Oracle Spatial Technology: Enabling Location Analysis in Oracle

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Overview

- Introduction
- Oracle Spatial: An Overview
- New Features in 10g
- Oracle Spatial in Action
**What is Spatial Data?**

GIS (mapping) data  
CAD data  
CAM data  
Address data

1 WTC, New York: Geocode to obtain Spatial location

**In General**

85% of Customer Data has a Spatial component e.g. zipcode, City, state
Integrating Spatial & eBusiness

Location adds significant value providing graphical view of supply chain, assets, customers, suppliers.
How to Manage Spatial Data: Early Spatial Systems - Hybrids

- Attributes in database
- Geometries in database - but in proprietary binary format
- IT can access geometries via proprietary interfaces only
- Poor integration
Open Spatial Databases: Oracle Spatial

- Spatial is native DBMS type
- Attributes and geometries integrated in database
- Supported by all GIS
- Supported by eBusiness applications
- Spatial data queried using SQL, Java
Oracle Stack is Spatially Enabled

- 3rd party GIS Tools
- Mobile & Wireless
- ERP Applications
- CRM Applications
- Business Intelligence
- XML Database
- JDeveloper Tools
- Design Tools
ORACLE 10g DATABASE

A Spatially-enabled Database
Oracle Spatial: Overview

Spatial Data Analysis, Mapviewer

Spatial Data Types

All Spatial Data Stored in the Database

Oracle10g Spatial

Spatial Access Through SQL

Spatial Indexing

Fast Access to Spatial Data
## Storing Spatial Data in Oracle

### Roads Table

<table>
<thead>
<tr>
<th>ROAD_ID</th>
<th>NAME</th>
<th>SURFACE</th>
<th>LANES</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pine Cir.</td>
<td>Asphalt</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2nd St.</td>
<td>Asphalt</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3rd St.</td>
<td>Asphalt</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
Example

```
SQL> CREATE TABLE roads (  
  2    name       VARCHAR2(30),  
  3    surface    VARCHAR2(30),  
  4    lanes      NUMBER,  
  5    location   MDSYS.SDO_GEOMETRY);
```

```
SQL> CREATE TABLE hospitals (  
  2    name       VARCHAR2(30),  
  3    location   MDSYS.SDO_GEOMETRY);
```
**SDO_GEOMETRY Type**

<table>
<thead>
<tr>
<th>SDO_TYPE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDO_GTYPE</td>
<td>Type of geometry</td>
</tr>
<tr>
<td>SDO_SRID</td>
<td>Coordinate System for Data</td>
</tr>
<tr>
<td>SDO_POINT</td>
<td>Type of Point</td>
</tr>
<tr>
<td>SDO_ELEM_INFO</td>
<td>Type of Element</td>
</tr>
<tr>
<td>SDO_ORDINATES</td>
<td>Type of Ordinate</td>
</tr>
</tbody>
</table>

- **SDO_GTYPE**: Type of geometry
  - Point (2001), Line (2002), Polygon (2003), Collection (2004), ...

- **SDO_SRID**: Coordinate System for Data
  - Geodetic, Projected, or Non-Earth
**SDO_GEOMETRY Type**

- **SDO_POINT of type**
  
  **SDO_POINT_TYPE:**
  
  - Attributes: X, Y, Z: Number
  
  - Specifies a point geometry

- **SDO_ELEM_INFO, SDO_ORDINATES:**

  Varray of Numbers
  
  - Varray of NUMBERs
  
  - Specify a **non-point** geometry

- **SDO_ORDINATES:** stores ordinates

- **SDO_ELEM_INFO:** interpret ordinates
Insertion in Spatial Tables

```sql
SQL> INSERT INTO hospitals values('St. John Hospital', SDO_GEOMETRY(2001, NULL, SDO_POINT_TYPE(-78, 37, NULL), NULL, NULL));
```

Data type: Geographic coordinates
Queries on Location in 10g

Find hospitals within 2-miles of World Trade Center

<table>
<thead>
<tr>
<th>SQL&gt; SELECT P.Name, P.Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>FROM Hospitals P,</td>
</tr>
<tr>
<td>Address_Master A</td>
</tr>
<tr>
<td>WHERE</td>
</tr>
<tr>
<td>A.St_Address=‘1 World Trade Center’</td>
</tr>
<tr>
<td>and A.City = ‘New York’</td>
</tr>
<tr>
<td>AND MDSYS.SDO_WITHIN_DISTANCE(</td>
</tr>
<tr>
<td>A.Location, P.Location,</td>
</tr>
<tr>
<td>‘distance=2’) = ‘TRUE’;</td>
</tr>
</tbody>
</table>
Indexes on Spatial Tables

SQL> CREATE INDEX hosp_sidx on hospitals(location) indextype is mdsys.spatial_index;

- Spatial index is Oracle’s R-tree
- Implemented using Oracle Extensibility
- Parallel Index Creation: Performance
- Partitioned Indexes on Partitioned Tables
  - Manageability, Scalability, Performance
- Supports a variety of spatial queries (operators)
Spatial Query Operators

- **SDO_WITHIN_DISTANCE:**
- **SDO_NN:** Nearest neighbor
  - Find nearest hospital to World Trade Center

```
SQL> SELECT P.Name, P.Address
2> FROM Hospitals P,
3> Address_Master A
4> WHERE
5> A.St_Address='1 World Trade Center'
6> AND A.City = 'New York'
7> AND MDSYS.SDO_NN(
8>     A.Location, P.Location)
9>     = 'TRUE' and rownum<=1;
```
**Spatial Query Operators (contd.)**

- **SDO_RELATE**: Find table rows (A) that interact with query geometry (B)

- **Interactions:**
  - Contains
  - Inside
  - OverlapBdyIntersect
  - Covers
  - Coveredby
  - OverlapBdyDisjoint
  - Touch
  - Equal
  - Disjoint
  - A red
  - B green
Spatial Analysis Functions (non-index based)

- Metric Functions
  - AREA, LENGTH, DISTANCE
  - E.g., select sdo_area(geom) from dual;

- Set Functions
  - Union, Intersection, Difference, XOR

- Analysis Functions
  - Buffer, Centroid, Convex Hull

- Aggregate Functions
  - Similar to SQL aggregates (sum, avg, etc)
  - aggregate unions, centroid, etc.
Oracle10g Location Features

**Locator**
- Points, lines, polys
- 2D, 3D, 4D data
- Spatial Operators
  - Within-distance
  - Spatial Relations
- Coordinate Systems
- Long Transactions
- Table Partitioning*
- Object Replication*
- Oracle10g Standard & Enterprise

**Spatial**
- All Locator features
- Linear Referencing
- Spatial Aggregates
- Coordinate Transforms
- Network Data Model
- Topology Data Model
- GeoRaster
- Geocoder
- Spatial Analytic Functions

* Available on Enterprise Edition Only
**Location-enabling Oracle Stack**

#### Web Services
- SOAP
- WSDL

#### Data Server
- Spatial
- Locator
- Oracle9i

#### Application Server
- Location Base Service Components
- TCA schema
- Field Service
- e-Business Suite

#### CRM & ERP Applications
- CRM & ERP Applications

#### Any device
- Oracle Location Technology
- Oracle core technologies
Oracle ApplicationServer 10g MapViewer

- Standard component of Oracle ApplicationServer 10g
- 100% J2EE compliant Mapping engine
- Tightly integrated with Oracle Locator and Oracle Spatial
- Provides an XML API for defining and deploying maps via the web
- Renders data from Oracle8i R3 and beyond
MapViewer: Map

- Renders data stored using Oracle’s native spatial data type (SDO_GEOMETRY)
- Maps are defined as a collection of themes
- Maps may contain a title, legend and footnote
- Theme styles can be based on attribute values (thematic maps)
- GIF, BMP and PNG image formats
MapViewer Architecture

DATABASE 9i

IAS 9i

MapViewer

JDBC

XML: MapRequest

HTTP

XML: MapResponse
New Features in Oracle Spatial 10g

- Network Data Model
- Topology Data Model
- GeoRaster
- Geocoder
- Spatial Analytic Functions
10g: Network Data Model

- **Network Data Model**
  - A data model to store network (graph) structure in the database
  - Explicitly stores and maintains connectivity of the network
  - Attributes at link and node level

- **Routing Engine**
  - Street navigation for single or multiple destinations
  - Provide network analysis functionality in the database

- **Supports network solutions (Tracing & Routing)**
  - Transportation and Transit Solutions
  - Field Service, Logistics
  - Location based Services and Telematics
10g: Topology Data Model

• New data model to store persistent topology
  - Easier to do data consistency checks in this model
  - Example: when the road moves, the property boundary automatically moves with it

• Topology Data Model and Schema
  - Describes how different spatial features are related to each other
  - A land parcel shares the boundary with a road

• 10g continues to support transient topology
  - Topology computed on demand
10g: GeoRaster

- **What is GeoRaster**
  - A new data type to store raster data
    - Satellite images, remote sensing data
  - An XML schema to store Metadata
    - Data source, layer information
    - Geo Referencing information
  - How to relate a pixel in the image to a longitude/latitude on Earth’s surface

- **Functionality**
  - Open, general purpose raster data model
  - Storage and indexing of raster data
    - No size limit for each raster object
  - Querying and analyzing raster data
  - Delivering GeoRaster to external consumers

- Publish as JPEG, GIFF images
10g Geocoder

- Generates latitude/longitude (points) from address
- International addressing standardization
- Formatted and unformatted addresses
- Tolerance parameters support fuzzy matching
- Record-level and batch processes
- Data provided by leading data vendors
10g: Spatial Analytic Functions

- Discovery based on Spatial Patterns
  - Explicitly materialize spatial relationships

- Usage
  - Insurance risk analysis, crime analysis
  - Demographic analysis, customer profiling
  - Epidemiology, Facility placement
  - Insurance Risk analysis:
    - cluster house-holds based on high risk neighborhoods
  - Identify business prospects across a region:
    - examine the average incomes across different regions of the space
Complying to Open Standards

- OGC (GML, OpenLS)
- ISO TC211
- W3C Consortium (XML/Web Services)
- J2EE
The Dominant Spatial Database

- **National Mapping, Cadasters & Hydrographic Agencies**
  - NIMA, USGS, US Army, Ordnance Survey (UK, IR, NI), Denmark, Sweden, The Netherlands, Poland, Australia

- **Transportation Management**
  - California, Iowa, Florida, Maine, Maryland, Minnesota, New York, Oklahoma, Pennsylvania, Alabama, Alberta, London Rail, Netherlands Transport, Australia, Austrian Rail, German Rail

- **Telco & Wireless LBS**
  - AT&T, Bell South, Cingular, DoCoMo, KDDI, Intrado, JPhone, Nextel, Sprint, T-Mobile, Telkom, Telenor, Telstra, Telus, Telia, Cellcom, Verizon, VIAG, Vodafone, Wind

- **Utilities**

- **Local Authorities**
  - New York City, Chicago, Los Angeles, San Jose, San Mateo, Washington DC, Cleveland, Detroit, Phoenix, Winnipeg, Vancouver, Edmonton, Stockholm...
Oracle Spatial in Action
Ordnance Survey, UK

- Captures data: Surveying
- Migrates (partially) from Complex Systems to Oracle (and Spatial) to manage Spatial Data

Maia (maintenance)

Mercury (publication)

Oracle 10G Spatial
OS Summary

- 450M features, 1TB Data
- Robustness, reliability, scalability, availability
- Expect financial and strategic gains from the move to Commercial Off-The-Shelf software (Oracle and ESRI)
New York City

- Department of Information Technology & Telecommunications
  - Developed standardized digital basemap for all agencies
    - 6,000 miles of underground pipes
    - 1 million water/sewer connections
    - 32,000 sq. miles of Infrastructure Data
    - 7,500 digital photographs
- The Office of Emergency Management created a public site for emergency preparedness
  - Extensively Used To Support
The consolidated spatial data warehouse was the foundation for NYC’s response to the recent tragedies:
- First responder deployment
- Critical infrastructure management
- Road closures
- Evacuation areas
- Damage assessment

The Office of Emergency Management created a public site for emergency preparedness:
- Hurricane flood risks and evacuation routes
- Heat Advisory “cool down locator” (pools, senior centers, community centers)

Department of Health uses the system to track instances of West Nile Virus.
City of Edmonton

- Integrated, central repository for spatial and relational data
  - Replaced 49 disparate land apps & 166 databases
  - Citywide sharing of standardized data
- Data feeds: land registry and surveys, utilities and phone co., tax assessments, Dept. of Public Works
- Users: engineers, planners, cartographers, city officials and departments, mortgage lenders, citizens
Oracle Spatial Technology: Summary

• An open repository for Geospatial data
• Integrate location & Business data in RDBMS
• Industry standard for Spatial data in RDBMS
• Robustness, reliability, scalability, availability
  - Support Terabytes of Data, 1000s of Users
• Security and Reliability
• Short & Long Transaction Management
What the Analysts are Saying about Oracle Spatial...

“In repeated surveys, IDC has found that Oracle is used in an 80%-90% share of Spatial Information Management oriented database installations.”

IDC, December 2002