Introduction to MySQL GIS: A Crash Course

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Agenda

1. About MySQL
2. GIS basics
3. Example
4. Future directions
About MySQL

- “The world's most popular open source DBMS”
  - Very popular in web backends
- Has had GIS support for many years
- Released version 5.7 in October 2015
  - Replaced old GIS engine with Boost.Geometry
  - The start of a GIS initiative at MySQL
  - Staffed up a GIS team
  - Main GIS feature: InnoDB spatial indexes
GIS Implementation

- Using Boost.Geometry (since MySQL 5.7)
  - Extending Boost.Geometry
  - Fixing bugs in Boost
  - Contributing back to Boost
- Built-in functionality
  - No plugins needed
GIS basics
“Geography is just physics slowed down, with a couple of trees stuck in it.”

— Terry Pratchett, in *The Last Continent*
Data types

- Geometry
  - Point
  - LineString
  - Polygon
  - GeometryCollection
    - MultiPoint
    - MultiLineString
    - MultiPolygon

Non-instantiable, but can be used as column type
Spatial reference systems

- Each geometry is in a spatial reference system (SRS)
  - Specified by SRID (integer)
  - Geometries in different SRSs can't be compared
- MySQL supports a 2d Cartesian system (infinite plane)
  - SRID 0 is default if no SRID is specified
    - Unless the import format defaults to another SRS, e.g., WGS 84 for GeoJSON
- Other reference systems
  - MySQL doesn't have a spatial reference system database
  - Computations are always done in a 2d Cartesian system
    - Will be correct for SRID 0 and projected SRSs
    - Exception: ST_Distance_Sphere
Point

Point(0, 0)

ST_GeomFromText('POINT(0 0)')

ST_GeomFromGeoJSON('{"type":"Point","coordinates":[0,0]}')

ST_PointFromGeohash('s000', 0)

ST_GeomFromWKB(0x0101000000000000000000000000000000000000, 0)

Spatial reference system identifier (SRID)
LineString

- Two or more points

LineString(Point(0, 0), Point(1, 1))

ST_GeomFromText('LINESTRING(0 0, 1 1)')

ST_GeomFromGeoJSON('{"type":"LineString","coordinates":[[0,0],[1,1]]}')
Polygon

- One exterior ring
- Zero or more inner rings (holes)
- At least four points in each ring
  - Start and end point is the same
- Clockwise and counterclockwise rings can be mixed

Polygon(LineString(Point(0, 0), Point(1, 0), Point(1, 1), Point(0, 0)))

ST_GeomFromText('POLYGON((0 0, 1 0, 1 1, 0 0), (0.2 0.1, 0.9 0.8, 0.9 0.1, 0.2 0.1))')

ST_GeomFromGeoJSON('{}type"":"Polygon","coordinates":[[[0,0],[1,0],[1,1],[0,0]]]')
MultiPoint

- One or more Point
  - Can't be empty

```
MultiPoint(Point(0, 0), Point(1, 1))
ST_GeomFromText('MULTIPOINT(0 0, 1 1)')
ST_GeomFromGeoJSON('{"type":"MultiPoint","coordinates":[[0,0],[1,1]]}')
```
MultiLineString

- One or more LineString
  - Can't be empty

MultiLineString(LineString(Point(0, 0), Point(1, 1)), LineString(Point(2, 2), Point(3, 3)))

ST_GeomFromText('MULTILINESTRING((0 0, 1 1),(2 2, 3 3))')

ST_GeomFromGeoJSON({'"type":"MultiLineString","coordinates":[[[0,0],[1,1]],[[2,2],[3,3]]]}')
MultiPolygon

- One or more Polygon
  - Can't be empty
- Polygons shouldn't overlap
  - May touch in a finite number of points

```
MultiPolygon(Polygon(LineString(Point(0, 0), Point(1, 0), Point(1, 1), Point(0, 0))))
ST_GeomFromText('MULTIPOLYGON(((0 0, 1 0, 1 1, 0 0)))')
ST_GeomFromGeoJSON('"type":"MultiPolygon","coordinates": [[[0,0],[1,0],[1,1],[0,0]]]}))
```
GeometryCollection

- Zero or more geometries
  - May be empty
- No restrictions on overlapping

GeometryCollection(0, 0), Linestring(1, 1), Point(2, 2))

ST_GeomFromText(GEOMETRYCOLLECTION(POINT(0 0), LINESTRING(1 1, 2 2)))

ST_GeomFromGeoJSON({"type":"GeometryCollection","geometries": [{"type":"Point","coordinates":[0,0]},{"type":"LineString","coordinates":[[1,1],[2,2]]}})
Data types summary

- MySQL stores shape and spatial reference system identificator (SRID)
- MySQL can store invalid geometries
  - Check with ST_IsValid
- Only GeometryCollections can be empty (not even subclasses)
  - No POINT EMPTY, MULTILINESTRING EMPTY, etc.
GIS functions

- Only defined for valid geometries
- The result is undefined for invalid geometries
  - A best effort result
  - A weird result
  - An error
- Check with ST_IsValid if unsure
- Mixing SRIDs is not allowed
  - Results in an error
Functions

- **Comparison**
  - ST_Contains, ST_Crosses, ST_Disjoint, ST_Equals, ST_Intersects, ST_Overlaps, ST_Touches, ST_Within

- **Set operations**
  - ST_Difference, ST_Intersection, ST_SymDifference, ST_Union

- **Measures**
  - ST_Area, ST_Distance, ST_Distance_Sphere, ST_Length

- **Extract properties**
  - ST_Dimension, ST_EndPoint, ST_ExteriorRing, ST_GeometryN, ST_GeometryType, ST_InteriorRingN, ST_IsClosed, ST_IsEmpty, ST_IsSimple, ST_IsValid, ST_PointN, ST_SRID, ST_StartPoint, ST_X, ST_Y
Functions

- Analysis
  - ST_Buffer, ST_Centroid, ST_ConvexHull, ST_Envelope, ST_MakeEnvelope, ST_Simplify,

- Helper functions
  - ST_LatFromGeohash, ST_LongFromGeohash, ST.Validate

- Import
  - ST_GeomCollFromTxt/ST_GeomCollFromText, ST_GeomCollFromWKB, ST_GeomFromGeoJSON, ST_GeomFromText, ST_GeomFromWKB, ST.LineFromText, ST.LineFromWKB, ST_MLineFromText, ST_MLineFromWKB, ST_MPointFromText, ST_MPointFromWKB, ST_MPolyFromText, ST_MPolyFromWKB, ST_PointFromGeohash, ST_PolyFromText, ST_PolyFromWKB

- Export
  - ST.AsBinary, ST.AsGeoJSON, ST.AsText, ST_Geohash
Optimization

- The optimizer automatically uses an R-tree index if it thinks it's beneficial
- The query must have a suitable WHERE clause
  - ST_Contains, ST_Crosses, ST_Disjoint, ST_Equals, ST_Intersects, ST_Overlaps, ST_Touches, ST_Within
  - MBRContains, MBRDisjoint, MBREquals, MBRIntersects, MBROverlaps, MBRTouches, MBRWithin
Example

- Sightseeing in Trondheim, Norway
- Database of popular places to visit
  - A unique ID
  - Position (point)
  - Descriptive text
Creating the table

CREATE TABLE sights (  
id INT AUTO_INCREMENT PRIMARY KEY,
pos POINT NOT NULL,
description VARCHAR(200),  
SPATIAL KEY my_r_tree(pos) ) ENGINE=InnoDB;

INSERT INTO sights (pos, description) VALUES (  
Point(10.3958, 63.4269), 'Nidaros Cathedral'  
);

SELECT ST_AsText(pos), description FROM sights;

ST_AsText(pos)        description
POINT(10.3958 63.4269) Nidaros Cathedral
Inserting data

INSERT INTO sights (pos, description) VALUES (  
    ST_GeomFromGeoJSON('{"type":"Point","coordinates":[10.4025,63.4194]}'),  
    'Norwegian University of Science and Technology'  
);

INSERT INTO sights (pos, description) VALUES (  
    ST_GeomFromText('POINT(10.3948 63.4225)', 4326),  
    'Student Society Building'  
);

INSERT INTO sights (pos, description) VALUES (  
    ST_GeomFromText('POINT(10.3951 63.4305)'),  
    'Olav Tryggvason Monument'  
);
Created using http://arthur-e.github.io/Wicket/
Map from Google Maps
Query

SET @city_center = ST_GeomFromText('POLYGON((10.3765 63.4292, 10.3847 63.4277, 10.3902 63.4247, 10.3986 63.4245, 10.4013 63.4264, 10.4013 63.4283, 10.4072 63.4347, 10.4037 63.4354, 10.3954 63.4350, 10.3799 63.4314, 10.3765 63.4292))');

SELECT description FROM sights WHERE ST_Within(pos, @city_center);
Query

SET @city_center = ST_GeomFromText(
  'POLYGON((10.3765 63.4292, 10.3847 63.4277, 10.3902 63.4247, 10.3986 63.4245,
    10.4013 63.4264, 10.4013 63.4283, 10.4072 63.4347, 10.4037 63.4354,
    10.3954 63.4350, 10.3799 63.4314, 10.3765 63.4292))'
);

SELECT description FROM sights
  WHERE ST_Within(pos, @city_center);

ERROR 3033 (HY000): Binary geometry function st_within given two geometries of
different srids: 4326 and 0, which should have been identical.
Query

UPDATE sights SET pos = ST_GeomFromWKB(ST_AsBinary(pos));

SELECT description FROM sights
WHERE ST_Within(pos, @city_center);

description
Nidaros Cathedral
Olav Tryggvason Monument

The WKB format doesn't preserve the SRID
Future directions
Future enhancements

- A non-flat Earth
  - Ellipsoidal Earth model
  - Projections
  - Transformations between these
- OGC and SQL/MM standard metadata tables (spatial reference systems, etc.)
- 3d and 4d support
  - 3dm, 3dz, 3dzm
- What else would you like to see?
  - Let us know!
“GIS is a form of digital mapping technology. Kind of like Google Earth, but better.”

— Arnold Schwarzenegger, Governor of California
Hardware and Software
Engineered to Work Together
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