Back to Basics: Using a Spatial Index to Find the Nearest Pub

Albert Godfrind – Spatial Solutions Architect at Oracle

albert.godfrind@oracle.com agodfrin agodfrind

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ORACLE

Using a spatial index to find the nearest pub

Albert Godfrind

Spatial and Graph Solutions Architect

May 2022

Photo by Astrid Schaffner on Unsplash

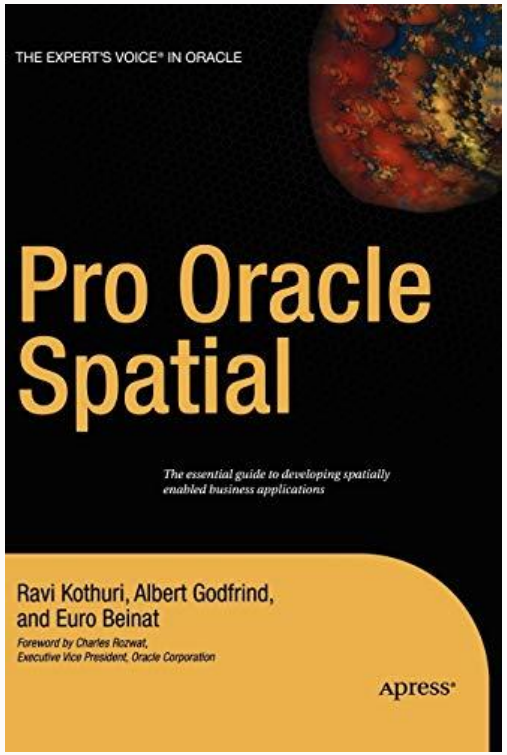
In IT for way too long!

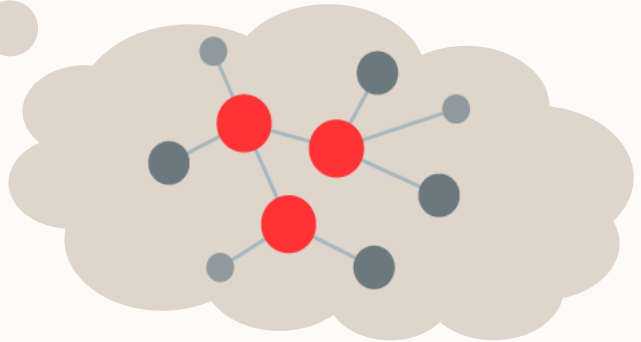
With Oracle for ever

Oracle Spatial Evangelist

Graph Evangelist

Author





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Act I – The Fundamentals

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What is Spatial Data?

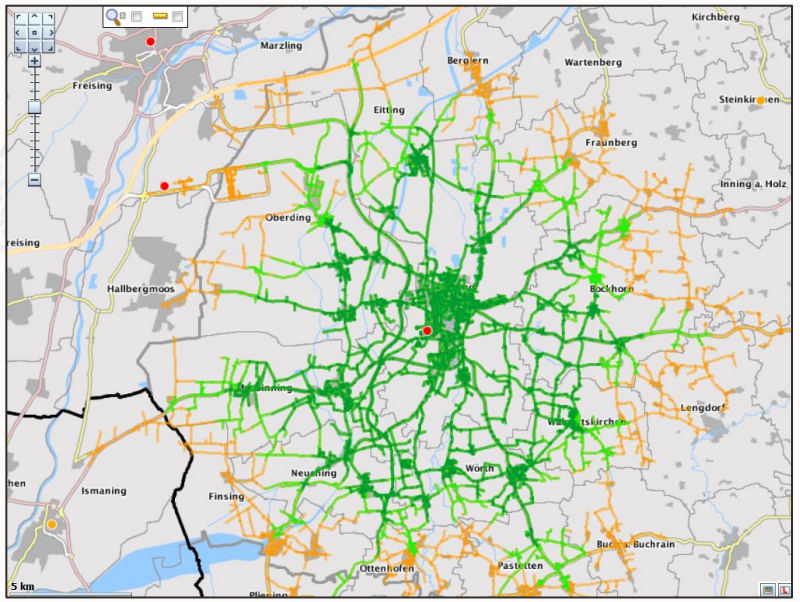
Business data that contains or describes **location**

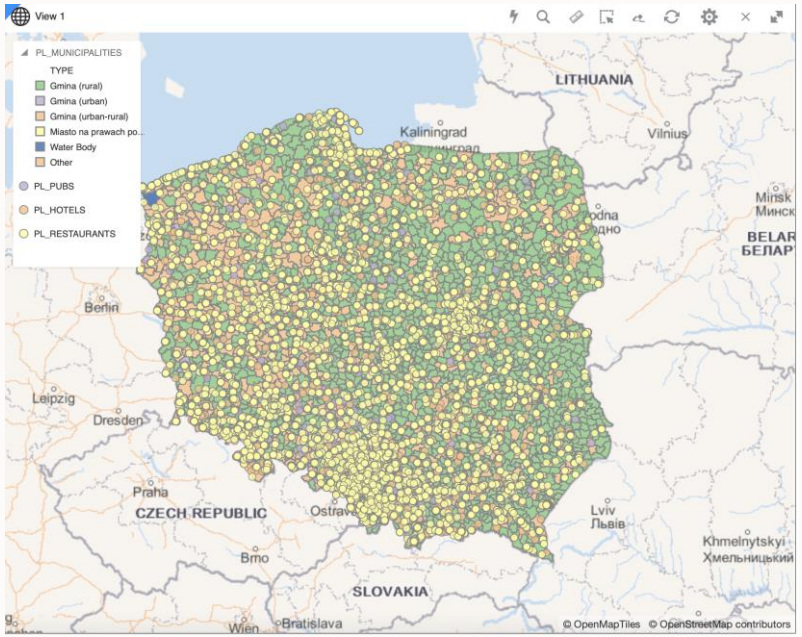
- Geographic features (roads, rivers, parks, etc.)
- Assets (cell tower, fire hydrant, electrical transformer, etc.)
- Sales data (sales territory, customer registration, etc.)
- Street and postal address (customers, stores, factory, etc.)

Anything connected to a physical location

Almost every database contains some form of business data that can be leveraged using spatial technologies

Just like time, location is a “**universal key**”





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Spatial Data and Databases: Types and Functions

Extending a database to handle new data requires …

✓ A **data type** to store it	**Object type**
✓ SQL **predicates** to query it	**Operators**
✓ Specific **indexes** to search it	**Domain Indexes**
✓ **Functions** to process it	**Stored Functions**

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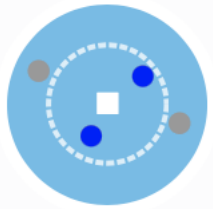
Fundamental Queries on Spatial Data

Return shapes having spatial relationships to another

SDO_RELATE

More information

- List all properties that are located in a flood zone …
- Detect whenever a vehicle enters a restricted area …
- How many customers live inside each of my sales districts …



Return shapes within a specified distance of another

SDO_WITHIN_DISTANCE

More information

- Find all the pubs that are within 500m of my hotel …
- Find land parcels that are within 100m of a river …
- List all households that live further than 10km from any hospital …

Return shapes nearest to another

SDO_NN

More information

- Find the 3 nearest restaurants to my current GPS location …
- For each customer, find the closest of our service centers to that customer …

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Typical Applications using Geospatial Data

Public sector

- Land use, infrastructure, planning, emergency services, reachability analysis, ...

Utilities

- Network planning and operation, outage analytics plant safety, field service planning…

Retail

- Location-based marketing, site planning, indoor customer flow analysis, ...

Financial services

- Targeted marketing, risk zone analysis, ...

Consumer

- Location-based services, friend finder, navigation guidance ...

... and many more

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Use Case: Outfront Media

Outfront Media – Outdoor media company managing >500K displays and billboards

Hurricane risk analysis solution

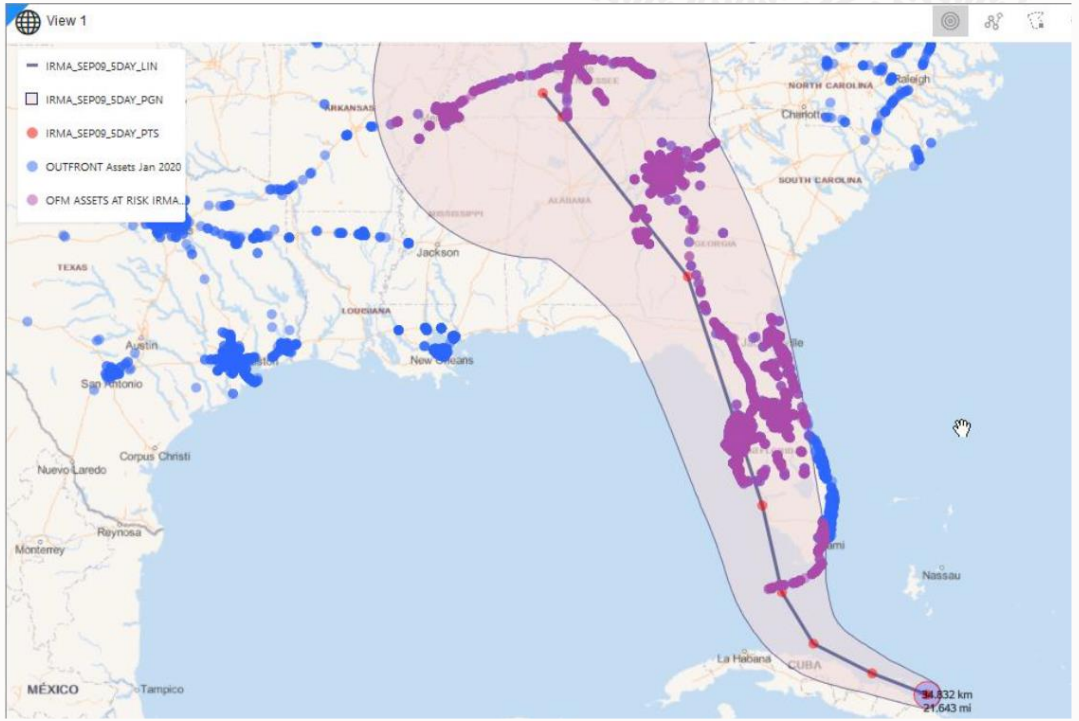
- Based on OAC and Spatial Studio
- Presented at Analytics and Data Summit

Business Case

- Minimize damage
- Prioritize by revenue and structure
- Minimize operational cost

Based on Hurricane forecasting data

- Data from NOAA
- In conjunction with asset location



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Use Case: Altistumiset.fi

Website for tracking Coronavirus cases in Finland

- Enabling individuals to actively check if they may have been exposed to Covid-19

Built by volunteers in 10 days

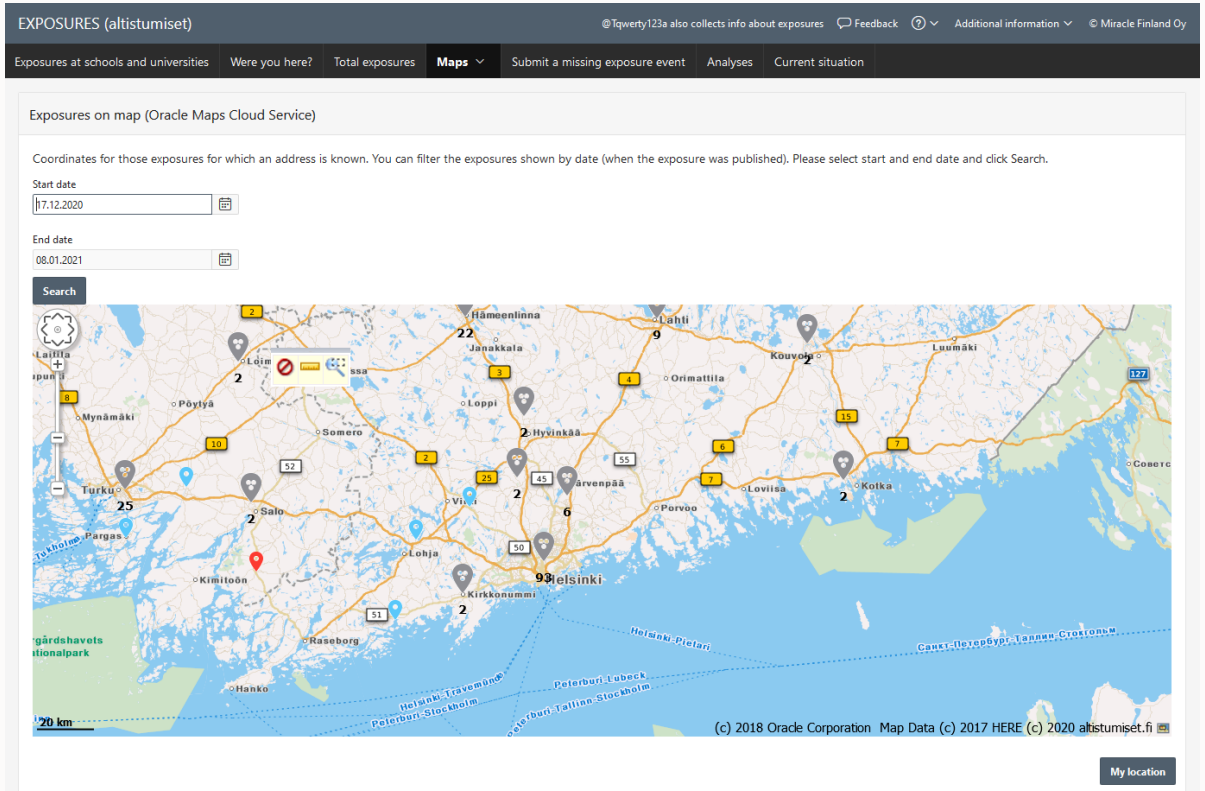
- Heli Helskyaho and team at Miracle Oy
- Oracle APEX and Oracle Spatial
- Visualization with Maps plug-ins
- Replaced solution using Excel sheets

Running on Autonomous Database

- Started on Free Tier

Extensive media coverage led to massive traffic

- 600000 visits/day (in a country of 5.5M inhabitants)



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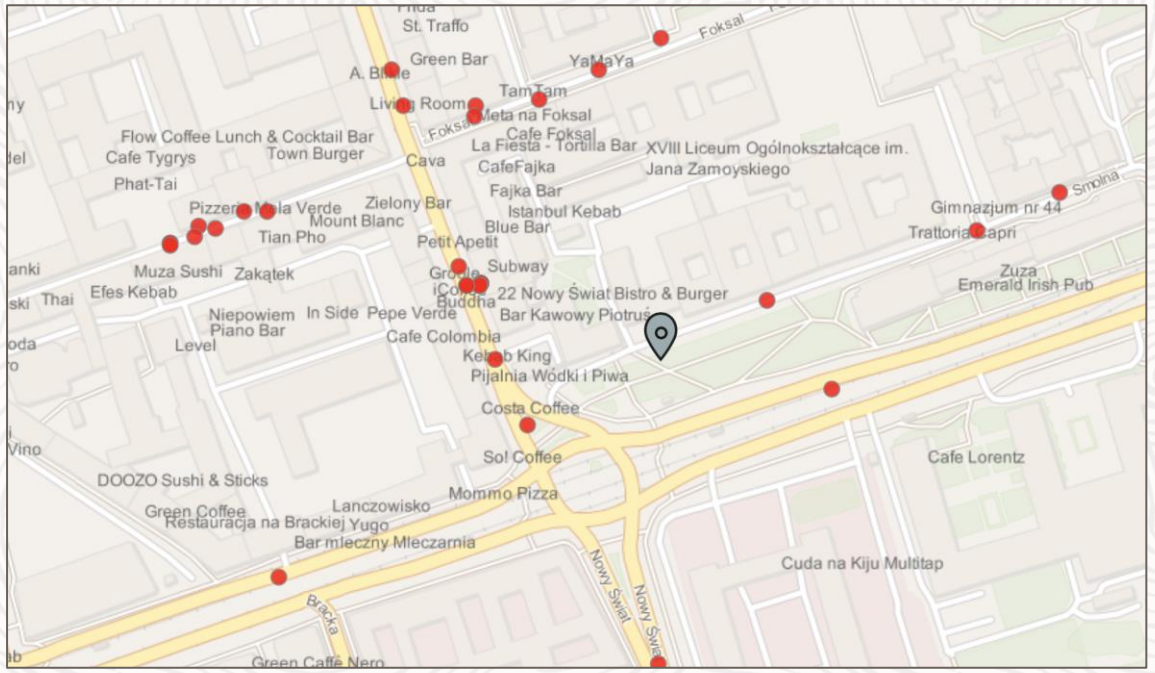
Act II – Click and Point



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The tool:

Introducing Spatial Studio – Self Service Spatial Analytics

Data **ingestion** and **enrichment**

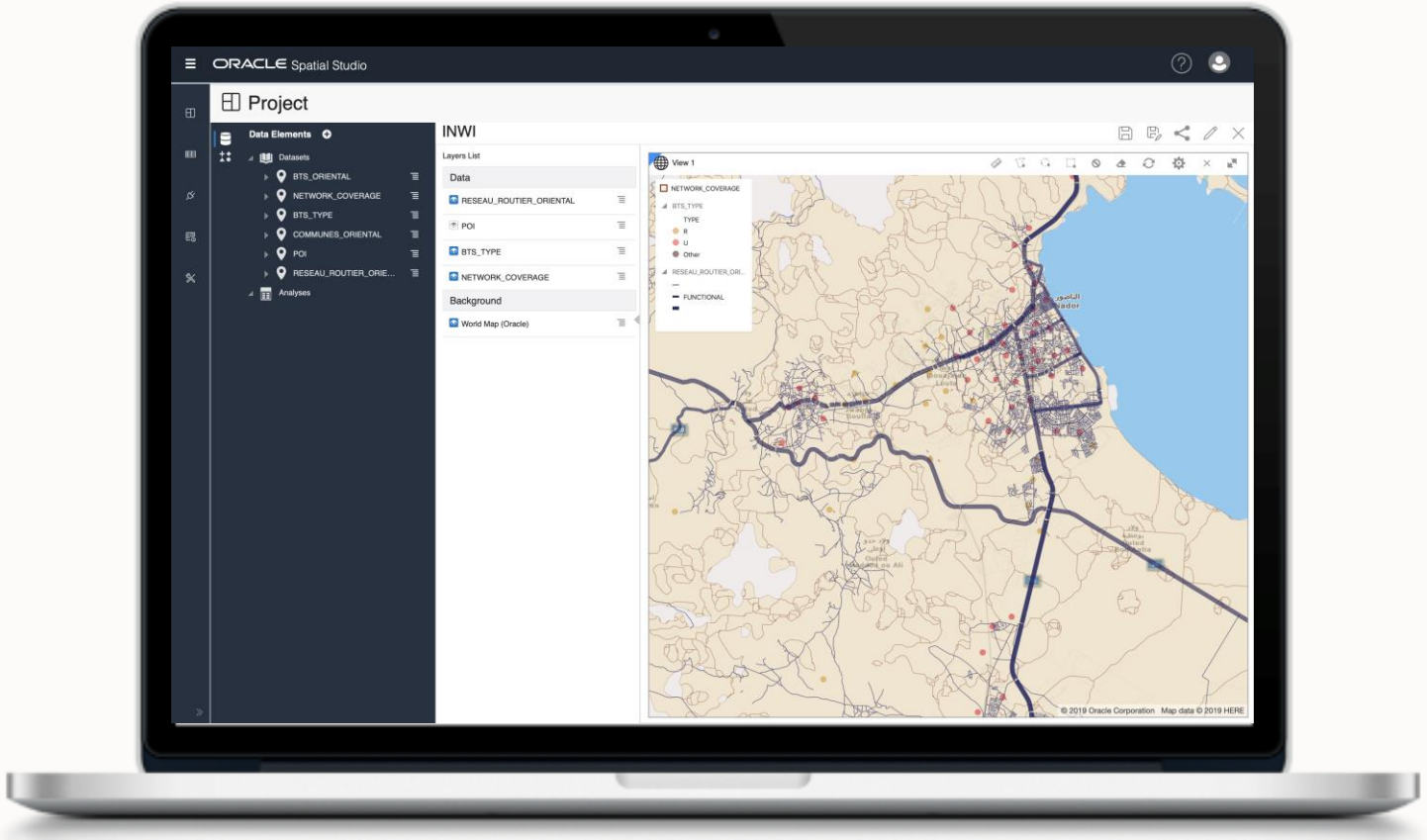
- Importing Spatial and non-spatial data
- Address geocoding
- Indexing

Interactive **analysis**

- Map visualization

Geospatial **processing**

- Creating analytical workflows



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No-Code Environment for Geospatial Analysis

Spatial Analysis Operations

All | Filter | Combine | Transform | Measure | Analytics

Search

Return shapes that interact with the minimum bounding rectangle of another

SDO_FILTER

More information

Return shapes nearest to another

SDO_NN

More information

Return shapes having spatial relationships to another

SDO_RELATE

More information

Return shapes having any spatial interaction with another

SDO_ANYINTERACT

More information

Return shapes that contain another

SDO_CONTAINS

More information

Return shapes that are inside another

SDO_INSIDE

More information

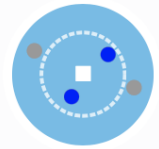
Return shapes outside of area(s)

ANALYSIS_OUTSIDE

Return shapes that overlap another

SDO_OVERLAPS

More information



Return shapes within a specified distance of another

SDO_WITHIN_DISTANCE

More information

Returns elements filtered by non spatial rules

ATTRIBUTE FILTER

Advanced

Return shapes covered by another

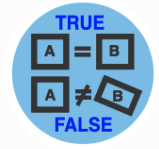
SDO_COVEREDBY

More information

Return shapes that cover another

SDO_COVERS

More information



Return shapes equal to another

SDO_EQUAL

More information

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Setting up Spatial Studio

Download from https://www.oracle.com/database/technologies/spatial-studio/oracle-spatial-studio-downloads.html

Oracle Spatial Studio Downloads

Download	Description	Version
Oracle Spatial Studio - Quick Start	V1020800-01.zip contains a self-contained, easy to deploy Quick Start of Oracle Spatial Studio	22.1
Oracle Spatial Studio	V1020799-01.zip contains a Java EE Enterprise Application aRchive (EAR) file for WebLogic Server	22.1

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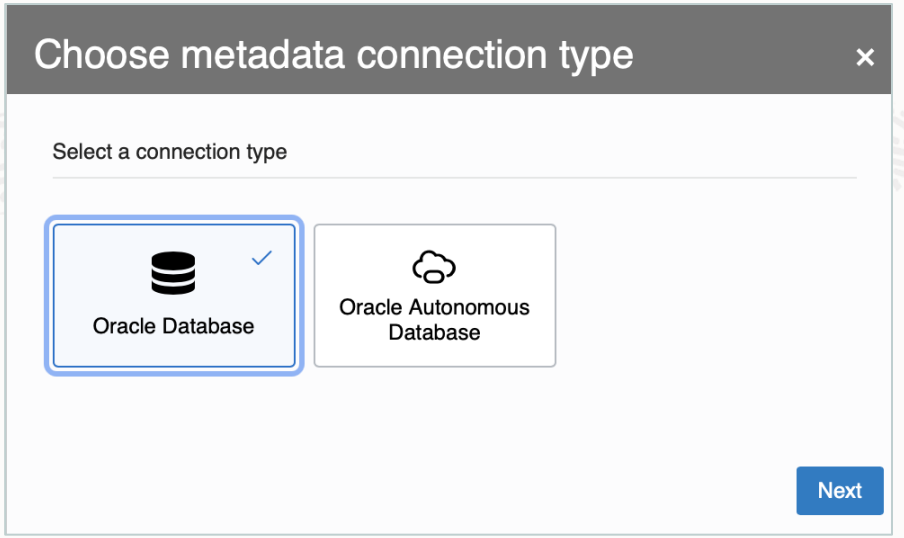
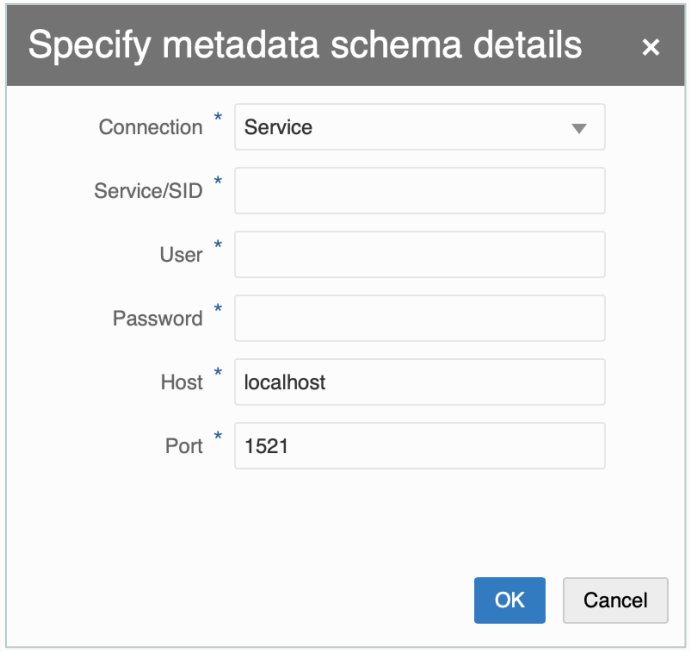
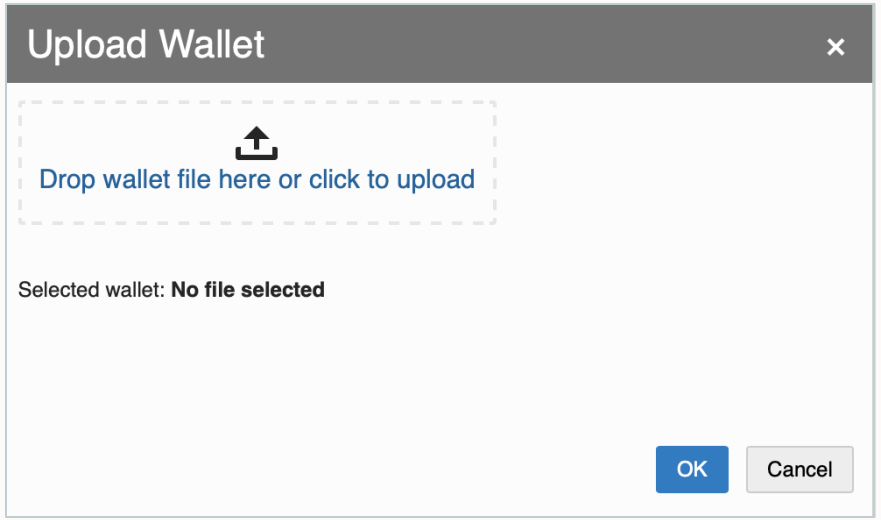
First-time Access Setup

Setup database connection for Studio's **repository**

Local database, cloud database, autonomous database …







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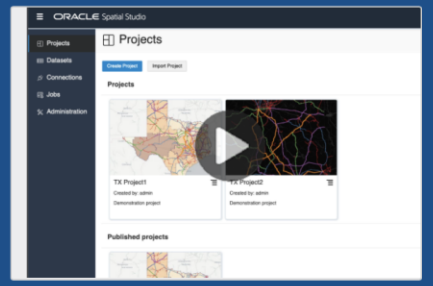
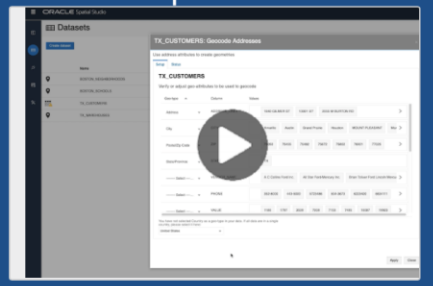
ORACLE Spatial Studio

Getting Started

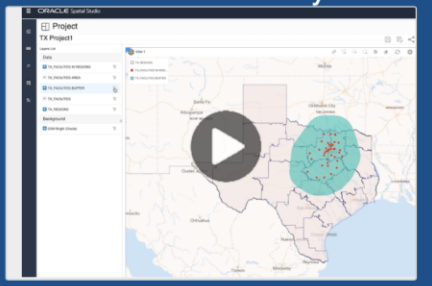
Overview



Prepare Data



Visualize and Analyze



Learn More

Documentation

Step 1
Create Connection

Step 2
Create Dataset

Step 3
Create Project

Display a menu

Connections

Create Connection

Search ...

Name	Type	Description	Last Modified Date
GRAPH	database		2021-09-10T13:04:31.274Z
SCOTT	database		2021-09-05T10:12:57.395Z
SPATIAL_STUDIO	database	Default Spatial Studio connection used to access sample data. This connection can also be used to store uploaded data.	2021-06-12T14:24:49.834439Z

Open #https://127.0.0.1:4040/spatialstudio/?root=datasources# on this page in a new tab behind the current one

Datasets

Create Dataset

Search ...

Name	Public	Connection	Last Modified Date	Description
ACCIDENTS		SCOTT	2021-08-29T17:15:20.837Z	
AIRPORTS		GRAPH	2021-07-22T13:39:54.027Z	New dataset.
PL_COUNTIES		SCOTT	2021-09-10T15:33:12.024Z	
PL_HOTELS		SCOTT	2021-09-10T14:19:18.671Z	
PL_MUNICIPALITIES		SCOTT	2021-09-10T15:38:07.778Z	
PL_PROVINCES		SCOTT	2021-09-10T15:31:12.904Z	
PL_PUBS		SCOTT	2021-09-10T14:14:32.802Z	
PL_RESTAURANTS		SCOTT	2021-09-10T14:34:26.063Z	
T1		SCOTT	2021-08-25T14:35:17.275Z	
US_CITIES		SCOTT	2021-06-13T09:45:59.571Z	New dataset.
US_INTERSTATES		SCOTT	2021-07-21T08:45:28.779Z	New dataset.
VELIB		SPATIAL_STUDIO	2021-08-24T10:00:10.834Z	
WORLD_AIRPORTS		SCOTT	2021-06-12T14:33:25.156Z	New dataset.
WORLD_AIRPORTS_H3		SCOTT	2021-08-12T09:14:29Z	Hex Dataset for WORLD_AIRPORTS
WORLD_CITIES		SCOTT	2021-06-12T14:48:15.055Z	New dataset.
WORLD_CITIES_H3		SCOTT	2021-08-12T09:13:51Z	Hex Dataset for WORLD_CITIES
WORLD_COUNTRIES		SCOTT	2021-06-23T08:54:03.455Z	New dataset.

Open #https://127.0.0.1:4040/spatialstudio/?root=datasets# on this page in a new tab behind the current one

Projects

Create Project | Import Project

Projects

Search ...

Airports

Created by: admin

A new project

POUG2021

Created by: admin

SPW

Created by: admin

US

Created by: admin

A new project

Velib

Created by: admin

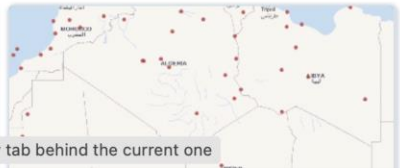
world

Created by: admin

A new project

Published projects

Search ...



Open #https://127.0.0.1:4040/spatialstudio/# on this page in a new tab behind the current one

ORACLE Spatial Studio

Data Elements

- Datasets
  - PL_PROVINCES
  - PL_COUNTIES
  - PL_MUNICIPALITIES
  - PL_PUBS
  - PL_HOTELS
  - PL_RESTAURANTS
- Analyses
  - PL_HOTELS BUFFER
  - PL_PUBS WITHIN DISTA...

Display a menu

POUG2021

Layers List

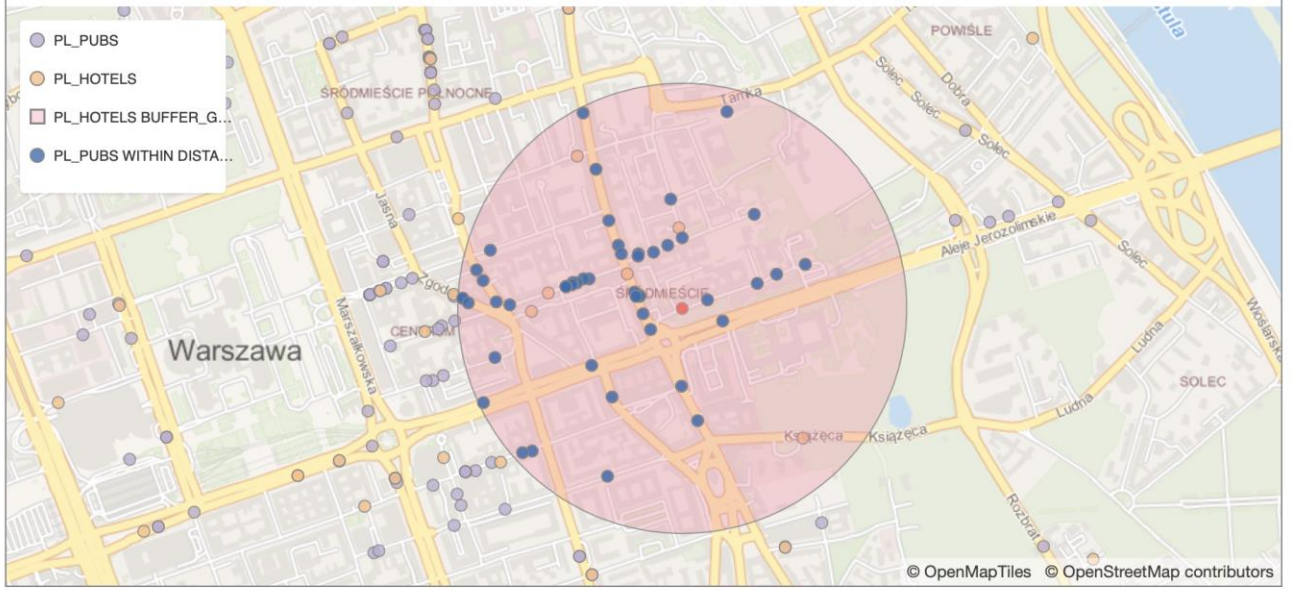
Data

- PL_PUBS WITHIN DISTANCE
- PL_HOTELS BUFFER_GEOMETRY
- PL_RESTAURANTS
- PL_HOTELS
- PL_PUBS
- PL_MUNICIPALITIES
- PL_COUNTIES
- PL_PROVINCES

Background

- OSM Bright

View 1



View 2

PUB_ID	NAME	HOUSE_NUMBER	STREET_NAME	MUNICIPALITY_NAME	REGI
998199680	O'MORGANS IRISH PUB	1	ULICA OKÓLNIK	WARSZAWA	WOJ.
998207750	BIERHALLE	64	ULICA NOWY ŚWIAT	WARSZAWA	WOJ.
998670930	NOSTALGIA CLUB&RESTAURANT	2	ULICA FOKSAL	WARSZAWA	WOJ.
998672486	KLUB&RESTAURANT PALMA	8	ULICA SMOLNA	WARSZAWA	WOJ.
998671324	SKARPA	5	ULICA MIKOŁAJA KOPERNIKA	WARSZAWA	WOJ.
1096797409	SAVOY HOTEL	58	ULICA NOWY ŚWIAT	WARSZAWA	WOJ.
998201933	LABIRYNT	12	ULICA SMOLNA	WARSZAWA	WOJ.
1192914376	LEGENDARNA RESTAURACJA KAMERALNA	3	ULICA MIKOŁAJA KOPERNIKA	WARSZAWA	WOJ.
1005288801	EMERALD IRISH PUB	11	ULICA SMOLNA	WARSZAWA	WOJ.

Page 1 (1-20 of at least 53 items) 1 2 3 ...

The Ingredients …

Bars, Pubs and Cafés in Poland :	File **pl_pubs.csv**	**Source:** Here
Hotels in Poland :	File **pl_hotels.xlsx**	
Restaurants in Poland :	File **pl_restaurants.json**	

Provinces (Województwa):	Table **PL_PROVINCES**	**Source:** gadm.org
Counties (Powiaty) :	Table **PL_COUNTIES**	
Municipalities (Gminy) :	Table **PL_MUNICIPALITIES**	

Other data sources …

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Tools and Ingredients are ready …

https://localhost:4040/spatialstudio

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Act III – Under the Hood

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Spatial Data and Databases: Types and Functions

Extending a database to handle new data requires …

✓ A **data type** to store it	**Object type**	**SDO_GEOMETRY**
✓ SQL **predicates** to query it	**Operators**	**SDO_INSIDE, SDO_TOUCH …**
✓ Specific **indexes** to search it	**Domain Indexes**	**RTREE**
✓ **Functions** to process it	**Stored Functions**	**BUFFER, AREA, UNION …**

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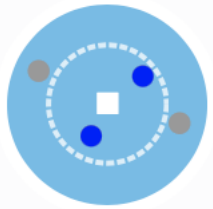
Fundamental Operations on Spatial Data

Return shapes having spatial relationships to another

SDO_RELATE

More information

```
SELECT v.vehicle_id, v.vehicle_position
FROM vehicles v, restricted_areas a
WHERE a.area_id = 51
AND SDO_INSIDE (v.vehicle_position, a.area_shape) = 'TRUE'
```



Return shapes within a specified distance of another

SDO_WITHIN_DISTANCE

More information

```
SELECT p.pub_id, p.phone_nr
FROM pubs p, hotel h
WHERE h.hotel_name = 'Hotel Indigo'
AND SDO_WITHIN_DISTANCE (
  p.pub_location, h.hotel_location, 'distance=500 unit=m'
) = 'TRUE'
```

Return shapes nearest to another

SDO_NN

More information

```
SELECT r.restaurant_id, r.phone_nr
FROM restaurants r
WHERE SDO_NN (
  r.restaurant_location, :my_location, 'sdo_num_res=3'
) = 'TRUE'
```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The SDO_GEOMETRY Object

```
SQL> CREATE TABLE us_states (
  2     state       VARCHAR2(30),
  3     totpop      NUMBER(9),
  4     geom        SDO_GEOMETRY
  5  );
```

```
SDO_GTYPE          NUMBER
SDO_SRID           NUMBER
SDO_POINT          SDO_POINT_TYPE
SDO_ELEM_INFO      SDO_ELEM_INFO_ARRAY
SDO_ORDINATES      SDO_ORDINATE_ARRAY
```


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The SDO_GEOMETRY Object

SDO_GTYPE:

A four-digit code that describes the type of the geometric object:

- Dimensionality: 2D, 3D, …
- Type: point, line, polygon …

SDO_SRID:

A code (number) that identifies the coordinate system of the geometric shape.

Code 4326 is the one for Longitude/Latitude (the GPS coordinates, aka WGS84)

SDO_POINT_TYPE:

```
x          NUMBER
y          NUMBER
z          NUMBER
```

Used for simple point geometries

SDO_ELEM_INFO_ARRAY:

```
VARRAY (1048576) OF NUMBER
```

Describes the internal structure of the geometry.

SDO_ORDINATE_ARRAY:

```
VARRAY (1048576) OF NUMBER
```

Contains all the coordinates of the geometry

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Creating Geometries

```
INSERT INTO us_cities (id, city, state_abrv, location )
VALUES (
  196,
  'Bismarck',
  'ND',
  SDO_GEOMETRY (
    2001, 4326,
    SDO_POINT_TYPE (-100.74869, 46.7666667, null),
    null, null
   )
);
```

Indexing Geometries

```
CREATE INDEX us_cities_sx ON us_cities (location )
INDEXTYPE IS mdsys.spatial_index
```


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Multiple Data Encodings …

Native SDO_GEOMETRY data type	`SDO_GEOMETRY(2001, 4326, SDO_POINT_TYPE(-73.943849, 40.6698, NULL), NULL, NULL)`
GeoJSON	`{"type": "Point", "coordinates": [-73.943849,40.6698] }`
GML	`<gml:Point srsName="EPSG:4326" xmlns:gml="http://www.opengis.net/gml"> <gml:coordinates decimal="." cs="," ts=" "> -73.943849,40.6698</gml:coordinates></gml:Point>`
KML	`<Point><extrude>0</extrude><tessellate>0</tessellate> <altitudeMode>relativeToGround</altitudeMode><coordinates> -73.943849,40.6698</coordinates></Point>`
WKT	`POINT (-73.943849,40.6698)`
WKB	`0000000001C0527C6805A2D730404455BC01A36E2F`

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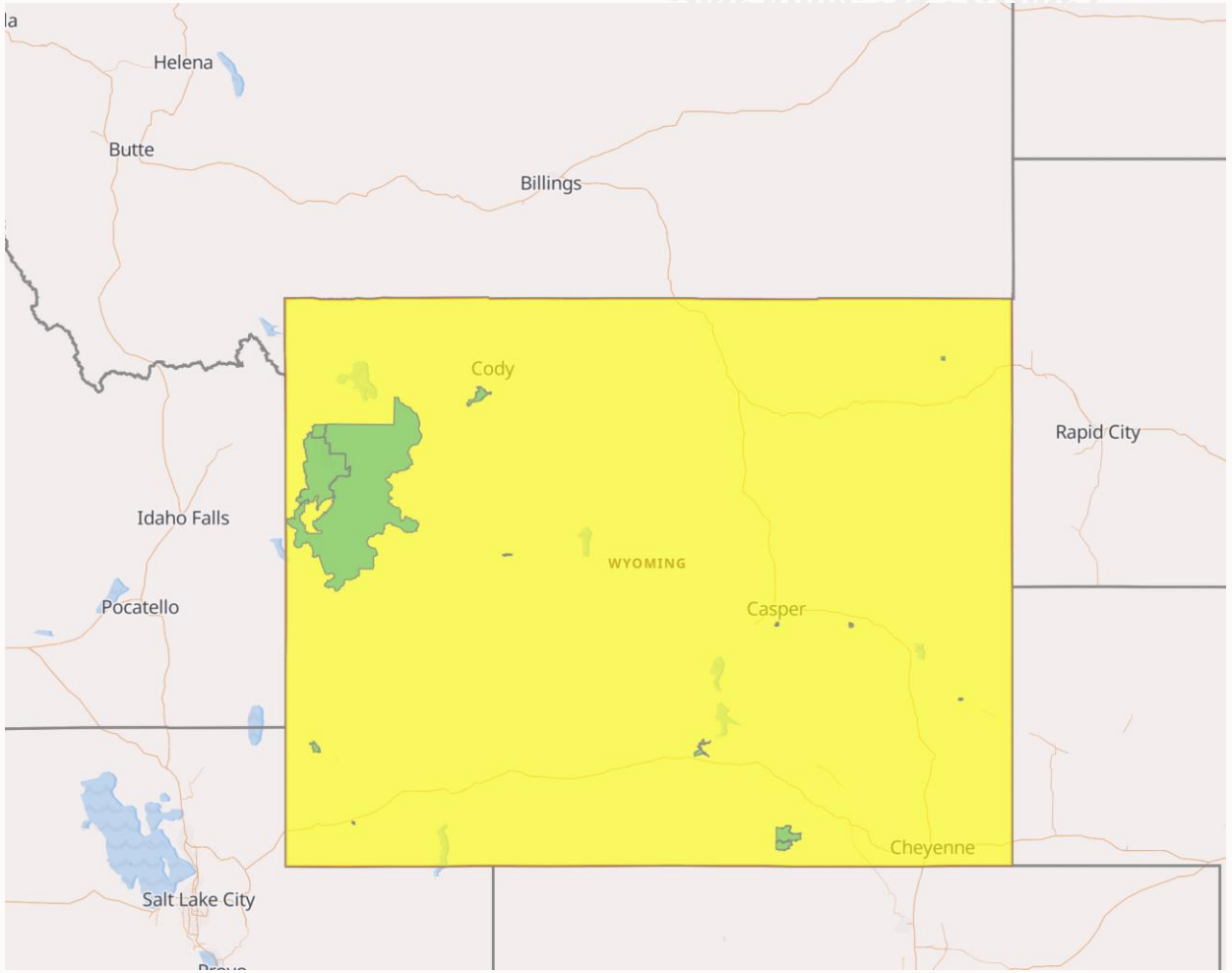
Example of Spatial Query (SDO_INSIDE)

Find all the parks fully contained **inside** the state of Wyoming

```
SELECT p.id, p.name
  FROM us_parks p, us_states s
 WHERE s.state = 'Wyoming'
   AND SDO_INSIDE (
         p.geom, s.geom
       ) = 'TRUE';
```



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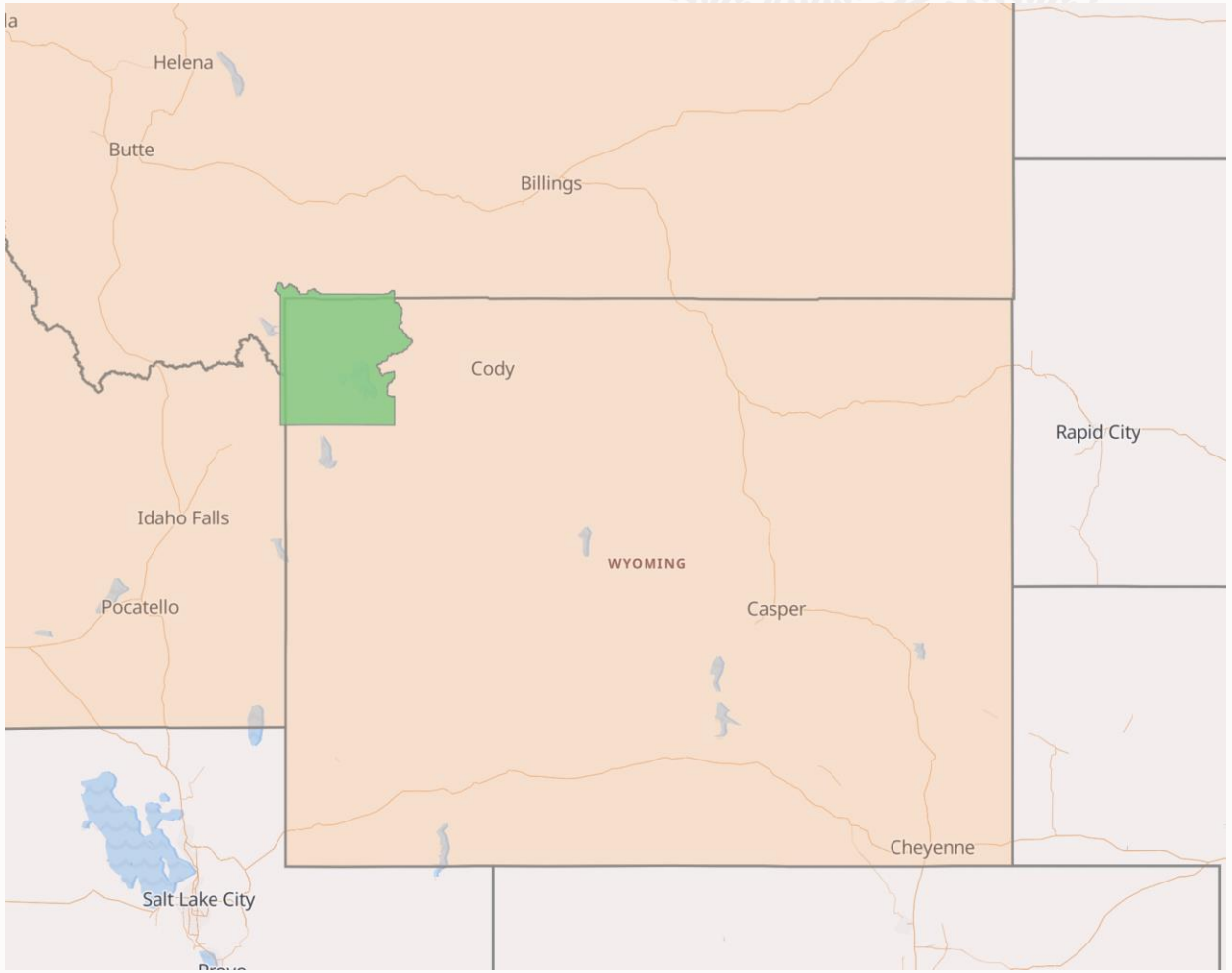
Example of Spatial Query (SDO_OVERLAPS)

Find all the states the Yellowstone National Park lies on …

```
SELECT s.id, s.state
  FROM us_parks p, us_states s
 WHERE p.name = 'Yellowstone NP'
   AND SDO_OVERLAPS (
         s.geom, p.geom
       ) = 'TRUE';
```



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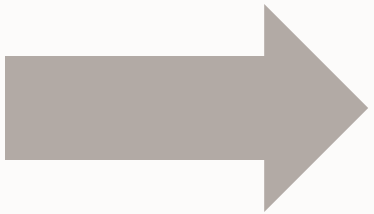
Example of Distance Query (SDO_WITHIN_DISTANCE)

Find all the cities within 100 miles of Boston, ordered by distance.

```
SELECT c1.city,
       SDO_GEOM.SDO_DISTANCE (
         c1.location, c2.location,
         0.5, 'unit=mile') distance
  FROM us_cities c1, us_cities c2
 WHERE c2.city = 'Boston'
   AND SDO_WITHIN_DISTANCE(
        c1.location, c2.location,
        'distance=100 unit=mile'
       ) = 'TRUE'
 ORDER BY distance;
```



Boston	0
Lowell	26.039707
Worcester	40.7874355
Providence	41.0584302
Springfield	79.5090887
Hartford	94.303397

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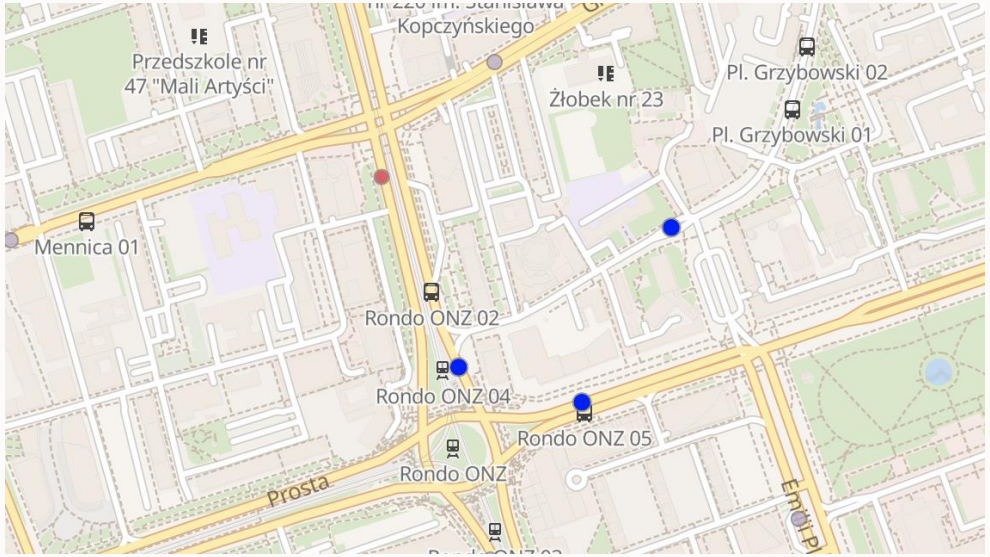
Example of Proximity Query (SDO_NN)

Find the **three closest** pubs to my hotel, ordered by distance.

```
SELECT p.pub_id, p.phone_nr,
       SDO_GEOM.SDO_DISTANCE (
         p.location, h.location)
       as distance
FROM   pubs p, hotels h
WHERE  h.hotel_name = 'The Westin Warsaw'
AND    SDO_NN (
        p.pub_location, h.hotel_location,'sdo_num_res=1'
       ) = 'TRUE'
ORDER BY distance;
```



PUB_ID	NAME	TELEPHONE_NUMBER	DISTANCE
1202735595	BROOKLYN	+(48)-221143434	194.518629
1176168302	KOSHER FALAFEL KOSZERNY FALAFEL	+(48)-531226385	279.446048
1212588903	PATERA COCTAIL & SUSHI BAR	+(48)-535333123	286.312078

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Many more kinds of Spatial Data ….

Vector

Points, lines, areas

3D

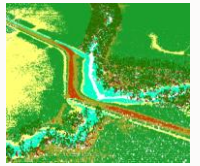
Solids, buildings, city models

Raster

Imagery, terrain models, statistic grids

Point clouds

Laser scanning, photogrammetry



Addresses

Geocoding and reverse geocoding

Road and Infrastructure Graphs

Routing, tracing

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Act IV: The Story Concludes

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Helpful Links ...

Spatial Features Homepage: oracle.com/goto/spatial

Map Visualization: bit.ly/OracleMapViz

Spatial Studio: www.oracle.com/database/technologies/spatial-studio/get-started.html

YouTube Channel: youtube.com/c/OracleSpatialandGraph

Blog: blogs.oracle.com/oraclespatial

LiveLabs Workshops: http://bit.ly/golivelabs

Forum: bit.ly/OracleSpatialHelp

Oracle Spatial and Graph User Group: linkedin.com/groups/1848520/

Twitter: @SpatialHannes @JeanIhm @oraspatialsig @agodfrin

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Oracle's Spatial Database

Oracle's spatial database is included in Oracle's converged database, allowing developers and analysts to get started easily with location intelligence analytics and mapping services. It enables Geographic Information System (GIS) professionals to successfully deploy advanced geospatial applications. Organizations can manage different types of geospatial data, perform hundreds of spatial analytic operations, and use interactive map visualization tools with the spatial features in Oracle Autonomous Database and Oracle Database.

Oracle's location and spatial platform delivers enterprise scalability, security, and performance to power the most demanding applications in Oracle Cloud Infrastructure and on-premises.

Helping fight COVID-19 in Finland using Oracle Cloud (9:29)

Experience spatial capabilities in Oracle Autonomous Database

Easily load and create spatial data, and visualize it.

Launch workshop

Overview of Oracle's spatial database

See how location intelligence data helps build smarter businesses.

Watch video (1:55)

Get started with Spatial Studio

Quickly download and get started with Spatial Studio to explore geospatial data.

Try Spatial

Spatial database and geospatial technologies

Comprehensive spatial, mapping, and location analytics platform that addresses business-critical requirements across industries, including transportation, utilities, retail, energy, public sector, defense, construction, and more.

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Resources

Oracle Spatial Studio

Get Started

Learn about Spatial Studio

About Oracle Spatial Studio
What is new in Release 22.1
Spatial Studio Best Practices

Install and Set Up Spatial Studio

Downloading and Installing Spatial Studio
Setting Up the Spatial Studio Metadata Schema

Major Features of Spatial Studio

Using Oracle Spatial Studio
Using a Map Visualization
Styling a Map Layer
Using a Cesium Map Visualization

Related Support

REST API Endpoints for Oracle Spatial Studio
Third-Party License Information for Spatial Studio

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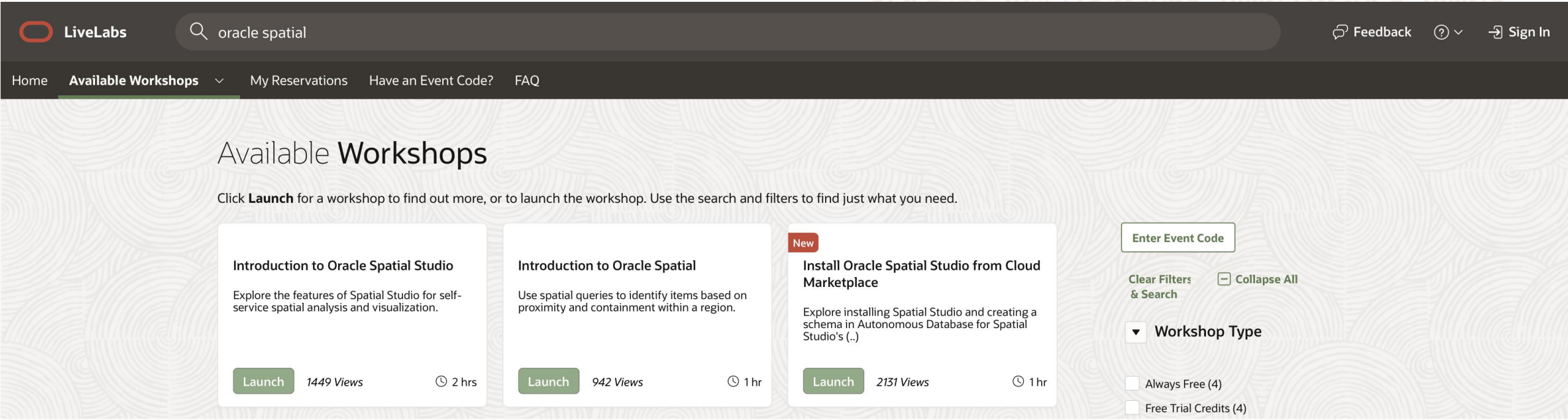
Live Labs



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