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A refresher on geospatial data

in SQL Server

Thomas Hütter

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A refresher on geospatial data in SQL Server

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- Application developer, consultant, accidental DBA, author
- Worked at consultancies, ISVs, end user companies
- Speaker at SQL events around Europe
- SQL Server > 6.5, Dynamics Nav > 3.0, R > 3.1.2

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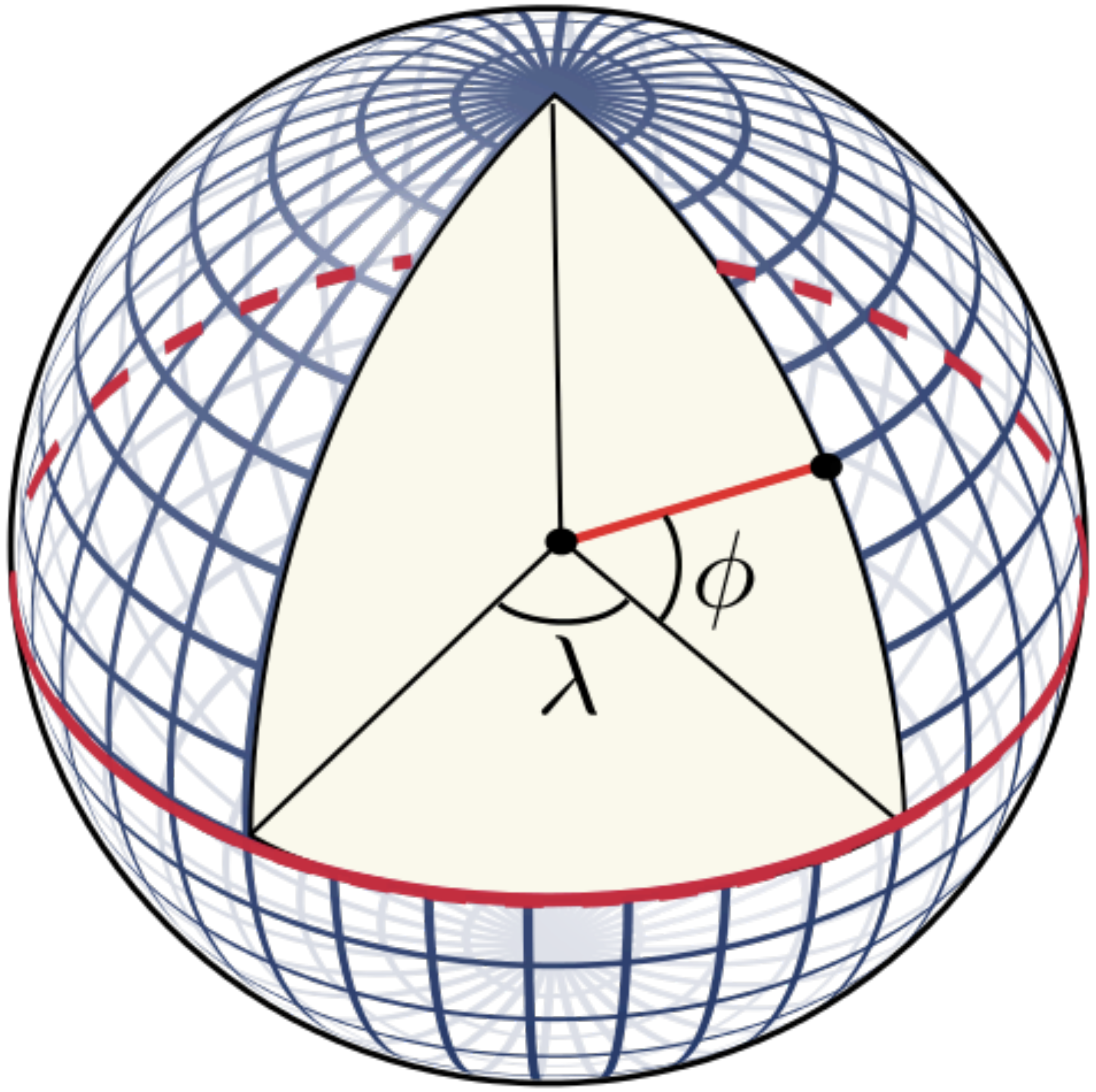
Agenda

- The concept of geospatial data
- History of geospatials in SQL Server
- From 0 to 2 dimensions: spatial types overview
- Getting spatial data into and out of SQL tables
- Functions, functions, functions…
- Practical applications
- Round-up; resources & credits; Q&A

The concept of geospatial data

Everything has a position (on the earth), purposes include visualization, analysis, design

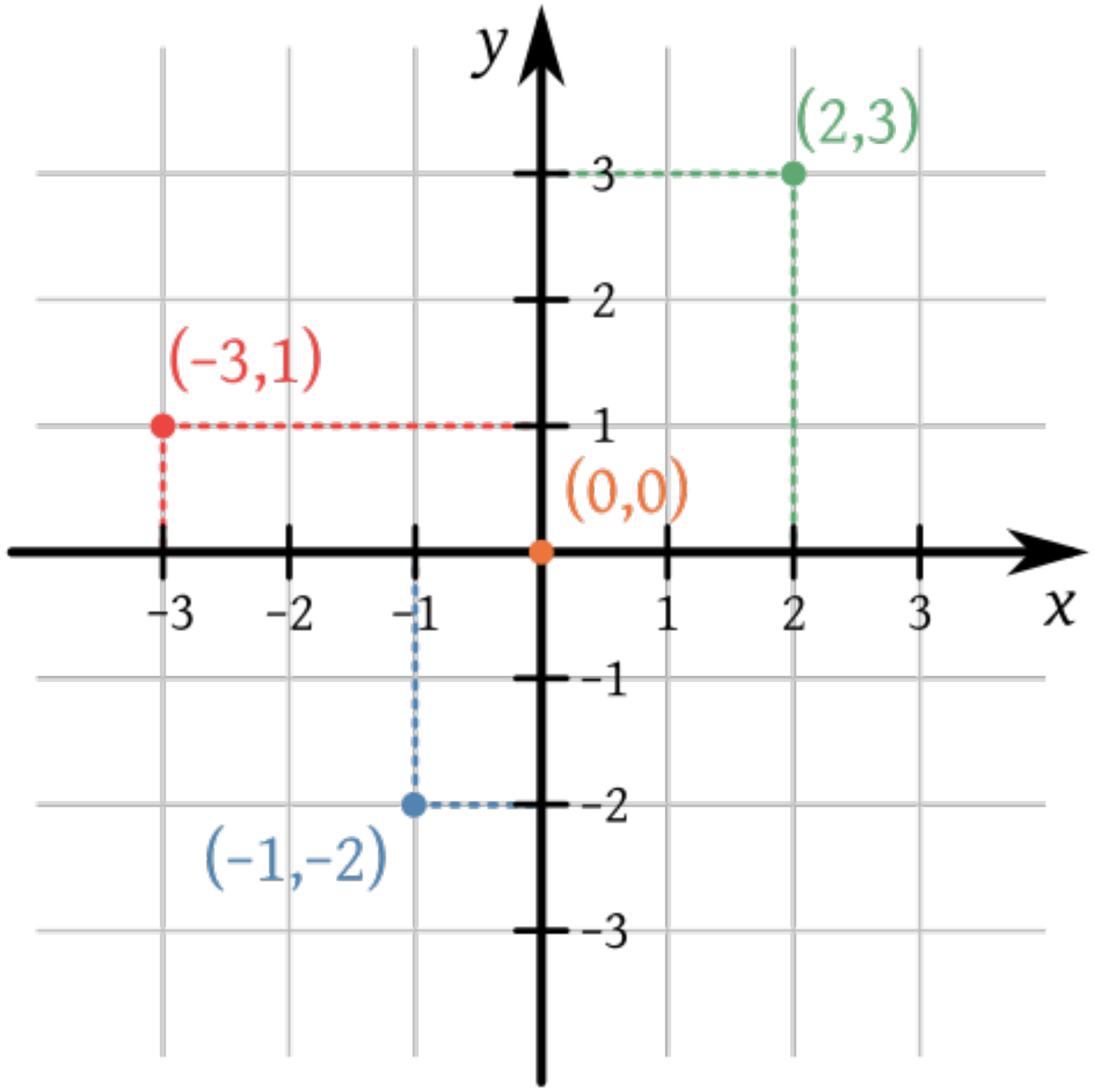


- *Geographic* data
  - position on the spheric surface of the earth
  - coordinates in degrees latitude + longitude
  - addresses, roads, cities, districts, countries…

The concept of geospatial data

Euclidian geometry dealing with points, lines, shapes, (bodies) in a Cartesian system

- *Geometric* data
  - position on a planar surface
  - coordinates in distance units X, Y
  - shop floor layout, warehouse, furniture…

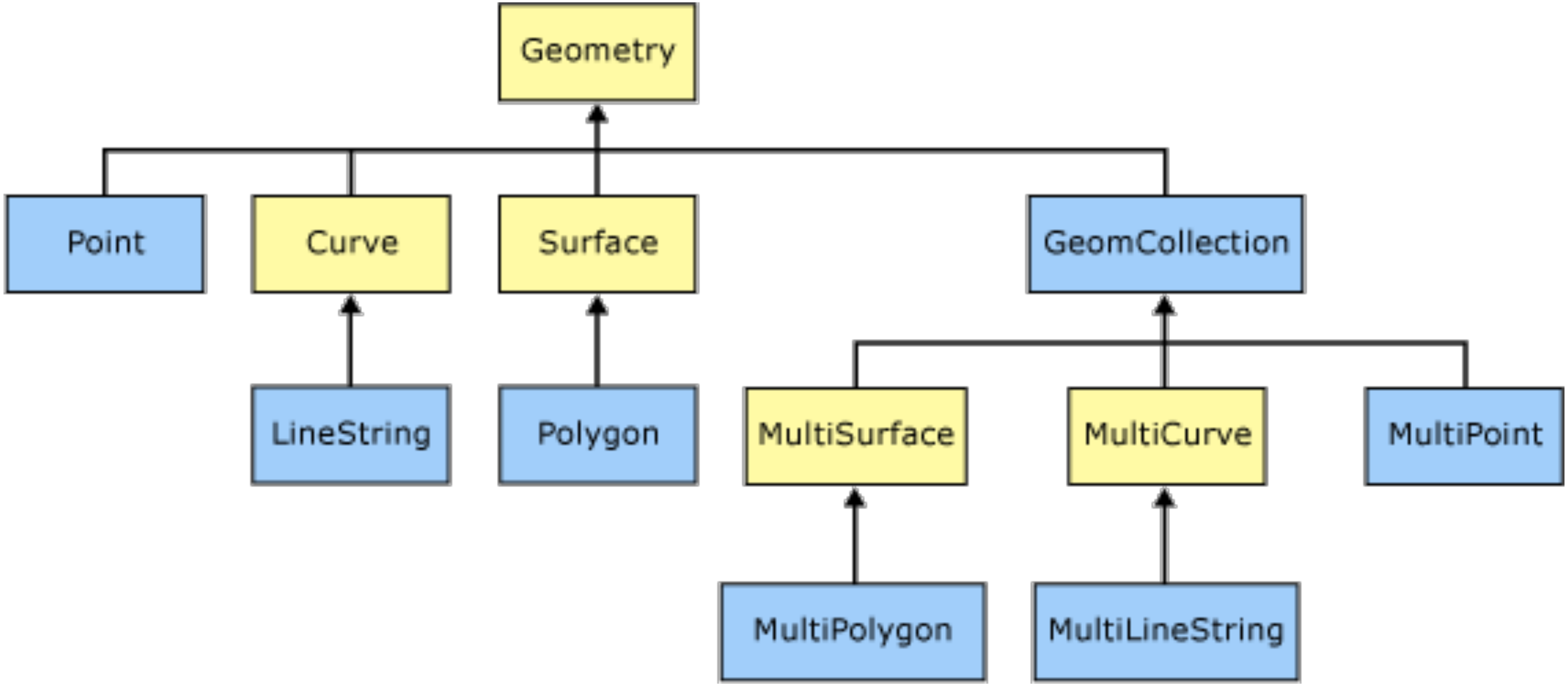


History of geospatials in SQL Server

SQL Server Versions with geospatial news

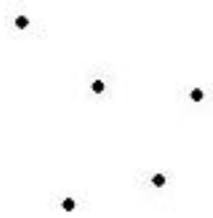
- 2008: New native geometry and geography data types and functions
- 2012: Enhancements: everything curved and „full globe“, aggregate functions, improvements in performance and precision
- 2014: . . .
- 2016: . . .
- 2017: . . .
- 2019: . . .

From 0 to 2 dimensions: spatial types overview

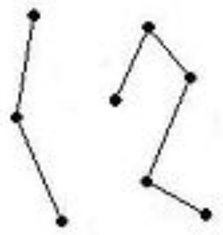


From 0 to 2 dimensions: spatial types overview

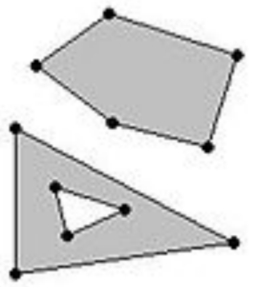
- 0 dimensions
  Point: defined by a single pair of coordinate values
  MultiPoint: collection of Points



- 1 dimension
  LineString: straight path segments connecting 2 or more points
  CircularString: arc shaped line connecting 3 or more points
  CompoundCurve: continuous curve between a set of points (Line or CircularStr)
  MultiLineString: collections of LineStrings



- 2 dimensions
  Polygons: area defined by (at least) an outer closed LineString
  CurvePolygons: area of LineString, CircularString or CompoundCurve
  MultiPolygon: collection of Polygons



- Special cases
  FullGlobe: represents the whole surface of the earth
  Empty geometries: geoms not containing any objects

From 0 to 2 dimensions: spatial types overview

CLR implementation, follows Open geospatial consortium (OGC) standards.

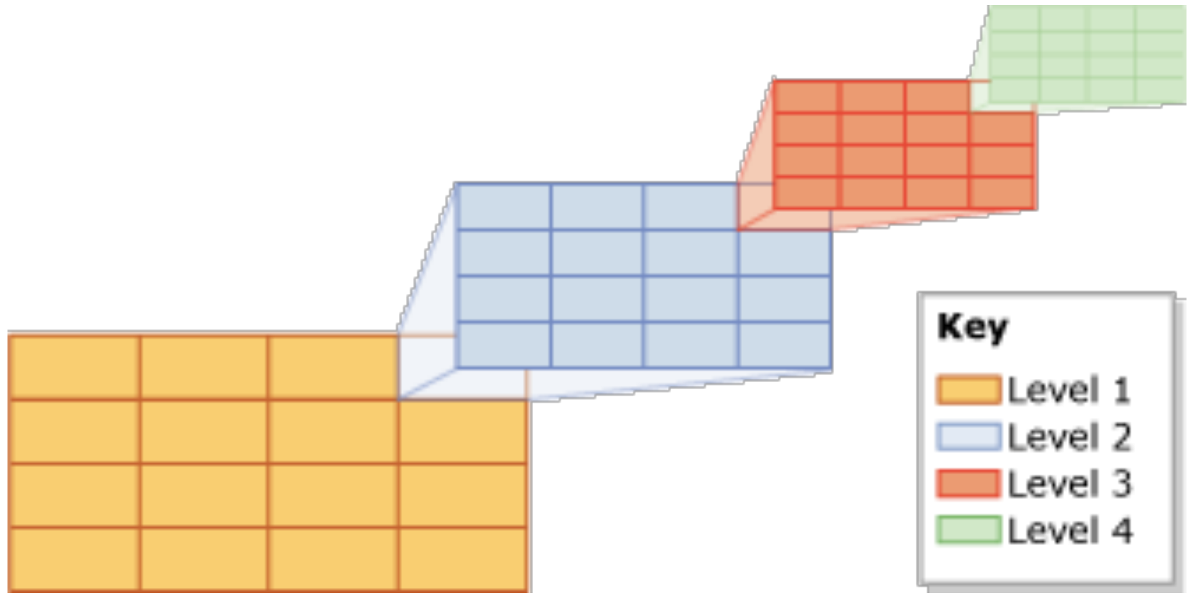
To make things comparable / relatable, we need a unified reference system

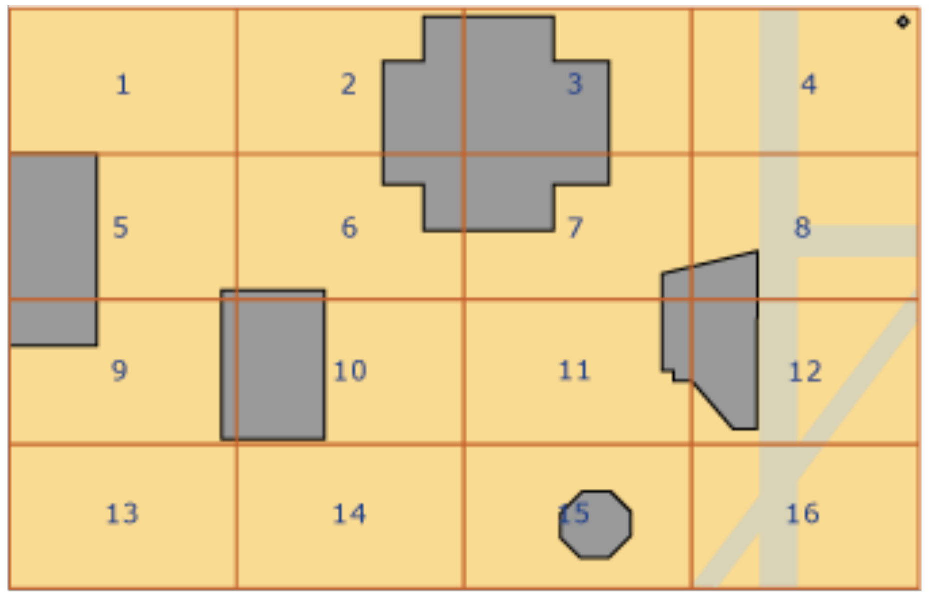
SQL Server 2012 comes with > 390 different SRIDs

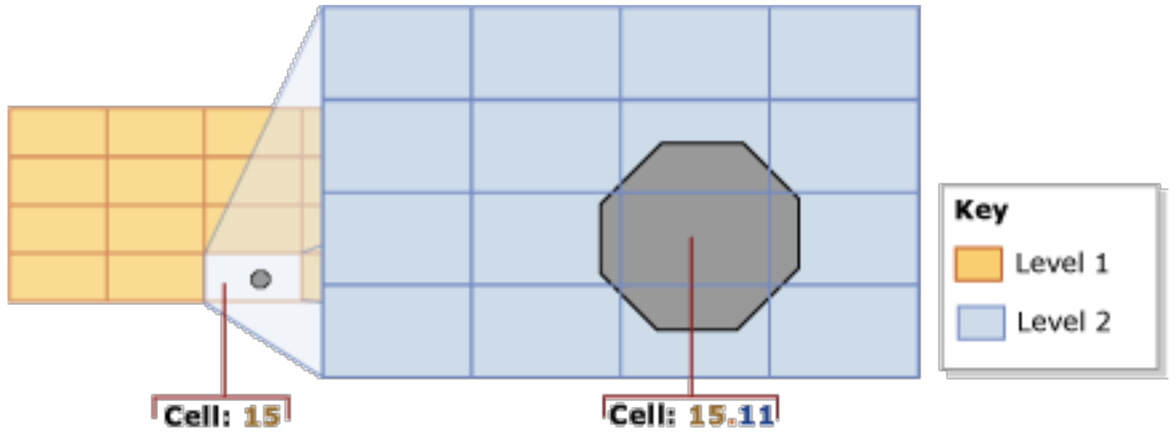
- Our default Spatial reference ID: EPSG 4326
  - Coordinate system: geographic ref WGS1984
  - Datum: ellipsoid according to World geodetic system 1984
  - Prime meridian: Greenwich
  - Projection: None
  - Unit of measurement: Degree

From 0 to 2 dimensions: spatial types overview

Spatial Indexes







- 4 level grid hierarchy
- Variable grid density per level
- Tesselation rules: covering, cells per object, deepest cell
- Optimized tessellation schemes for geometry/geography
- Support queries that include a spatial operator in the WHERE clause
- Implemented using B-Trees

Overview: https://docs.microsoft.com/en-us/sql/relational-databases/spatial/spatial-indexes-overview?view=sql-server-2017

Getting spatial data into and out of SQL tables

- Input from and output to (choices onboard):

  WKT = well known text `POINT(30 10)`
  WKB = well known binary `0x010100000000000000000003E400000…`
  GML = geometry markup language (yet another XML dialect)

  graphical output also to the SSMS spatial results tab

- Tools:
  free Windows app: Shape2SQL (2008)
  free command line tool: ogr2ogr
  commercial packages: Safe FME, ArcGIS, QGIS…
  or: write your own app ;-)

Getting spatial data into and out of SQL tables

- Spatial data input from **WKT** = well known text

  generic functions:
  `STGeomFromText(WKT, SRID)` and `Parse(WKT)` for SRID = 0

  specific functions, include type check:
  `STxxxFromText, xxx ∊ Point, Line, Poly, MPoint, MLine, MPoly, GeomColl`

  examples:
  `geometry::STPointFromText(‘POINT (30 10)’, 0)`
  `geometry::STPolyFromText(‘POLYGON ((30 10, 40 40, 20 40, 10 20, 30 10), 0)`

- Spatial data output to **WKT**
  `SELECT geom.STAsText()` results in `POINT (30 10)`
  `SELECT geom.AsTextZM()` and `geom.ToString()` include any Z (elevation) and M (measure) values: `POINT (30 10 5 17)`

Getting spatial data into and out of SQL tables

- Spatial data input from **WKB** = well known binary

  generic function `STGeomFromWKB(WKB, SRID)` and specific functions, including type check:
  `STxxxFromWKB, xxx ∊ Point, Line, Poly, MPoint, MLine, MPoly, GeomColl`

- Spatial data output to **WKB**
  `SELECT geom.STAsBinary()`

- Spatial data input from **GML** = geometry markup language

  generic function `GeomFromGML(GML, SRID)`

- Spatial data output to **GML**
  `SELECT geom.AsGML()`

Functions, functions, functions

Properties of a geometry

- `STDimension()` returns the max number of dimensions
  point = 0, line string = 1, polygon = 2, empty = -1
- `STGeometryType()` returns a text description of the type of the geom,
  i.e. Point, LineString, MultiPolygon …
- `InstanceOf(geom_type)` tests if a geom is of a specified type,
  e.g. InstanceOf(‘CircularString’), returns boolean 0 or 1
- `STIsSimple()` is true if the geom does not intersect itself
- `STIsClosed()` is true if the start and end point are the same
- `STIsRing()` is equal to the geom being simple *and* closed

Functions, functions, functions

Properties of a geometry

- `STNumPoints()` returns the number of points in the geometry
- `STIsEmpty()` is geom an empty geometry (= 0 points)?
- `STStartPoint(), STPointN(n), STEndPoint()`
  return the start point, *n*th point, end point of the geometry
- `STNumGeometries()` returns the number of geometries
- `STGeometryN(n)` returns the *n*th geometry in a collection
- `STPointOnSurface()` returns an arbitrary point within the geom
- `STX, STY, Long, Lat, Z, M, HasZ, HasM`
  return the respective coordinates (or their existence)

Functions, functions, functions

Properties of a geometry

- `STCentroid() / EnvelopeCenter()` for geography
  return a point defining the centroid („center of gravity“)
- `STBoundary()` returns the boundaries of the geometry
- `STEnvelope() / STEnvelopeAngle()` returns the geom’s bounding box
- `STConvexHull()` returns the convex hull for the geometry
- `STBuffer(dist)` returns a buffer zone with radius *dist* around the geom
  see also `BufferWithTolerance(…), BufferWithCurves(…)`
- `STLength(), STArea()` return the length and area of a geometry
- `STSrid` returns or sets the Spatial Reference ID of the geom

Practical applications

- `GeomA.STUnion(GeomB)` creates a union of two spatial items

- `GeomA.STDifference(GeomB)` forms a geometry from all the points in GeomA that are not also in GeomB - this is *not* symmetric, while `A.STSymDifference(B)` is symmetric: points in either A or B, not both

- Aggregate functions on single geo columns: `Union~, Envelope~ ConvexHull~ and CollectionAggregate(geocolumn)`

Practical applications

- `GeomA.STDistance(GeomB)` calculates the shortest distance
- `GeomA.ShortestLineTo(GeomB)` forms a geometry representing the shortest line connecting two geometries

- `GeomA.STIntersects(GeomB)` if GeomA intersects with GeomB, with complementary function `STDisjoint()`, special cases, for geometry objects only: `STCrosses(), STTouches(), STOverlaps(), STContains()`
- `GeomA.STIntersection(GeomB)` returns that part of GeomA which intersects with GeomB

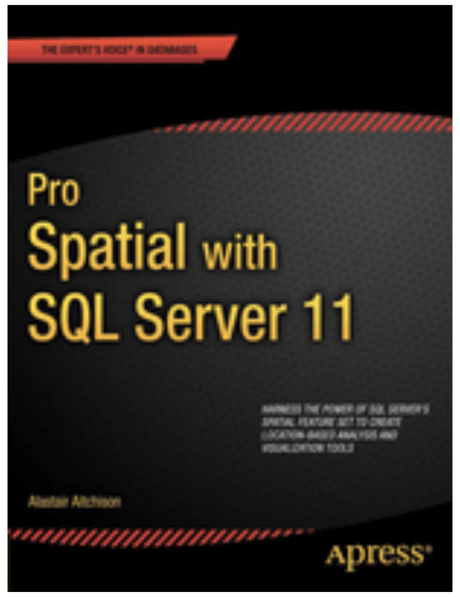
Round-up

- Geospatial data type in SQL Server since 2008, added features 2012
- Geography for spheric data, geometry for planar data
- Data types for all kind of geo objects, calculations only up to 2D
- Can be constructed via text, binary or GML
- Dozens of built-in functions to query, compare, analyze geom objects
- Write spatial queries to answer practical business questions
- Foundation to build up on

Resources on- and offline, credits

- Microsoft docs: https://docs.microsoft.com/en-us/sql/relational-databases/spatial/spatial-data-sql-server?view=sql-server-2017 (© MS for most illustrations used here) incl. link to whitepaper „New spatial features in SQL Server 2012“
- WGS84: https://en.wikipedia.org/wiki/World_Geodetic_System#WGS84
- Well-known text / binary: https://en.wikipedia.org/wiki/Well-known_text
- Open geospatial consortium: http://www.opengeospatial.org/
- GML Standard at OGC: http://www.opengeospatial.org/standards/gml
- EPSG Geodetic Parameter Registry: http://www.epsg-registry.org/

- Pro Spatial with SQL Server 2012, Alastair Aitchison, Apress, ISBN 978-1430234913



Resources on- and offline, credits

- www.geodatenzentrum.de Shapefiles for administrative areas of Germany (© GeoBasis-DE / BKG 2018)
- http://www.diva-gis.org/gdata Adm. shapefiles for Poland
- (www.mygeoposition.com Geocoding) currently out of service
  http://www.gpsvisualizer.com/geocoding.html
- SQL Server 2008 (!) Spatial Tools (Shape2SQL, SQLSpatial Query Tool) :
  https://www.sharpgis.net/page/SQL-Server-2008-Spatial-Tools

A refresher on geospatial data in SQL Server

Time for some Q & A:

That is: questions that might be of common interest,
and their answers might fit into the remaining time :-)

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Thank you for your interest & keep in touch:

- @DerFredo https://twitter.com/DerFredo
- de.linkedin.com/in/derfredo
- www.xing.com/profile/Thomas_Huetter

This file and all demo scripts can be found at:
https://github.com/SQLThomas/Conferences/tree/master/Join2018