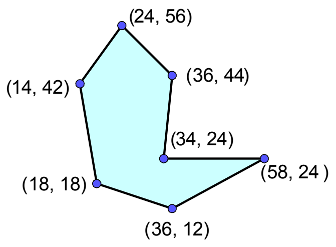
Figure 2-4 Examples of spatial objects that cannot be represented as Polygon.



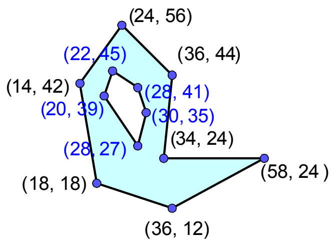
2.1.5.5 Examples

The following are some examples of INSERT SQL statements and the resultant POLYGONs.

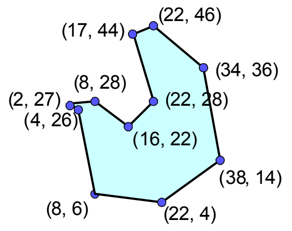
```
CREATE TABLE lake ( id INTEGER, obj GEOMETRY );
INSERT INTO lake VALUES (1, GEOMETRY'POLYGON(( 14 42, 18 18, 36 12, 58 24, 34
24, 36 44, 24 56, 14 42 ))');
```



```
INSERT INTO lake VALUES (2, GEOMFROMTEXT('POLYGON(( 14 42, 18 18, 36 12, 58
24, 34 24, 36 44, 24 56, 14 42 ), ( 20 39, 28 27, 30 35, 28 41, 22 45, 20 39
))'));
```

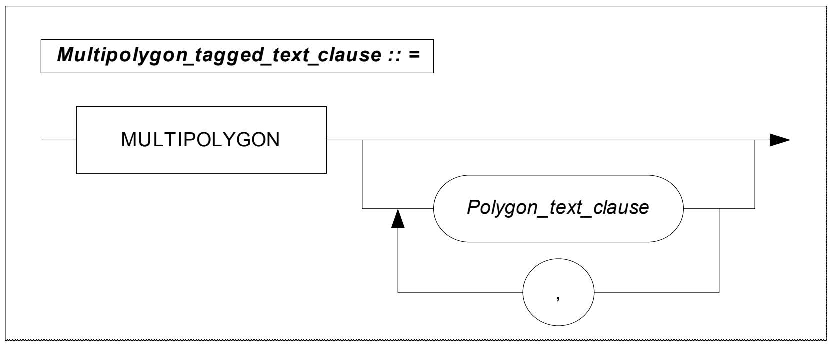


```
INSERT INTO lake VALUES (3, POLYFROMTEXT('POLYGON(( 8 6, 22 4, 38 14, 34 36,
22 46, 17 44, 22 28, 16 22, 8 28, 2 27, 4 26, 8 6 ))'));
```



2.1.6 MULTIPOLYGON

2.1.6.1 Syntax



```
MULTIPOLYGON( ( (x1 y1, x2 y2, x3 y3 [, xn yn ]) [, (x1 y1, x2 y2, x3
y3 [, xn yn ] ) ] ) [ ( (x1 y1, x2 y2, x3 y3 [, xn yn ]) [, (x1 y1, x2
y2, x3 y3 [, xn yn ] ) ] ) ] ) )
```

2.1.6.2 Description

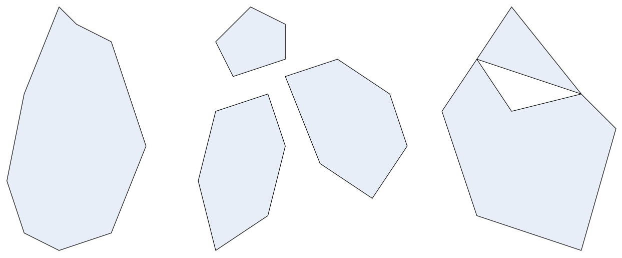
A MultiPolygon is a collection class that comprises Polygons as its constituent elements. It is a two-dimensional simple unclosed spatial object comprising one or more POLYGONs as its elements. The interior of the spatial object is the surfaces defined by the constituent POLYGONs. The exterior is the surrounding surface, not including the POLYGONs. Its boundary is defined by the LINESTRINGs that define exterior and interior rings of the constituent POLYGONs.

2.1.6.3 Characteristics

- A MULTIPOLYGON is a simple closed spatial object.
- The boundary of a MULTIPOLYGON is a set of LINESTRINGs.

The following figure shows examples of MULTIPOLYGONs. The third MultiPolygon doesn't comprise an exterior Polygon and an interior Polygon, but two Polygons, one of which is above the other.

Figure 2-5 Examples of MULTIPOLYGONs



2.1.6.4 Limitations

- The intersection of the interiors of two Polygons that comprise a MultiPolygon is an empty set.

  ```
  ∀ M ∈ MultiPolygon, ∀ Pi, Pj ∈ M.Geometries(), i ≠ j, Interior(Pi) ∩
  Interior(Pj) = Ø
  ```

- Two LINESTRINGs that form all or part of the boundary of a MULTIPOLYGON can only meet each other at individual POINTS, and both LINESTRINGs must have POINTs defined where they meet.

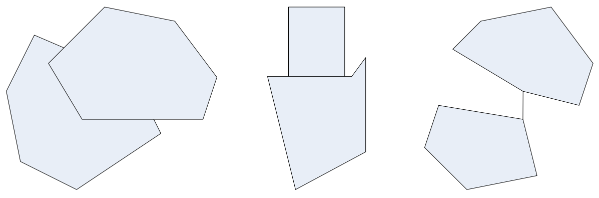
  ```
  ∀ M ∈ MultiPolygon, ∀ Pi, Pj ∈ M.Geometries(), ∀ ci ∈ Pi.Boundar-
  ies(), cj ∈ Pj.Boundaries() ,ci ∩ cj = {p1, ....., pk | pi ∈ Point, 1
  <= i <= k}
  ```

- A MULTIPOLYGON cannot have a segment protruding from it, nor can it have within any of its constituent POLYGONs a point that is not part of a closed LINESTRING.

  ```
  ∀ M ∈ MultiPolygon, M = Closure(Interior(M))
  ```

The following figure shows objects that do not satisfy the above criteria, and thus cannot be represented as MULTIPOLYGONs.

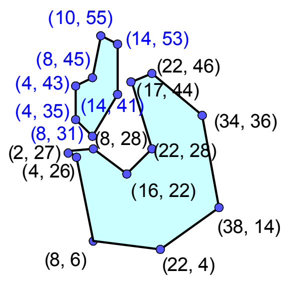
Figure 2-6 Examples of spatial objects that cannot be represented as MULTIPOLYGONs



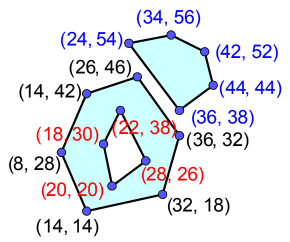
2.1.6.5 Examples

The following are some examples of INSERT SQL statements and the resultant MULTIPOLYGONs.

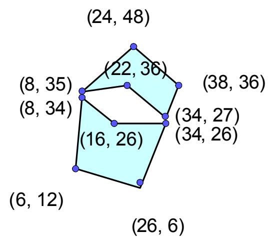
```
CREATE TABLE lake ( id INTEGER, obj GEOMETRY );
INSERT INTO lake VALUES (1, GEOMETRY'MULTIPOLYGON(((8 6, 22 4, 38 14, 34 36,
22 46, 17 44, 22 28, 16 22, 8 28, 2 27, 4 26, 8 6 )), (( 4 35, 8 31, 14 41, 14
53, 10 55, 8 45, 4 43, 4 35 )))');
```



```
INSERT INTO lake VALUES (2, GEOMFROMTEXT('MULTIPOLYGON((( 8 28, 14 14, 32 18,
36 32, 26 46, 14 42, 8 28 ), ( 18 30, 20 20, 28 26, 22 38, 18 30 )), (( 24 54,
36 38, 44 44, 42 52, 34 56, 24 54 )))'));
```

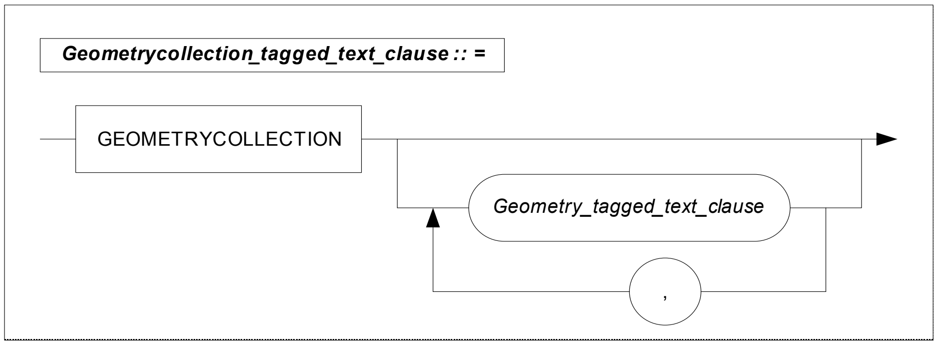


```
INSERT INTO lake VALUES (3, MPOLYFROMTEXT('MULTIPOLYGON((( 8 34, 6 12, 26 6,
34 26, 16 26, 8 34 )), (( 8 35, 22 36, 34 27, 38 36, 24 48, 8 35 )))'));
```



2.1.7 GEOMETRYCOLLECTION

2.1.7.1 Syntax


Geometrycollection_tagged_text_clause : : =
GEOMETRYCOLLECTION
Geometry_tagged_text_clause
,

```
GEOMETRYCOLLECTION( Point | LineString | Polygon | MultiPoint | Mul-
tiLineString | MultiPolygon, [Point | LineString | Polygon | Multi-
Point | MultiLineString | MultiPolygon ] )
```

- Point: This is a POINT type object
- LineString: This is a LINESTRING type object
- Polygon: This is a POLYGON type object
- MultiPoint: This is a MULTIPOINT type object
- MultiLineString: This is a MULTILINESTRING type object
- MultiPolygon: This is a MULTIPOLYGON type object

2.1.7.2 Description

A GEOMETRYCOLLECTION is a set of one or more spatial objects.

A GEOMETRYCOLLECTION is a spatial object that has a maximum of two dimensions and comprises two or more spatial objects as its elements. These elements cannot themselves be other GEOMETRY-COLLECTION type objects, meaning that the GEOMETRYCOLLECTION type cannot be nested. The interior of the spatial object is the collective interiors of all of the constituent spatial objects, and its boundary is the boundaries of all spatial objects in it. The exterior is the surrounding surface, not including the elements that the GEOMETRYCOLLECTION comprises.

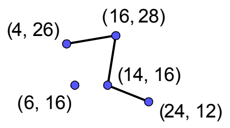
2.1.7.3 Limitations

The criteria for a GEOMETRYCOLLECTION object depend on the criteria for each of the spatial objects that comprise the GEOMETRYCOLLECTION.

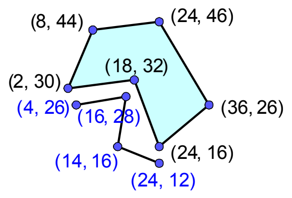
2.1.7.4 Examples

The following are some examples of INSERT SQL statements and the resultant GEOMETRYCOLLEC-TION type objects.

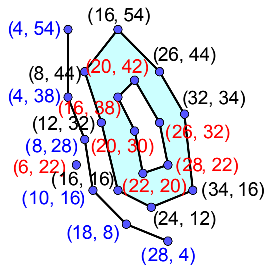
```
CREATE TABLE test1 ( id INTEGER, obj GEOMETRY );
INSERT INTO test1 VALUES (1, GEOMETRY'GEOMETRYCOLLECTION( POINT( 6 16 ), LIN-
ESTRING( 4 26, 16 28, 14 16, 24 12 ))');
```



```
INSERT INTO test1 VALUES (2, GEOMFROMTEXT('GEOMETRYCOLLECTION( LINESTRING( 4
26, 16 28, 14 16, 24 12 ), POLYGON(( 2 30, 18 32, 24 16, 36 26, 24 46, 8 44,
2 30 )))'));
```



```
INSERT INTO test1 VALUES (3, GEOMCOLLFROMTEXT ('GEOMETRYCOLLECTION (POINT( 6
22 ), LINESTRING( 4 54, 4 38, 8 28, 10 16, 18 8, 28 4 ), POLYGON(( 8 44, 12
32, 16 16, 24 12, 34 16, 32 34, 26 44, 16 54, 8 44 ), ( 16 38, 20 30, 22 20,
28 22, 26 32, 20 42, 16 38 )))'));
```



2.2 The Format of the GEOMETRY Data Type

In ALTIBASE HDB, the GEOMETRY data type can be represented using any of the three ways described below:

- WKT (Well-Known Text): This is a text format in which a spatial object is represented using letters and numbers so that it can be processed directly within SQL applications and the like. The WKT format was designed to have a simple grammar and be easy to read.
- WKB (Well-Known Binary): This is a format in which a spatial object is represented in binary form. It was designed so that it would be efficient to transfer and perform operations on GEOMETRY type data.
- Internal Binary: This is the format in which data are stored within ALTIBASE HDB. It was designed so that it would be efficient to manage and perform spatial operations on spatial data. Data saved in the internal binary format of ALTIBASE HDB can only be manipulated using the C API. The C API will be described in Chapter3: Spatial Application Development.

2.2.1 WKT (Well-Known Text)

WKT (Well-known Text) is a format for representing a spatial object using letters and numbers. WKT is defined using Backus-Naur Form (BNF) notation, as shown below:

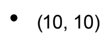
```
<Geometry Tagged Text> : =
<Point Tagged Text>
| <LineString Tagged Test>
| <Polygon Tagged Test>
| <MultiPoint Tagged Test>
| <MultiLineString Tagged Test>
| <MultiPolygon Tagged Test>
| <GeometryCollection Tagged Test>
<Point Tagged Test> : = POINT <Point Text>
<LineString Tagged Text> : = LINESTRING <LineString Test>
<Polygon Tagged Text> := POLYGON <Polygon Text>
<Multipoint Tagged Text> : = MULTIPOINT (Multipoint Text>
<MultiLineString Tagged Text> : = MULTILINESTRING (MultiLineString Text>
<MultiPolygon Tagged Text> : = MULTIPOLYGON <MultiPolygon Text>
<GeometryCollection Tagged Test> : = GEOMETRYCOLLECTION <GeometryCollection
Text>
<Point Text> : = ( <Point> )
<Point> : = <x> <y>
<x> : = double precision literal
<y> : = double precision literal
<LineString Text> : = ( <Point > {, <Point > } * )
<Polygon Text> : = ( <LineString Text > {, < LineString Text > } * )
<MultiPoint Text> : = ( <Point Text > {, <Point Text > } * )
<MultiLineString Text> : = ( <LineString Test > {, < LineString Text > } * )
<MultiPolygon Text> : = ( < Polygon Text > {, < Polygon Text > } * )
<GeometryCollection Text> : = ( <Geometry Tagged Text > {, <Geometry Tagged
Text> } * )
```

2.2.1.1 Examples

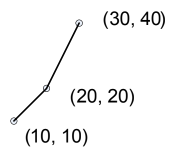
Format	WKT Expression	Description
Point	POINT (10 10)	A Point
LineString	LINESTRING (10 10, 20 20, 30 40)	A LineString having three points
Polygon	POLYGON ((10 10, 10 20, 20 20, 20 15, 10 10))	A Polygon consisting of one exterior ring and zero interior rings
MultiPoint	MULTIPOINT (10 10, 20 20)	A MultiPoint comprising two Points
MultiLineS-tring	MULTILINESTRING ((10 10, 20 20), (15 15, 30 15))	A MultiLineString comprising two LineS-trings
MultiPolygon	MULTIPOLYGON (((10 10, 10 20, 20 20, 20 15, 10 10)), ((60 60, 70 70, 80 60, 60 60)))	A MultiPolygon comprising two Polygons
GeometryCol-lection	GEOMETRYCOLLECTION (POINT (10 10), POINT (30 30), LINESTRING (15 15, 20 20))	A collection of spatial objects comprising two points and one LineString

The examples of spatial data shown in WKT format above are shown graphically below:

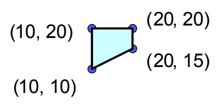
- Point



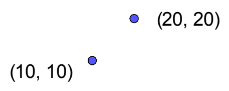
- LineString



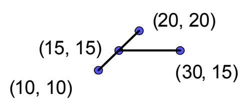
- Polygon



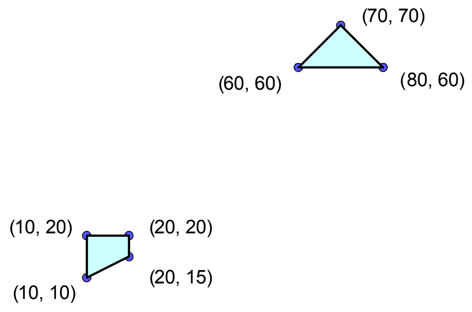
- MultiPoint



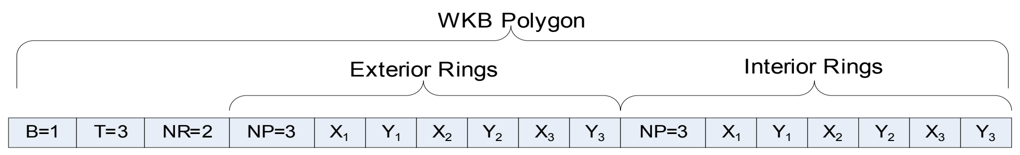
- MultiLineString



- MultiPolygon



- GeometryCollection



Byte Order NDR (B=1), Polygon Type (T=3) with 2 Linear Rings (NR=2) having 3 Points (NP=3)

2.2.2 WKB (Well-Known Binary)

WKB (Well-known Binary) is a format in which a spatial object is represented in binary form.

This is the binary form put forth in the OGC Standards. It is used to ensure data compatibility between heterogeneous spatial DBMSs.

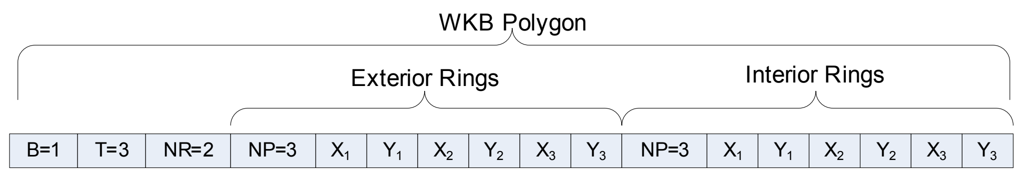
The WKB format represents a spatial object using UNSIGNED INTEGER and DOUBLE type numerical data. It is encoded using either NDR or XDR, which differ from each other with respect to byte order (Endian).

The byte order of XDR, which stands for “External Data Representation”, is Big Endian, whereas that of NDR, which stands for “Network Data Representation”, is Little Endian. The UNSIGNED INTEGER data type is a 32-bit data type whose value can be a positive integer in the range from 0 to 4294967295. DOUBLE is a 64-bit double precision data type that follows the IEEE 754 double precision format for representing double precision numbers.

The WKB representation of spatial objects is shown below. The basic type is the POINT, which is represented using two DOUBLE type numbers. The representations of all other kinds of spatial objects are based on the definition of the POINT, or on the definitions of other spatial objects that are themselves defined based on the definition of the POINT.

```
/ / Basic Type definitions
/ / byte : 1 byte
/ / unit32 : 32 bit unsigned integer (4 bytes)
/ / double : double precision number (8 bytes)
/ / Building Blocks : Point, LinearRing

Point {
double x ;
double y ;
} ;

LinearRing {
unit32 numPoints ;
Point points{numPoints} ;
}

enum wkbGeometryType {
wkbPoint = 1,
wkbLineString = 2,
wkbPolygon = 3,
wkbMultiPoint = 4,
wkbMultiLineString = 5,
wkbMultiPolygon = 6,
wkbGeometryCollection = 7
} ;

enum wkbByteorder {
wkbXDR = 0 ;/ / Big Endian
wkbNDR = 1 ;/ / Little Endian
} ;

WKBPoint {
byte byteOrder ;
unit32 wkbType ; / / 1
Point point ;
}

WKBLineString {
byte byteOrder ;
unit32 wkbType ; / / 2
unit32 numPoints ;
Point points{numPoints} ;
}

WKBPolygon {
byte byteOrder ;
unit32 wkbType ; / / 3
unit32 numRings ;
LinearRing rings{numRings} ;
}

WKBMultiPoint {
byte byteOrder ;
unit32 wkbType ; / / 4
unit32 num_wkbPoints ;
WKBPoint WKBpoints{num_wkbPoints} ;
}

WKBMultiLineString {
byte byteOrder ;
unit32 wkbType ; / / 5
unit32 num_wkbLineStrings ;
WKBLineString WKBLineStrings{num_wkbLineStrings} ;
}

WKBMultiPolygon {
byte byteOrder ;
unit32 wkbType ; / / 6
unit32 num_wkbPolygons ;
WKBPolygon wkbPolygons{num_wkbPolygons} ;
}

WKBGeometry {
union {
WKBPoint point ;
WKBLineString linestring ;
WKBPolygon polygon ;
WKBGeometryCollection collection ;
WKBMultiPoint mpoint ;
WKBMultiLineString mlinestring ;
WKBMultiPolygon mpolygon ;
}
} ;

WKBGeometryCollection {
byte byte_order ;
unit32 wkbType ; / / 7
unit32 num_wkbGeometries ;
WKBGeometry wkbGeometries{num_wkbGeometries} ;
} ;
```

2.2.2.1 Example of WKB Structure



Byte Order NDR (B=1), Polygon Type (T=3) with 2 Linear Rings (NR=2) having 3 Points (NP=3)

In this example, the Little Endian (NDR) byte order is used, and a POLYGON with one exterior ring and one interior ring is described. Each of the exterior and interior rings consists of three points.

2.3 DDL For Geometry

The syntax and features of the SQL DDL statements that are used to create database objects will now be described with reference to examples. In this section, a detailed description will be provided only of the aspects that are directly related to the use of the GEOMETRY data type. For more general and complete information on the syntax and features of the SQL statements described below, please refer to the *ALTIBASE HDB SQL Reference*.

2.3.1 CREATE TABLE

2.3.1.1 Syntax[1]

```
CREATE TABLE table_name (column_name GEOMETRY [(precision)] );
```

2.3.1.2 Description

precision

This is used to specify the maximum size of the column to be created. The allowable range is from 16 bytes to 100 megabytes. If it is not specified, the column will have the default size, which is 32,000 bytes. Any attempt to INSERT a spatial object that occupies more space than the precision specified here will fail.

2.3.1.3 Limitations

The following limitations apply to the use of the GEOMETRY column:

- A GEOMETRY column cannot be used as a primary key.
- The UNIQUE constraint cannot be specified for a GEOMETRY column.

2.3.1.4 Examples

- Create a table having an *id* column, whose type is INTEGER, and an *obj* column, whose type is GEOMETRY. (Here, the maximum size of the GEOMETRY column will be the default maximum size.)

```
iSQL> CREATE TABLE t1 ( id INTEGER, obj GEOMETRY );
Create success.
```

- Create a table having an *id* column, whose type is INTEGER, as well as a GEOMETRY column named *obj* having a maximum size of 128 bytes.

```
iSQL> CREATE TABLE t2 ( id INTEGER, obj GEOMETRY (128) );
Create success.
```

1. For more information on the CREATE TABLE statement, please refer to the explanation in the *SQL Reference*.

2.3.2 CREATE INDEX

2.3.2.1 Syntax[1]

```
CREATE INDEX index_name ON table_name ( column_name ) [INDEXTYPE IS
RTREE];
```

2.3.2.2 Description

When an index is created on the basis of a GEOMETRY type column, there is no need to specify INDEXTYPE, as an R-Tree index will be automatically created. If INDEXTYPE set to BTREE, an error will occur.

2.3.2.3 Limitations

The use of a GEOMETRY type column as the basis for the creation of an index is subject to the following limitations:

- The UNIQUE option cannot be specified for the index.
- The use of a GEOMETRY type column in a so-called "compound index" is not supported. That is, if an index is created on the basis of two or more columns, none of those columns can be a GEOMETRY type column.
- R-Tree indexes can be based on GEOMETRY type columns only.

2.3.2.4 Examples

- Create the R-Tree index *idx_t1* based on the GEOMETRY type column *obj* in table *t1*.

```
iSQL> CREATE INDEX idx_t1 ON t1 ( obj );
Create success.
```

- Create the R-Tree index *idx_t2* based on the GEOMETRY type column *obj* in table *t2*.

```
iSQL> CREATE INDEX idx_t2 ON t2 ( obj ) INDEXTYPE IS RTREE;
Create success.
```

- The following example shows that an attempt to create an R-Tree index on the basis of a non-GEOMETRY type column will fail.

```
iSQL> CREATE INDEX idx_t3 ON t3 ( id ) INDEXTYPE IS RTREE;
[ERR-31237 : cannot create index in the datatype.]
```

1. For more information on the CREATE INDEX statement, please refer to the explanation in the *SQL Reference*.

2.4 Spatial Functions in ALTIBASE HDB

This section describes the spatial functions that are supported for use in ALTIBASE HDB.

2.4.1 Types of Spatial Functions

The spatial functions that are available in ALTIBASE HDB can be broadly classified as follows based on their characteristics:

- Basic Functions: These functions are used to check the values of attributes, both general attributes and those specific to the GEOMETRY type.
- Spatial Analysis Functions: These functions are used to perform various analytical tasks on GEOMETRY type data.
- Spatial Object Creation Functions: These functions are used to create spatial objects in WKT or WKB format, rather than in the internal storage format of ALTIBASE HDB.

2.5 Basic Spatial Functions

2.5.1 DIMENSION

2.5.1.1 Syntax

```
DIMENSION( GEOMETRY )
```

2.5.1.2 Description

This function returns the minimum number of dimensions that are needed in order to represent a spatial object.

This function returns -1 if the spatial object is EMPTY, 0 for POINT and MULTIPOINT type objects, 1 for LINESTRING and MULTILINESTRING type objects, and 2 for POLYGON and MULTIPOLYGON type objects.

If this function is executed on a GEOMETRYCOLLECTION type object comprising several different types of spatial objects as its constituent elements, it returns the number of dimensions needed to represent the constituent element having the largest number of dimensions.

2.5.1.3 Return Type

INTEGER

2.5.1.4 Example

```
iSQL> SELECT F1, DIMENSION(F2) FROM TB1;
F1            DIMENSION(F2)
-----------------------------
100
101            0
102            0
103            1
104            1
105            2
106            2
107            2
108            1
109           -1
10 rows selected.
```

2.5.2 GEOMETRYTYPE

2.5.2.1 Syntax

```
GEOMETRYTYPE( GEOMETRY )
```

2.5.2.2 Description

This function returns the name of the subtype of a GEOMETRY object.

The subtype name is one of the following, returned in string form:

- NULL
- EMPTY[1]
- POINT
- LINESTRING
- POLYGON
- MULTIPOINT
- MULTILINESTRING
- MULTIPOLYGON
- GEOMETRYCOLLECTION

2.5.2.3 Return Type

VARCHAR

2.5.2.4 Example

```
iSQL> SELECT F1, GEOMETRYTYPE(F2) FROM TB1;
F1            GEOMETRYTYPE(F2)
-------------------------------------------------
100
101           POINT
102           MULTIPOINT
103           LINESTRING
104           MULTILINESTRING
105           POLYGON
106           POLYGON
107           MULTIPOLYGON
108           GEOMETRYCOLLECTION
109           EMPTY
10 rows selected.
```

2.5.3 ENVELOPE

2.5.3.1 Syntax

```
ENVELOPE( GEOMETRY )
```

1. The EMPTY subtype is created only as a result of performing operations on spatial objects, and cannot be explicitly created by the user.

2.5.3.2 Description

This function returns the Minimum Bounding Rectangle (MBR) for a spatial object in the form of a POLYGON. This POLYGON is defined by the corner points of the bounding rectangle, namely (MINX, MINY), (MAXX, MINY), (MAXX, MAXY), (MINX, MAXY) and (MINX, MINY).

2.5.3.3 Return Type

GEOMETRY

2.5.3.4 Example

```
iSQL> SELECT F1, ASTEXT(ENVELOPE(F2)) FROM TB1 WHERE GEOMETRYTYPE(F2) =
'POLYGON';
F1
-------------
ASTEXT(ENVELOPE(F2))
-------------------------------------------------
105
POLYGON((0 0, 0 10, 10 10, 10 0, 0 0))
106
POLYGON((3 5, 3 9, 7 9, 7 5, 3 5))
2 rows selected.
```

2.5.4 ASTEXT

2.5.4.1 Syntax

```
ASTEXT( GEOMETRY[,precision] )
```

2.5.4.2 Description

This function returns a spatial object in WKT (Well-Known Text) format.

The precision argument can be used to set the maximum length of the WKT. The default value is 256 bytes. This argument can be set anywhere in the range from 32 to 32,000.

2.5.4.3 Return Type

VARCHAR

2.5.4.4 Example

```
iSQL> SELECT F1, ASTEXT(F2) FROM TB1;
F1
-------------
ASTEXT(F2)
-------------------------------------------------100
101
POINT(1 1)
102
MULTIPOINT(1 1, 2 2)
```

```
103
LINESTRING(1 1, 2 2)
104
MULTILINESTRING((1 1, 2 2), (3 3, 4 5))
105
POLYGON((0 0, 10 0, 10 10, 0 10, 0 0))
106
POLYGON((3 5, 7 5, 7 9, 3 9, 3 5), (4 6, 4 8, 6 8, 6 6, 4 6))
107
MULTIPOLYGON(((1 1, 2 1, 2 2, 1 2, 1 1)), ((3 3, 3 5, 5 5, 5 3, 3 3)))
108
GEOMETRYCOLLECTION( POINT(1 1) , LINESTRING(2 2, 3 3) )
109
EMPTY
10 rows selected.
```

2.5.5 ASBINARY

2.5.5.1 Syntax

```
ASBINARY( GEOMETRY )
```

2.5.5.2 Description

This function returns a spatial object in WKB (Well-Known Binary) format.

2.5.5.3 Return Type

BINARY

2.5.5.4 Example[1]

```
iSQL> SELECT F1, ASTEXT(GEOMFROMWKB(ASBINARY(F2))) FROM TB1;
F1
--------------
ASTEXT(GEOMFROMWKB(ASBINARY(F2)))
--------------------------------------------------100
101
POINT(1 1)
102
MULTIPOINT(1 1, 2 2)
103
LINESTRING(1 1, 2 2)
104
MULTILINESTRING((1 1, 2 2), (3 3, 4 5))
105
POLYGON((0 0, 10 0, 10 10, 0 10, 0 0))
106
POLYGON((3 5, 7 5, 7 9, 3 9, 3 5), (4 6, 4 8, 6 8, 6 6, 4 6))
107
```

1. Because the ASBINARY function returns a GEOMETRY object in binary form, its content cannot be viewed in a console window. Accordingly, the ASTEXT function has been provided for use in converting a GEOMETRY object to WKT format so that it can be output in a readily understandable form.

```
MULTIPOLYGON(((1 1, 2 1, 2 2, 1 2, 1 1)), ((3 3, 3 5, 5 5, 5 3, 3 3)))
108
ASBINARY
109

10 rows selected.
```

2.5.6 ISEMPTY

2.5.6.1 Syntax

```
ISEMPTY( GEOMETRY )
```

2.5.6.2 Description

Returns 1 if a spatial object does not have any coordinates. Otherwise, it returns 0 (zero).

2.5.6.3 Return Type

INTEGER

2.5.6.4 Example

```
iSQL> SELECT F1, ISEMPTY(F2) FROM TB1;
F1           ISEMPTY(F2)
---------------------------
100
101          0
102          0
103          0
104          0
105          0
106          0
107          0
108          0
109          1
10 rows selected.
```

2.5.7 ISSIMPLE

2.5.7.1 Syntax

```
ISSIMPLE( GEOMETRY )
```

2.5.7.2 Description

This function returns 1 if a GEOMETRY object does not have any exceptional points, such as points of intersection or contact. If the GEOMETRY object has any such points, it returns 0 (zero).

The POINT, POLYGON and MULTIPOLYGON subtypes are always simple. The LINESTRING subtype is simple as long as its constituent segments do not intersect each other. The MULTIPOINT subtype is simple as long as no two of its constituent points have the same coordinates. The MULTILINESTRING type is simple if all of its LINESTRINGs are simple and they intersect only at their boundary points.

2.5.7.3 Return Type

INTEGER

2.5.7.4 Example

```
iSQL> SELECT F1, ISSIMPLE(F2) FROM TB1;
F1            ISSIMPLE(F2)
----------------------------
100
101           1
102           1
103           1
104           1
105           1
106           1
107           1
108           1
109           1
10 rows selected.
```

2.5.8 ISVALID

2.5.8.1 Syntax

```
ISVALID( GEOMETRY )
```

2.5.8.2 Description

This function allows you to test whether a GEOMETRY object meets its requirements for validity.

If a GEOMETRY object meets all of the criteria for validity for that subtype, this function returns 1. If the object in question does not meet all of its criteria for validity, this function returns 0. Be careful to avoid inserting invalid GEOMETRY objects into the DBMS, as this will result in errors or unpredictable results.

2.5.8.3 Return Type

INTEGER

2.5.8.4 Example

```
iSQL> SELECT F1, ISVALID(F2) FROM TB1;
F1            ISVALID(F2)
-----------------------------
100           1
101           1
102           1
103           1
104           1
```

```
105          1
106          1
107          1
108          1
109          1
10 rows selected.
```

2.5.9 BOUNDARY

2.5.9.1 Syntax

```
BOUNDARY( GEOMETRY )
```

2.5.9.2 Description

This function returns the boundary of a GEOMETRY object.

If the argument is a GEOMETRY object whose subtype is POINT, MULTIPOINT, closed LINESTRING, or closed MULTILINESTRING, or if it is an EMPTY object, this function returns EMPTY. If the argument is a POLYGON having one or more interior rings or a MULTIPOLYGON comprising such POLYGONs, this function returns multiple objects.

2.5.9.3 Return Type

GEOMETRY

2.5.9.4 Example

```
iSQL> SELECT F1, ASTEXT(BOUNDARY(F2)) FROM TB1;
F1
--------------
ASTEXT(BOUNDARY(F2))
--------------------------------------------------
100

101
EMPTY
102
EMPTY
103
MULTIPOINT(1 1, 2 2)
104
MULTIPOINT(1 1, 2 2, 3 3, 4 5)
105
LINESTRING(0 0, 10 0, 10 10, 0 10, 0 0)
106
MULTILINESTRING((3 5, 7 5, 7 9, 3 9, 3 5), (4 6, 4 8, 6 8, 6 6, 4 6))
107
MULTILINESTRING((1 1, 2 1, 2 2, 1 2, 1 1), (3 3, 3 5, 5 5, 5 3, 3 3))
108
EMPTY
109
EMPTY
10 rows selected.
```

2.5.10 X (COORDX)

2.5.10.1 Syntax

```
X( GEOMETRY )
```

or

```
COORDX( GEOMETRY )
```

2.5.10.2 Description

This function returns the x coordinate of a GEOMETRY object whose subtype is POINT.

This function returns an error if the subtype of the GEOMETRY object is not POINT.

2.5.10.3 Return Type

DOUBLE

2.5.10.4 Example

```
iSQL> SELECT F1, COORDX(F2) FROM TB1 WHERE GEOMETRYTYPE(F2) = 'POINT';
F1            COORDX(F2)
--------------------------------------
101           1
1 row selected.

iSQL> SELECT F1, X(F2) FROM TB1;
F1            X(F2)
--------------------------------------
100
101           1
[ERR-A1019 : Inapplicable object type]
2 rows selected.
```

2.5.11 Y (COORDY)

2.5.11.1 Syntax

```
Y( GEOMETRY )
```

or

```
COORDY( GEOMETRY )
```

2.5.11.2 Description

This function returns the y coordinate of a GEOMETRY object whose subtype is POINT.

This function returns an error if the subtype of the GEOMETRY object is not POINT.

2.5.11.3 Return Type

DOUBLE

2.5.11.4 Example

```
iSQL> SELECT F1, COORDY(F2) FROM TB1 WHERE GEOMETRYTYPE(F2) = 'POINT';
F1             COORDY(F2)
--------------------------------------
101            1
1 row selected.

iSQL> SELECT F1, Y(F2) FROM TB1;
F1             Y(F2)
--------------------------------------
100
101            1
[ERR-A1019 : Inapplicable object type]
2 rows selected.
```

2.5.12 MINX

2.5.12.1 Syntax

```
MINX( GEOMETRY )
```

2.5.12.2 Description

This function returns the minimum x coordinate value for the minimum bounding rectangle of the GEOMETRY object in question. If the subtype of the GEOMETRY object is POINT, this function simply returns the x coordinate of the POINT.

Note: To determine the coordinate values for the minimum bounding rectangle for the results of a query, use the MINX, MINY, MAXX, and MAXY functions together with the MIN and MAX aggregate functions.

```
SELECT MIN(MINX(F2)), MIN(MINY(F2)), MAX(MAXX(F2)), MAX(MAXY(F2) FROM TB1;
```

2.5.12.3 Return Type

DOUBLE

2.5.12.4 Example

```
iSQL> SELECT F1, MINX(F2) FROM TB1;
F1             MINX(F2)
-----------------------------
100
101            1
102            1
103            1
104            1
105            0
106            3
107            1
```

```
108          1
109
10 rows selected.
```

2.5.13 MINY

2.5.13.1 Syntax

```
MINY( GEOMETRY )
```

2.5.13.2 Description

This function returns the minimum y coordinate value for the minimum bounding rectangle of the GEOMETRY object in question. If the subtype of the GEOMETRY object is POINT, this function simply returns the y coordinate of the POINT.

2.5.13.3 Return Type

DOUBLE

2.5.13.4 Example

```
iSQL> SELECT F1, MINY(F2) FROM TB1;
F1           MINY(F2)
-----------------------------
100
101          1
102          1
103          1
104          1
105          0
106          5
107          1
108          1
109
10 rows selected.
```

2.5.14 MAXX

2.5.14.1 Syntax

```
MAXX( GEOMETRY )
```

2.5.14.2 Description

This function returns the maximum x coordinate value for the minimum bounding rectangle of the GEOMETRY object in question. If the subtype of the GEOMETRY object is POINT, this function simply returns the x coordinate of the POINT.

2.5.14.3 Return Type

DOUBLE

2.5.14.4 Example

```
iSQL> SELECT F1, MAXX(F2) FROM TB1;
F1             MAXX(F2)
-----------------------------
100
101            1
102            2
103            2
104            4
105            10
106            7
107            5
108            3
109
10 rows selected.
```

2.5.15 MAXY

2.5.15.1 Syntax

```
MAXY( GEOMETRY )
```

2.5.15.2 Description

This function returns the maximum y coordinate value for the minimum bounding rectangle of the GEOMETRY object in question. (+If the subtype of the GEOMETRY object is POINT, this function simply returns the y coordinate of the POINT.

2.5.15.3 Return Type

DOUBLE

2.5.15.4 Example

```
iSQL> SELECT F1, MAXY(F2) FROM TB1;
F1             MAXY(F2)
-----------------------------
100
101            1
102            2
103            2
104            5
105            10
106            9
107            5
108            3
109
10 rows selected.
```

2.5.16 GEOMETRYLENGTH

2.5.16.1 Syntax

```
GEOMETRYLENGTH( GEOMETRY )
```

2.5.16.2 Description

This function returns the length of a LINESTRING or MULTILINESTRING type GEOMETRY object.

If the subtype of the GEOMETRY type is not LINESTRING or MULTILINESTRING, this function returns an error.

2.5.16.3 Return Type

DOUBLE

2.5.16.4 Example

```
iSQL> SELECT F1, GEOMETRYLENGTH(F2) FROM TB1 WHERE GEOMETRYTYPE(F2) = 'LINES-
TRING' OR GEOMETRYTYPE(F2) = 'MULTILINESTRING';
SELECT F1, GEOMETRYLENGTH(F2) FROM TB1;F1 GEOMETRYLENGTH(F2)
--------------------------------------
103        1.4142135623731
104        3.65028153987288
2 rows selected.

iSQL> SELECT F1, GEOMETRYLENGTH(F2) FROM TB1;
F1 GEOMETRYLENGTH(F2)
--------------------------------------
100
[ERR-A1019 : Inapplicable object type]
1 row selected.
```

2.5.17 STARTPOINT

2.5.17.1 Syntax

```
STARTPOINT( GEOMETRY )
```

2.5.17.2 Description

This function returns the start point of a LINESTRING.

If the subtype of the GEOMETRY type argument is not LINESTRING, this function returns an error.

2.5.17.3 Return Type

GEOMETRY

2.5.17.4 Example

```
iSQL> SELECT F1, ASTEXT(STARTPOINT(F2)) FROM TB1 WHERE GEOMETRYTYPE(F2) =
'LINESTRING';
F1
--------------
ASTEXT(STARTPOINT(F2))
-------------------------------------------------103
POINT(1 1)
1 row selected.

iSQL> SELECT F1, ASTEXT(STARTPOINT(F2)) FROM TB1;
F1
--------------
ASTEXT(STARTPOINT(F2))
-------------------------------------------------100
[ERR-A1019 : Inapplicable object type]
1 row selected.
```

2.5.18 ENDPOINT

2.5.18.1 Syntax

```
ENDPOINT( GEOMETRY )
```

2.5.18.2 Description

This function returns the end point of a LINESTRING.

If the subtype of the GEOMETRY type argument is not LINESTRING, this function returns an error.

2.5.18.3 Return Type

GEOMETRY

2.5.18.4 Example

```
iSQL> SELECT F1, ASTEXT(ENDPOINT(F2)) FROM TB1 WHERE GEOMETRYTYPE(F2) = 'LIN-
ESTRING';
F1
--------------
ASTEXT(ENDPOINT(F2))
-------------------------------------------------103
POINT(2 2)
SELECT F1, ASTEXT(ENDPOINT(F2)) FROM TB1;
1 row selected.

iSQL> SELECT F1, ASTEXT(ENDPOINT(F2)) FROM TB1;
F1
--------------
ASTEXT(ENDPOINT(F2))
-------------------------------------------------100
[ERR-A1019 : Inapplicable object type]
1 row selected.
```

2.5.19 ISCLOSED

2.5.19.1 Syntax

```
ISCLOSED( GEOMETRY )
```

2.5.19.2 Description

This function returns 1 if LINESTRING is closed, that is, if the following expression is true:

```
(StartPoint(geometry) = EndPoint(geometry))
```

If the start point and the end point are not the same, that is, if the above expression is false, this function returns 0 (zero).

If the subtype of the GEOMETRY type argument is not LINESTRING or MULTILINESTRING, this function returns an error.

2.5.19.3 Return Type

INTEGER

2.5.19.4 Example

```
iSQL> SELECT F1, ISCLOSED(F2) FROM TB1 WHERE GEOMETRYTYPE(F2) = 'LINESTRING'
OR GEOMETRYTYPE(F2) = 'MULTILINESTRING';
F1 ISCLOSED(F2)
----------------------------
103 0
104 0
2 rows selected.

iSQL> SELECT F1, ISCLOSED(F2) FROM TB1;
F1 ISCLOSED(F2)
----------------------------
100
[ERR-A1019 : Inapplicable object type]
1 row selected.
```

2.5.20 ISRING

2.5.20.1 Syntax

```
ISRING( GEOMETRY )
```

2.5.20.2 Description

This function returns 1 if the LINESTRING or MULTILINESTRING type argument is simple and closed. The test of whether a LINESTRING is closed is as follows:

```
(StartPoint(geometry) = EndPoint(geometry))
```

If the input LINESTRING or MULTILINESTRING is not simple, not closed, or neither simple nor closed, this function returns 0 (zero).

If the subtype of the GEOMETRY type argument is not a LINESTRING or a MULTILINESTRING, this function outputs an error.

2.5.20.3 Return Type

INTEGER

2.5.20.4 Example

```
iSQL> SELECT F1, ISRING(F2) FROM TB1 WHERE GEOMETRYTYPE(F2) = 'LINESTRING' OR
GEOMETRYTYPE(F2) = 'MULTILINESTRING';
F1           ISRING(F2)
---------------------------
103          0
104          0
2 rows selected.

iSQL> SELECT F1, ISRING(F2) FROM TB1;
F1           ISRING(F2)
---------------------------
100
[ERR-A1019 : Inapplicable object type]
1 row selected.
```

2.5.21 NUMPOINTS

2.5.21.1 Syntax

```
NUMPOINTS( GEOMETRY )
```

2.5.21.2 Description

This function returns the number of POINTs that comprise a GEOMETRY object.

2.5.21.3 Return Type

INTEGER

2.5.21.4 Example

```
iSQL> select f1, numPoints(f2) from TB1;
F1       NUMPOINTS(F2)
-----------------------------
100
101      1
102      2
103      2
104      4
105      5
106      10
```

```
107      10
108      3
[ERR-A1019 : Inapplicable object type]
9 rows selected.
```

2.5.22 POINTN

2.5.22.1 Syntax

```
POINTN( GEOMETRY, N )
```

2.5.22.2 Description

This function returns the Nth POINT that comprises the input LINESTRING type GEOMETRY object.

This function outputs an error if N is 0 (zero) or negative, if N is greater than the number of POINTs in LINESTRING, or if the subtype of the GEOMETRY type argument is not LINESTRING.

2.5.22.3 Return Type

GEOMETRY

2.5.22.4 Example

```
iSQL> SELECT F1, ASTEXT(POINTN(F2, 2)) FROM TB1 WHERE GEOMETRYTYPE(F2) = 
'LINESTRING';
F1
--------------
ASTEXT(POINTN(F2, 2))
------------------------------------------------103
POINT(2 2)
1 row selected.

iSQL> SELECT F1, ASTEXT(POINTN(F2, 1)) FROM TB1;
F1
--------------
ASTEXT(POINTN(F2, 1))
------------------------------------------------100
[ERR-A1019 : Inapplicable object type]
1 row selected.
```

2.5.23 AREA

2.5.23.1 Syntax

```
AREA( GEOMETRY )
```

2.5.23.2 Description

This function returns the area of an input POLYGON or MULTIPOLYGON type GEOMETRY object.

If the subtype of the input GEOMETRY type is not POLYGON or MULTIPOLYGON, this function outputs an error.

2.5.23.3 Return Type

DOUBLE

2.5.23.4 Example

```
iSQL> SELECT F1, AREA(F2) FROM TB1 WHERE GEOMETRYTYPE(F2) = 'POLYGON';
F1            AREA(F2)
--------------------------------------
105           100
106           12
2 rows selected.

iSQL> SELECT F1, AREA(F2) FROM TB1;
F1            AREA(F2)
--------------------------------------
100
[ERR-A1019 : Inapplicable object type]
1 row selected.
```

2.5.24 CENTROID

2.5.24.1 Syntax

```
CENTROID( GEOMETRY )
```

2.5.24.2 Description

This function returns the mathematical center of gravity of an input POLYGON type GEOMETRY object.

Note that the resultant center of gravity may not actually be located within the surface of the input POLYGON or MULTIPOLYGON.

If the subtype of the input GEOMETRY type is not POLYGON or MULTIPOLYGON, this function outputs an error.

2.5.24.3 Return Type

GEOMETRY

2.5.24.4 Example

```
iSQL> SELECT F1, ASTEXT(CENTROID(F2)) FROM TB1 WHERE GEOMETRYTYPE(F2) =
'POLYGON' OR GEOMETRYTYPE(F2) = 'MULTIPOLYGON';
F1
--------------
ASTEXT(CENTROID(F2))
105
```

```
POINT(5 5)
106
POINT(5 7)
107
POINT(2.75 2.75)
3 rows selected.

iSQL> SELECT F1, ASTEXT(CENTROID(F2)) FROM TB1;
F1
--------------
ASTEXT(CENTROID(F2))
100

[ERR-A1019 : Inapplicable object type]
1 row selected.
```

2.5.25 POINTONSURFACE

2.5.25.1 Syntax

```
POINTONSURFACE( GEOMETRY )
```

2.5.25.2 Description

This function returns a POINT that is guaranteed to be in the interior or on the boundary of an input POLYGON type GEOMETRY object.

If the subtype of the input GEOMETRY type is not POLYGON or MULTIPOLYGON, this function outputs an error.

2.5.25.3 Return Type

GEOMETRY

2.5.25.4 Example

```
iSQL> SELECT F1, ASTEXT(POINTONSURFACE(F2)) FROM TB1 WHERE GEOMETRYTYPE(F2) =
'POLYGON' OR GEOMETRYTYPE(F2) = 'MULTIPOLYGON';
F1
--------------
ASTEXT(POINTONSURFACE(F2))
--------------------------------------------------
105
POINT(5 5)
106
POINT(3.5 7)
107
POINT(1.5 1.5)
3 rows selected.

iSQL> SELECT F1, ASTEXT(POINTONSURFACE(F2)) FROM TB1;
F1
--------------
ASTEXT(POINTONSURFACE(F2))
--------------------------------------------------100
```

```
 [ERR-A1019 : Inapplicable object type]
1 row selected.
```

2.5.26 EXTERIORRING

2.5.26.1 Syntax

```
EXTERIORRING( GEOMETRY )
```

2.5.26.2 Description

This function returns the exterior ring of an input POLYGON type GEOMETRY object. If the input POLYGON has no interior ring, the return value is the same as the boundary of the POLYGON.

If the subtype of the input GEOMETRY type is not POLYGON, this function outputs an error.

2.5.26.3 Return Type

GEOMETRY

2.5.26.4 Example

```
iSQL> SELECT F1, ASTEXT(EXTERIORRING(F2)) FROM TB1 WHERE GEOMETRYTYPE(F2) =
'POLYGON';
F1
--------------
ASTEXT(EXTERIORRING(F2))

----------------------------------------------------------------------------
----------------------------------------------------------------------------
----------------------------------------------------------------------------
--------------------------------
105
LINESTRING(0 0, 10 0, 10 10, 0 10, 0 0)
106
LINESTRING(3 5, 7 5, 7 9, 3 9, 3 5)
2 rows selected.

iSQL> SELECT F1, ASTEXT(EXTERIORRING(F2)) FROM TB1;
F1
--------------
ASTEXT(EXTERIORRING(F2))
--------------------------------------------------100

[ERR-A1019 : Inapplicable object type]
1 row selected.
```

2.5.27 NUMINTERIORRING

2.5.27.1 Syntax

```
NUMINTERIORRING( GEOMETRY )
```

2.5.27.2 Description

This function returns the number of interior rings that the input POLYGON type GEOMETRY object comprises. This function returns 0 (zero) if the POLYGON has no interior rings.

If the subtype of the input GEOMETRY type is not POLYGON, this function outputs an error.

2.5.27.3 Return Type

INTEGER

2.5.27.4 Example

```
iSQL> SELECT F1, NUMINTERIORRING(F2) FROM TB1 WHERE GEOMETRYTYPE(F2) = 'POLY-
GON';
F1          NUMINTERIORRING(F2)
-----------------------------------
105         0
106         1
2 rows selected.

iSQL> SELECT F1, NUMINTERIORRING(F2) FROM TB1;
F1          NUMINTERIORRING(F2)
-----------------------------------
100
[ERR-A1019 : Inapplicable object type]
1 row selected.
```

2.5.28 INTERIORRINGN

2.5.28.1 Syntax

```
INTERIORRINGN( GEOMETRY, N )
```

2.5.28.2 Description

This function returns the Nth interior ring of the input POLYGON type GEOMETRY object.

If N is 0 or negative, or if N is greater than the number of interior rings in the POLYGON, this function returns an error.

If the subtype of the input GEOMETRY type is not POLYGON, this function outputs an error.

2.5.28.3 Return Type

GEOMETRY

2.5.28.4 Example

```
iSQL> SELECT F1, ASTEXT(INTERIORRINGN(F2, 1)) FROM TB1 WHERE GEOMETRYTYPE(F2)
= 'POLYGON' AND NUMINTERIORRING(F2) > 0;
F1
```

```
--------------
ASTEXT(INTERIORRINGN(F2, 1))
----------------------------------------------------------------------------
----------------------------------------------------------------------------
----------------------------------------------------------------------------
--------------------------------
106
LINESTRING(4 6, 4 8, 6 8, 6 6, 4 6)
1 row selected.

iSQL> SELECT F1, ASTEXT(INTERIORRINGN(F2, 1)) FROM TB1;
F1
--------------
ASTEXT(INTERIORRINGN(F2, 1))
--------------------------------------------------100

[ERR-A1019 : Inapplicable object type]
1 row selected.
```

2.5.29 NUMGEOMETRIES

2.5.29.1 Syntax

```
NUMGEOMETRIES( GEOMETRY )
```

2.5.29.2 Description

This function returns the number of GEOMETRY objects in the input GEOMETRYCOLLECTION type GEOMETRY object.

If the input argument is not a multiple object or a GEOMETRYCOLLECTION type object, this function outputs an error.

2.5.29.3 Return Type

INTEGER

2.5.29.4 Example

```
iSQL> SELECT F1, NUMGEOMETRIES(F2) FROM TB1 WHERE GEOMETRYTYPE(F2) = 'GEOME-
TRYCOLLECTION';
F1           NUMGEOMETRIES(F2)
--------------------------------
108          2
1 row selected.

iSQL> SELECT F1, NUMGEOMETRIES(F2) FROM TB1;
F1           NUMGEOMETRIES(F2)
--------------------------------
100
[ERR-A1019 : Inapplicable object type]
1 row selected.
```

2.5.30 GEOMETRYN

2.5.30.1 Syntax

```
GEOMETRYN( GEOMETRY, N )
```

2.5.30.2 Description

This function returns the Nth GEOMETRY object in the input GEOMETRYCOLLECTION type GEOMETRY object.

If N is less than 1 or greater than the number of GEOMETRY objects in the input GEOMETRYCOLLECTION, or if the input argument is not a multiple object or a GEOMETRYCOLLECTION type object, this function returns an error.

2.5.30.3 Return Type

GEOMETRY

2.5.30.4 Example

```
iSQL> SELECT F1, ASTEXT(GEOMETRYN(F2, 1)) FROM TB1 WHERE GEOMETRYTYPE(F2) =
'GEOMETRYCOLLECTION';
F1
--------------
ASTEXT(GEOMETRYN(F2, 1))
--------------------------------------------------108
POINT(1 1)
1 row selected.

iSQL> SELECT F1, ASTEXT(GEOMETRYN(F2, 1)) FROM TB1;
F1
--------------
ASTEXT(GEOMETRYN(F2, 1))
--------------------------------------------------100

[ERR-A1019 : Inapplicable object type]
1 row selected.
```

2.6 Spatial Analysis Functions

2.6.1 DISTANCE

2.6.1.1 Syntax

```
DISTANCE( GEOMETRY1, GEOMETRY2 )
```

2.6.1.2 Description

This function returns the shortest distance between two points in two respective GEOMETRY objects.

2.6.1.3 Return Type

DOUBLE

2.6.1.4 Example

```
iSQL> SELECT TB1.F1, TB2.F1, DISTANCE(TB1.F2, TB2.F2) FROM TB1, TB2 WHERE
TB1.F1 + 100 = TB2.F1;
F1     F1     DISTANCE(TB1.F2, TB2.F2)
---------------------------------------------------
100    200
101    201    12.7279220613579
102    202    11.3137084989848
103    203    11.3137084989848
104    204    7.81024967590665
105    205    2
106    206    1
107    207    7.07106781186548
108    208    9.89949493661167
109    209    0
10 rows selected.
```

2.6.2 BUFFER

2.6.2.1 Syntax

```
BUFFER( GEOMETRY, NUMBER )
```

2.6.2.2 Description

This function returns a GEOMETRY object that contains all points that are spaced apart from the input GEOMETRY object by the distance indicated by the NUMBER argument or less, i.e. returns a buffer around the input GEOMETRY object.

The subtype of the GEOMETRY input argument cannot be a GEOMETRYCOLLECTION object. Additionally, the distance (indicated by the NUMBER argument) must be greater than 0 (zero).

2.6.2.3 Return Type

GEOMETRY

2.6.2.4 Example

```
iSQL> SELECT F1, ASTEXT(BUFFER(F2, 10)) FROM TB1 WHERE GEOMETRYTYPE(TB1.F2) =
'GEOMETRYCOLLECTION';
[ERR-A1019 : Inapplicable object type]
iSQL> SELECT F1, ASTEXT(BUFFER(F2, 10)) FROM TB1 WHERE DIMENSION(F2) = 0;
 F1          ASTEXT(BUFFER(F2, 10))
 -----------------------------------
 101
 POLYGON((11 1, 9.660254 6, 6 9.660254, 1 11, -4 9.660254, -7.660254 6, -9 1,
-7.660254 -4, -4 -7.660254, 1 -9, 6 -7.660254, 9.660254 -4, 11 1))
 102
 POLYGON((2 12, -3 10.66025, -4 9.660254, -6.660254 7, -7.660254 6, -9 1, -
7.660254 -4, -4 -7.660254, 1 -9, 6 -7.660254, 9.66 0254 -4, 10.66025 -3, 12 2,
10.66025 7, 7 10.66025, 2 12))
 2 rows selected.
```

2.6.3 CONVEXHULL

2.6.3.1 Syntax

```
CONVEXHULL( GEOMETRY )
```

2.6.3.2 Description

This function returns a GEOMETRY object that represents the smallest closed convex polygon that surrounds a GEOMETRY object.

The subtype of the GEOMETRY input argument cannot be a GEOMETRYCOLLECTION object.

2.6.3.3 Return Type

GEOMETRY

2.6.3.4 Example

```
iSQL> SELECT F1, ASTEXT(CONVEXHULL(F2)) FROM TB1
 WHERE GEOMETRYTYPE(TB1.F2) = 'GEOMETRYCOLLECTION';
[ERR-A1019 : Inapplicable object type]
iSQL> SELECT F1, ASTEXT(CONVEXHULL(F2)) FROM TB1
 WHERE GEOMETRYTYPE(TB1.F2) = 'POLYGON';
F1
--------------
ASTEXT(CONVEXHULL(F2))
----------------------------------------------------------------------------
----------------------------------------------------------------------------
----------------------------------------------------------------------------
-------------------------------
105
POLYGON((0 10, 0 0, 10 0, 10 10, 0 10))
```

```
106
POLYGON((3 9, 3 5, 7 5, 7 9, 3 9))
2 rows selected.
```

2.6.4 INTERSECTION

2.6.4.1 Syntax

```
INTERSECTION( GEOMETRY1, GEOMETRY2 )
```

2.6.4.2 Description

This function returns the intersection(s) of the input GEOMETRY1 and GEOMETRY2 GEOMETRY objects in the form of an output GEOMETRY object.

Neither of the GEOMETRY input arguments can be a GEOMETRYCOLLECTION object.

2.6.4.3 Return Type

GEOMETRY

Example

```
iSQL> SELECT TB1.F1, TB2.F1,
      ASTEXT(INTERSECTION(TB1.F2, TB2.F2)) FROM TB1, TB2
      WHERE GEOMETRYTYPE(TB1.F2) != 'GEOMETRYCOLLECTION';
F1      F1         ASTEXT(INTERSECTION(TB1.F2, TB2.F2))
--------------------------------------------------
101     200


101     201
EMPTY

101     202
EMPTY

101     203
EMPTY

101     204
EMPTY

101     205
EMPTY

101     206
EMPTY

101     207
EMPTY

[ERR-A1019 : Inapplicable object type]
8 rows selected.


iSQL> SELECT TB1.F1, TB2.F1,
      ASTEXT(INTERSECTION(TB1.F2, TB2.F2))
      FROM TB1, TB2
      WHERE GEOMETRYTYPE(TB1.F2) = 'POLYGON'
      AND GEOMETRYTYPE(TB2.F2) = 'POLYGON';
F1          F1
---------------------------
ASTEXT(INTERSECTION(TB1.F2, TB2.F2))
----------------------------------------------------------------------------
----------------------------------------------------------------------------
----------------------------------------------------------------------------
--------------------------------
105         205
POLYGON((10 10, 2 10, 2 2, 10 2, 10 10))
105         206
POLYGON((9 5, 8 5, 8 3, 9 3, 9 5), (8.8 3.2, 8.2 3.2, 8.2 4.8, 8.8 4.8, 8.8
3.2))
106         205
POLYGON((7 9, 3 9, 3 5, 7 5, 7 9), (6 6, 4 6, 4 8, 6 8, 6 6))
106         206
EMPTY
4 rows selected.
```

2.6.5 UNION

2.6.5.1 Syntax

```
UNION( GEOMETRY1, GEOMETRY2 )
```

2.6.5.2 Description

This function returns a new GEOMETRY object that represents the union (i.e. the combined total) of two GEOMETRY objects.

Neither of the GEOMETRY input arguments can be a GEOMETRYCOLLECTION object. Additionally, the two GEOMETRY objects must have the same number of dimensions.

2.6.5.3 Return Type

GEOMETRY

2.6.5.4 Example

```
iSQL> SELECT ASTEXT(UNION(TB1.F2, TB2.F2)) FROM TB1, TB2
      WHERE DIMENSION(TB1.F2) = 1 AND DIMENSION(TB2.F2) = 2;
[ERR-A1019 : Inapplicable object type]

iSQL> SELECT ASTEXT(UNION(TB1.F2, TB2.F2)) FROM TB1, TB2
      WHERE GEOMETRYTYPE(TB1.F2) = 'POLYGON'
      AND GEOMETRYTYPE(TB2.F2) = 'POLYGON';
ASTEXT(UNION(TB1.F2, TB2.F2))
----------------------------------------------------------------------------
----------------------------------------------------------------------------
----------------------------------------------------------------------------
--------------------------------
POLYGON((12 12, 2 12, 2 10, 0 10, 0 0, 10 0, 10 2, 12 2, 12 12))
POLYGON((10 10, 0 10, 0 0, 10 0, 10 10))
POLYGON((12 12, 2 12, 2 2, 12 2, 12 12))
MULTIPOLYGON(((8 3, 9 3, 9 5, 8 5, 8 3), (8.2 3.2, 8.2 4.8, 8.8 4.8, 8.8 3.2,
8.2 3.2)), ((3 5, 7 5, 7 9, 3 9, 3 5), (4 6, 4 8, 6 8, 6 6, 4 6)))
4 rows selected.
```

2.6.6 DIFFERENCE

2.6.6.1 Syntax

```
DIFFERENCE( GEOMETRY1, GEOMETRY2 )
```

2.6.6.2 Description

This function returns the difference between two GEOMETRY objects.

The difference between two GEOMETRY objects is the portion of GEOMETRY1 that does not overlap with GEOMETRY2.

Neither of the GEOMETRY input arguments can be a GEOMETRYCOLLECTION object. Additionally, the two GEOMETRY objects must have the same number of dimensions.

2.6.6.3 Return Type

GEOMETRY

2.6.6.4 Example

```
iSQL> SELECT ASTEXT(DIFFERENCE(TB1.F2, TB2.F2)) FROM TB1, TB2
      WHERE DIMENSION(TB1.F2) = 1 AND DIMENSION(TB2.F2) = 2;
[ERR-A1019 : Inapplicable object type]

iSQL> SELECT ASTEXT(DIFFERENCE(TB1.F2, TB2.F2)) FROM TB1, TB2
      WHERE GEOMETRYTYPE(TB1.F2) = 'POLYGON'
      AND GEOMETRYTYPE(TB2.F2) = 'POLYGON';
ASTEXT(DIFFERENCE(TB1.F2, TB2.F2))
------------------------------------------------------------------------------
------------------------------------------------------------------------------
------------------------------------------------------------------------------
--------------------------------
PPOLYGON((2 10, 0 10, 0 0, 10 0, 10 2, 2 2, 2 10))
MULTIPOLYGON(((8.8 4.8, 8.2 4.8, 8.2 3.2, 8.8 3.2, 8.8 4.8)), ((10 10, 0 10,
0 0, 10 0, 10 10), (9 3, 8 3, 8 5, 9 5, 9 3)))
EMPTY
POLYGON((7 9, 3 9, 3 5, 7 5, 7 9), (6 6, 4 6, 4 8, 6 8, 6 6))
4 rows selected.
```

2.6.7 SYMDIFFERENCE

2.6.7.1 yntax

```
SYMDIFFERENCE( GEOMETRY1, GEOMETRY2 )
```

2.6.7.2 Description

This function returns a GEOMETRY object that represents the two input GEOMETRY objects, excluding the intersection between the two input objects. That is, it returns a GEOMETRY object that represents the part of GEOMETRY1 that is not included in GEOMETRY2, together with the part of GEOMETRY2 that is not included in GEOMETRY1.

Neither of the GEOMETRY input arguments can be a GEOMETRYCOLLECTION object. Additionally, the two GEOMETRY objects must have the same number of dimensions.

2.6.7.3 Return Type

GEOMETRY

2.6.7.4 Example

```
iSQL> SELECT ASTEXT(SYMDIFFERENCE(TB1.F2, TB2.F2))
      FROM TB1, TB2
      WHERE DIMENSION(TB1.F2) = 1 AND DIMENSION(TB2.F2) = 2;
[ERR-A1019 : Inapplicable object type]

iSQL> SELECT ASTEXT(SYMDIFFERENCE(TB1.F2, TB2.F2))
      FROM TB1, TB2
      WHERE GEOMETRYTYPE(TB1.F2) = 'POLYGON'
      AND GEOMETRYTYPE(TB2.F2) = 'POLYGON';
ASTEXT(SYMDIFFERENCE(TB1.F2, TB2.F2))
----------------------------------------------------------------------------
----------------------------------------------------------------------------
----------------------------------------------------------------------------
--------------------------------
MULTIPOLYGON(((12 12, 2 12, 2 10, 10 10, 10 2, 12 2, 12 12)), ((2 10, 0 10, 0
0, 10 0, 10 2, 2 2, 2 10)))
MULTIPOLYGON(((8.8 4.8, 8.2 4.8, 8.2 3.2, 8.8 3.2, 8.8 4.8)), ((10 10, 0 10,
0 0, 10 0, 10 10), (9 3, 8 3, 8 5, 9 5, 9 3)))
MULTIPOLYGON(((6 8, 4 8, 4 6, 6 6, 6 8)), ((12 12, 2 12, 2 2, 12 2, 12 12), (7
5, 3 5, 3 9, 7 9, 7 5)))
MULTIPOLYGON(((7 9, 3 9, 3 5, 7 5, 7 9), (6 6, 4 6, 4 8, 6 8, 6 6)), ((9 5, 8
5, 8 3, 9 3, 9 5), (8.8 3.2, 8.2 3.2, 8.2 4.8, 8.8 4.8, 8.8 3.2)))
4 rows selected.
```

2.7 Spatial Object Creation Functions

2.7.1 GEOMFROMTEXT

2.7.1.1 Syntax

```
GEOMFROMTEXT( WKT[1] )
```

2.7.1.2 Description

This function accepts a description of a spatial object in WKT (Well-known Text) format as input and creates and outputs a GEOMETRY object.

The input can be any type of spatial object that can be described using WKT.

If the syntax of the input WKT is not valid, this function outputs an error.

2.7.1.3 Return Type

GEOMETRY

2.7.1.4 Example

```
iSQL> INSERT INTO TB3 VALUES (101, GEOMFROMTEXT('GEOMETRYCOLLECTION( POINT(10 
10), POINT(30 30), LINESTRING(15 15, 20 20))'));
1 row inserted.

iSQL> SELECT ID, ASTEXT(OBJ) FROM TB3;
ID
--------------
ASTEXT(OBJ)
---------------------------------------------------
101
GEOMETRYCOLLECTION( POINT(10 10) , POINT(30 30) , LINESTRING(15 15, 20 20) )
1 row selected.

iSQL> INSERT INTO TB3 VALUES (102, GEOMFROMTEXT('POLYGON((10 10, 10 20, 20 
20, 20 15, 10))'));
[ERR-A101A : Error parsing well-known-text]
```

2.7.2 POINTFROMTEXT

2.7.2.1 Syntax

```
POINTFROMTEXT( WKT )
```

1. For more information on the syntax of WKT (Well-Known Text), please refer to 2.2.1 WKT (Well-Known Text).

2.7.2.2 Description

This function accepts a spatial object in WKT (Well-known Text) format as input and creates and outputs a GEOMETRY object whose subtype is POINT.

If the syntax of the input WKT is not valid, or if the WKT describes a GEOMETRY subtype other than a POINT, this function outputs an error.

This function returns NULL if the value of the WKT argument is NULL.

2.7.2.3 Return Type

GEOMETRY

2.7.2.4 Example

```
iSQL> INSERT INTO TB3 VALUES (102, POINTFROMTEXT('POINT(10 10)'));
1 row inserted.

iSQL> SELECT ID, ASTEXT(OBJ) FROM TB3 WHERE GEOMETRYTYPE(OBJ) = 'POINT';
ID
--------------
ASTEXT(OBJ)
---------------------------------------------------
102
POINT(10 10)
1 row selected.
iSQL> INSERT INTO TB3 VALUES (103, POINTFROMTEXT('GEOMETRYCOLLECTION(POINT(10
10), POINT(30 30), LINESTRING(15 15, 20 20))'));
[ERR-A1019 : Inapplicable object type]
```

2.7.3 LINEFROMTEXT

2.7.3.1 Syntax

```
LINEFROMTEXT( WKT )
```

2.7.3.2 Description

This function accepts a spatial object in WKT (Well-known Text) format as input and creates and outputs a GEOMETRY object whose subtype is LINESTRING.

If the syntax of the input WKT is not valid, or if the WKT describes a GEOMETRY subtype other than a LINESTRING, this function outputs an error.

This function returns NULL if the value of the WKT argument is NULL.

2.7.3.3 Return Type

GEOMETRY

2.7.3.4 Example

```
iSQL> INSERT INTO TB3 VALUES (103, LINEFROMTEXT('LINESTRING(10 10, 20 20, 30
40)'));
1 row inserted.

iSQL> SELECT ID, ASTEXT(OBJ) FROM TB3 WHERE GEOMETRYTYPE(OBJ) = 'LINESTRING';
ID
--------------
ASTEXT(OBJ)
-------------------------------------------------
103
LINESTRING(10 10, 20 20, 30 40)
1 row selected.

iSQL> INSERT INTO TB3 VALUES (104, LINEFROMTEXT('MULTIPOLYGON(((10 10, 10 20,
20 20, 20 15, 10 10)), ((60 60, 70 70, 80 60, 60 60)))'));
[ERR-A1019 : Inapplicable object type]
```

2.7.4 POLYFROMTEXT

2.7.4.1 Syntax

```
POLYFROMTEXT( WKT )
```

2.7.4.2 Description

This function accepts a spatial object in WKT (Well-known Text) format as input and creates and outputs a GEOMETRY object whose subtype is POLYGON.

If the syntax of the input WKT is not valid, or if the WKT describes a GEOMETRY subtype other than a POLYGON, this function outputs an error.

This function returns NULL if the value of the WKT argument is NULL.

2.7.4.3 Return Type

GEOMETRY

2.7.4.4 Example

```
iSQL> INSERT INTO TB3 VALUES (104, POLYFROMTEXT('POLYGON((10 10, 10 20, 20
20, 20 15, 10 10))'));
1 row inserted.

iSQL> SELECT ID, ASTEXT(OBJ) FROM TB3 WHERE GEOMETRYTYPE(OBJ) = 'POLYGON';
ID
--------------
ASTEXT(OBJ)
-------------------------------------------------
104
POLYGON((10 10, 10 20, 20 20, 20 15, 10 10))
1 row selected.

iSQL> INSERT INTO TB3 VALUES (105, POLYFROMTEXT('MULTILINESTRING((10 10, 20
20), (15 15, 30 15))'));
[ERR-A1019 : Inapplicable object type]
```

2.7.5 MPOINTFROMTEXT

2.7.5.1 Syntax

```
MPOINTFROMTEXT( WKT )
```

2.7.5.2 Description

This function accepts a spatial object in WKT (Well-known Text) format as input and creates and outputs a GEOMETRY object whose subtype is MULTIPOINT.

If the syntax of the input WKT is not valid, or if the WKT describes a GEOMETRY subtype other than a MULTIPOINT object, this function outputs an error.

This function returns NULL if the value of the WKT argument is NULL.

2.7.5.3 Return Type

GEOMETRY

2.7.5.4 Example

```
iSQL> INSERT INTO TB3 VALUES (105, MPOINTFROMTEXT('MULTIPOINT(10 10, 20
20)'));
1 row inserted.

iSQL> SELECT ID, ASTEXT(OBJ) FROM TB3 WHERE GEOMETRYTYPE(OBJ) = 'MULTIPOINT';
ID
--------------
ASTEXT(OBJ)
--------------------------------------------------
105
MULTIPOINT(10 10, 20 20)
1 row selected.

iSQL> INSERT INTO TB3 VALUES (106, MPOINTFROMTEXT('LINESTRING(10 10, 20 20,
30 40)'));
[ERR-A1019 : Inapplicable object type]
```

2.7.6 MLINEFROMTEXT

2.7.6.1 Syntax

```
MLINEFROMTEXT( WKT )
```

2.7.6.2 Description

This function accepts a spatial object in WKT (Well-known Text) format as input and creates and outputs a GEOMETRY object whose subtype is MULTILINESTRING.

If the syntax of the input WKT is not valid, or if the WKT describes a GEOMETRY subtype other than a MULTILINESTRING object, this function outputs an error.

This function returns NULL if the value of the WKT argument is NULL.

2.7.6.3 Return Type

GEOMETRY

2.7.6.4 Example

```
iSQL> INSERT INTO TB3 VALUES (106, MLINEFROMTEXT('MULTILINESTRING((10 10, 20
20), (15 15, 30 15))'));
1 row inserted.

iSQL> SELECT ID, ASTEXT(OBJ) FROM TB3 WHERE GEOMETRYTYPE(OBJ) = 'MULTILINES-
TRING';
ID
--------------
ASTEXT(OBJ)
---------------------------------------------------
106
MULTILINESTRING((10 10, 20 20), (15 15, 30 15))
1 row selected.

iSQL> INSERT INTO TB3 VALUES (107, MLINEFROMTEXT('POINT(10 10)'));
[ERR-A1019 : Inapplicable object type]
```

2.7.7 MPOLYFROMTEXT

2.7.7.1 Syntax

```
MPOLYFROMTEXT( WKT )
```

2.7.7.2 Description

This function accepts a spatial object in WKT (Well-known Text) format as input and creates and outputs a GEOMETRY object whose subtype is MULTIPOLYGON.

If the syntax of the input WKT is not valid, or if the WKT describes a GEOMETRY subtype other than a MULTIPOLYGON object, this function outputs an error.

This function returns NULL if the value of the WKT argument is NULL.

2.7.7.3 Return Type

GEOMETRY

2.7.7.4 Example

```
iSQL> INSERT INTO TB3 VALUES (107, MPOLYFROMTEXT('MULTIPOLYGON(((10 10, 10
20, 20 20, 20 15, 10 10)), ((60 60, 70 70, 80 60, 60 60)))'));
1 row inserted.

iSQL> SELECT ID, ASTEXT(OBJ) FROM TB3 WHERE GEOMETRYTYPE(OBJ) = 'MULTIPOLY-
GON';
ID
--------------
ASTEXT(OBJ)
------------------------------------------------
107
MULTIPOLYGON(((10 10, 10 20, 20 20, 20 15, 10 10)), ((60 60, 70 70, 80 60, 60
60)))
1 row selected.

iSQL> INSERT INTO TB3 VALUES (108, MPOLYFROMTEXT('MULTIPOINT(10 10, 20
20)'));
[ERR-A1019 : Inapplicable object type]
```

2.7.8 GEOMCOLLFROMTEXT

2.7.8.1 Syntax

```
GEOMCOLLFROMTEXT( WKT )
```

2.7.8.2 Description

This function accepts a spatial object in WKT (Well-known Text) format as input and creates and outputs a GEOMETRY object whose subtype is GEOMETRYCOLLECTION.

If the syntax of the input WKT is not valid, or if the WKT describes a GEOMETRY subtype other than a GEOMETRYCOLLECTION, this function outputs an error.

This function returns NULL if the value of the WKT argument is NULL.

2.7.8.3 Return Type

GEOMETRY

2.7.8.4 Example

```
iSQL> INSERT INTO TB3 VALUES (108, GEOMCOLLFROMTEXT('GEOMETRYCOLLEC-
TION(POINT(10 10), POINT(30 30), LINESTRING(15 15, 20 20))'));
1 row inserted.

iSQL> SELECT ID, ASTEXT(OBJ) FROM TB3 WHERE GEOMETRYTYPE(OBJ) = 'GEOMETRYCOL-
LECTION';
ID
--------------
ASTEXT(OBJ)
------------------------------------------------
101
GEOMETRYCOLLECTION( POINT(10 10) , POINT(30 30) , LINESTRING(15 15, 20 20) )
```

```
108
GEOMETRYCOLLECTION( POINT(10 10) , POINT(30 30) , LINESTRING(15 15, 20 20) )
2 rows selected.

iSQL> INSERT INTO TB3 VALUES (109, GEOMCOLLFROMTEXT('POLYGON((10 10, 10 20,
20 20, 20 15, 10 10))'));
[ERR-A1019 : Inapplicable object type]
```

2.7.9 GEOMFROMWKB

2.7.9.1 Syntax

```
GEOMFROMWKB( WKB )
```

2.7.9.2 Description

This function accepts a spatial object in WKB (Well-Known Binary) format as input and creates and outputs a GEOMETRY object.

2.7.9.3 Return Type

GEOMETRY

2.7.10 POINTFROMWKB

2.7.10.1 Syntax

POINTFROMWKB(WKB)

2.7.10.2 Description

This function accepts a spatial object in WKB (Well-Known Binary) format as input and creates and outputs a GEOMETRY object whose subtype is POINT.

If the input WKB information describes a GEOMETRY subtype other than a POINT, this function returns an error.

2.7.10.3 Return Type

GEOMETRY

2.7.11 LINEFROMWKB

2.7.11.1 Syntax

```
LINEFROMWKB( WKB )
```

2.7.11.2 Description

This function accepts a spatial object in WKB (Well-Known Binary) format as input and creates and outputs a GEOMETRY object whose subtype is LINESTRING.

If the input WKB information describes a GEOMETRY subtype other than a LINESTRING, this function outputs an error.

2.7.11.3 Return Type

GEOMETRY

2.7.12 POLYFROMWKB

2.7.12.1 Syntax

```
POLYFROMWKB( WKB )
```

2.7.12.2 Description

This function accepts a spatial object in WKB (Well-Known Binary) format as input and creates and outputs a GEOMETRY object whose subtype is POLYGON.

If the input WKB information describes a GEOMETRY subtype other than a POLYGON, this function outputs an error.

2.7.12.3 Return Type

GEOMETRY

2.7.13 MPOINTFROMWKB

2.7.13.1 Syntax

```
MPOINTFROMWKB( WKB )
```

2.7.13.2 Description

This function accepts a spatial object in WKB (Well-Known Binary) format as input and creates and outputs a GEOMETRY object whose subtype is MULTIPOINT.

If the input WKB information describes a GEOMETRY subtype other than a MULTIPOINT object, this function returns an error.

2.7.13.3 Return Type

GEOMETRY

2.7.14 MLINEFROMWKB

2.7.14.1 Syntax

```
MLINEFROMWKB( WKB )
```

2.7.14.2 Description

This function accepts a spatial object in WKB (Well-Known Binary) format as input and creates and outputs a GEOMETRY object whose subtype is MULTILINESTRING.

If the input WKB information describes a GEOMETRY subtype other than a MULTILINESTRING object, this function returns an error.

2.7.14.3 Return Type

GEOMETRY

2.7.15 MPOLYFROMWKB

2.7.15.1 Syntax

```
MPOLYFROMWKB( WKB )
```

2.7.15.2 Description

This function accepts a spatial object in WKB (Well-Known Binary) format as input and creates and outputs a GEOMETRY object whose subtype is MULTIPOLYGON.

If the input WKB information describes a GEOMETRY subtype other than a MULTIPOLYGON object, this function returns an error.

2.7.15.3 Return Type

GEOMETRY

2.7.16 GEOMCOLLFROMWKB

2.7.16.1 Syntax

```
GEOMCOLLFROMWKB( WKB[1] )
```

1. For more information on WKB (Well-Known Binary), please refer to 2.2.2 WKB (Well-Known Binary).

2.7.16.2 Description

This function accepts a spatial object in WKB (Well-Known Binary) format as input and creates and outputs a GEOMETRY object whose subtype is GEOMETRYCOLLECTION.

If the input WKB information describes a GEOMETRY subtype other than a GEOMETRYCOLLECTION, this function returns an error.

2.7.16.3 Return Type

GEOMETRY

2.8 The Dimensionally Extended Nine- Intersection Model (DE-9IM)

2.8.1 Spatial Relational Operators in the Dimensionally Extended Nine-Intersection Model (DE-9IM)

The “Simple Features for SQL” specification, proposed by the OGC, sets forth the Dimensionally Extended Nine-Intersection Model (DE-9IM). This model is used to test whether a spatial topological relationship exists between two spatial objects.

The DE-9IM describes the following kinds of spatial relationships:

- Equals
- Disjoint
- Intersects
- Touches
- Crosses
- Within
- Contains
- Overlaps

These are described in greater detail later in this section.

The Dimensionally Extended Nine-Intersection Model is used to determine whether a relationship exists between the interior, boundary, or exterior of one spatial object and the interior, boundary, or exterior of another spatial object. Thus, there are nine possible relationships between two spatial objects, and these nine possibilities can be arranged in a 3x3 matrix.

For a given spatial object a, I(a), B(a) and E(a) respectively represent the interior, boundary and exterior of the spatial object. dim(x) returns the number of dimensions of the relationship between the spatial objects. The return value can be one of -1, 0, 1 or 2.

If dim(x) returns -1, the two spatial objects do not intersect each other.

For example, the intersection between the boundaries of two Polygons can consist of Points and LineStrings. In this case, dim(B(a) ∩ B(b)) returns the greater number of dimensions between Points, which have zero dimensions, and LineStrings, which have one dimension; that is, it returns a value of 1.

The Dimensionally Extended Nine-Intersection Matrix (DE-9IM), which includes all nine possible combinations described above, is shown in the following table.

Table 2-2 DE-9IM

	Interior	Boundary	Exterior
Interior	dim(I(a) ∩ I(b))	dim(I(a) ∩ B(b))	dim(I(a) ∩ E(b))
Boundary	dim(B(a) ∩ I(b))	dim(B(a) ∩ B(b))	dim(B(a) ∩ E(b))
Exterior	dim(E(a) ∩ I(b))	dim(E(a) ∩ B(b))	dim(E(a) ∩ E(b))

The result returned by a spatial relational operator can be tested by comparing it with the above pattern matrix, which shows all of the possible values according to the DE-9IM.

The pattern matrix contains the allowable values for each intersection. These values are as follows:

T	An intersection must exist. dim ∈ (0, 1, 2).
F	An intersection must not exist. dim = -1.
*	It does not matter whether an intersection exists. dim ∈ (-1, 0, 1, 2).
0	An intersection must exist, and it must be 0-dimensional. dim = 0.
1	An intersection must exist, and it must be 1-dimensional. dim = 1.
2	An intersection must exist, and it must be 2-dimensional. dim = 2.

For example, the pattern matrix for the DISJOINT operator, which tests whether two spatial objects have no intersection between them, is as follows:

Table 2-3 The Pattern Matrix for the DISJOINT Operator

	I (geometry2)	B (geometry2)	E (geometry2)
I (geometry1)	F	F	*
B (geometry1)	F	F	*
E (geometry1)	*	*	*

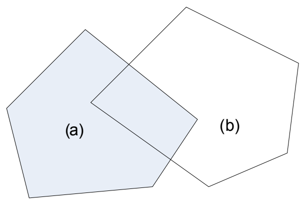
In order for two spatial objects to have the DISJOINT relationship therebetween, there must be no intersections between the interiors or boundaries of the two objects. The other conditions do not matter, i.e. relationships involving the exterior of either object are not important. The above pattern matrix can be expressed in string form as shown below:

```
FF*FF****
```

When expressed in string form in this way, the relationship can be tested for using the RELATE operator.

The following figure shows the DE-9IM pattern matrix for two overlapping Polygons (a) and (b).

Figure 2-7 The DE-9IM pattern matrix for two overlapping Polygons



	I(b)	B(b)	E(b)
I(a)	2	1	2
B(a)	1	0	1
E(a)	2	1	2

As noted above, the DE-9IM sets forth 8 kinds of spatial relationships that can exist between two spatial objects. These are defined below:

Table 2-4 Definition of Spatial Relational Operations

Operation	Description
DISJOINT(a, b)	a ? b = Ø
TOUCHES(a, b)	(I(a) ? I(b) = Ø) ? (a ? b) ≠ Ø
WITHIN(a, b)	(a ? b = a) ? (I(a) ? E(b) ≠ Ø)
CONTAINS(a, b)	WITHIN(b, a)
OVERLAPS(a, b)	(dim(I(a)) = dim(I(b)) = dim(I(a) ? I(b))) ? (a ? b ≠ a) ? (a ? b ≠ b)
CROSSES(a, b)	(dim(I(a) ? I(b) < max(dim(I(a)), dim(I(b)))) ? (a ? b ≠ a) ? (a ? b ≠ b)
INTERSECTS(a, b)	NOT DISJOINT(a, b)
EQUALS(a, b)	(dim(I(a)) = dim(I(b))) ? (dim(B(a)) = dim(B(b))) ? (dim(E(a)) = dim(E(b)))

2.8.1.1 Topological Predicates and Corresponding Pattern Matrices

ALTIBASE HDB provides operators for testing for each of the relationships set forth in the DE-9IM. These are described below.

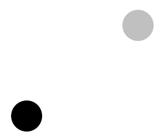
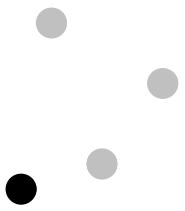
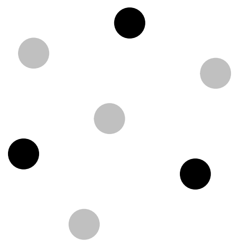
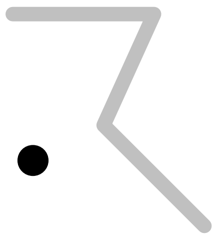
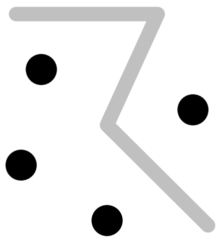
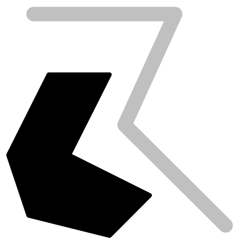
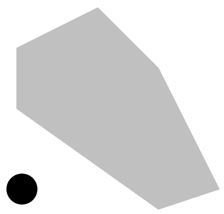
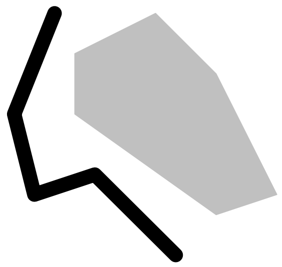
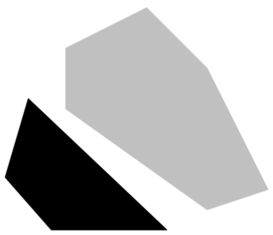
DISJOINT

This operator tests whether two spatial objects have no intersection therebetween.

The definition of the operator and the DE-9IM pattern matrix string passed to the RELATE operator are as follows:

```
DISJOINT(a, b)
⇔ (I(a) ∩ I(b) = Ø) ∧ (I(a) ∩ B(b) = Ø) ∧ (B(a) ∩ I(b) = Ø) ∧
(B(a) ∩ B(b) = Ø)
⇔ RELATE(a, b, ‘FF * FF * * * * ’)
```

The following figure shows examples of the DISJOINT relationship between spatial objects:

		
POINT/POIN T	POINT/MultiPoint	MultiPoint/MultiPoint
		
Point/LineString	MultiPoint/LineString	Polygon/LineString
		
Point/Polygon	LineString/Polygon	Polygon/Polygon

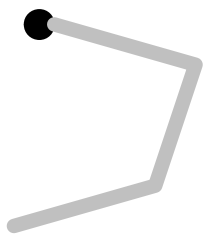
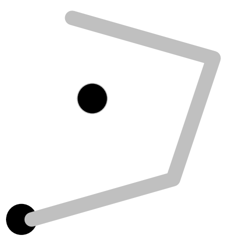
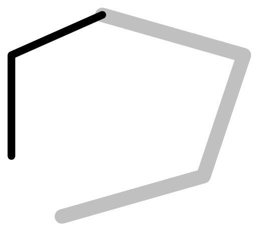
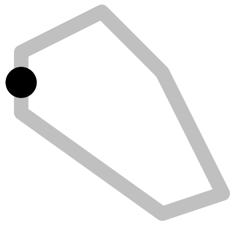
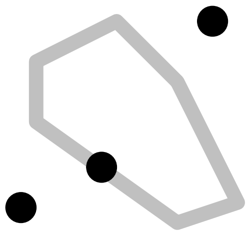
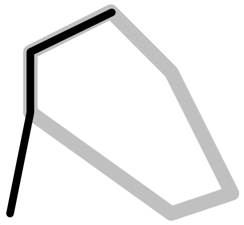
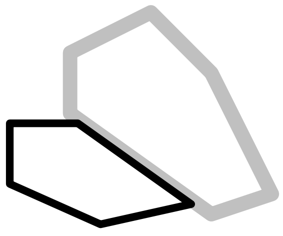
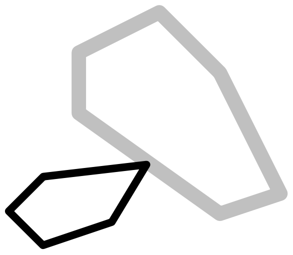
TOUCHES

This operator tests whether two spatial objects touch each other at one or more points.

The definition of the operator and the DE-9IM pattern matrix string passed to the RELATE operator are as follows:

```
TOUCHES(a, b)
⇔ (I(a) ∩ I(b) = Ø) ∧ (B(a) ∩ I(b) ≠ Ø) ∨ (I(a) ∩ B(b) ≠ Ø) ∨
(B(a) ∩ B(b) ≠ Ø))
⇔ RELATE (a, b, 'FT * * * * * * * ') ∨ RELATE (a, b, 'F * * T * * * * *
') ∨ RELATE (a, b, 'F * * * T * * * * ')
```

The following figure shows examples of the TOUCHES relationship between spatial objects:

		
Point/LineString	MultiPoint/LineString	LineString/LineString
		
Point/Polygon	MultiPoint/Polygon	LineString/Polygon
		
Polygon/Polygon	Polygon/Polygon	

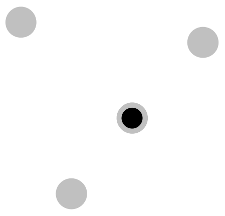
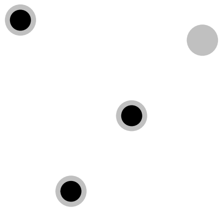
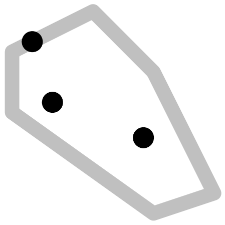
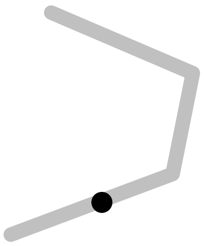
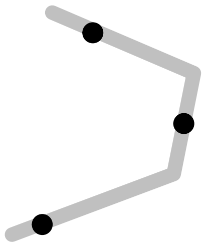
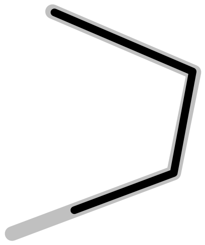
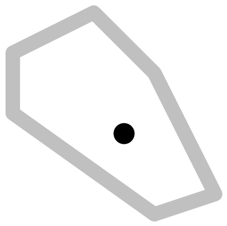
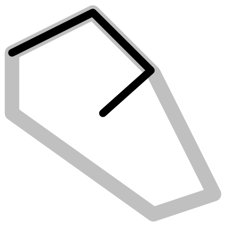
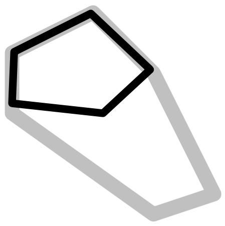
WITHIN

This operator tests whether the first spatial object completely includes the second spatial object.

The definition of the operator and the DE-9IM pattern matrix string passed to the RELATE operator are as follows:

```
WITHIN(a, b)
⇔ (I(a) ∩ I(b) ≠ Ø) ∧ (I(a) ∩ E(b) =Ø) ∧ (B(a) ∩ E(b) =Ø))
⇔ RELATE (a, b, 'TF * F * * * * * ')
```

The following figure shows examples of the WITHIN relationship between spatial objects:

		
Point/MultiPoint	MultiPoint/MultiPoint	MultiPoint/Polygon
		
Point/LineString	MultiPoint/LineString	LineString/LineString
		
LineString/LineString	LineString/Polygon	Polygon/Polygon

In the above figure, the grey spatial object represents spatial object *a* and the black spatial object represents spatial object *b*.

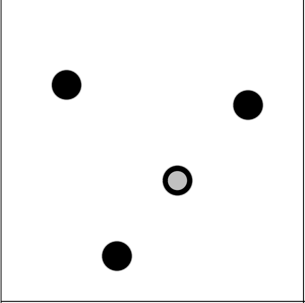
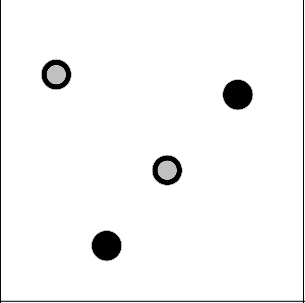
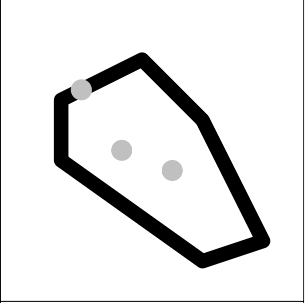
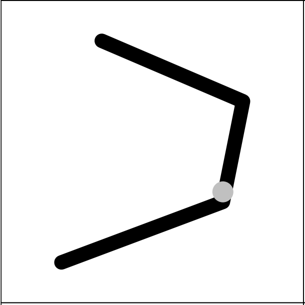
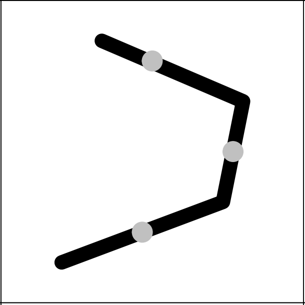
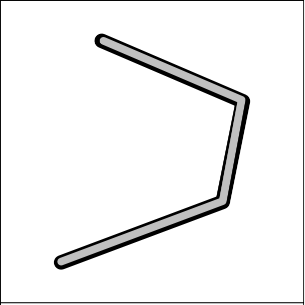
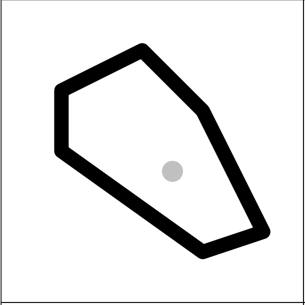
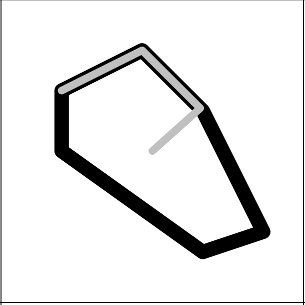
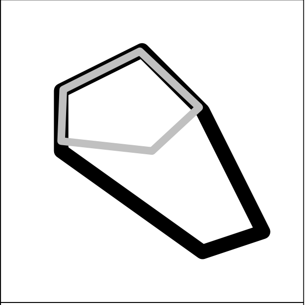
CONTAINS

This operator tests whether the second spatial object completely includes the first spatial object. This operator is the reverse of the WITHIN operator.

The definition of the operator is as follows:

```
CONTAINS(a, b) ⇔ WITHIN(b, a)
```

The following figure shows examples of the CONTAINS relationship between spatial objects:

		
MultiPoing/Point	MultiPoint/MultiPoint	Polygon/MultiPoint
		
LineString/Point	LineString/MultiPoint	LineString/LineString
		
Polygon/Point	Polygon/LineString	Polygon/Polygon

In the above figure, the black spatial object represents spatial object *a* and the grey spatial object represents spatial object *b*. In all cases, spatial object *a* contains spatial object *b*.

OVERLAPS

This operator tests whether two spatial objects having the same number of dimensions include only a part of each other.

The OVERLAPS relationship is defined differently depending on the spatial objects in question: Polygon and Polygon, LineString and LineString, Point and Point.

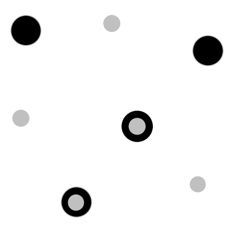
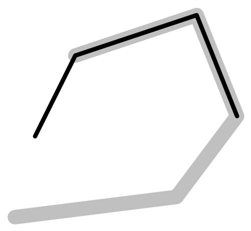
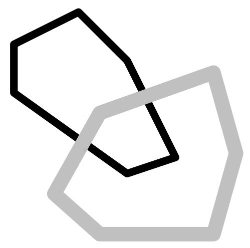
The OVERLAPS relationship between LineString and LineString is as follows:

```
OVERLAPS(a, b)
⇔ (dim(I(a) ∩ I(b) = 1) ∧ (I(a) ∩ E(b) ≠ Ø) ∧ (E(a) ∩ I(b) ≠ Ø))
⇔ RELATE (a, b, '1 * T * * * T * * ')
```

The OVERLAPS relationship between other kinds of spatial objects is defined as follows:

```
OVERLAPS(a, b)
⇔ (I(a) ∩ I(b) ≠ Ø) ∧ (I(a) ∩ E(b) ≠ Ø) ∧ (E(a) ∩ I(b) =Ø))
⇔ RELATE (a, b, 'T * T * * * T * * ')
```

The following figure shows examples of the OVERLAPS relationship between spatial objects:

		
MultiPoint/MultiPoint	LineString/LineString	Polygon/Polygon

CROSSES

This operator tests whether two spatial objects intersect each other. Additionally, it can also be used to test for an intersection between two LineStrings.

The CROSSES relationship is defined differently depending on the spatial objects in question: Point and LineString, Point and Polygon, LineString and LineString, LineString and Polygon.

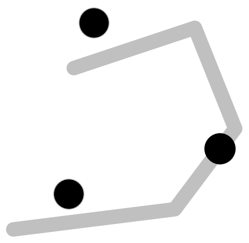
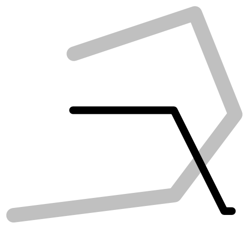
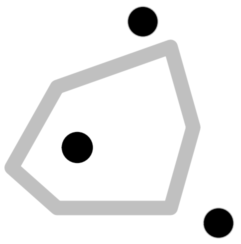
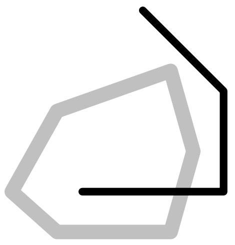
The CROSSES relationship between LineString and LineString is defined as follows:

```
CROSSES(a, b)
⇔ (dim(I(a) ∩ I(b)) = 0
⇔ RELATE (a, b, '0 * * * * * * * * ')
```

The CROSSES relationship between other combinations of object subtypes is defined as follows:

```
CROSSES(a, b)
⇔ (I(a) ∩ I(b) ≠ Ø) ∧ (I(a) ∩ E(b) ≠ Ø)
⇔ RELATE (a, b, 'T * T * * * * * * ')
```

The following figure shows examples of the CROSSES relationship between spatial objects:

	
MultiPoint/LineString	LineString/LineString
	
MultiPoint/Polygon	LineString/Polygon

INTERSECTS

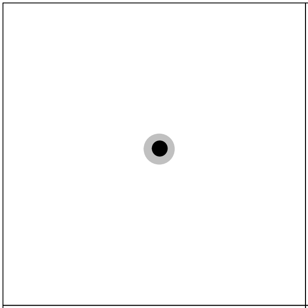
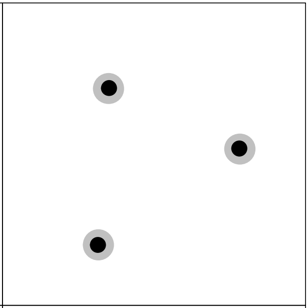
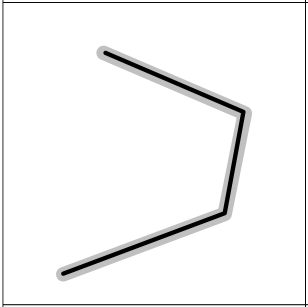
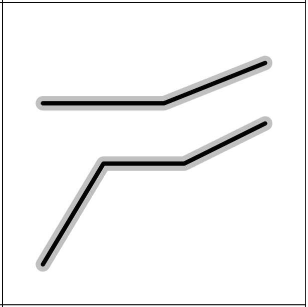
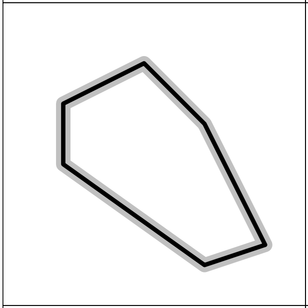
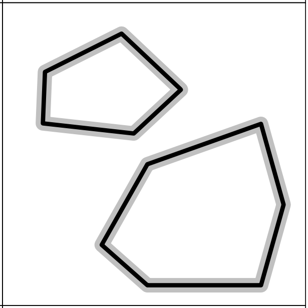
The definition of this operator is as follows:

```
INTERSECTS(a, b) ⇔ ! DISJOINT(a, b)
```

EQUALS

This operator tests whether two spatial objects are topologically identical.

The following figure shows examples of the EQUALS relationship between spatial objects:

	
Point/Point	MultiPoint/MultiPoint
	
LineString/LineString	MultiLineString/ MultiLineString
	
Polygon/Polygon	MultiPolygon/MultiPolyg on

2.9 Spatial Relational Operators in ALTIBASE HDB SQL

This section describes the spatial relational operators that are available in ALTIBASE HDB.

2.9.1 EQUALS

2.9.1.1 Syntax

```
EQUALS( GEOMETRY1, GEOMETRY2 )
```

2.9.1.2 Description

EQUALS returns TRUE if the two GEOMETRY objects are topologically identical, and FALSE if they differ.

2.9.1.3 Return Type

BOOLEAN

2.9.1.4 Example

```
iSQL> SELECT a.F1, b.F1 FROM TB1 a, TB1 b WHERE EQUALS(a.F2, b.F2);
F1            F1
---------------------------
101           101
102           102
103           103
104           104
105           105
106           106
107           107
108           108
8 rows selected.
```

2.9.2 DISJOINT

2.9.2.1 Syntax

```
DISJOINT( GEOMETRY1, GEOMETRY2 )
```

2.9.2.2 Description

DISJOINT returns TRUE if there is no intersection between the two GEOMETRY objects, and FALSE otherwise.

DISJOINT returns the opposite of the value returned by INTERSECTS.

2.9.2.3 Return Type

BOOLEAN

2.9.2.4 Example

```
iSQL> SELECT TB1.F1, TB2.F1 FROM TB1, TB2 WHERE DISJOINT(TB1.F2, TB2.F2) AND
GEOMETRYTYPE(TB1.F2) = 'POLYGON';
F1          F1
---------------------------
105         207
105         208
105         209
106         201
106         202
106         203
106         204
106         206
106         207
106         208
106         209
11 rows selected.
```

2.9.3 INTERSECTS

2.9.3.1 Syntax

```
INTERSECTS( GEOMETRY1, GEOMETRY2 )
```

2.9.3.2 Description

INTERSECTS returns TRUE if the two GEOMETRY objects intersect each other, and FALSE if they do not intersect each other.

INTERSECTS returns the opposite of the value returned by DISJOINT.

2.9.3.3 Return Type

BOOLEAN

2.9.3.4 Example

```
iSQL> SELECT TB1.F1, TB2.F1 FROM TB1, TB2 WHERE INTERSECTS(TB1.F2, TB2.F2);
F1          F1
---------------------------
102         205
103         205
104         205
105         201
105         202
105         203
105         204
105         205
105         206
```

```
106         205
107         205
108         205
12 rows selected.
```

2.9.4 TOUCHES

2.9.4.1 Syntax

```
TOUCHES( GEOMETRY1, GEOMETRY2 )
```

2.9.4.2 Description

TOUCHES returns TRUE when the two GEOMETRY objects contact each other at one or more points, and FALSE otherwise.

2.9.4.3 Return Type

BOOLEAN

2.9.4.4 Example

```
iSQL> SELECT TB1.F1, TB2.F1 FROM TB1, TB2 WHERE TOUCHES(TB1.F2, TB2.F2);
F1          F1
---------------------------
102         205
103         205
105         201
105         202
105         203
105         204
108         205
7 rows selected.
```

2.9.5 CROSSES

2.9.5.1 Syntax

```
CROSSES( GEOMETRY1, GEOMETRY2 )
```

2.9.5.2 Description

CROSSES returns TRUE when two GEOMETRY objects having different numbers of dimensions intersect each other, and FALSE otherwise.

Additionally, CROSSES is also used to test for an intersection between two LINESTRINGs.

2.9.5.3 Return Type

BOOLEAN

2.9.5.4 Example

```
iSQL> SELECT a.F1, b.F1 FROM TB1 a, TB1 b WHERE CROSSES(a.F2, b.F2);
F1           F1
---------------------------
102          108
1 rows selected.
```

2.9.6 WITHIN

2.9.6.1 Syntax

```
WITHIN( GEOMETRY1, GEOMETRY2 )
```

2.9.6.2 Description

WITHIN returns TRUE if the first GEOMETRY object is completely included in the second GEOMETRY object, and FALSE otherwise.

2.9.6.3 Return Type

BOOLEAN

2.9.6.4 Example

```
iSQL> SELECT TB1.F1, TB2.F1 FROM TB1, TB2 WHERE WITHIN(TB1.F2, TB2.F2);
F1           F1
---------------------------
106          205
1 rows selected.
```

2.9.7 CONTAINS

2.9.7.1 Syntax

```
CONTAINS( GEOMETRY1, GEOMETRY2 )
```

2.9.7.2 Description

CONTAINS returns TRUE if the first GEOMETRY object completely includes the second GEOMETRY object, and FALSE otherwise.

2.9.7.3 Return Type

BOOLEAN

2.9.7.4 Example

```
iSQL> SELECT TB1.F1, TB2.F1 FROM TB1, TB2 WHERE CONTAINS(TB1.F2, TB2.F2);
F1             F1
----------------------------
105            206
1 row selected.
```

2.9.8 OVERLAPS

2.9.8.1 Syntax

```
OVERLAPS( GEOMETRY1, GEOMETRY2 )
```

2.9.8.2 Description

OVERLAPS returns TRUE if two GEOMETRY objects include only part, but not all, of each other, and FALSE otherwise.

2.9.8.3 Return Type

BOOLEAN

2.9.8.4 Example

```
iSQL> SELECT TB1.F1, TB2.F1 FROM TB1, TB2 WHERE OVERLAPS(TB1.F2, TB2.F2);
F1             F1
----------------------------
105            205
107            205
2 rows selected.
```

2.9.9 RELATE

2.9.9.1 Syntax

```
RELATE( GEOMETRY1, GEOMETRY2 , patterns )
```

2.9.9.2 Description

RELATE returns TRUE if the relationship between two GEOMETRY objects matches the given pattern matrix string, and FALSE otherwise.

2.9.9.3 Return Type

BOOLEAN

2.9.9.4 Example

```
iSQL> SELECT TB1.F1, TB2.F1 FROM TB1, TB2 WHERE RELATE(TB1.F2, TB2.F2,
'T**F*****');
F1  F1
---------------------------
105 206
1 rows selected.

iSQL> SELECT TB1.F1, TB2.F1 FROM TB1, TB2 WHERE RELATE(TB1.F2, TB2.F2,
'T*T***T**');
F1 F1
---------------------------
104         205
105         205
107         205
3 rows selected.
```

2.9.10 ISMBRINTERSECTS

2.9.10.1 Syntax

```
ISMBRINTERSECTS( GEOMETRY1, GEOMETRY2 );
```

2.9.10.2 Description

ISMBRINTERSECTS returns TRUE if the MBRs (Minimum Bounding Rectangles) of the two GEOMETRY objects intersect each other, and FALSE otherwise.

2.9.10.3 Return Type

BOOLEAN

2.9.10.4 Example

```
iSQL> SELECT TB1.F1, TB2.F1 FROM TB1, TB2 WHERE ISMBRINTERSECTS(TB1.F2,
TB2.F2);
F1          F1
---------------------------
102         205
103         205
104         205
105         201
105         202
105         203
105         204
105         205
105         206
105         207
105         208
106         205
```

```
107         205
108         205
14 rows selected.
```

2.9.11 ISMBRWITHIN

2.9.11.1 Syntax

```
ISMBRWITHIN( GEOMETRY1, GEOMETRY2 );
```

2.9.11.2 Description

ISMBRWITHIN returns TRUE if the minimal bounding rectangle of the first GEOMETRY object is completely included within that of the second GEOMETRY object, and FALSE otherwise.

2.9.11.3 Return Type

BOOLEAN

2.9.11.4 Example

```
iSQL> SELECT TB1.F1, TB2.F1 FROM TB1, TB2 WHERE ISMBRWITHIN(TB1.F2, TB2.F2);
F1           F1
---------------------------
106          205
1 rows selected.
```

2.9.12 ISMBRCONTAINS

2.9.12.1 Syntax

```
ISMBRCONTAINS( GEOMETRY1, GEOMETRY2 );
```

2.9.12.2 Description

ISMBRCONTAINS returns TRUE if the minimal bounding rectangle of the first GEOMETRY object completely includes that of the second GEOMETRY object, and FALSE otherwise.

2.9.12.3 Return Type

BOOLEAN

2.9.12.4 Example

```
iSQL> SELECT TB1.F1, TB2.F1 FROM TB1, TB2 WHERE ISMBRCONTAINS(TB1.F2, 
TB2.F2);
F1          F1
---------------------------
```

```
105         201
105         206
2 rows selected.
```

2.10 Reserved Words

The following words have been set aside as reserved words in Spatial SQL, and thus cannot be used as the names of tables, columns, users, or other database objects.

AREA	ASBINARY
ASTEXT	BOUNDARY
BUFFER	CENTROID
CONTAINS	CONVEXHULL
COORDX	COORDY
CROSSES	DIFFERENCE
DIMENSION	DISJOINTS
DISTANCEEN	DPOINT
ENVELOPE	EQUALS
EXTERIORRING	GEOMCOLLFROMTEXT
GEOMCOLLFROMWKB	GEOMETRY
GEOMETRYCOLLECTION	GEOMETRYLENGTH
GEOMETRYN	GEOMETRYTYPE
GEOMFROMTEXT	GEOMFROMWKB
INTERIORRINGN	INTERSECTION
INTERSECTS	ISCLOSED
ISEMPTY	ISRING
ISSIMPLE	LINEFROMTEXT
LINEFROMWKB	LINESTRING
MLINEFROMTEXT	MLINEFROMWKB
MPOINTFROMTEXT	MPOINTFROMWKB
MPOLYFROMTEXT	MPOLYFROMWKB
MULTILINESTRING	MULTIPOINT
MULTIPOLYGON	NUMGEOMETRIES
NUMINTERIORRING	NUMPOINTS
OVERLAPS	POINT
POINTFROMTEXT	POINTFROMWKB
POINTN	POINTONSURFACE
POLYFROMTEXT	POLYFROMWKB
POLYGON	RELATE
ST_GEOMETRY	STARTPOINT
SYMDIFFERENCE	TOUCHES
UNION	WITHIN
X	Y
MINX	MINY
MAXX	MAXY
ISVALID	

3 Spatial Application Development

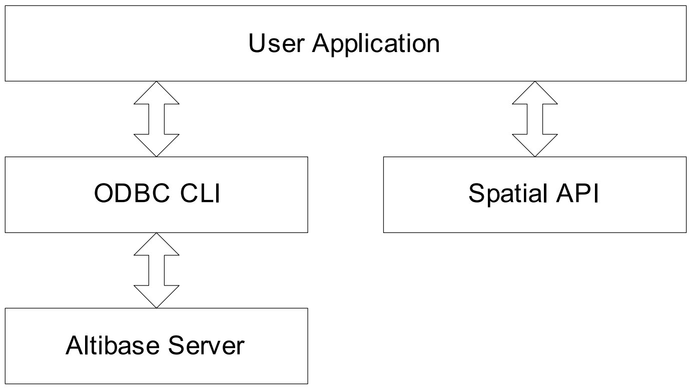
This chapter describes the Spatial API, which can be used by an application developer to access spatial data.

3.1 Using the Spatial API

This section describes how to use the Spatial API. For more information on the ODBC CLI, please refer to the *ODBC Reference*.

3.1.1 The Relationship between the Spatial API and the ODBC CLI

The Spatial API is a library that is useful for accessing spatial objects via the ODBC CLI. It is used together with the ODBC CLI to write an ODBC application that uses spatial objects. As shown in the following diagram, the Spatial API is not directly called using the ODBC CLI, nor is it used to access an ALTIBASE HDB server directly. Rather, it is used alongside the ODBC CLI and an ALTIBASE HDB server to create and interpret spatial data.

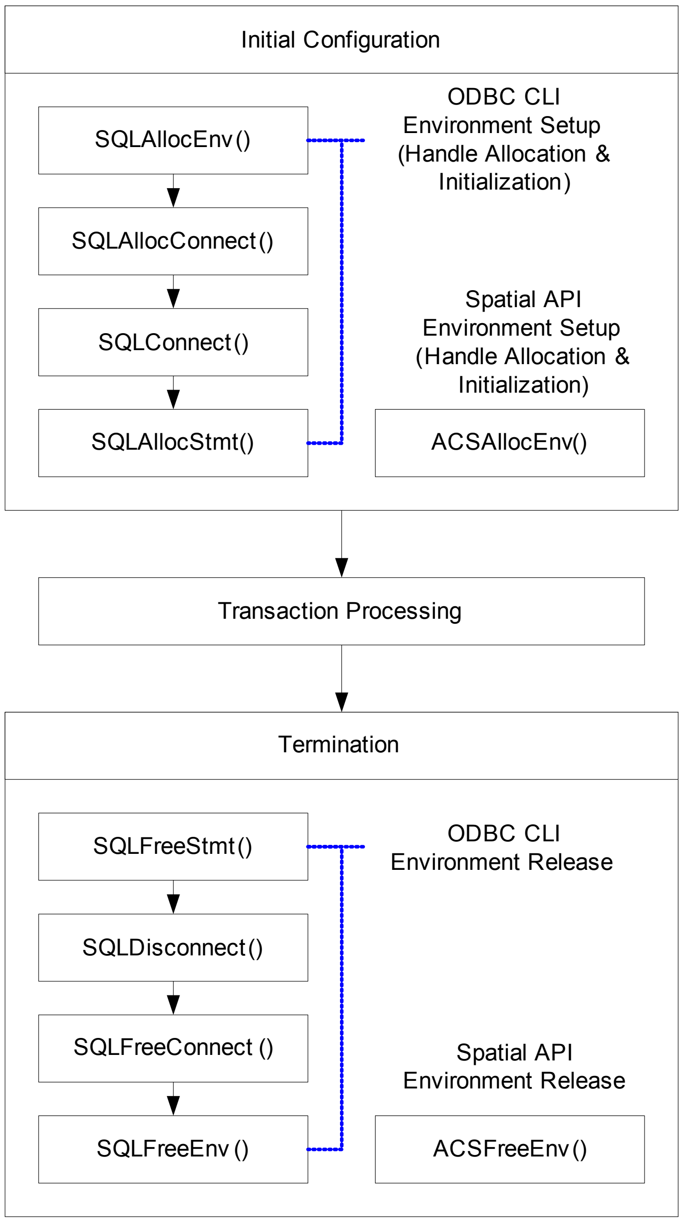


3.1.2 Basic Usage

As shown in the following diagram, a typical ODBC application can be divided into 3 stages. The Spatial API is called between these stages.

- Initial Configuration
- Transaction Processing
- Termination

Certain tasks, such as processing diagnostic messages, are conducted throughout an application, and thus do not fall into only one of the above three stages.



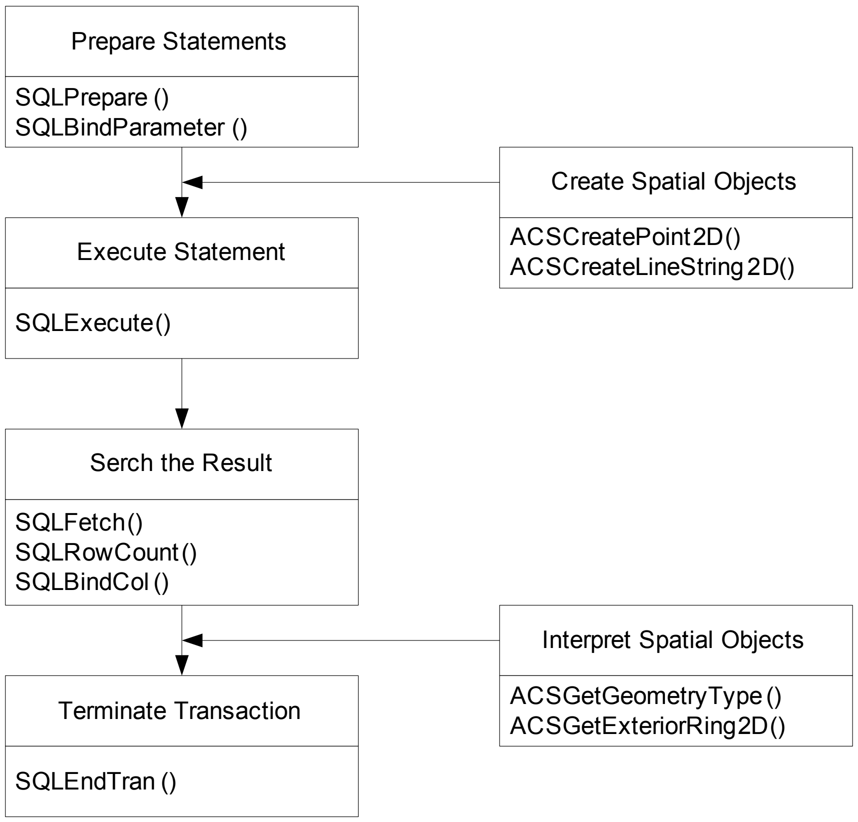
3.1.3 Initial Configuration

In this stage, environment settings are made, and connection handles are allocated and initialized.

The handles that must be allocated during the initial configuration include those that are needed to call the Spatial API. It doesn't matter whether the Spatial API or the ODBC API is initialized first.

3.1.4 Transaction Processing

The procedure by which SQL statements are typically processed using the ODBC CLI is illustrated in the following diagram. Between ODBC calls, spatial object creation and search functions are called in order to manipulate spatial objects.



3.1.5 Termination

After the handles that were allocated to the application have been terminated and the memory that was allocated thereto has been freed, the application itself is terminated.

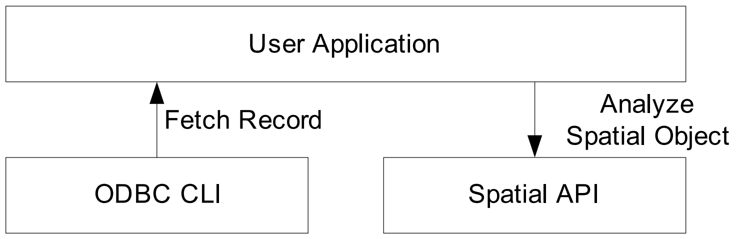
3.2 Examples of Application Programming

3.2.1 Search for Spatial Object

The general method of querying spatial objects is shown below.

The ODBC CLI is used to execute a SELECT statement to search for records.

The Spatial API is used to interpret the GEOMETRY type columns in the retrieved records.



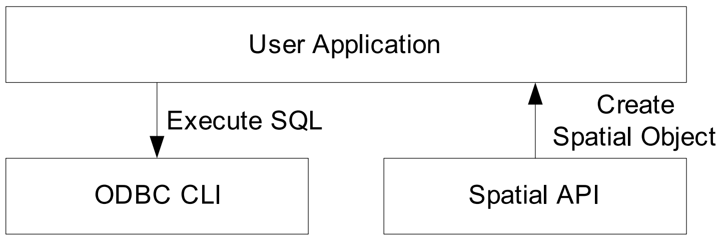
A sample application in which spatial objects are queried can be found at: `$ALTIBASE_HOME/sample/SPATIAL/selectObject.cpp`

3.2.2 Inserting, Updating, and Deleting Spatial Objects

Generally, spatial objects are inserted, updated and deleted as shown below.

First, the Spatial API is used to create a spatial object.

Then, the ODBC CLI is used to execute an INSERT, UPDATE or DELETE statement.



Sample applications in which spatial objects are inserted, updated and deleted can be found at:

- `$ALTIBASE_HOME/sample/SPATIAL/insertObject.cpp`
- `$ALTIBASE_HOME/sample/SPATIAL/updateObject.cpp`
- `$ALTIBASE_HOME/sample/SPATIAL/deleteObject.cpp`

3.3 Data Types and Functions for Use with the Spatial API

3.3.1 The Names of Basic Data Types

To ensure compatibility with C data types across platforms, the basic data types that are available in the Spatial API use the names of corresponding ODBC data types, or aliases for those types.

The exact data type definitions can be checked by viewing the contents of: `$ALTIBASE_HOME/include/acsTypes.h`

The following table provides a brief description of each of the basic data types:

ODBC Type	Alias	Meaning
SQLSCHAR	SChar	8-bit signed char
SQLCHAR	UChar	8-bit unsigned char
SQLSMALLINT	SShort	16-bit signed small integer
SQLUSMALLINT	UShort	16-bit unsigned small integer
SQLINTEGER	SInt	32-bit signed integer
SQLUINTEGER	UInt	32-bit unsigned integer
SQLBIGINT	SLong	64-bit signed big integer
SQLUBIGINT	ULong	64-bit unsigned big integer
SQLREAL	SFloat	32-bit signed float
SQLDOUBLE	SDouble	64-bit signed double float
SQLLEN	vSLong	32-bit signed integer on 32-bit platform 64 bit signed integer on 64-bit platform
SQLULEN	vULong	32-bit unsigned integer on 32-bit platform 64 bit unsigned integer on 64-bit platform

3.3.2 The Structure of Spatial Data Types

The names of the spatial object data structures that are stored internally in the ALTIBASE HDB server have the prefix “std” (which stands for “Spatio-Temporal Datatype”). Each data structure is stored, managed and interpreted in the same way on the server as it is in client applications.

The definitions of these data structures can be checked by viewing the contents of: `$ALTIBASE_HOME/include/stdNativeTypes.i`

By way of example, the data structure for a 2-dimensional Point object is as follows:

Object Type	Member	Type	Meaning
stdPoint2DType	mType	UShort	= 2001
	mByteOrder	SChar	Byte order
	mPadding	SChar	A padding byte for memory alignment
	mSize	UInt	The size of the object, including the header
	mMBR	StdMBR	Minimum bounding rectangle
	mPoint	stdPoint2D	Point

3.3.3 The Name of API Functions

The names of the Spatial API functions have the prefix "ACS", which signifies "ALTIBASE HDB Call-level Spatial".

These functions are classified as follows, and are described in corresponding sections:

- Handle & Error Management Functions
- Spatial Object Creation Functions
- Spatial Object Querying Functions
- Endian Functions

The interface for each function can also be checked directly by viewing the following file: `$ALTIBASE_HOME/include/ulsAPI.i`

3.4 Handle & Error Management Functions

3.4.1 ACSAllocEnv

This function allocates and initializes a handle, which is required in order to use the Spatial API.

3.4.1.1 Syntax

```
ACSRETURN ACSAllocEnv( ACSHENV * aHandle );
```

3.4.1.2 Argument

Data Type	Argument	Input/Output	Description
ACSHENV *	aHandle	Output	This is a pointer to an environment handle.

3.4.1.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

3.4.1.4 Description

A handle must be allocated in order to use the Spatial API in client applications. One of the functions of this environment handle is to manage information about errors that occur during the use of the Spatial API.

3.4.1.5 Diagnosing Errors

If this function returns ACS_INVALID_HANDLE, either NULL was input for the aHandle function argument, or else there is insufficient memory to allocate the environment handle.

3.4.1.6 Related Function

ACSFreeEnv

3.4.1.7 Example

```
ACSHENV sAcsEnv;
if ( ACSAllocEnv(&sAcsEnv) != ACS_SUCCESS )
{
 printf("ACSAllocEnv error!!\n");
 exit(-1);
}
```

3.4.2 ACSFreeEnv

This function terminates a Spatial API handle.

3.4.2.1 Syntax

```
ACSRETURN ACSFreeEnv( ACSHENV  aHandle );
```

3.4.2.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.

3.4.2.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

3.4.2.4 Description

This function returns the memory that was obtained for an environment handle using ACSAllo-cEnv().

3.4.2.5 Related Function

ACSAllocEnv

3.4.2.6 Example

```
ACSHENV sAcsEnv;
…
ACSFreeEnv( sAcsEnv );
```

3.4.3 ACSError

This function is used to retrieve error information after a call to a Spatial API function fails.

3.4.3.1 Syntax

```
ACSRETURN ACSError( ACSHENV          aHandle,
                    SQLUINTEGER    * aErrorCode,
                    SQLSCHAR      ** aErrorMessage,
                    SQLSMALLINT    * aErrorMessageLength );
```

3.4.3.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
SQLUINTEGER*	aErrorCode	Output	This is a pointer to a buffer in which the error code is returned.
SQLSCHAR **	aErrorMessage	Output	This is a pointer to a buffer in which the error message is returned.
SQLSMALLINT*	aErrorMessage-Length	Output	This is a pointer to a buffer containing the size of the returned error message, in bytes.

3.4.3.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

3.4.3.4 Description

This function is used to retrieve error information after a call to a Spatial API function fails.

3.4.3.5 Related Function

ACSAllocEnv

3.4.3.6 Example

```
ACSHENV sAcsEnv;
SQLUINTEGER sAcsErrNo;
SQLSCHAR * sErrMsg;
SQLSMALLINT sMsgLength;
…
if( ACSCreatePoint2D( sAcsEnv, sGeoBuffer, sGeoBufferSize, & sPoint, 0, &
sGeomSize )!= ACS_SUCCESS )
{
  if( ACSError( sAcsEnv, & sAcsErrNo, & sErrMsg, & sMsgLength ) ==
ACS_SUCCESS )
  {
    printf( "ERROR(%d) : %s\n", sErrNo, sErrMsg );
  }
}
```

3.5 Spatial Object Creation Functions

3.5.1 ACSCreatePoint2D

This function is used to create a POINT spatial object in 2-dimensional space.

3.5.1.1 Syntax

```
ACSRETURN ACSCreatePoint2D( ACSHENV            aHandle,
                            stdGeometryType  * aBuffer,
                            SQLLEN             aBufferSize,
                            stdPoint2D       * aPoint,
                            SQLINTEGER         aSRID,
                            SQLLEN           * aObjLength );
```

3.5.1.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdGeometryType *	aBuffer	Output	This is a pointer to a buffer in which to store the data for the Point object to be created.
SQLLEN	aBufferSize	Input	This is the maximum size of *aBuffer*, in bytes.
stdPoint2D *	aPoint	Input	This is a pointer to information about the location of the Point object to be created.
SQLINTEGER	aSRID	Input	This is the spatial reference system ID of the input spatial object *aPoint* (reserved for future use).
SQLLEN *	aObjLength	Output	This is a pointer to a buffer in which the size of the spatial object that was created is returned.

3.5.1.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.5.1.4 Description

This function is used to create a POINT spatial object as a GEOMETRY type from location data stored in the `stdPoint2D` structure. The definition of the `stdPoint2D` structure can be checked in the $ALTIBASE_HOME/include/stdNativeTypes.i file.

If *aBuffer* is NULL, only the size of the spatial object that was created is returned in *aObjLength*.

3.5.1.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F5(332277)	Insufficient Buffer Space	This error code indicates that the spatial object to be created is larger than the input buffer.

3.5.1.6 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/insertObject.cpp

3.5.2 ACSCreateLineString2D

This function is used to create a LINESTRING spatial object in 2-dimensional space.

3.5.2.1 Syntax

```
ACSRETURN ACSCreateLineString2D( ACSHENV               aHandle,
                                 stdGeometryType     * aBuffer,
                                 SQLLEN                aBufferSize,
                                 SQLUINTEGER           aNumPoints,
                                 stdPoint2D          * aPoints,
                                 SQLINTEGER            aSRID,
                                 SQLLEN              * aObjLength );
```

3.5.2.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdGeometryType *	aBuffer	Output	This is a pointer to a buffer in which to store the data for the LineString object to be created.

Data Type	Argument	Input/Output	Description
SQLLEN	aBufferSize	Input	This is the maximum size of *aBuffer*, in bytes.
SQLUINTEGER	aNumPoints	Input	This is the number of points in the object to be created.
stdPoint2D *	aPoints	Input	This is an array of Points in which to hold the coordinates of the points of the object to be created.
SQLINTEGER	aSRID	Input	This is the spatial reference system ID of the input spatial object *aPoints* (reserved for future use).
SQLLEN *	aObjLength	Output	This is a pointer to a buffer in which the size of the spatial object that was created is returned.

3.5.2.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.5.2.4 Description

This function is used to create a LINESTRING spatial object as a GEOMETRY type from input Points.

If *aBuffer* is NULL, only the size of the spatial object to be created will be returned in *aObjLength*.

3.5.2.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F5(332277)	Insufficient Buffer Space	This error code indicates that the spatial object to be created is larger than the input buffer.

Error Code	Description	Notes
0x511F8(332280)	Invalid Input Value	This error code indicates that an input value is not valid. The value of *aNumPoints* must be 2 or greater.

3.5.2.6 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/insertObject.cpp

3.5.3 ACSCreateLinearRing2D

This function is used to create a LINEARRING spatial object in 2-dimensional space.

3.5.3.1 Syntax

```
ACSRETURN ACSCreateLinearRing2D( ACSHENV            aHandle,
                                 stdLinearRing2D  * aBuffer,
                                 SQLLEN             aBufferSize,
                                 SQLUINTEGER        aNumPoints,
                                 stdPoint2D       * aPoints,
                                 SQLLEN           * aObjLength );
```

3.5.3.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdLinearRing2D *	aBuffer	Output	This is a pointer to a buffer in which to store the data for the LinearRing object to be created.
SQLLEN	aBufferSize	Input	This is the maximum size of *aBuffer*, in bytes.
SQLUINTEGER	aNumPoints	Input	This is the number of points in *aPoints*.
stdPoint2D *	aPoints	Input	This is an array of Points in which to hold the coordinates of the points of the object to be created.
SQLLEN *	aObjLength	Output	This is a pointer to a buffer in which the size of the spatial object that was created is returned.

3.5.3.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.5.3.4 Description

This function is used to create a LINEARRING spatial object in 2-dimensional space from input Points. The created LINEARRING object has the stdLinearRing2D structure, and is subsequently used to create a Polygon GEOMETRY object.

If *aBuffer* is NULL, only the size of the spatial object to be created will be returned in *aObjLength*.

3.5.3.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F5(332277)	Insufficient Buffer Space	This error code indicates that the spatial object to be created is larger than the input buffer.
0x511F8(332280)	Invalid Input Value	This error code indicates that an input value is not valid. The value of *aNumPoints* must be 2 or greater.

3.5.3.6 Related Function

ACSCreatePolygon2D

3.5.3.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/insertObject.cpp

3.5.4 ACSCreatePolygon2D

This function is used to create a POLYGON spatial object in 2-dimensional space.

3.5.4.1 Syntax

```
ACSRETURN ACSCreatePolygon2D( ACSHENV              aHandle,
                              stdGeometryType    * aBuffer,
                              SQLLEN               aBufferSize,
                              SQLUINTEGER            aNumRings,
                              stdLinearRing2D     ** aRings,
                              SQLINTEGER             aSRID,
                              SQLLEN               * aObjLength );
```

3.5.4.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdGeometryType*	aBuffer	Output	This is a pointer to a buffer in which to store the data for the spatial object to be created.
SQLLEN	aBufferSize	Input	This is the maximum size of *aBuffer*, in bytes.
SQLUINTEGER	aNumRings	Input	This is the number of rings in *aRings*.
stdLinearRing2D**	aRings	Input	This is an array of pointers to the Ring type objects that the Polygon will comprise.
SQLINTEGER	aSRID	Input	This is the spatial reference system ID of the input spatial object *aRings* (reserved for future use).
SQLLEN *	aObjLength	Output	This is a pointer to a buffer in which the size of the spatial object that was created is returned.

3.5.4.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.5.4.4 Description

This function is used to create a Polygon GEOMETRY object from input LinearRings stored in a `stdLinearRing2D` structure. The definition of the `stdLinearRing2D` structure can be checked in the $ALTIBASE_HOME/include/stdNativeTypes.i file.

If *aBuffer* is NULL, only the size of the spatial object that was created is returned in *aObjLength*.

3.5.4.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F5(332277)	Insufficient Buffer Space	This error code indicates that the spatial object to be created is larger than the input buffer.
0x511F8(332280)	Invalid Input Value	This error code indicates that an input value is not valid. The value of *aNumRings* must be 1 or greater.

3.5.4.6 Related Function

ACSCreateLinearRing2D

3.5.4.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/insertObject.cpp

3.5.5 ACSCreateMultiPoint2D

This function is used to create a MULTIPOINT spatial object in 2-dimensional space.

3.5.5.1 Syntax

```
ACSRETURN ACSCreateMultiPoint2D( ACSHENV              aHandle,
                                 stdGeometryType    * aBuffer,
                                 SQLLEN               aBufferSize,
                                 SQLUINTEGER          aNumPoints,
                                 stdPoint2DType    ** aPoints,
                                 SQLLEN             * aObjLength );
```

3.5.5.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdGeometryType *	aBuffer	Output	This is a pointer to a buffer in which to store the data for the spatial object to be created.

Data Type	Argument	Input/Output	Description
SQLLEN	aBufferSize	Input	This is the maximum size of *aBuffer*, in bytes.
SQLUINTEGER	aNumPoints	Input	This is the number of Point objects in *aPoints*.
stdPoint2DType **	aPoints	Input	This is an array of pointers to the Point objects that the MultiPoint object comprises.
SQLLEN *	aObjLength	Output	This is a pointer to a buffer in which the size of the spatial object that was created is returned.

3.5.5.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.5.5.4 Description

This function is used to create a MultiPoint GEOMETRY object from the input Point objects.

If *aBuffer* is NULL, only the size of the spatial object that was created is returned in *aObjLength*.

3.5.5.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F5(332277)	Insufficient Buffer Space	This error code indicates that the spatial object to be created is larger than the input buffer.
0x511F8(332280)	Invalid Input Value	This error code indicates that an input value is not valid. The value of *aNumPoints* must be 1 or greater.

3.5.5.6 Related Function

ACSCreatePoint2D

3.5.5.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/insertObject.cpp

3.5.6 ACSCreateMultiLineString2D

This function is used to create a MULTILINESTRING spatial object in 2-dimensional space.

3.5.6.1 Syntax

```
ACSRETURN ACSCreateMultiLineString2D( ACSHENV                 aHandle,
                                      stdGeometryType       * aBuffer,
                                      SQLLEN                  aBufferSize,
                                      SQLUINTEGER             aNumLineStrings,
                                      stdLineString2DType  ** aLineStrings,
                                      SQLLEN                * aObjLength );
```

3.5.6.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdGeometryType *	aBuffer	Output	This is a pointer to a buffer in which to store the data for the spatial object to be created.
SQLLEN	aBufferSize	Input	This is the maximum size of *aBuffer*, in bytes.
SQLUINTEGER	aNumLineStrings	Input	This is the number of LineS-trings in *aLineStrings*.
stdLineString2DType **	aLineStrings	Input	This is an array of pointers to the LineString objects that the MultiLineString object com-prises.
SQLLEN *	aObjLength	Output	This is a pointer to a buffer in which the size of the spatial object that was created is returned.

3.5.6.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.5.6.4 Description

This function is used to create a MultiLineString GEOMETRY object from the input LineString objects.

If *aBuffer* is NULL, only the size of the spatial object that was created is returned in *aObjLength*.

3.5.6.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F5(332277)	Insufficient Buffer Space	This error code indicates that the spatial object to be created is larger than the input buffer.
0x511F8(332280)	Invalid Input Value	This error code indicates that an input value is not valid. The value of *aNumLineStrings* must be 1 or greater.

3.5.6.6 Related Function

ACSCreateLineString2D

3.5.6.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/insertObject.cpp

3.5.7 ACSCreateMultiPolygon2D

This function is used to create a MULTIPOLYGON spatial object in 2-dimensional space.

3.5.7.1 Syntax

```
ACSRETURN ACSCreateMultiPolygon2D( ACSHENV              aHandle,
                                   stdGeometryType    * aBuffer,
                                   SQLLEN               aBufferSize,
                                   SQLUINTEGER          aNumPolygons,
                                   stdPolygon2DType  ** aPolygons,
                                   SQLLEN             * aObjLength );
```

3.5.7.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdGeometryType *	aBuffer	Output	This is a pointer to a buffer in which to store the data for the spatial object to be created.
SQLLEN	aBufferSize	Input	This is the maximum size of *aBuffer*, in bytes.
SQLUINTEGER	aNumPolygons	Input	This is the number of Polygons in *aPolygons*.
stdPolygon2DType **	aPolygons	Input	This is an array of pointers to the Polygon objects that the MultiPolygon object comprises.
SQLLEN *	aObjLength	Output	This is a pointer to a buffer in which the size of the spatial object that was created is returned.

3.5.7.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.5.7.4 Description

This function is used to create a MultiPolygon GEOMETRY object from the input Polygon objects.

If *aBuffer* is NULL, only the size of the spatial object that was created is returned in *aObjLength*.

3.5.7.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.

Error Code	Description	Notes
0x511F5(332277)	Insufficient Buffer Space	This error code indicates that the spatial object to be created is larger than the input buffer.
0x511F8(332280)	Invalid Input Value	This error code indicates that an input value is not valid. The value of *aNumLineStrings* must be 1 or greater.

3.5.7.6 Related Function

ACSCreatePolygon2D

3.5.7.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/insertObject.cpp

3.5.8 ACSCreateGeomCollection2D

This function is used to create a GEOMETRYCOLLECTION spatial object in 2-dimensional space.

3.5.8.1 Syntax

```
ACSRETURN ACSCreateGeomCollection2D( ACSHENV                aHandle,
                                     stdGeometryType      * aBuffer,
                                     SQLLEN                 aBufferSize,
                                     SQLUINTEGER            aNumGeometries,
                                     stdGeometryType     ** aGeometries,
                                     SQLLEN               * aObjLength );
```

3.5.8.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdGeometryType *	aBuffer	Output	This is a pointer to a buffer in which to store the data for the spatial object to be created.
SQLLEN	aBufferSize	Input	This is the maximum size of *aBuffer*, in bytes.
SQLUINTEGER	aNumGeome-tries	Input	This is the number of spatial objects in *aGeometries*.

Data Type	Argument	Input/Output	Description
stdGeometryType **	aGeometries	Input	This is an array of pointers to the spatial objects that the GeometryCollection object comprises.
SQLLEN *	aObjLength	Output	This is a pointer to a buffer in which the size of the spatial object that was created is returned.

3.5.8.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.5.8.4 Description

This function is used to create a GEOMETRYCOLLECTION spatial object from the input GEOMETRY objects.

If *aBuffer* is NULL, only the size of the spatial object that was created is returned in *aObjLength*.

3.5.8.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F5(332277)	Insufficient Buffer Space	This error code indicates that the spatial object to be created is larger than the input buffer.
0x511F8(332280)	Invalid Input Value	This error code indicates that an input value is not valid. The value of *aNumLineStrings* must be 1 or greater.

3.5.8.6 Related Functions

ACSCreatePoint2D

ACSCreateLineString2D

ACSCreatePolygon2D

ACSCreateMultiPoint2D

ACSCreateMultiLineString2D

ACSCreateMultiPolygon2D

3.5.8.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/insertObject.cpp

3.6 Spatial Object Querying Functions

3.6.1 ACSGetGeometryType

This function is used to determine the type of a spatial object.

3.6.1.1 Syntax

```
ACSRETURN ACSGetGeometryType( ACSHENV              aHandle,
                              stdGeometryType    * aGeometry,
                              stdGeoTypes        * aGeoType );
```

3.6.1.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdGeometryType *	aGeometry	Input	This is a pointer to a spatial object.
stdGeoTypes *	aGeoType	Output	This is a pointer to a buffer in which the type of the input spatial object is returned.

3.6.1.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.6.1.4 Description

This function is used to determine the type of a spatial object.

The type of a spatial object is one of the following:

```
typedef enum stdGeoTypes
{
  STD_UNKNOWN_TYPE = 0,
  STD_POINT_2D_TYPE = 2001,
  STD_LINESTRING_2D_TYPE = 2003,
  STD_POLYGON_2D_TYPE = 2005,
  STD_MULTIPOINT_2D_TYPE = 2011,
  STD_MULTILINESTRING_2D_TYPE = 2013,
  STD_MULTIPOLYGON_2D_TYPE = 2015,
  STD_GEOCOLLECTION_2D_TYPE = 2020,
  STD_NULL_TYPE = 9990, // Null Geometry Object
  STD_EMPTY_TYPE = 9991 // Empty Geometry Object
} stdGeoTypes;
```

3.6.1.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F9(332281)	Invalid Spatial Object	This error code indicates that the input spatial object is not valid.

3.6.1.6 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/selectObject.cpp

3.6.2 ACSGetGeometrySize

This function is used to determine the amount of storage space that a spatial object occupies.

3.6.2.1 Syntax

```
ACSRETURN ACSGetGeometrySize( ACSHENV             aHandle,
                              stdGeometryType   * aGeometry,
                              SQLLEN            * aGeomSize );
```

3.6.2.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdGeometryType *	aGeometry	Input	This is a pointer to the spatial object.
SQLLEN *	aGeomSize	Output	This is a pointer to a buffer in which the amount of storage space occupied by the input spatial object will be returned.

3.6.2.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.6.2.4 Description

This function is used to determine the amount of storage space that a spatial object occupies.

3.6.2.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F9(332281)	Invalid Spatial Object	This error code indicates that the input spatial object is not valid.
0x511FB(332283)	Spatial Object Not Supported	This error code indicates that the type of the input spatial object is not supported for use with this function.

3.6.2.6 Example

```
ACSHENV sAcsEnv;
stdGeometryType * sSubObj;
SQLLEN sGeomSize;
…
if( ACSGetGeometrySize( sAcsEnv, sSubObj, & sGeomSize ) == ACS_SUCCESS )
{
   printf( "Geometry Size = %d\n", sGeomSize );
}
else
{
   exit(-1);
}
```

3.6.3 ACSGetGeometrySizeFromWKB

This function is used to determine the size of a GEOMETRY object. It is used before a spatial object in WKB (Well-Known Binary) format is converted to a GEOMETRY object.

3.6.3.1 Syntax

```
ACSRETURN ACSGetGeometrySizeFromWKB(
    ACSHENV              aHandle,
    SQLCHAR            * aWKB,
    SQLUINTEGER          aWKBLength,
    SQLLEN             * aSize );
```

3.6.3.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
SQLCHAR *	aWKB	Input	This is a string for a spatial object in WKB format.
SQLUINTEGER	aWKBLength	Input	This is the length of *aWKB*, in bytes.
SQLLEN *	aSize	Output	This is a pointer to a buffer in which the size of the GEOMETRY object is returned.

3.6.3.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.6.3.4 Description

This function is used to determine the size of a GEOMETRY object. It is used before a spatial object in WKB (Well-Known Binary) format is converted to a GEOMETRY object.

3.6.3.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x511FC(332284)	Invalid WKB	This error message indicates that the format of the specified WKB is not valid.

3.6.3.6 Example

```
ACSHENV              sAcsEnv;
SQLCHAR            * sWKB;
SQLUINTEGER          sWKBLength;
SQLLEN               sSize;
…
if( ACSGetGeometryType( sAcsEnv, sWKB, sWKBLength, & sSize )
    == ACS_SUCCESS )
{
    printf( "Geometry Size = %d\n", sSize );
}
else
{
    exit(-1);
}
```

3.6.4 ACSGetNumGeometries

This function is used to determine the number of child spatial objects in a compound spatial object, such as a MultiPoint, MultiLineString, MultiPolygon or GeometryCollection object.

3.6.4.1 Syntax

```
ACSRETURN ACSGetNumGeometries( ACSHENV                aHandle,
                               stdGeometryType      * aGeometry,
                               SQLUINTEGER          * aNumGeometries );
```

3.6.4.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdGeometryType *	aGeometry	Input	This is a pointer to a spatial object.
SQLUINTEGER *	aNumGeome-tries	Output	This is a pointer to a buffer in which the number of child spa-tial objects that the input com-pound spatial object comprises is returned.

3.6.4.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.6.4.4 Description

This function is used to determine the number of child spatial objects in a compound spatial object, such as a MultiPoint, MultiLineString, MultiPolygon or GeometryCollection object.

3.6.4.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F9(332281)	Invalid Spatial Object	This error code indicates that the input spatial object is not valid.
0x511FB(332283)	Spatial Object Not Supported	This error code indicates that the type of the input spatial object is not supported for use with this function.

3.6.4.6 Related Function

ACSGetGeometryN

3.6.4.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/selectObject.cpp

3.6.5 ACSGetGeometryN

This function is used to get the Nth child spatial object in a compound spatial object, such as a MultiPoint, MultiLineString, MultiPolygon or GeometryCollection object.

3.6.5.1 Syntax

```
ACSRETURN ACSGetGeometryN( ACSHENV                aHandle,
                           stdGeometryType      * aGeometry,
                           SQLUINTEGER            aNth,
                           stdGeometryType     ** aSubGeometry );
```

3.6.5.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdGeometryType *	aGeometry	Input	This is a pointer to a spatial object whose child object is to be retrieved.
SQLUINTEGER	aNth	Input	This indicates which of the compound spatial object's child spatial objects is to be retrieved. The child spatial objects of a compound spatial object are numbered starting at 1.

Data Type	Argument	Input/Output	Description
stdGeometryType **	aSubGeometry	Output	This is a pointer to a pointer to a buffer in which the child spatial object is returned.

3.6.5.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.6.5.4 Description

This function is used to get the Nth child spatial object in a compound spatial object, such as a MultiPoint, MultiLineString, MultiPolygon or GeometryCollection object.

3.6.5.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F9(332281)	Invalid Spatial Object	This error code indicates that the input spatial object is not valid.
0x511F8(332280)	Invalid Input Value	This error code indicates that an input value is not valid. The value of *aNth* must satisfy the expression: `1 <= aNth <= (the number of child objects in aGeometry)`
0x511FB(332283)	Spatial Object Not Supported	This error code indicates that the type of the input spatial object is not supported for use with this function.

3.6.5.6 Related Function

ACSGetNumGeometries

3.6.5.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/selectObject.cpp

3.6.6 ACSGetExteriorRing2D

This function is used to return the exterior ring (“ExteriorRing”) of a Polygon object.

3.6.6.1 Syntax

```
ACSRETURN ACSGetExteriorRing2D( ACSHENV                aHandle,
                                stdPolygon2DType     * aPolygon,
                                stdLinearRing2D     ** aLinearRing );
```

3.6.6.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdPolygon2DType *	aPolygon	Input	This is a pointer to the Polygon object whose ExteriorRing is to be returned.
stdLinearRing2D **	aLinearRing	Output	This is a pointer to a pointer to a buffer in which the returned ExteriorRing is stored.

3.6.6.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.6.6.4 Description

This function is used to return the exterior ring of a Polygon object. An ExteriorRing is the outermost LinearRing of a Polygon object. A Polygon object has only one ExteriorRing.

3.6.6.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F9(332281)	Invalid Spatial Object	This error code indicates that the input spatial object is not valid.

Error Code	Description	Notes
0x511FB(332283)	Spatial Object Not Supported	This error code indicates that the type of the input spatial object is not supported for use with this function. The type of *aPolygon* must be STD_POLYGON_2D_TYPE.

3.6.6.6 Related Functions

ACSGetNumInteriorRing2D

ACSGetInteriorRingNPolygon2D

ACSGetNumPointsLinearRing2D

ACSGetPointsLinearRing2D

ACSGetPointNLinearRing2D

3.6.6.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/selectObject.cpp

3.6.7 ACSGetNumInteriorRing2D

This function is used to determine the number of interior rings (“InteriorRing”) in a Polygon object.

3.6.7.1 Syntax

```
ACSRETURN ACSGetNumInteriorRing2D( ACSHENV             aHandle,
                                   stdPolygon2DType  * aPolygon,
                                   SQLUINTEGER       * aNumInterinor );
```

3.6.7.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdPolygon2DType *	aPolygon	Input	This is a pointer to the Polygon object for which it is desired to know the number of Interior-Rings.
SQLUINTEGER *	aNumInterior	Output	This is a pointer to a buffer in which the number of Interior-Rings is returned.

3.6.7.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.6.7.4 Description

This function is used to determine the number of interior rings ("InteriorRing") in a Polygon object. A Polygon can have 0 or more InteriorRings.

3.6.7.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F9(332281)	Invalid Spatial Object	This error code indicates that the input spatial object is not valid.
0x511FB(332283)	Spatial Object Not Supported	This error code indicates that the type of the input spatial object is not supported for use with this function.

3.6.7.6 Related Functions

ACSGetExteriorRing2D

ACSGetInteriorRingNPolygon2D

ACSGetNumPointsLinearRing2D

ACSGetPointsLinearRing2D

ACSGetPointNLinearRing2D

3.6.7.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/selectObject.cpp

3.6.8 ACSGetInteriorRingNPolygon2D

This function is used to return the Nth InteriorRing of a Polygon object.

3.6.8.1 Syntax

```
ACSRETURN ACSGetInteriorRingNPolygon2D( ACSHENV                aHandle,
                                        stdPolygon2DType     * aPolygon,
                                        SQLUINTEGER            aNth,
                                        stdLinearRing2D     ** aLinearRing );
```

3.6.8.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdPolygon2DType *	aPolygon	Input	This is a pointer to the Polygon object whose Nth InteriorRing is to be returned.
SQLUINTEGER	aNth	Input	This indicates which Interior-Ring to return.
stdLinearRing2D **	aLinearRing	Output	This is a pointer to a pointer to a buffer in which to return the InteriorRing.

3.6.8.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.6.8.4 Description

This function is used to return the Nth InteriorRing of a Polygon object. A Polygon can have 0 or more InteriorRings.

3.6.8.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F9(332281)	Invalid Spatial Object	This error code indicates that the input spa-tial object is not valid.

Error Code	Description	Notes
0x511F8(332280)	Invalid Input Value	This error code indicates that an input value is not valid. The value of *aNth* must satisfy the following expression: `1 <= aNth <= (the number of InteriorRings in aPolygon)`
0x511FB(332283)	Spatial Object Not Supported	This error code indicates that the type of the input spatial object is not supported for use with this function.

3.6.8.6 Related Functions

ACSGetExteriorRing2D

ACSGetNumInteriorRing2D

ACSGetNumPointsLinearRing2D

ACSGetPointsLinearRing2D

ACSGetPointNLinearRing2D

3.6.8.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/selectObject.cpp

3.6.9 ACSGetNumPointsLineString2D

This function is used to determine the number of Points that a LineString object comprises.

3.6.9.1 Syntax

```
ACSRETURN ACSGetNumPointsLineString2D( ACSHENV                aHandle,
                                       stdLineString2DType  * aLineString,
                                       SQLUINTEGER          * aNumPoints );
```

3.6.9.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is a pointer to an environment handle.
stdLineString2DType *	aPolygon	Input	This is a pointer to the LineString object for which it is desired to know the number of Points.

Data Type	Argument	Input/Output	Description
SQLUINTEGER *	aNumPoints	Output	This is a pointer to a buffer in which the number of Points is returned.

3.6.9.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.6.9.4 Description

This function is used to determine the number of Points that a LineString object comprises. A LineString must have at least two Points.

3.6.9.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F9(332281)	Invalid Spatial Object	This error code indicates that the input spatial object is not valid.
0x511FB(332283)	Spatial Object Not Supported	This error code indicates that the type of the input spatial object is not supported for use with this function.

3.6.9.6 Related Functions

ACSGetPointsLineString2D

ACSGetPointNLineString2D

3.6.9.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/selectObject.cpp

3.6.10 ACSGetPointNLineString2D

This function is used to return the Nth Point in a LineString object.

3.6.10.1 Syntax

```
ACSRETURN ACSGetPointNLineString2D( ACSHENV                  aHandle,
                                    stdLineString2DType    * aLineString,
                                    SQLUINTEGER              aNth,
                                    stdPoint2D             * aPoint );
```

3.6.10.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdLineString2DType *	aPolygon	Input	This is a pointer to the LineS-tring object whose Nth Point is to be returned.
SQLUINTEGER	aNth	Input	This indicates which Point to return.
stdPoint2D *	aPoint	Output	This is a pointer to a buffer in which to return the Point.

3.6.10.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.6.10.4 Description

This function is used to return the Nth Point in a LineString object.

3.6.10.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F9(332281)	Invalid Spatial Object	This error code indicates that the input spa-tial object is not valid.

Error Code	Description	Notes
0x511F8(332280)	Invalid Input Value	This error code indicates that an input value is not valid. The value of *aNth* must satisfy the following expression: `1 <= aNth <= (the number of Points in the input LineString)`
0x511FB(332283)	Spatial Object Not Supported	This error code indicates that the type of the input spatial object is not supported for use with this function.

3.6.10.6 Related Functions

ACSGetNumPointsLineString2D

ACSGetPointsLineString2D

3.6.10.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/selectObject.cpp

3.6.11 ACSGetPointsLineString2D

This function returns an array of Points that constitute a LineString object.

3.6.11.1 Syntax

```
ACSRETURN ACSGetPointsLineString2D( ACSHENV                    aHandle,
                                    stdLineString2DType     * aLineString,
                                    stdPoint2D             ** aPoints );
```

3.6.11.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdLineString2DType *	aPolygon	Input	This is a pointer to the LineS-tring object for which the pointer to the array of Points will be returned.
stdPoint2D **	aPoints	Output	This is a pointer to a pointer to a buffer in which to return the Points.

3.6.11.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.6.11.4 Description

This function returns an array of Points that constitute a LineString object.

3.6.11.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F9(332281)	Invalid Spatial Object	This error code indicates that the input spa-tial object is not valid.
0x511FB(332283)	Spatial Object Not Supported	This error code indicates that the type of the input spatial object is not supported for use with this function.

3.6.11.6 Related Functions

ACSGetNumPointsLineString2D

ACSGetPointNLineString2D

3.6.11.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/selectObject.cpp

3.6.12 ACSGetNumPointsLinearRing2D

This function is used to determine the number of Points that a LinearRing object comprises.

3.6.12.1 Syntax

```
ACSRETURN ACSGetNumPointsLinearRing2D( ACSHENV                 aHandle,
                                       stdLinearRing2DType   * aLinearRing,
                                       SQLUINTEGER           * aNumPoints );
```

3.6.12.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdLinearRing2DType *	aPolygon	Input	This is a pointer to the Linear-Ring object for which it is desired to know the number of Points.
SQLUINTEGER*	aNumPoints	Output	This is a pointer to a buffer in which the number of Points is returned.

3.6.12.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.6.12.4 Description

This function is used to determine the number of Points that a LinearRing object comprises. A LinearRing must have at least two Points.

3.6.12.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F9(332281)	Invalid Spatial Object	This error code indicates that the input spatial object is not valid.
0x511FB(332283)	Spatial Object Not Supported	This error code indicates that the type of the input spatial object is not supported for use with this function.

3.6.12.6 Related Functions

ACSGetPointsLinearRing2D

ACSGetPointNLinearRing2D

3.6.12.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/selectObject.cpp

3.6.13 ACSGetPointNLinearRing2D

This function is used to get the Nth Point of a LinearRing object.

3.6.13.1 Syntax

```
ACSRETURN ACSGetPointNLinearRing2D( ACSHENV                   aHandle,
                                    stdLinearRing2DType     * aLinearRing,
                                    SQLUINTEGER               aNth,
                                    stdPoint2D              * aPoint );
```

3.6.13.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdLinearRing2DType *	aPolygon	Input	This is a pointer to the Linear-Ring object whose Nth Point is to be returned.
SQLUINTEGER	aNth	Input	This indicates which Point to return.
stdPoint2D *	aPoint	Output	This is a pointer to a buffer in which the Point is returned.

3.6.13.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.6.13.4 Description

This function is used to get the Nth Point of a LinearRing object.

3.6.13.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F9(332281)	Invalid Spatial Object	This error code indicates that the input spatial object is not valid.
0x511F8(332280)	Invalid Input Value	This error code indicates that an input value is not valid. The value of *aNth* must satisfy the expression: `1 <= aNth <= (the number of Points in LinearRing)`
0x511FB(332283)	Spatial Object Not Supported	This error code indicates that the type of the input spatial object is not supported for use with this function.

3.6.13.6 Related Functions

ACSGetNumPointsLinearRing2D

ACSGetPointsLinearRing2D

3.6.13.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/selectObject.cpp

3.6.14 ACSGetPointsLinearRing2D

This function returns the array of Points that constitute a LineString object.

3.6.14.1 Syntax

```
ACSRETURN ACSGetPointsLineString2D( ACSHENV                    aHandle,
                                    stdLineString2DType     * aLineString,
                                    stdPoint2D             ** aPoints );
```

3.6.14.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdLineString2DType *	aPolygon	Input	This is a pointer to the LinearRing object for which the pointer to the array of Points will be returned.

Data Type	Argument	Input/Output	Description
stdPoint2D **	aPoints	Output	This is a pointer to a pointer to a buffer in which to return the Points.

3.6.14.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.6.14.4 Description

This function returns the array of Points that constitute a LineString object.

3.6.14.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F9(332281)	Invalid Spatial Object	This error code indicates that the input spatial object is not valid.
0x511FB(332283)	Spatial Object Not Supported	This error code indicates that the type of the input spatial object is not supported for use with this function.

3.6.14.6 Related Functions

ACSGetNumPointsLineString2D

ACSGetPointNLineString2D

3.6.14.7 Example

Sample code can be found at: $ALTIBASE_HOME/sample/SPATIAL/selectObject.cpp

3.7 Endian Functions

3.7.1 ACSEndian

This function is used to forcibly convert the Endian of a spatial object.

3.7.1.1 Syntax

```
ACSRETURN ACSEndian( ACSHENV                 aHandle,
                     stdGeomeryType        * aGeometry );
```

3.7.1.2 Arguments

Data Type	Argument	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdGeometryType *	aGeometry	Input/Output	This is a pointer to the spatial object whose Endian is to be converted.

3.7.1.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.7.1.4 Description

This function is used to forcibly convert the Endian of a spatial object.

3.7.1.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.
0x511F9(332281)	Invalid Data Type	This error code indicates that the input spatial object is not valid.

3.7.1.6 Related Function

ACSAdjustBytOrder

3.7.2 ACSAdjustByteOrder

This function is used to convert the Endian of a spatial object to that of the corresponding platform.

3.7.2.1 Syntax

```
ACSRETURN ACSAdjustByteOrder( ACSHENV                aHandle,
                              stdGeomeryType       * aGeometry );
```

3.7.2.2 Arguments

Data Type	Arguments	Input/Output	Description
ACSHENV	aHandle	Input	This is an environment handle.
stdGeometryType*	aGeometry	Input/Output	This is a pointer to the spatial object whose Endian is to be converted.

3.7.2.3 Return Values

ACS_SUCCESS

ACS_INVALID_HANDLE

ACS_ERROR

3.7.2.4 Description

This function is used to convert the Endian (i.e. byte order) of a spatial object to that of the corresponding platform. If the byte order of a spatial object is different from that of a client host, the byte order of the spatial object is converted so that it is the same as that of the client. If the byte order of the client and the spatial object are the same to begin with, then no conversion is performed.

3.7.2.5 Diagnosing Errors

If this function returns ACS_ERROR, use ACSError() to check the information related to the error.

Error Code	Description	Notes
0x5101C(331804)	NULL Parameter	This error code indicates a NULL function argument.

Error Code	Description	Notes
0x511F9(332281)	Invalid Spatial Object	This error code indicates that the input spatial object is not valid.

3.7.2.6 Related Function

ACSEndian

Appendix A. Limitations on the Use of Spatial Data in ALTIBASE HDB

With the expansion of ALTIBASE HDB into the realm of spatial data, it is inevitable that some of ALTIBASE HDB extensive functionality remains as yet unsupported for use with spatial data. The current limitations are explained in detail in this Appendix.

Limitations on GEOMETRY Type Columns

Constraints

In ALTIBASE HDB, the use of various kinds of constraints is supported to ensure the validity of data.

At present, the only such constraint that can be applied to GEOMETRY type columns is the NOT NULL constraint. None of the other constraints can be used with spatial data.

Indexes

The R-Tree index is provided for use in indexing spatial data. The R-Tree index cannot be created with the UNIQUE attribute, and cannot be created on the basis of multiple columns.

As with other kinds of indexes, an R-Tree index can be stored permanently by creating it with the SET PERSISTENT option.

Triggers

The same limitations that apply to the use of triggers with stored procedures also apply to the use of triggers with spatial data. Additionally, the value of a GEOMETRY type column, including the so-called “before-image” and “after-image” values, cannot be used in a trigger.

Stored Procedures

GEOMETRY type data cannot be used as stored procedure parameters or as local variables within stored procedures.

Stored Functions

As with stored procedures, GEOMETRY type data cannot be used as stored function parameters or as local variables within stored functions. Additionally, the GEOMETRY type cannot be designated as the return type of a stored function.

Appendix B. Spatial Schema

This Appendix provides a reference for the table schema and data used in the examples throughout this manual.

Sample Table Information

Purpose

Information on the sample tables that are used to help explain the syntax and functionality of ALTIBASE HDB Spatial SQL is provided here.

Schema

Table *TB1*

Primary Key: *F1*

Initial Number of Records: 10

Column Name	Data Type	Description
F1	INTEGER	Identifier
F2	GEOMETRY	spatial data

Table *TB2*

Primary Key: *F1*

Initial Number of Records: 10

Column Name	Data Type	Description
F1	INTEGER	Identifier
F2	GEOMETRY	spatial data

Table *TB3*

Primary Key: *ID*

Initial Number of Records: 0

Column Name	Data Type	Description
ID	INTEGER	Identifier
OBJ	GEOMETRY	spatial data

Sample Data

The results of execution of the SQL statements in the examples in this manual are based on the following initial sample data:

Table *TB1*

```
CREATE TABLE TB1 (F1 INTEGER PRIMARY KEY, F2 GEOMETRY);
CREATE INDEX RT_IDX_TB1 ON TB1(F2) ;

INSERT INTO TB1 VALUES (100, NULL);
INSERT INTO TB1 VALUES (101, GEOMETRY'POINT(1 1)');
INSERT INTO TB1 VALUES (102, GEOMETRY'MULTIPOINT(1 1, 2 2)');
INSERT INTO TB1 VALUES (103, GEOMETRY'LINESTRING(1 1, 2 2)');
INSERT INTO TB1 VALUES (104, GEOMETRY'MULTILINESTRING((1 1, 2 2), (3 3, 4 
5))');
INSERT INTO TB1 VALUES (105, GEOMETRY'POLYGON((0 0, 10 0, 10 10, 0 10, 0 0
))');
INSERT INTO TB1 VALUES (106, GEOMETRY'POLYGON((3 5, 7 5, 7 9, 3 9, 3 5 ), ( 4 
6, 4 8 , 6 8, 6 6 , 4 6 ))');
INSERT INTO TB1 VALUES (107, GEOMETRY'MULTIPOLYGON(((1 1, 2 1, 2 2, 1 2, 1 
1)), ((3 3, 3 5, 5 5, 5 3, 3 3)))');
INSERT INTO TB1 VALUES (108, GEOMFROMTEXT('GEOMETRYCOLLECTION(POINT(1 1), 
LINESTRING(2 2, 3 3))'));
INSERT INTO TB1 VALUES (109, BOUNDARY(GEOMETRY'POINT(10 10)'));

iSQL> SELECT F1 FROM TB1 ;
F1
--------------
100
101
102
103
104
105
106
107
108
109
10 rows selected.
```

Table *TB2*

```
CREATE TABLE TB2 (F1 INTEGER PRIMARY KEY, F2 GEOMETRY);
CREATE INDEX RT_IDX_TB2 ON TB2(F2) ;
```

```
INSERT INTO TB2 VALUES (200, NULL);
INSERT INTO TB2 VALUES (201, GEOMETRY'POINT(10 10)');
INSERT INTO TB2 VALUES (202, GEOMETRY'MULTIPOINT(10 10, 20 20)');
INSERT INTO TB2 VALUES (203, GEOMETRY'LINESTRING(10 10, 20 20, 30 40)');
INSERT INTO TB2 VALUES (204, GEOMETRY'MULTILINESTRING((10 10, 20 20), (15 15, 
30 15))');
INSERT INTO TB2 VALUES (205, GEOMETRY'POLYGON((2 2, 12 2, 12 12, 2 12 ))');
INSERT INTO TB2 VALUES (206, GEOMETRY'POLYGON((8 3, 9 3, 9 5, 8 5, 8 3 ),( 8.2 
3.2, 8.2 4.8, 8.8 4.8 , 8.8 3.2 ,8.2 3.2 ))');
INSERT INTO TB2 VALUES (207, GEOMETRY'MULTIPOLYGON(((10 10, 10 20, 20 20, 20 
15, 10 10)), ((60 60, 70 70, 80 60, 60 60)))');
INSERT INTO TB2 VALUES (208, GEOMFROMTEXT('GEOMETRYCOLLECTION( POINT(10 10), 
POINT(30 30), LINESTRING(15 15, 20 20))'));
INSERT INTO TB2 VALUES (209, BOUNDARY(GEOMETRY'POINT(10 10)'));

iSQL> SELECT F1 FROM TB2;
F1
--------------
200
201
202
203
204
205
206
207
208
209
10 rows selected.
```

Table *TB3*

```
CREATE TABLE TB3(ID INTEGER PRIMARY KEY, OBJ GEOMETRY);
CREATE INDEX RT_IDX_TB3 ON TB3(OBJ) ;
```

Appendix C. Geometry Reference Tables

This Appendix discusses how to install and use the SPATIAL_REF_SYS and GEOMETRY_COLUMNS meta tables, which satisfy the OGC standard, and additionally outlines the limitations related to their use.

Geometry Reference Tables

The geometry reference tables are used to manage Spatial Reference IDs (SRIDs) and the Spatial Reference System (SRS).

Installation

These reference tables are added by using iSQL (or the like) to execute the script located at $ALTIBASE_HOME/thirdparty/ArcGIS/geometry_colums.sql, which was installed along with the ALTIBASE HDB package.

<Example>

```
$ isql -u sys -p manager -f $ALTIBASE_HOME/thirdparty/ArcGIS/
geometry_columns.sql
```

Usage

SPATIAL_REF_SYS and GEOMETRY_COLUMNS are public synonyms for meta tables. These tables can only be queried, but not modified, by general users.

ADDGEOMETRYCOLUMNS and DROPGEOMETRYCOLUMNS are public synonyms for stored procedures, and can be used to insert information into, and delete information from, the GEOMETRY_COLUMNS meta table.

Besides the Spatial Reference System information, if it is desired to add additional information to the geometry reference tables, modify the script located at $ALTIBASE_HOME/thirdparty/ArcGIS/geometry_colums.sql.

Limitations

- These meta tables are read-only.
- Operations on GEOMETRY objects that have different SRID values are not supported.
- Only the SYS user can use the ADDGEOMETRYCOLUMNS and DROPGEOMETRYCOLUMNS stored procedures.

- A spatial object cannot be converted from one spatial reference system to another.

GEOMETRY_COLUMNS

The GEOMETRY_COLUMNS meta table is used to define and manage SRIDs (Spatial Reference IDs) for GEOMETRY type columns.

Column name	Type	Description
TABLE_SCHEMA	VARCHAR(256)	This is the name of the owner of the table.
TABLE_NAME	VARCHAR(256)	This is the name of the table.
GEOMETRY_COLUMN	VARCHAR(256)	This is the name of the GEOMETRY type column.
COORD_DIMENSION	INTERGER	This is the number of dimensions of the GEOMETRY type object stored in the GEOMETRY type column.
SRID	INTERGER	This is the Spatial Reference Identifier.

SPATIAL_REF_SYS

The SPATIAL_REF_SYS meta table is used to manage information about Spatial Reference Identifiers (SRIDs) and the corresponding Spatial Reference System (SRS).

Column name	Type	Description
SRID	INTEGER	This is an internally used Spatial Reference Identifier.
AUTH_NAME	VARCHAR(80)	This is a standard name.
AUTH_SRID	INTERGER	This is a standard Spatial Reference Identifier.
SRTEXT	VARCHAR (2048)	This is a description of the Spatial Reference System in OGC-WKT form.
PROJ4TEXT	VARCHAR (2048)	This is information for use with PROJ4.

Related Stored Procedures

ADDGEOMETRYCOLUMNS

Syntax

```
ADDGEOMETRYCOLUMNS(f_schema VARCHAR(40),
                   f_table_name VARCHAR(40),
                   f_column_name VARCHAR(40),
                   srid INTEGER);
```

Description

This registers an existing GEOMETRY type column in the GEOMETRY_COLUMNS meta table.

Argument	Data Type	Description
f_schema	VARCHAR(40)	This is the owner of the table.
f_table_name	VARCHAR(40)	This is the name of the table.
f_column_name	VARCHAR(40)	This is the name of the GEOMETRY type column.
SRID	INTEGER	This is the identifier of the spatial reference system.

Limitations

The following limitations apply to the use of ADDGEOMETRYCOLUMNS:

- The specified owner and table must exist in the database.
- The specified column must be a GEOMETRY type column.
- The specified SRID must exist in the SYSTEM_REF_SYSTEM meta table.

Error Messages

The following errors may be raised when this stored procedure is executed.

Error Message	Description
This SRID value is out of range.	This error is raised in response to an attempt to assign an unregistered SRID to a column.
Only a geometry column can be added.	This error is raised in response to an attempt to add a column that is not a GEOMETRY type column.

Error Message	Description
It is impossible to add a nonexistent column.	This error is raised in response to an attempt to add a column that does not exist.
This column has already been added.	This error is raised in response to an attempt to add a column that has already been registered in the meta table.

Example

```
ISQL> exec AddGeometryColumns( 'SYS', 'T2', 'I1', 100 );
Execute success.
ISQL> exec AddGeometryColumns( 'SYS', 'T2', 'I1', -1 );
[ERR-F1F14 : This column is already added.
0027 : RAISE_APPLICATION_ERROR(990996,'This column is already added.');
ISQL> exec AddGeometryColumns( 'SYS', 'T2', 'I1', -1 );
[ERR-F1F14 : This column is already added.
0027 :RAISE_APPLICATION_ERROR(990996,'This column is already added.');
 ^ ^
]
```

DROPGEOMETRYCOLUMNS

Syntax

```
DROPGEOMETRYCOLUMNS( varchar(40),
                     varchar(40),
                     varchar(40) );
```

Description

This procedure is used to delete an entry corresponding to a GEOMETRY type column from the GEOMETRY_COLUMNS meta table.

Argument	Data Type	Description
f_schema	VARCHAR(40)	This is the owner of the table.
f_table_name	VARCHAR(40)	This is the name of the table.
f_column_name	VARCHAR(40)	This is the name of the GEOMETRY type column.

Restriction

The following limitations apply to the use of DROPGEOMETRYCOLUMN.

- The specified owner and table must exist in the database.
- The specified column must be a GEOMETRY type column.

- The specified SRID must exist in the SYSTEM_REF_SYSTEM meta table.

Error Message

Error Message	Description
This column is not a geometry column.	This error is raised in response to an attempt to delete a column that is not a GEOMETRY type column.
It is impossible to drop a nonexistent col-umn.	This error is raised in response to an attempt to delete a column that does not exist.

Example

```
iSQL> exec DropGeometryColumns( 'SYS', 'T2', 'I1' );
Execute success.
ISQL> exec DropGeometryColumns( 'SYS', 'T1', 'I1' );
[ERR-F1F13 : This column is not geometry column.
0016 : RAISE_APPLICATION_ERROR(990995,'This column is not geometry column.');
```

Related Stored Procedures

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