Spatial Databases

Spatial Data Analysis and Simulation modelling,
2020, Dr. Zhiyong Wang

Learning goals

- The basic concepts of spatial databases
- Learn to create your own spatial database
- Learn to import geo-data into the spatial database
- Learn to perform simple and complex spatial queries.

Outline

- Spatial Databases
- PostGIS
  - Install and set up PostGIS
  - Spatial data types and geometric types
  - Spatial reference ID
  - Spatial functions
- Practical examples
  - Non-spatial query
  - Spatial query

Spatial Databases

What is a spatial database?

A spatial database is a database that is optimized for storing and querying data that represents objects defined in a geometric space.

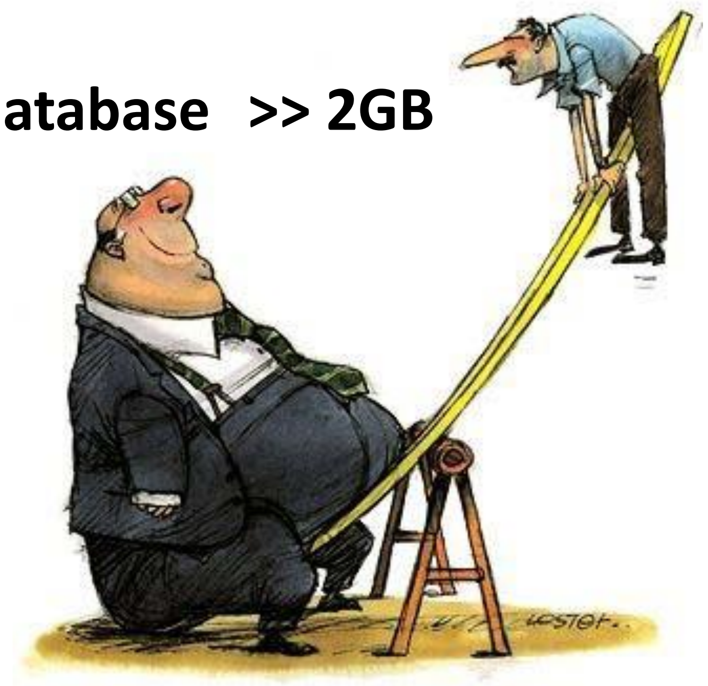
From https://en.wikipedia.org/wiki/Spatial_database

Why spatial databases?

Spatial databases VS Shapefiles

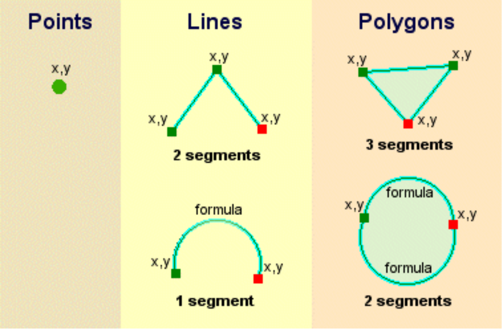
Shapefile < 2GB

Spatial database >> 2GB



Why spatial databases?

Vector data



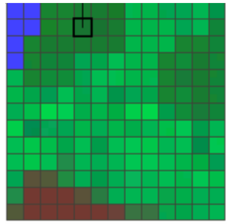
Spatial databases

Spatial analysis

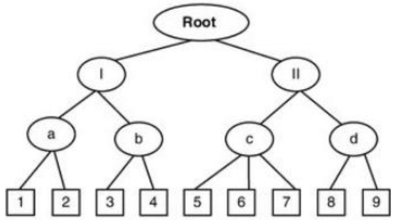
- Spatial join
- Spatial aggregation
- Spatial computation

…….

Raster data



Spatial indexing



Examples of spatial databases

PostgreSQL

PostgreSQL / PostGIS (open source)

ORACLE

SPATIAL

Oracle / Oracle Spatial and Graph

IBM

DB2

DB2 spatial extender

SpatiaLite (dateibasiert)

NoSQL:

geomesa

PostGIS

Postgresql

Postgresql is a free and open-source relational database management system (RDBMS).

-- over 30 years of active development

-- provides a variety of datatypes

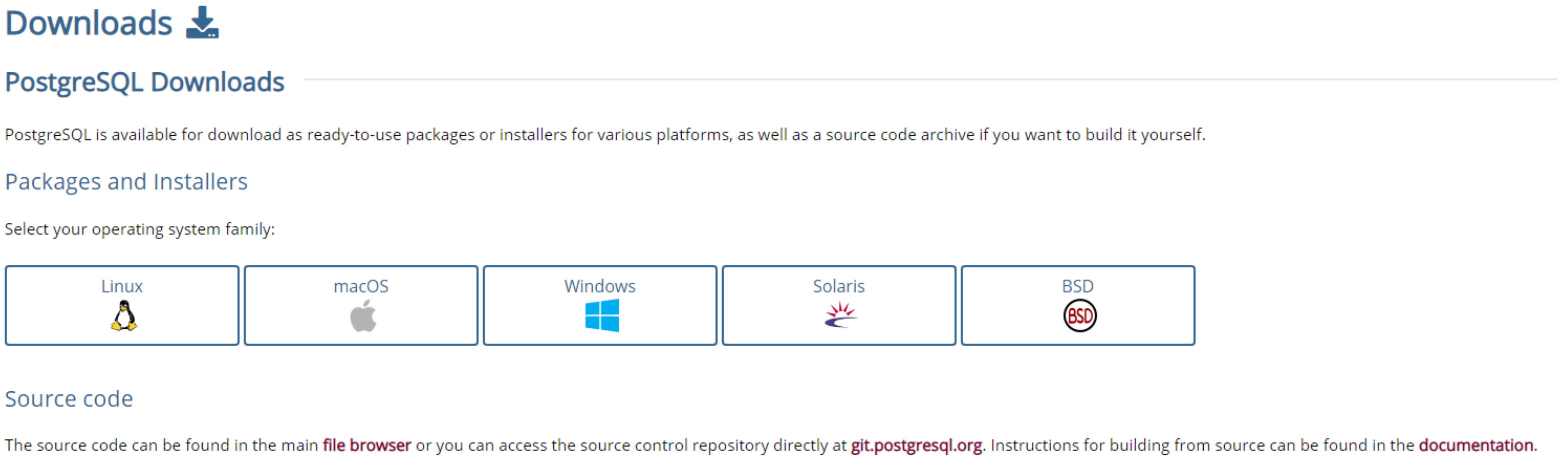
-- available for many operating systems

PostGIS

PostGIS adds spatial capabilities to the PostgreSQL relational database. It is an extension of PostgreSQL, and enables it to store, query, and manipulate spatial data.

Install PostgreSQL /PostGIS

- Install PostgreSQL



Downloads

PostgreSQL Downloads

PostgreSQL is available for download as ready-to-use packages or installers for various platforms, as well as a source code archive if you want to build it yourself.

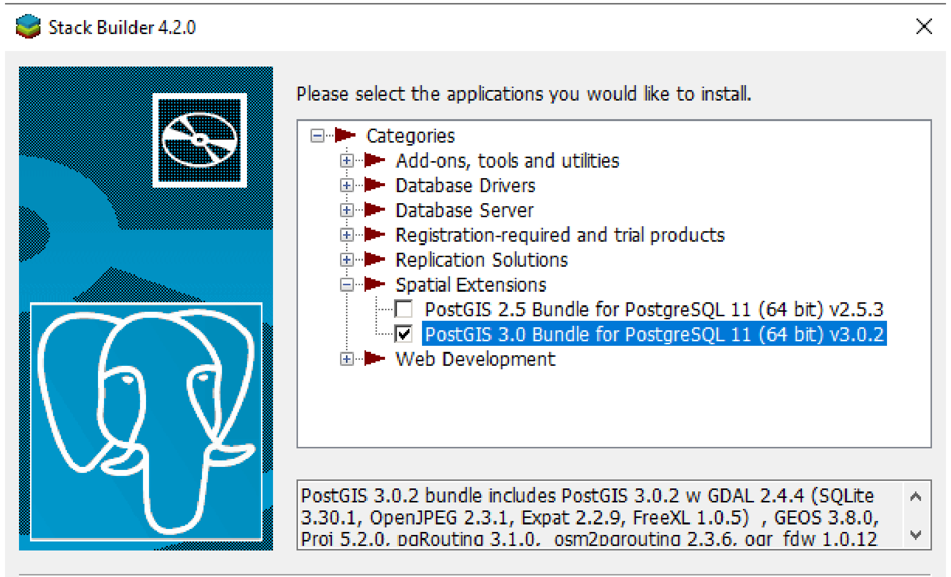
Packages and Installers

Select your operating system family:

Source code

The source code can be found in the main file browser or you can access the source control repository directly at git.postgresql.org. Instructions for building from source can be found in the documentation.

- Install PostGIS



Stack Builder 4.2.0

Please select the applications you would like to install.

```
Categories
  Add-ons, tools and utilities
  Database Drivers
  Database Server
  Registration-required and trial products
  Replication Solutions
  Spatial Extensions
    □ PostGIS 2.5 Bundle for PostgreSQL 11 (64 bit) v2.5.3
    ☑ PostGIS 3.0 Bundle for PostgreSQL 11 (64 bit) v3.0.2
  Web Development
```

PostGIS 3.0.2 bundle includes PostGIS 3.0.2 w GDAL 2.4.4 (SQLite 3.30.1, OpenJPEG 2.3.1, Expat 2.2.9, FreeXL 1.0.5) , GEOS 3.8.0, Proj 5.2.0, pgRouting 3.1.0, osm2pgrouting 2.3.6, ogr_fdw 1.0.12

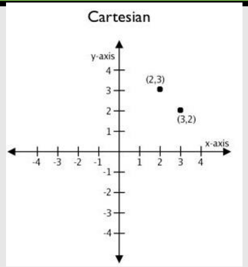
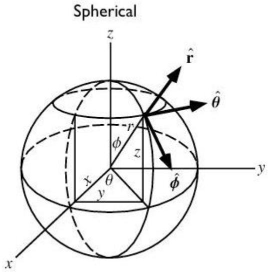
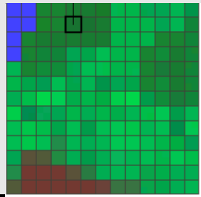
Set up PostGIS

- Activate the PostGIS extension in PostgreSQL

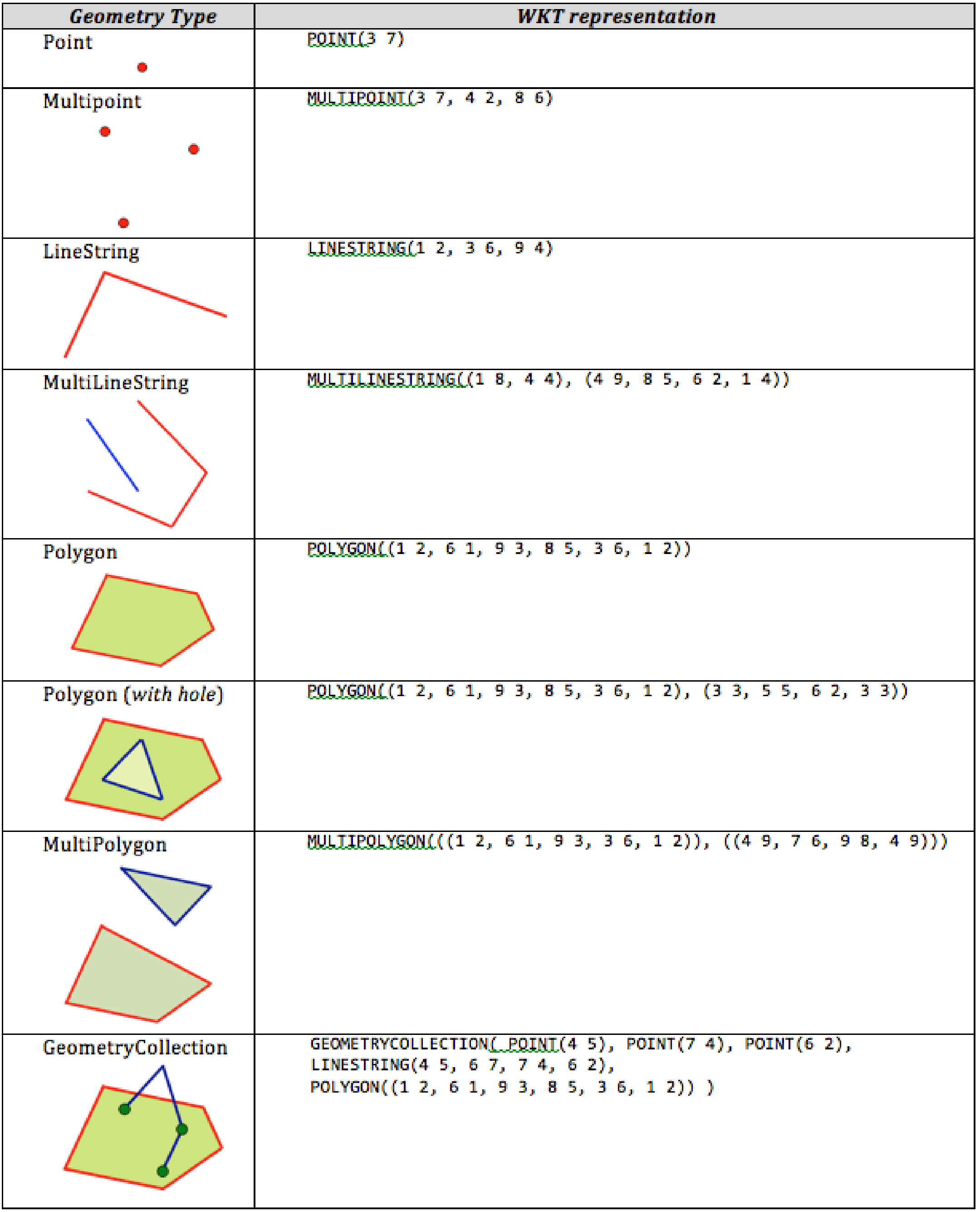
```
CREATE DATABASE ads_db;
CREATE EXTENSION postgis;
```

This will install the corresponding PostGIS functions in the public schema.
In addition, a table "spatial_ref_sys" and four views "geometry_columns", "geography_columns", "raster_columns" and "raster_overviews" are created.

PostGIS: Spatial datatypes

Spatial Data type	Description
Geometry	Represent a feature in planar (Euclidean) coordinate systems. 
Geography	Represent a feature in geodetic coordinate systems. Geodetic coordinates are spherical coordinates expressed in angular units (degrees). 
Raster	Represent raster data (imported from TIFFs, PNGs) 

PostGIS – Geometric types



Geometry Type	*WKT representation*
Point	POINT(3 7)
Multipoint	MULTIPOINT(3 7, 4 2, 8 6)
LineString	LINESTRING(1 2, 3 6, 9 4)
MultiLineString	MULTILINESTRING((1 8, 4 4), (4 9, 8 5, 6 2, 1 4))
Polygon	POLYGON((1 2, 6 1, 9 3, 8 5, 3 6, 1 2))
Polygon (*with hole*)	POLYGON((1 2, 6 1, 9 3, 8 5, 3 6, 1 2), (3 3, 5 5, 6 2, 3 3))
MultiPolygon	MULTIPOLYGON(((1 2, 6 1, 9 3, 3 6, 1 2)), ((4 9, 7 6, 9 8, 4 9)))
GeometryCollection	GEOMETRYCOLLECTION(POINT(4 5), POINT(7 4), POINT(6 2), LINESTRING(4 5, 6 7, 7 4, 6 2), POLYGON((1 2, 6 1, 9 3, 8 5, 3 6, 1 2)))

PostGIS: Spatial Reference ID

- A Spatial Reference Identifier (SRID) is an identifier associated with a specific coordinate system.
- All existing projections are stored in the **spatial_ref_sys** table.

SRID:28992 --- Amersfoort / RD New

SRID:4326 --- WGS 84 (World Geodetic System)

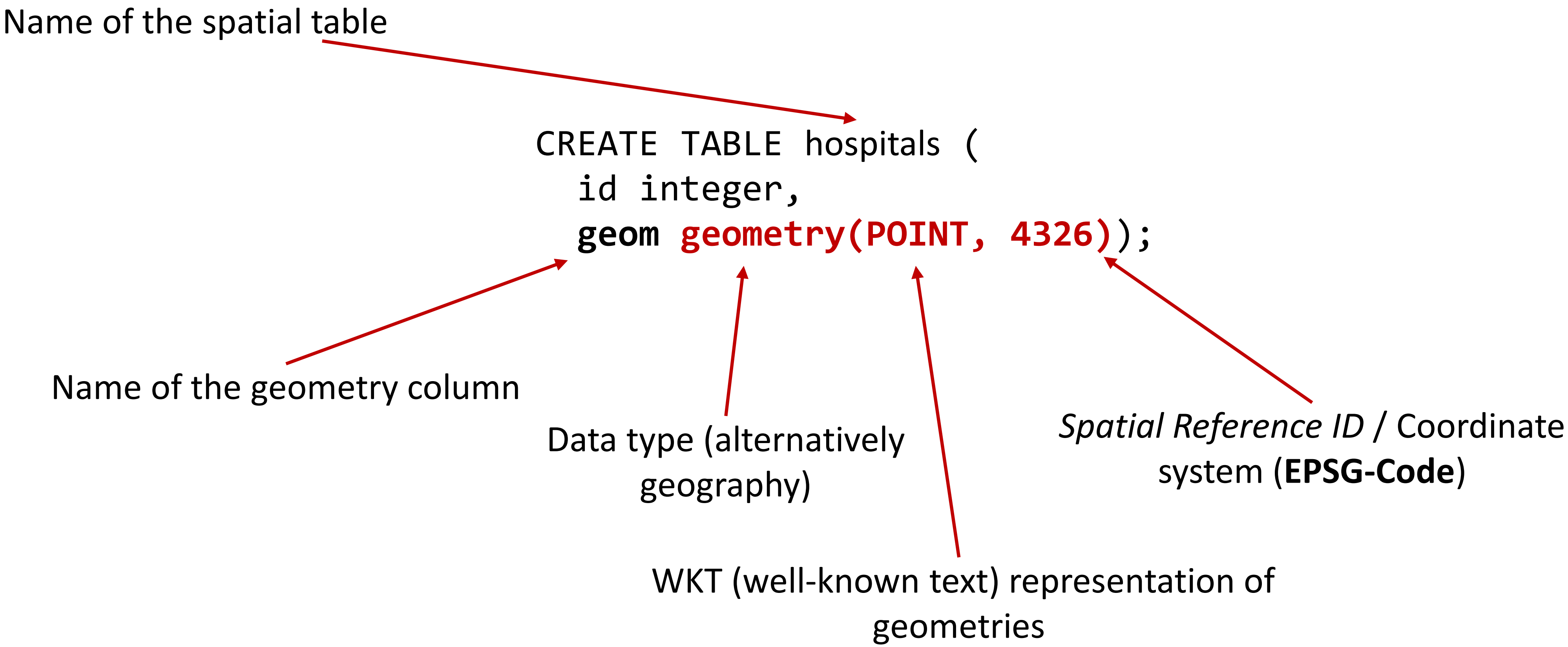
- Search for suitable SRID or EPSG codes:
  - http://www.epsg-registry.org
  - http://spatialreference.org/ref/epsg/

PostGIS: spatial functions

Creation, access, editing and output of geometries

- Creation of points, lines and polygons:
  - ST_MakePoint, ST_MakeLine, ST_MakePolygon
- Access to geometries:
  - ST_StartPoint, ST_EndPoint, ST_X, ST_Y
- Access to properties:
  - ST_IsValid, ST_IsClosed, ST_Npoints, ST_IsSimple
- Edit geometries:
  - ST_AddPoint, ST_Multi, ST_Translate
- Ouput geometries:
  - ST_AsText, ST_AsKML, ST_AsGML

PostGIS : create spatial tables



Name of the spatial table

```
CREATE TABLE hospitals (
  id integer,
  geom geometry(POINT, 4326));
```

Name of the geometry column

Data type (alternatively geography)

WKT (well-known text) representation of geometries

Spatial Reference ID / Coordinate system (**EPSG-Code**)

PostGIS : Create and import geometries

- Insert geodata (vector) into tables, using **INSERT INTO .....**

```
INSERT INTO hospitals (id, geom)
 VALUES (1,
  ST_GeomFromText('POINT(…)', 4326), -- WKT representation of geometries + SRID
);
-- other formats possible, e.g. ST_GeomFromGML
```

  - via GUI (e.g., pgAdmin (www.pgadmin.org))

  - via command line (ogr2ogr, shp2pgsql…)

  e.g., ogr2ogr -f “PostgreSQL” PG:”host=<hostname> dbname=<dbname> user=<yourusername> password=<yourpassword>” <dir>\yourdatafile.shp

  - and many more

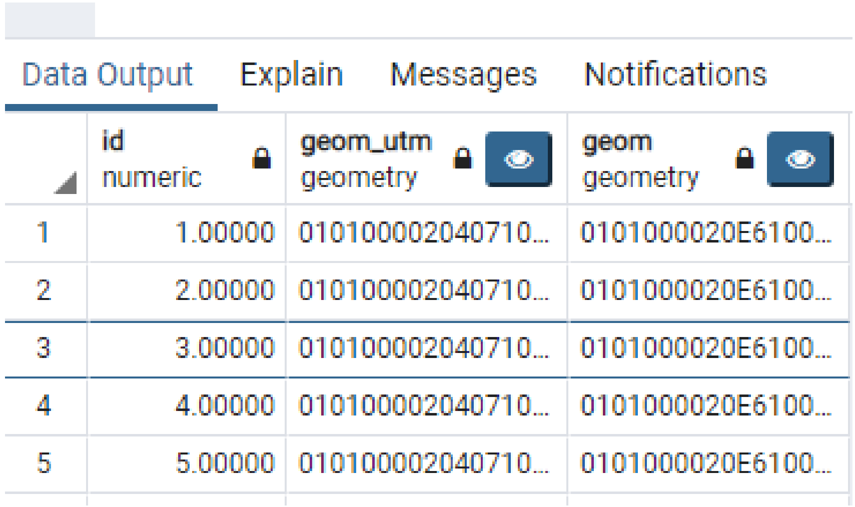
  http://postgis.net/workshops/postgis-intro/loading_data.html
  https://techcommunity.microsoft.com/t5/azure-database-for-postgresql/importing-spatial-data-to-postgis/ba-p/1255421

PostGIS: Transformation

- Coordinate transformation of a geometry column:

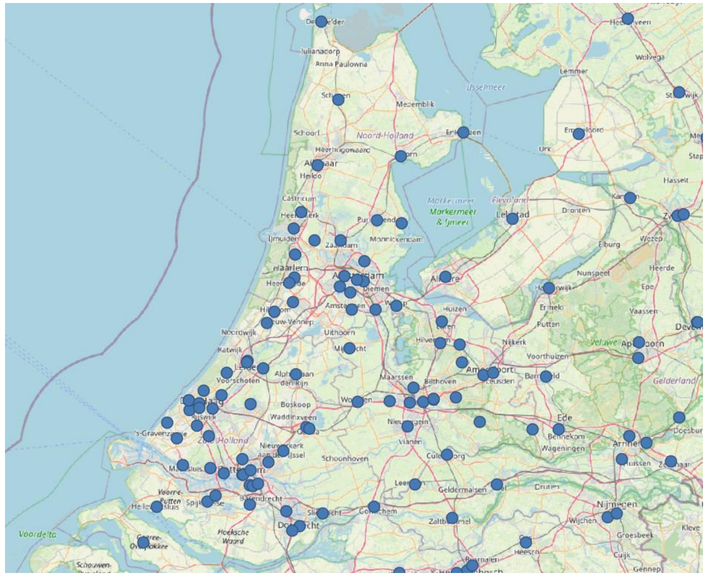
```
ALTER TABLE hospitals
 ADD COLUMN geom_utm geometry(POINT, 28992);

UPDATE hospitals SET geom_utm = ST_Transform(geom, 28992);
```



	id numeric	geom_utm geometry	geom geometry
1	1.00000	010100002040710...	0101000020E6100...
2	2.00000	010100002040710...	0101000020E6100...
3	3.00000	010100002040710...	0101000020E6100...
4	4.00000	010100002040710...	0101000020E6100...
5	5.00000	010100002040710...	0101000020E6100...

Use case

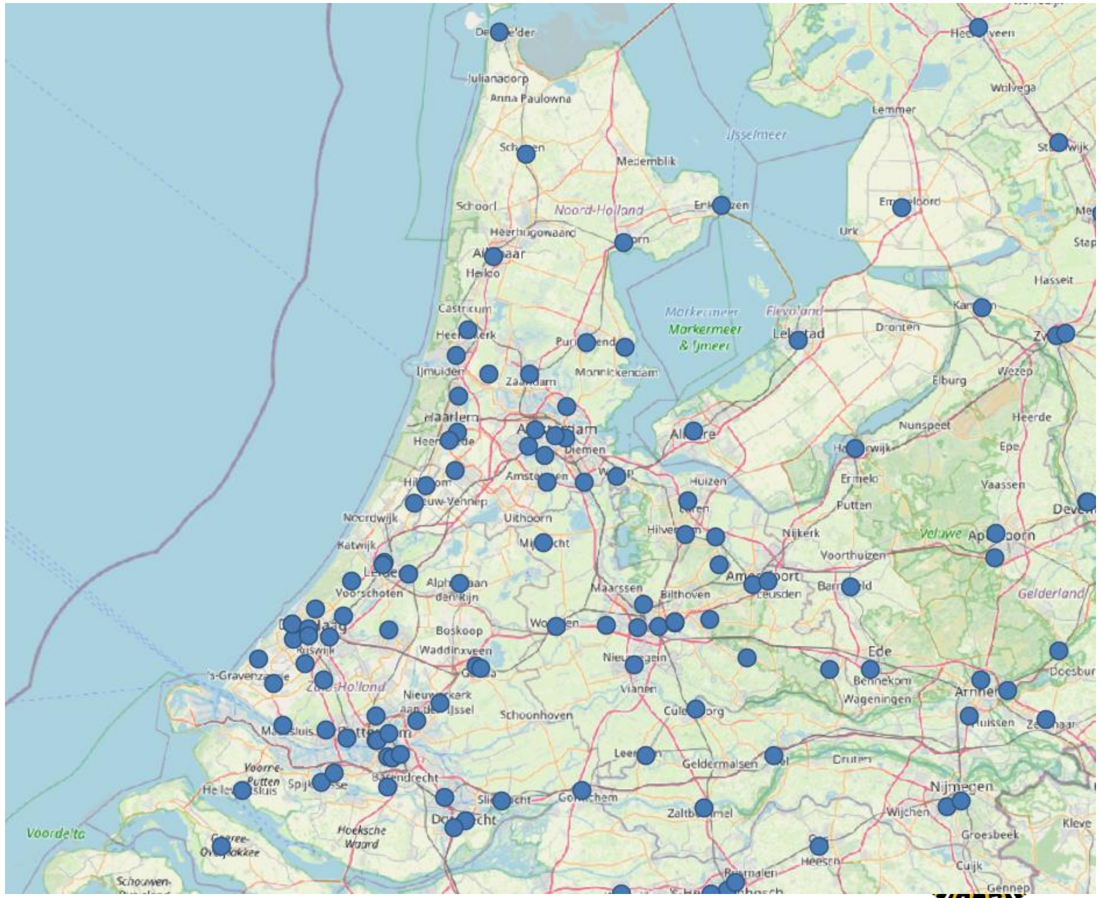


Hospitals in the Netherlands

Practical examples: non-spatial query

- **SELECT** count (*) **FROM** hospitals

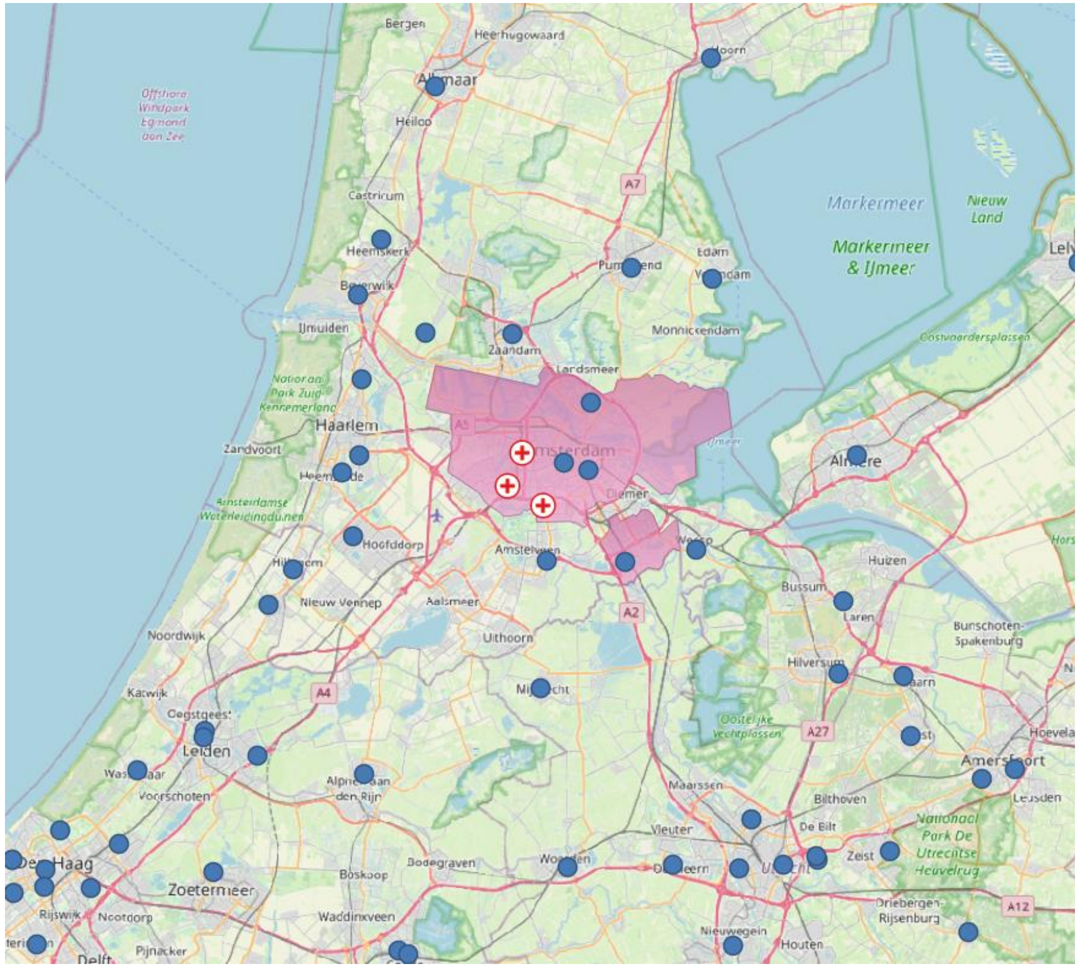
Result:
186



Practical examples: spatial query

- **SELECT count(*) from** hospitals hp **JOIN** municipality_ams ma **on st_contains(**ga.geom, hp.geom**)**

Result:
7

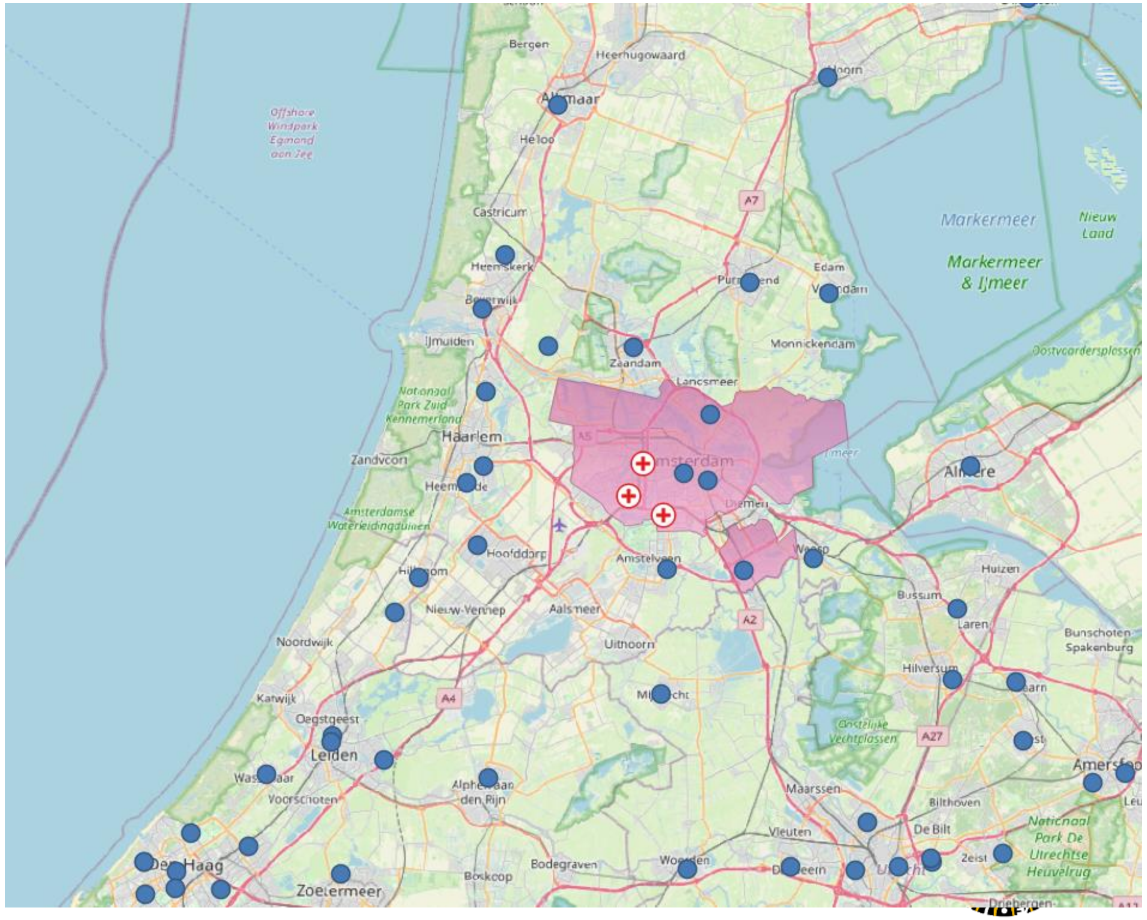


https://postgis.net/docs/ST_Contains.html

Practical examples: spatial query

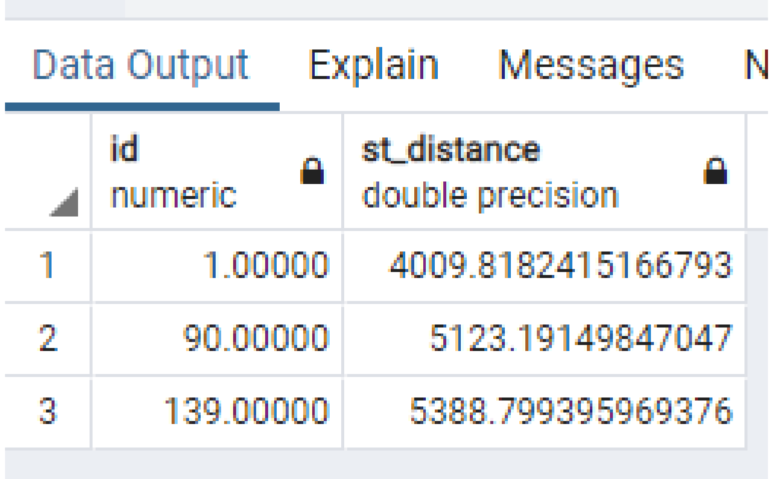
- **SELECT count(*) from** hospitals hp **JOIN** gemeente_ams ga **on st_contains(**ga.geom, hp.geom**) where** hp.id > 100

Result:
3

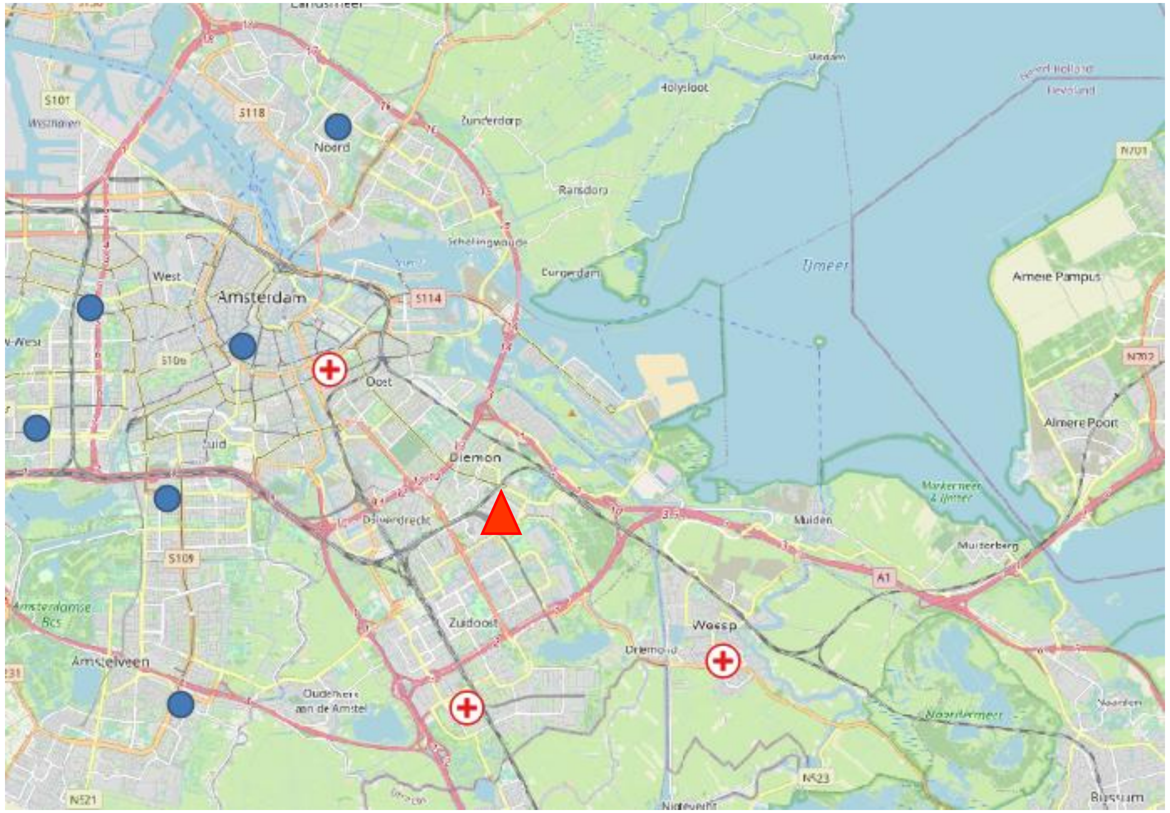


Practical examples: spatial query

- **SELECT** id, st_distance(ST_SetSRID(ST_MakePoint(126706.3, 482433.8),28992), geom) **from** hospitals **ORDER BY** st_distance(ST_SetSRID(ST_MakePoint(126706.3, 482433.8),28992), geom) **ASC limit** 3;



	id numeric	st_distance double precision
1	1.00000	4009.8182415166793
2	90.00000	5123.19149847047
3	139.00000	5388.799395969376



Reference

- Introduction to PostGIS https://postgis.net/workshops/postgis-intro/
- PostGIS 2.4.5dev Manual: http://postgis.net/docs/manual-2.4/
- Open Geospatial Consortium Inc. (2011) OpenGIS Implementation Stadnard for Geographic information - Simple feature access - Part 1: Common architecture. & Part 2: SQL option.
- Rigaux, P., Scholl, M. & Voisard, A. (2002) Spatial databases with application to GIS. San Francisco, CA.

Questions (Q&A session)

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