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Making Sense of Location

Tracking, Visualizing & Analyzing Objects in 2D, 3D & 4D

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ITOUG TechDays 2020


@SpatialHannes

Safe Harbor

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Tracking and Tracing – Analysis of Moving Objects

Lots of use cases involving moving objects transmitting location data

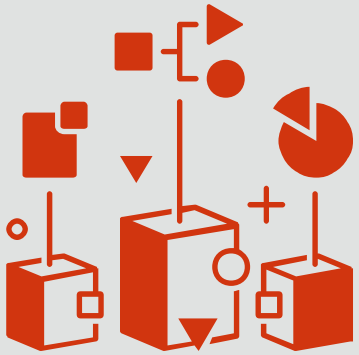
- Smart Cities, Public Transport, Traffic Services, ...
- Internet of Things (IoT)
- Industry 4.0 / Supply Chain Management
- Location-based Services, eg. Targeted Marketing based on location of consumer

Enabling Geospatial Applications on Every Platform

Oracle Database Spatial Features

Exadata,
Non-Engineered Systems

Oracle Big Data Spatial and Graph



Big Data Appliance,
Commodity Hadoop, Spark

Cloud Services

Database Cloud Service,
Exadata Cloud Service,
Autonomous Database
(partial)

New licensing model

- Spatial features of the database no longer require Spatial and Graph option
  - Spatial Vector Acceleration, Network Data Model, Spatial Studio, Map visualization, etc.
  - Same change applies to Advanced Analytics Option
- Features are included in all editions of the database
  - Enterprise Edition and SE2
  - For all releases under Premier or Active Support, ie. 11.2.0.4. and above
- Key part of „converged database“ strategy
  - Making developer APIs available free of charge
- Continuation of trend to include more capabilities in database
  - Spatial -> Locator
  - More capabilities in Cloud Services
- Note: Licensing of Big Data Spatial and Graph is not being changed

Agenda

1. Geospatial Data in the Database
2. Using the Database for Tracking and Tracing
3. Visualizing Results on a Map
4. Advanced Analysis using Road Networks
5. Stream Analytics and Event-driven Architectures

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Geospatial Data in the Database

What is Spatial Data

Integral part of almost every database
Business data that contains or describes location

- Geographic features (roads, rivers, parks, etc.)
- Assets (pipe lines, cables, transformers,
- Sales data (sales territory, customer registration, etc.)
- Street and postal address (customers, stores, factories, etc.)

Anything associated with a physical location
Described by coordinates or implicitly as text (place name), …
Location is a “universal key” relating otherwise unrelated entities

Required database capabilities for geospatial analysis

Data type to store points, lines, areas, solids, ...

- In two or three dimensions
- Taking into account coordinate system

Topological Operators

- Point-in-polygon, intersecting linestrings, overlapping areas, ...

Geometric Functions

- Calculating areas, distances, buffer zones, ...

Spatial Indices

- Fast access to relevant data

Storing spatial data in SDO_GEOMETRY

Table Counties

ID	NAME	BOUNDARY
NUMBER	VARCHAR2	SDO_GEOMETRY

SDO_GTYPE	NUMBER
SDO_SRID	NUMBER
SDO_POINT	SDO_POINT_TYPE
SDO_ELEM_INFO	SDO_ELEM_INFO_ARRAY
SDO_ORDINATES	SDO_ORDINATE_ARRAY

Creating Geometric Objects

Creating point data …

```
select sdo_geometry('POINT (10 50)', 4326) from dual;

SDO_GEOMETRY
--------------------------------------------------------------------
SDO_GEOMETRY(2001, 4326, SDO_POINT_TYPE(10, 50, NULL), NULL, NULL)
```

Alternatively …

```
select sdo_geometry(2001, 4326, sdo_point_type(10,50,null), null, null) from dual;

SDO_GEOMETRY
--------------------------------------------------------------------
SDO_GEOMETRY(2001, 4326, SDO_POINT_TYPE(10, 50, NULL), NULL, NULL)
```

Accessing Coordinates in SDO_GEOMETRY

Which points describe the boundary of Germany?

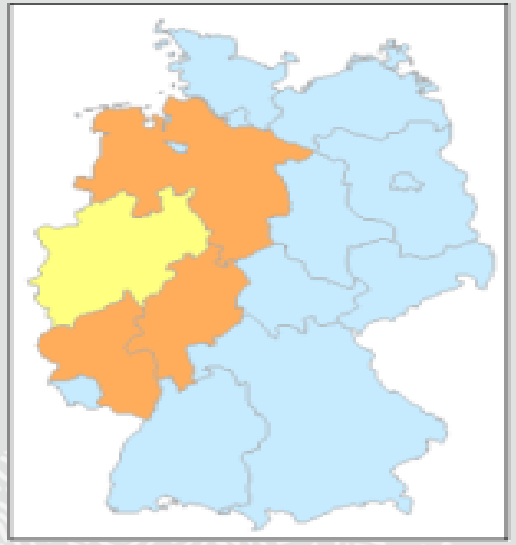
```
SQL> select k.id, k.x, k.y from
  2    countries c,
  3    table(sdo_util.getvertices(c.geometry)) k
  4  where country_name='GERMANY';

        ID          X          Y
---------- ---------- ----------
         1 14,7200450  51,582406
         2 14,7554651  51,603937
         3 14,7570239  51,644129
         :          :          :
```

Example: Spatial SQL Queries

Which German Länder are touching North-Rhine Westphalia?

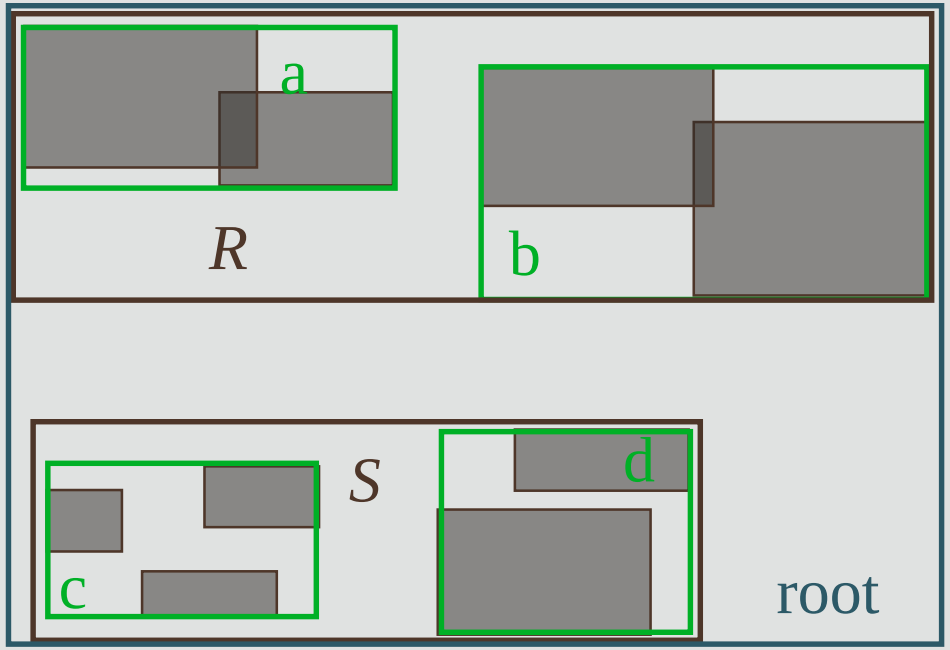
```
select l1.name
from laender l1, laender l2
where l2.name='NRW' and
sdo_relate(
  l1.boundary, l2.boundary,
  'mask=touch'
)='TRUE'
```

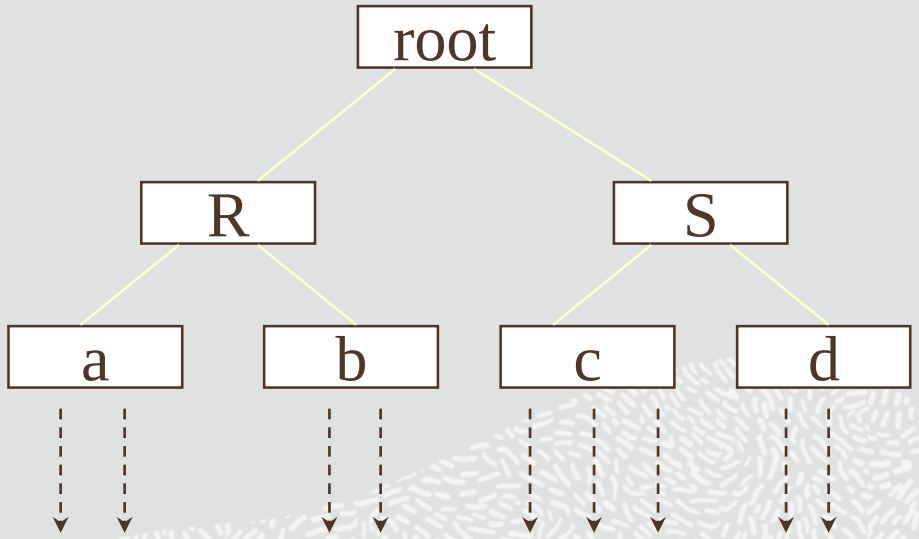


Using spatial (R-Tree) index for query optimization

- Two-step filter process
- Checking interaction between minimum bounding rectangle first, then detailed test

Spatial Index – Structure of an R-Tree





Combined spatial and non-spatial queries

Which customers are in Brandenburg and generate revenue >4000?

```
select name, revenue
from customers c, geo_laender gl
where
sdo_anyinteract(c.geometry, gl.geometry) = 'TRUE'
and gl.feature_name='Brandenburg'and revenue > 4000

NAME                                REVENUE
------------------------------ ----------
Freie Tanke                          4876
SB Tank                              4798
Tankstelle Schönefeld                4598
Tankstelle Dreieck Havelland         7896
:                                       :
```

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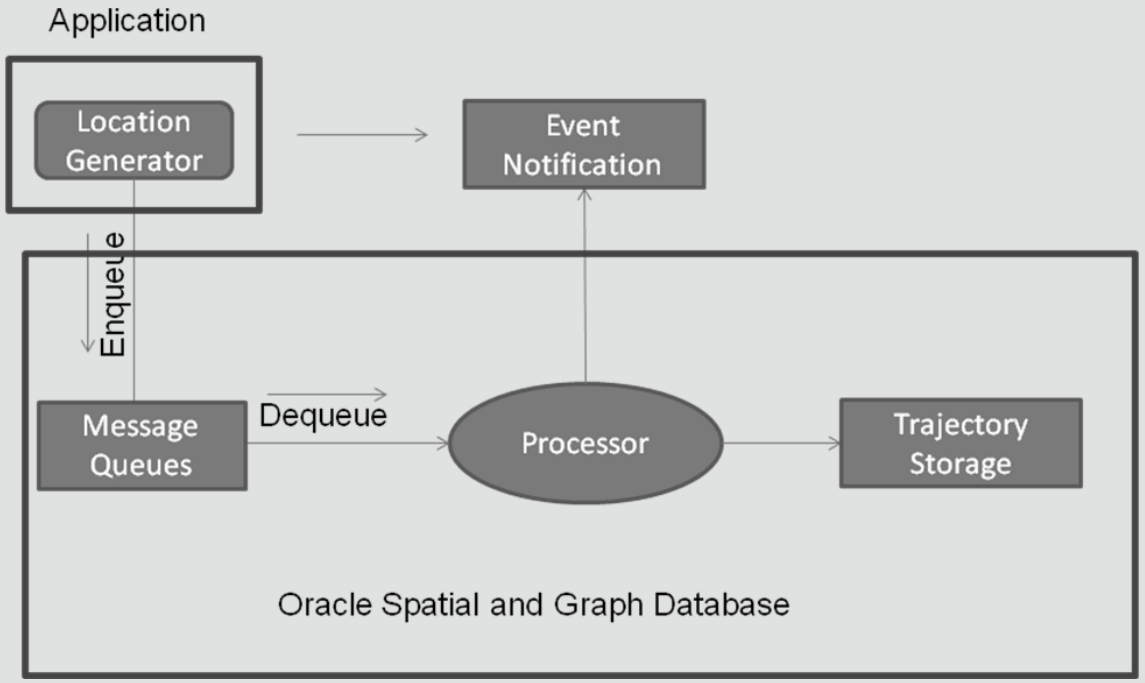
Using the Database for Tracking and Tracing

Location tracking in Oracle Database



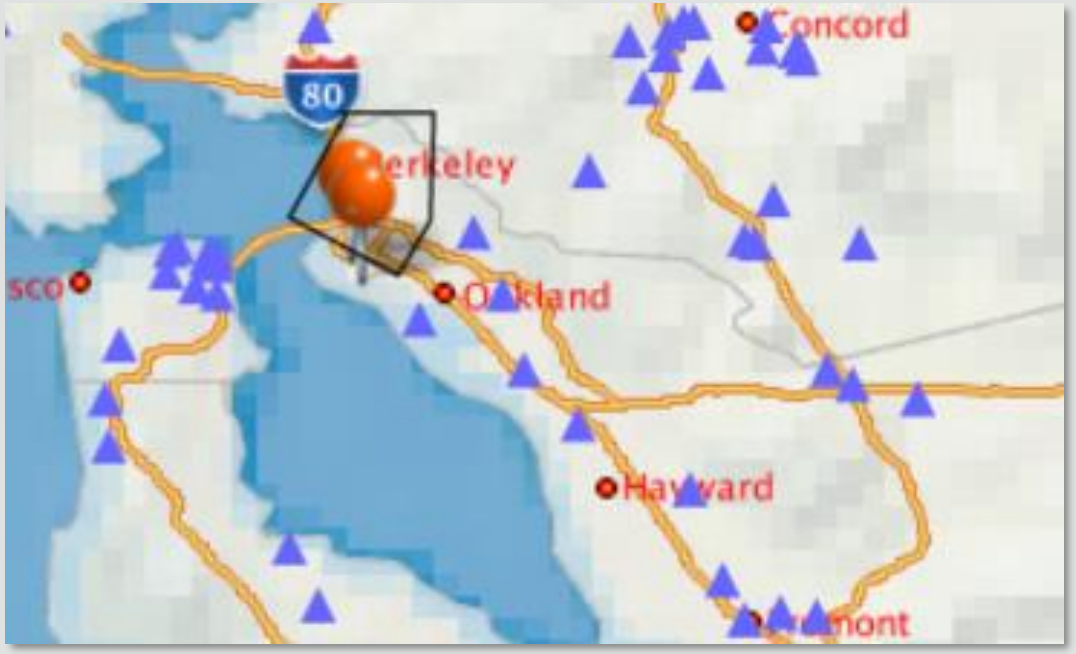
- **New APIs in Oracle 12.2**
- **Tracking many moving objects against many regions**
- **Enhanced „point-in-polygon“ analysis**
  - Tracking multiple objects simultaneosly through parallelelism
  - Designed to scale to millions of objects
- **Java API and PL/SQL API for event capture and processing**
  - Using Advanced Queuing in database for performance and async. processing

Location Tracking API workflow

- Create regions of interest in database as polygon geometries
- Initialize the location tracking server
  - Initialization of 3 queues: one for receiving location objects, one for receiving location messages, and one for storing the notifications after the locations are processed
  - Each location object (moving item) has many location messages, can be persisted
- PL/SQL APIs to create location objects and insert location messages
- Java Applications can use AQ Java API to insert data into the input queues
  - JMX queues used for maximum performance
- Alerts are sent to output queue
  - Subscription to output queue for further processing

Location Tracking – Use cases

- Raise alert when object enters area-of-interest



- Raise alert when object leaves area-of-interest (Geofencing)

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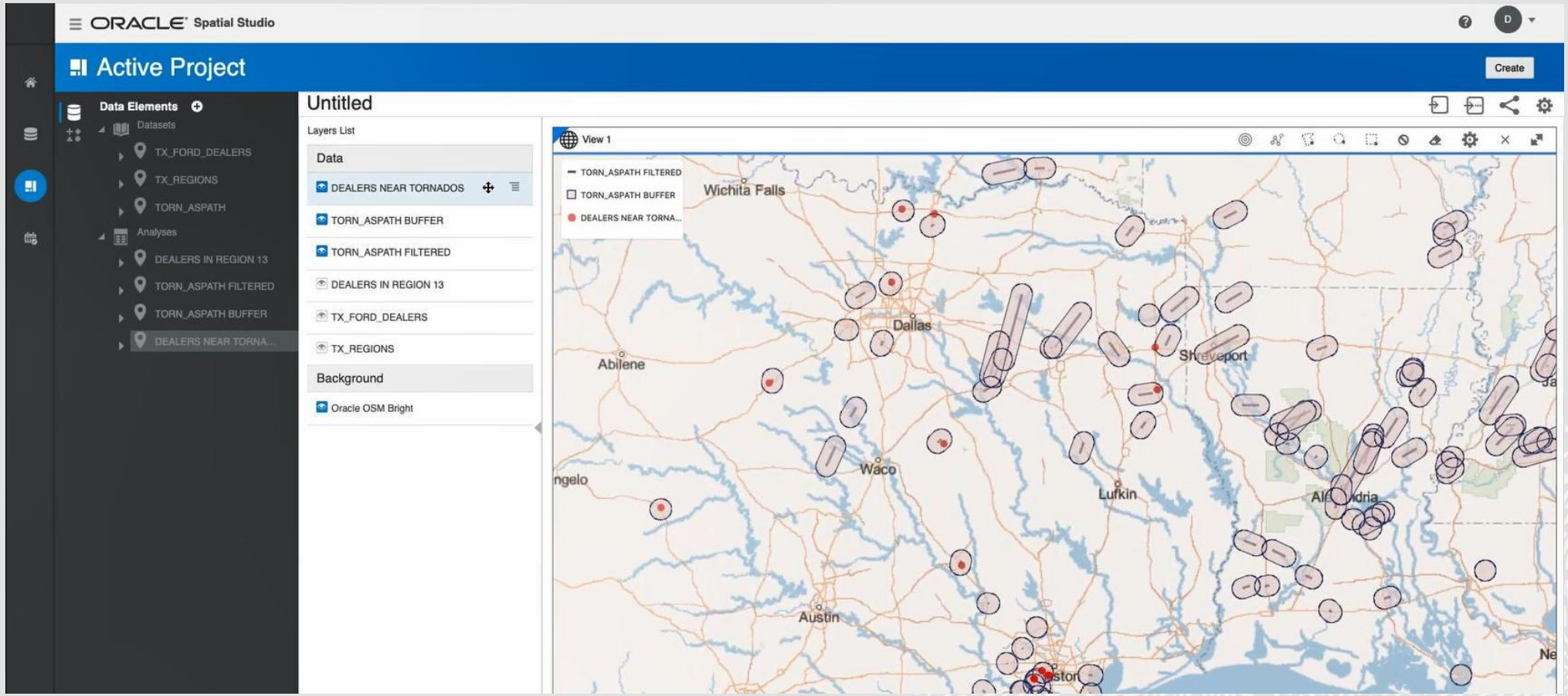
Visualizing Results on a Map

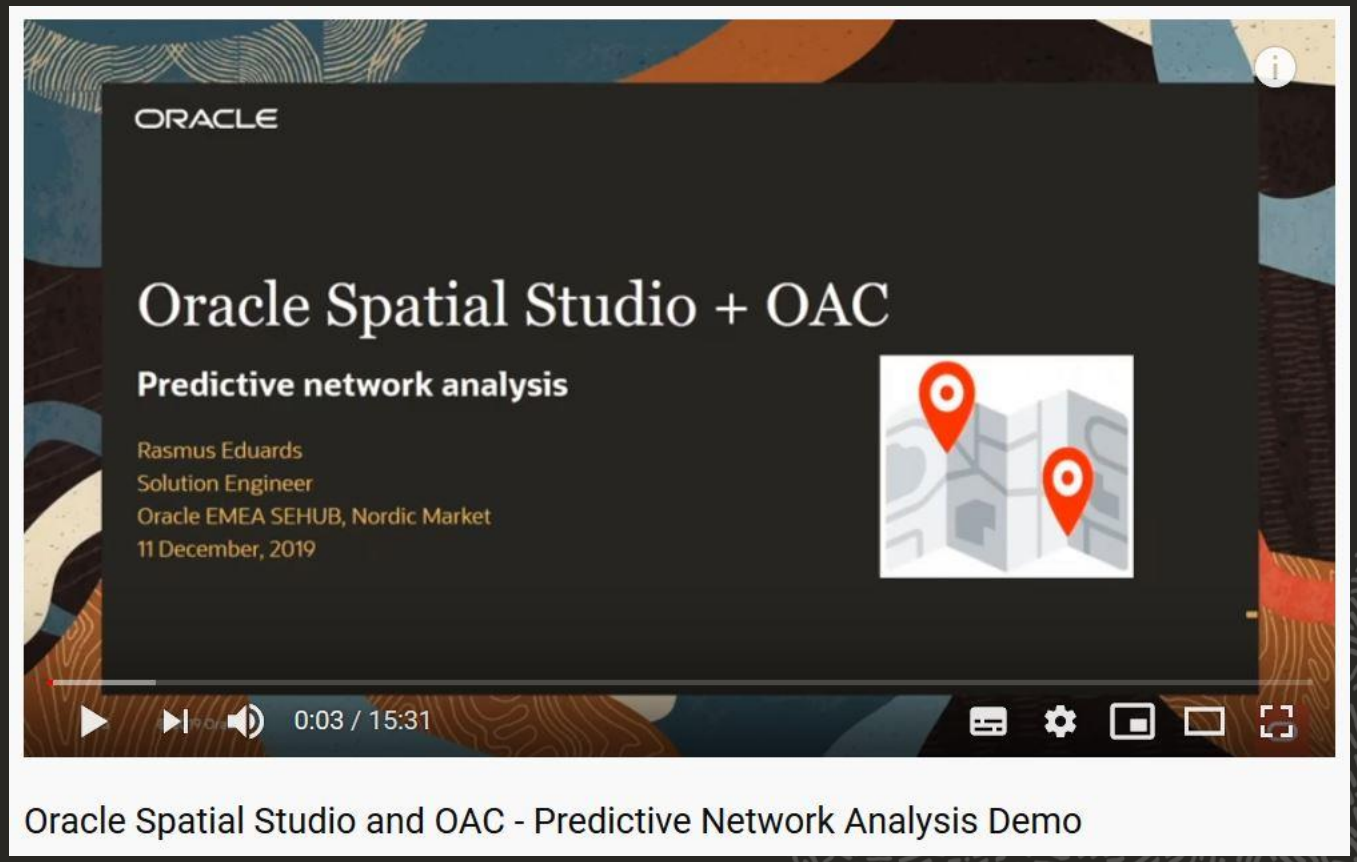
Rendering Maps with Spatial Studio



Spatial Studio can do more than just visualization

- **Prepare** address and coordinate data for spatial analysis and mapping
  Geocode customer and stores addresses
- **Visualize** data on interactive maps along with other contextual layers
  Navigate interactive map with customers, suppliers, sales regions…
- **Associate** data through spatial relationships
  Determine the customers located within a proposed new sales region
- **Enrich** data with spatial attributes and metrics for downstream analytics
  Enrich customers with their associated sales region and distance from supplier
- **Integrate** spatial content and analysis results via REST
  Access customers with enrichments as GeoJSON and integrate with applications

Using Spatial Studio with Oracle Analytics Cloud

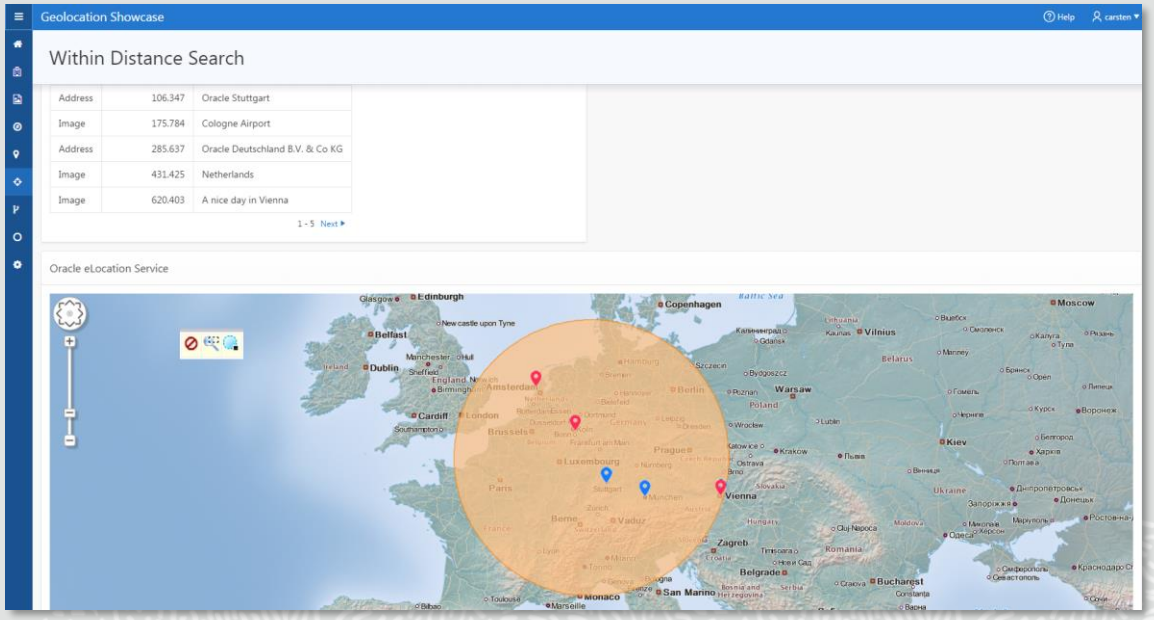


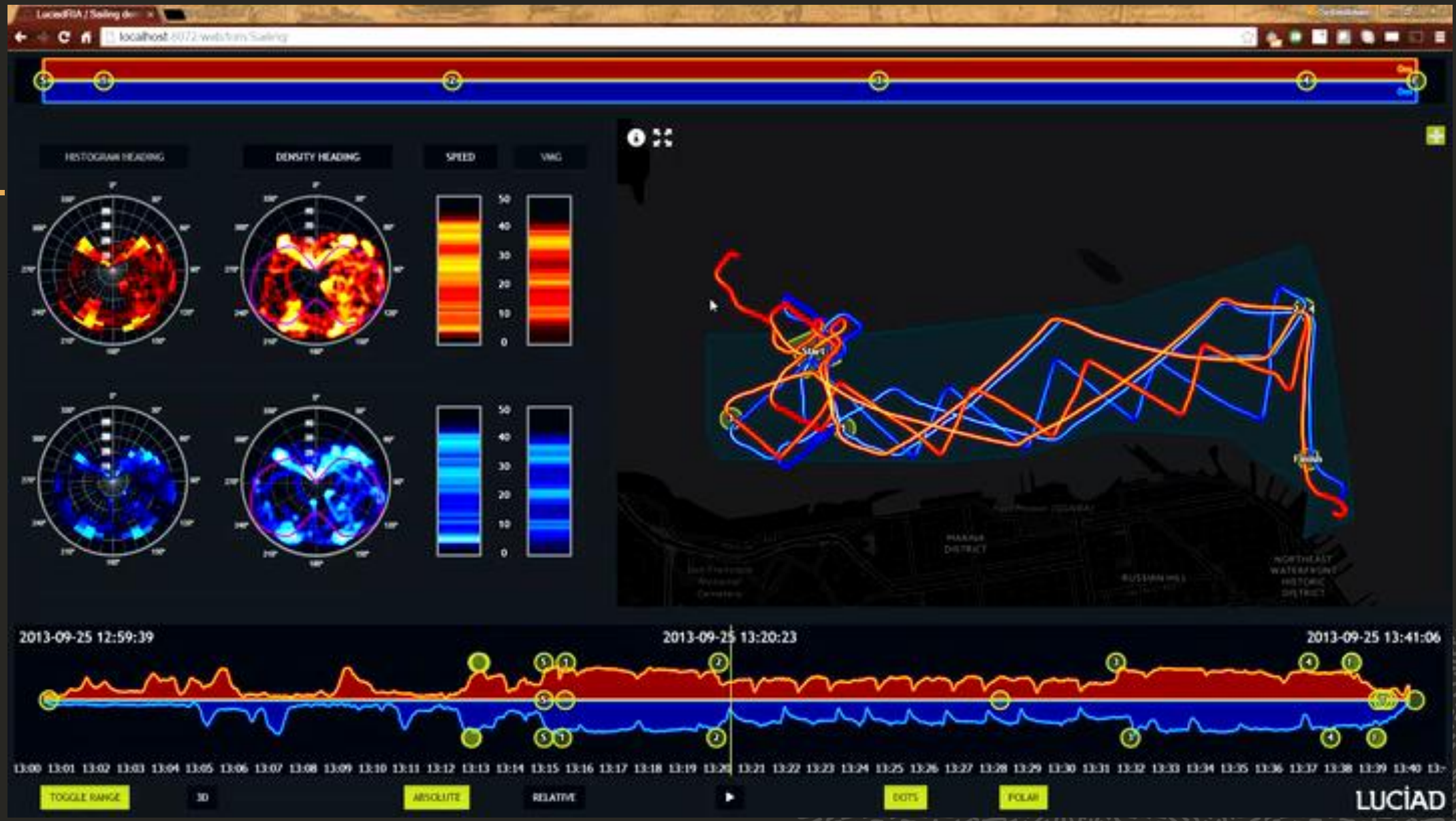
Oracle Spatial Studio and OAC - Predictive Network Analysis Demo

https://youtu.be/kgOf7rIL7E8

Creating mash-ups with Map Visualization Component

- **HTML5-based visualization component**
  - Free with all editions of the database
- **Rendering dynamic maps**
  - Data from database
  - Data from external sources (WMS, WFS, GeoRSS, WMTS)
  - Integration of Google Maps, etc.
- **Available as plug-in for Apex**
  - Geolocation Showcase
- **Many 3rd Party Tools available as well**
  - eg. Luciad RIA, working with OracleJET





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Advanced Analysis using Road Networks

Tracking und Tracing based on Road Network

Object position not sufficient in all cases, but position on road network required

- eg. exact route needed, despite GPS inaccuracies/errors
- eg. route planning, calculating (remaining) drivetime

Road network as reference dataset needed

- Commercially available from HERE, Tomtom
- OpenStreetMap converter available from CISS TDI

Required database functionality

- Support for linear coordinate systems
- Network data model (graph), routing engine

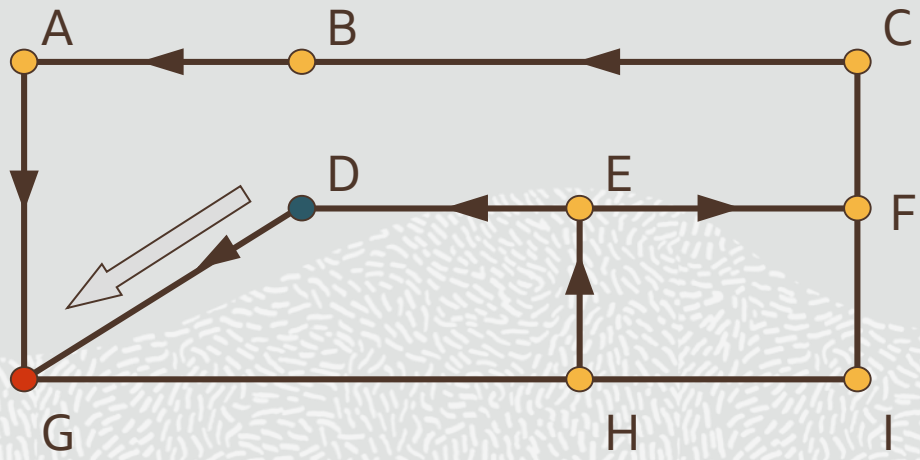
Routing based on Network Data Model

Entire road network stored as nodes and edges of a graph
- With or without road segment geometry

Connectivitiy and cost (eg. drivetime) per road segment

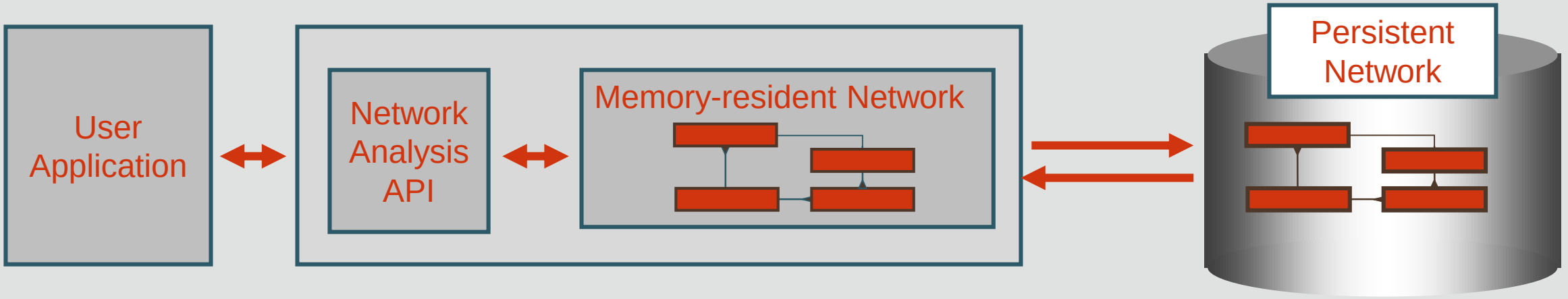
Enabling network analysis
- Using graph algorithms
- Based on directed or undirected graph
- Optionally taking cost into account

Data Management API
- Caching, Partitioning, load-on-demand, ...



Nearest neighbor in a directed graph

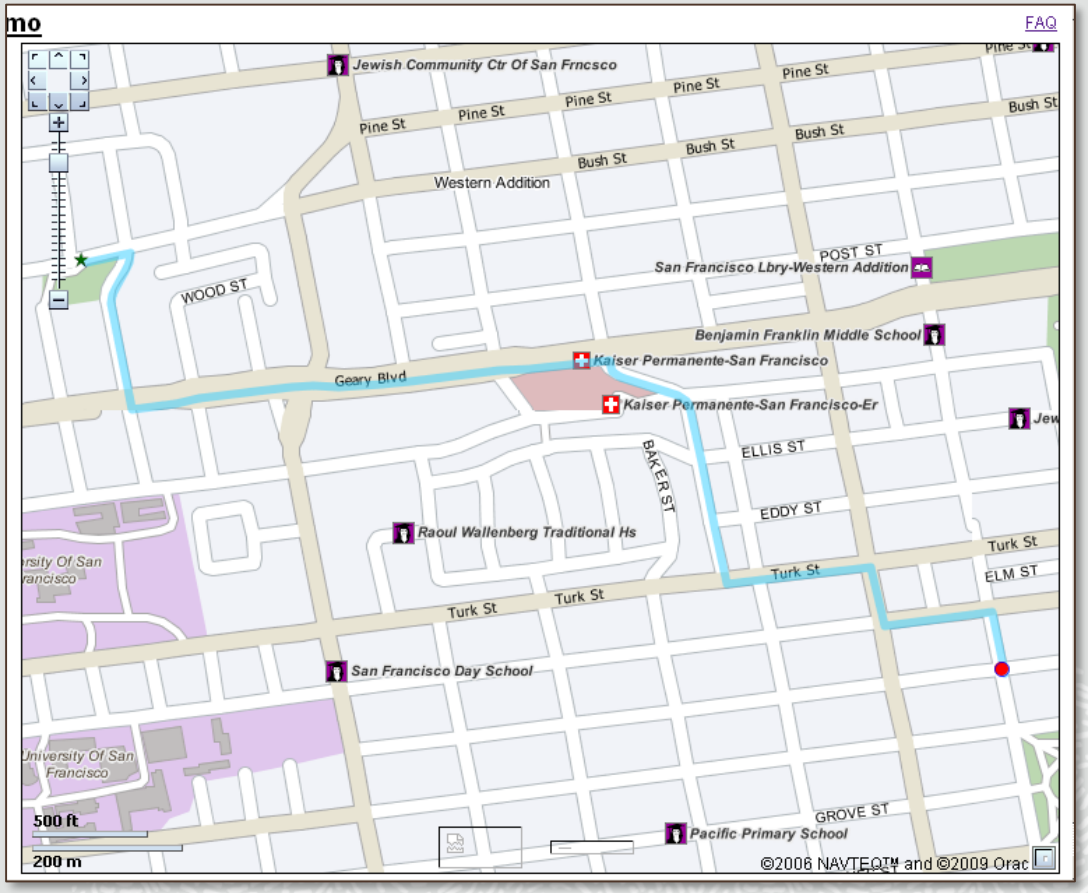
Routing based on Network Data Model: Architecture



- Java runtime env. to keep network in memory (at least partially)
- Java API for analytic functions on network graph
- Network can be hierarchically organized and partitioned
  - Load-on-demand API manages network caching

Network Data Model: Analysis

- Shortest path analysis
- Nearest neighbor analysis
- Within cost analysis
- Network Buffer (forward and reverse)
- Reachable/Reaching nodes
- K-shortest paths analysis
- Traveling salesman problem
- Multiple TSPs/Single Depot (new)



Time Support for Routing Engine

- **Routing Engine understands date and time**
  - Temporal constraints and temporal penalty
- **Specify start date/time in route request**
  - start_date, start_time, date_format, time_format,
- **The result will show arrival date/time**
  - At intermediate and end points.
  - return_route_time, return_subroute_time,
- **Uses Time Zone Data**

```
<?xml version="1.0" standalone="yes"?>
<route_request id="1"
  route_preference=”fastest"
  return_driving_directions="true“
  distance_unit="mile”
  time_unit="minute”
  start_date=“05-Aug-2016”
  start_time=“10:41”
  return_route_time=“true”
  return_route_geometry="false">
  <start_location>
    ...
  </start_location>
  <end_location>
    ...
  </end_location>
</route_request>
```

Routing Using Traffic Patterns

- **Requires Traffic Patterns in data set**
- **Specify a start date/time in route requests**
- **Specify that you want to use traffic patterns**

  route_preference=traffic
- **Choose traffic sampling precision**

  traffic_sampling_id=1 (15 minutes) or 2 (hour)
- **Route optimization is based on traffic and time**

```
<?xml version="1.0" standalone="yes"?>
<route_request id="1"
  route_preference=”traffic"
  return_driving_directions="true“
  distance_unit="mile”
  time_unit="minute”
  start_date=“05-Aug-2016”
  start_time=“10:41”
  return_route_time=“true“
  traffic_sampling=“1”
  return_route_geometry="false">
  <start_location>
    ...
  </start_location>
  <end_location>
    ...
  </end_location>
</route_request>
```

INM Spatial Data Warehouse

Institute for Emergency Medicine and Management in Medicine

Emergency Services Planning in Bavaria
- State-wide planning and optimization
- Site planning for ambulance bases, What-if analysis, ...

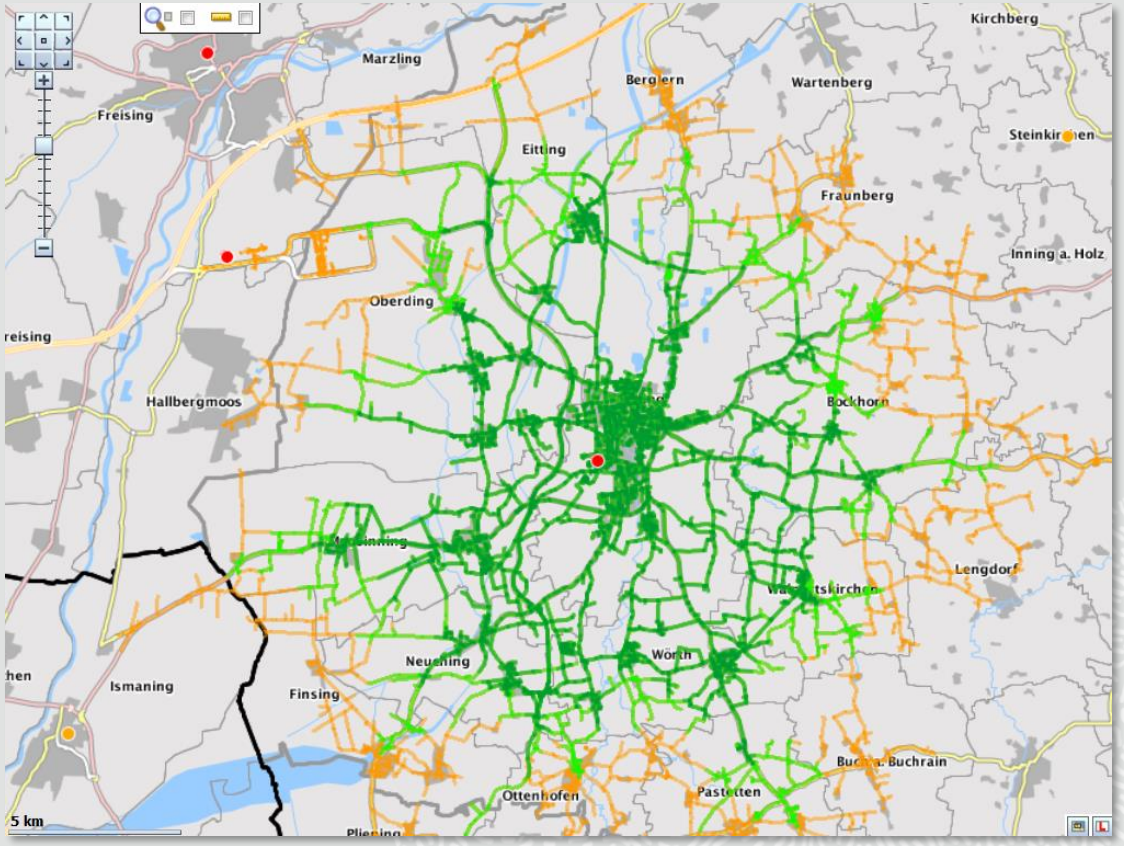
Based on 2TB data warehouse of emergency mission data
- Location and status information plus medical data

Combined with road network data, hospital locations, helicopter bases, ...
- Including individual speed profiles per road segment

Calculating drive-time areas, hospital service areas, ...
- Simulation model, ensuring compliance with legal mandate

INM Spatial Data Warehouse

Determining drivetime area based on road network



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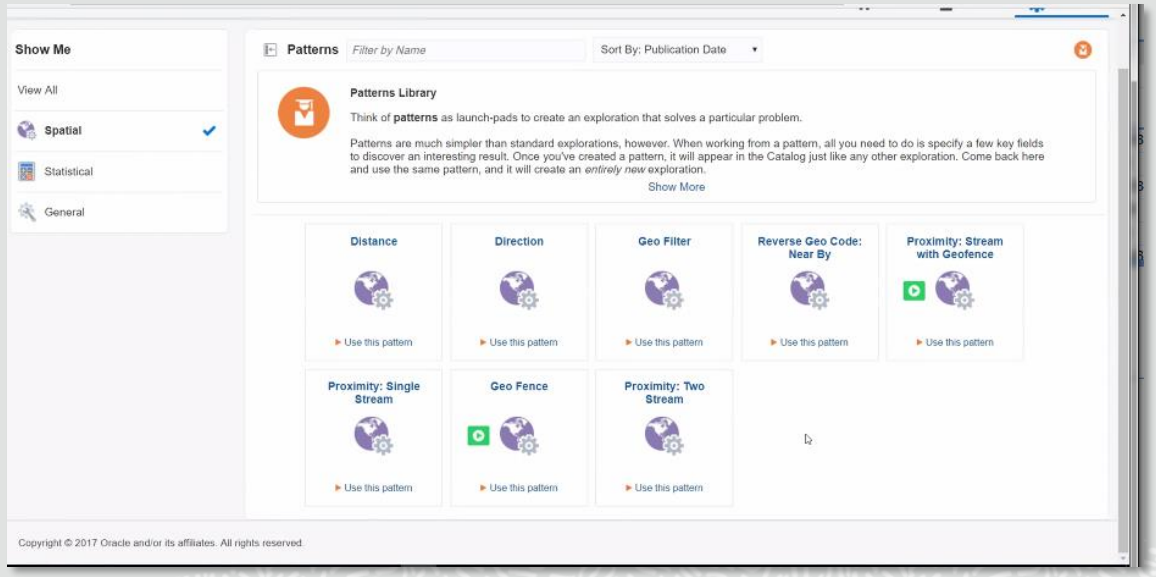
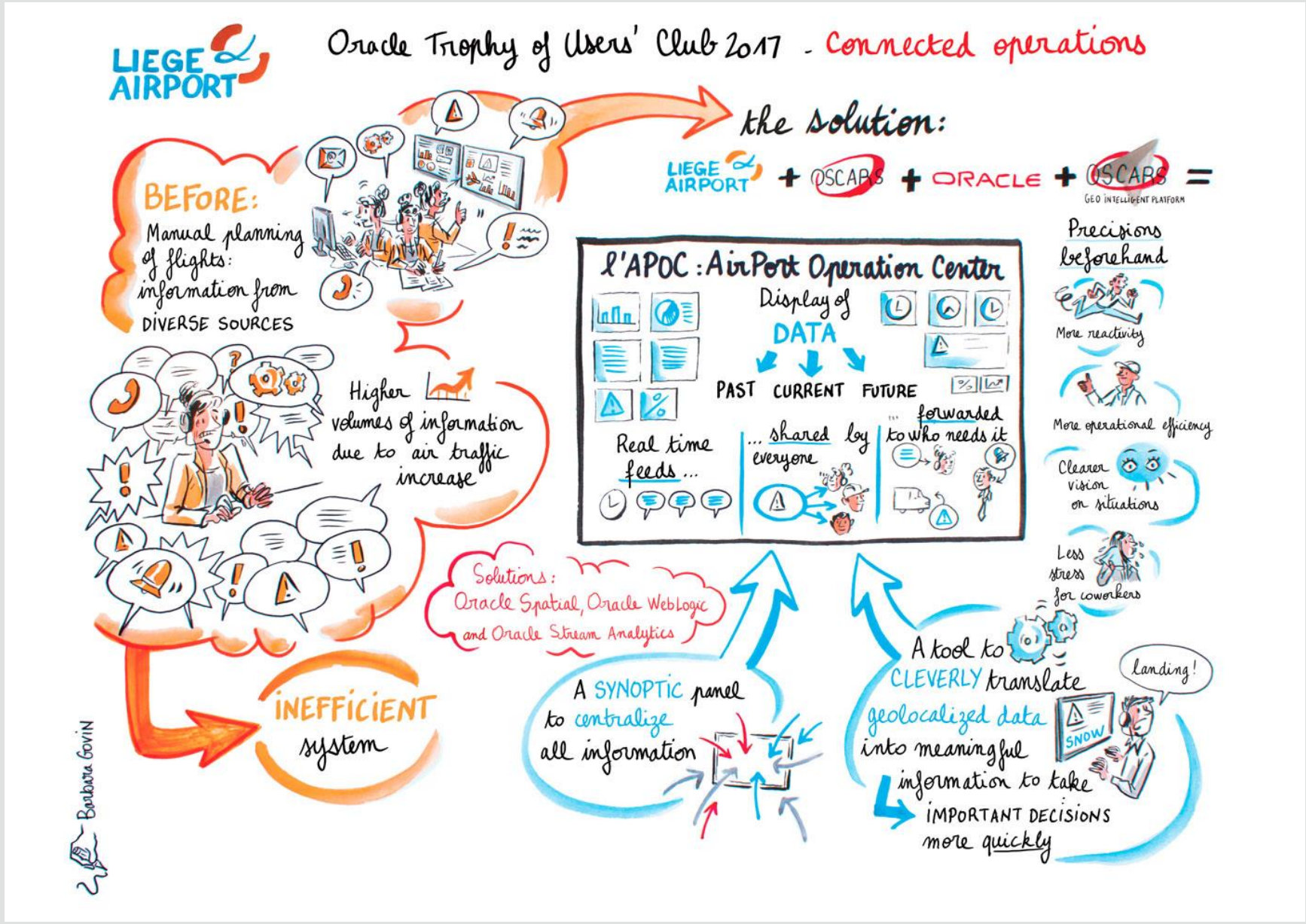
Stream Analytics and Event-driven Architectures

Oracle Stream Analytics for more demanding cases

- **Complex event processing**
  - Streaming data correlation and aggregation
  - Pattern Matching
  - Spatial Analytics
  - Machine Learning probability scoring
  - Graphical Visualization
- **Event-driven architecture**
  - Application development with zero coding
- **Based on messaging integration**
  - Kafka support
- **Various location-related patterns prebuilt**




LIEGE AIRPORT



OSCARS GeoIntelligence Platform (GIP) at Liège Airport

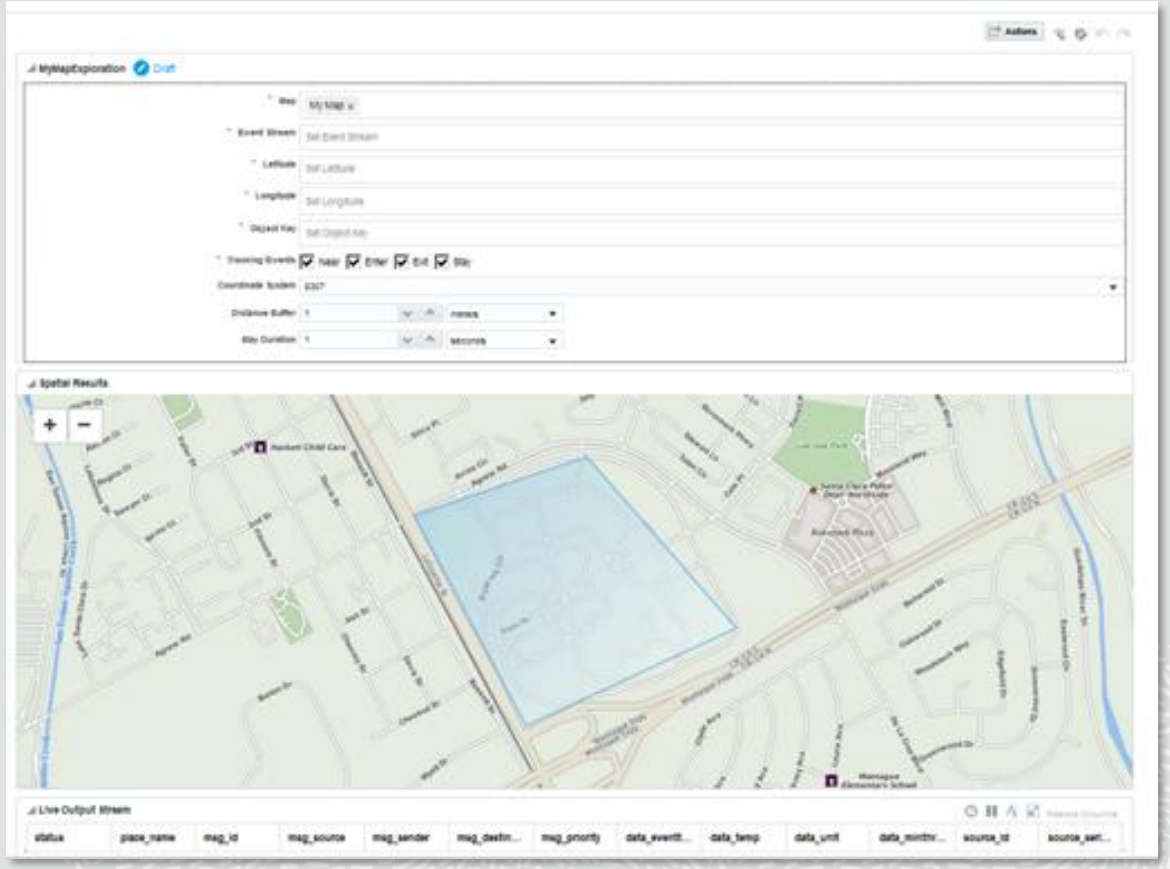
- Real-time platform to track movements of all vehicles
  - Integrated data platform for all relevant consumers of information
- Event-driven Architecture with Rules Engine
  - Based on Oracle Spatial and Graph, Weblogic, Stream Analytics
- Targeted distribution of relevant events in real-time
  - Faster and better decisions
  - Regulatory compliance
- Simple extension to other data sources
  - Could even be used to track individual passengers

OSCARS

GEO INTELLIGENT PLATFORM

Oracle Internet of Things (IoT) Cloud Service

- **Event-driven Architecture**
  - Built on top of Stream Analytics
- **Simplified application development, no coding required**
  - Support for different sensor types
  - Including device management
  - Comprehensive analytics
  - Application integration
- **Geospatial design patterns included**
  - Location-related events pre-defined (enter, exit, near, stay)
  - Definition of areas-of-interest integrated



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Wrap up

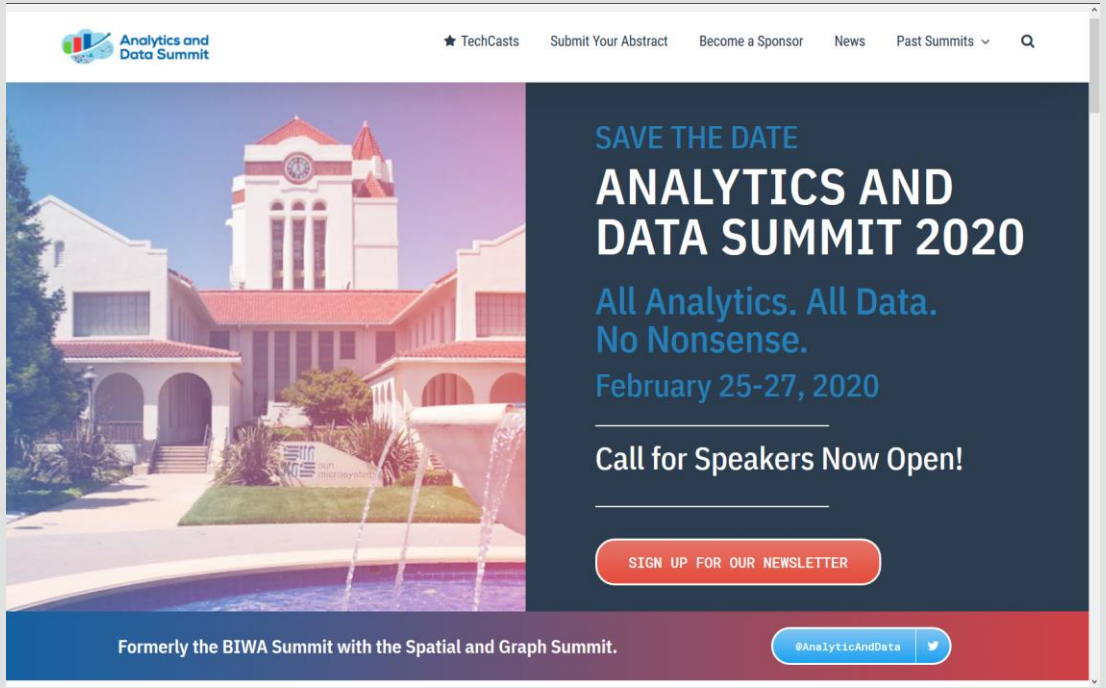
Further information

- Blogs, including announcement of licensing change
  - https://blogs.oracle.com/oraclespatial
- General information on oracle.com
  - www.oracle.com/goto/spatial
- Oracle Community forum
  - https://community.oracle.com/community/database/oracle-database-options/spatial
- Social Media
  - LinkedIn: „Oracle Spatial and Graph“ group
  - Twitter: @SpatialHannes, @agodfrin, @kpatenge

Spatial @ Analytics and Data Summit 2020

February 25-27, 2020, Oracle Santa Clara campus, Santa Clara, CA

- Dedicated track for Spatial technologies
- Wide variety of talks
  - Keynote by US Census Bureau
  - Outfront Media
  - ITG (Warsaw)
  - Geospace, HERE, OSCARS,...
- Complete agenda is now available
- www.analyticsanddatasummit.org



Thank you

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