Oracle’s Spatial Technologies

Oracle Locator
Oracle Spatial
OracleAS MapViewer
Presenters

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Agenda

• Spatial Data Challenges
• Oracle Spatial
  • Linear Referencing Systems
  • Spatial Aggregate Functions
  • Spatial and Locator
  • Oracle Application Server MapViewer
• Oracle Spatial Technology Partners
• New Major Release: Oracle 10g
• Oracle Spatial – Beyond 10g
In the Past
Challenge of Integrating GIS & MIS

GIS/Design

MIS

Spatial Data

Tabular Data

Geo Engineering Server

Enterprise Data Server

GIS/Design

MIS
Evolution of GIS

Past

Monolithic GIS
Proprietary Files

Application

Spatial Middleware
Proprietary APIs

Traditional DBMS

Standalone

Proprietary Middleware

Today

Spatially Enabled Database

Application

Map Server
Open APIs

Internet Platform
Oracle Spatial 10g
Oracle Spatial Development History

- **Oracle 7.1.6**
  - Points Only

- **Oracle 7.3.3**
  - Points, Lines, Polygons
  - Quad-Tree indexing

- **Oracle 8i Spatial**
  - Spatial Data Option
    - Points Only
  - Spatial Operators
  - Coordinate Transformation
  - Linear Referencing
  - Spatial Replication
  - Spatial Partitioning

- **Oracle 9i Spatial**
  - Object Data type
  - Circles, Arcs
  - R-Tree Indexing
  - Topology/Distance Operators
  - Spatial Functions
  - Oracle Enterprise Manager (OEM)

- **10g Database**
  - Raster Data Management
  - Topology & Networking
  - Spatial Analysis and Mining

Timeline:
- 1994: Oracle 7
  - No Spatial Capability
- 1995: Oracle 7.1.6
  - MultiDimension
- 1997: Oracle 7.3.3
- 1999: Oracle 8i Spatial
- 2001: Oracle 9i Spatial
- 2003: 10g Database
- 2004: 2005
Oracle10\textsuperscript{g} Core Spatial Capabilities

Spatial Data Types

- Points
- Polygons
- Lines

All Spatial Data Stored in the Database

Spatial Analysis Through SQL

```sql
SELECT a.customer_name, a.phone_number
FROM policy Holders a
WHERE sdo_within_distance( a.geom, hurricane_path_geom,
  'distance = 10 unit = mile') = 'TRUE';
```

Spatial Indexing

Fast Access to Spatial Data
Longitude/Latitude Data Considerations
Whole Earth Model

- P1 and P2 are 1 degree apart (about 111 Km apart)
- P3 and P4 are 1 degree apart (about 10 Km apart)
- Oracle Spatial can operate on Longitude/Latitude data
Coordinate Systems

• Support for whole Earth model (latitude/longitude)
  • Ellipsoidal computations
  • Accurate distance and area calculations (unit support)
  • Support for geometries that span the poles and the 180 meridian

• Support for projected coordinate systems
  • Cartesian computations
  • Many supported: UTM, State Plane, and many more…
  • Geometries fall off the edges of the projection

• Support for non-Earth coordinates (e.g., floor plan)
Ship Track That Crosses the 180 Meridian
Oracle Spatial
Linear Referencing Systems (LRS)
What Is Linear Referencing (LRS)?

Commonly used in many GIS applications such as:
- transportation (road network)
- utilities (pipeline and gas lines)
LRS Concepts

Clip from measure 5 to 20
A.K.A. Dynamic Segmentation

(5,10,0) -> (15,5,11.2) -> (40,5,38) -> (50,15,53.8) -> (55,20,60)

(53,17) is located at measure 52
A.K.A. Locate Point
LRS Application – Oracle Spatial

• **US Airspace Boundary Crossing Application**
  - Oracle Spatial functions to calculate intersection of flight paths and US airspaces.
  - Linear Referencing to interpolate the time and altitude for entry/exit points of US airspace.
  - Accurately charge foreign carriers for the amount of time in US airspace.

![Diagram of US airspace with flight paths and points of interest marked with symbols for actual radar blips and computed coordinates.](image)
OracleAS MapViewer and Oracle Spatial LRS

- MapViewer application for flight plan visualization
- Spatial analysis to project current flight position to next waypoint of original flight plan.
- Another example of LRS functionality
Oracle Spatial
Spatial Aggregate Functions
Spatial Aggregate Functions - Example

Generate New York state boundary by aggregating counties

```sql
SELECT SDO_AGGR_UNION(sdo_aggr_type(a.geometry, 0.5))
FROM counties
WHERE state = 'New York';
```
SDO_AGGR_CONVEXHULL

- Snap a rubber band around contaminated wells
- Dynamically generate new region
- Further analysis with new region, e.g.
  - Search for chemical plants within 5 miles of new region
Oracle Spatial 10<sup>g</sup>
New Feature - GeoRaster
Raster Data and Cell Size

Coarser resolution

Finer resolution
Raster/Vector Data Differences

Vector Data                  Vector Coordinates                     Raster Data

-74.1651749, 41.339141

-74.1651749, 41.339141,
-74.1651749, 39.559004,
-72.9792214, 39.559004,
-72.9792214, 41.339141
Grid Raster Data

A Value Attribute Table (VAT) is used to map the stored numeric values to the meaning of that value.

An example value attribute table for geological raster data:

<table>
<thead>
<tr>
<th>CELL VALUE</th>
<th>GEOLOGICAL PERIOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quaternary</td>
</tr>
<tr>
<td>2</td>
<td>Tertiary</td>
</tr>
<tr>
<td>3</td>
<td>Paleocene-Cretaceous</td>
</tr>
<tr>
<td>4</td>
<td>Mesozoic</td>
</tr>
<tr>
<td>5</td>
<td>Gondwana</td>
</tr>
<tr>
<td>6</td>
<td>Early Palaeozoic</td>
</tr>
<tr>
<td>7</td>
<td>Proterozoic</td>
</tr>
<tr>
<td>8</td>
<td>Early Proterozoic</td>
</tr>
<tr>
<td>9</td>
<td>Archaean</td>
</tr>
<tr>
<td>0</td>
<td>Blank Cell (no data)</td>
</tr>
</tbody>
</table>

A value attribute table can also contain user-defined columns.
Grid Raster Data

A **COLORMAP** table is used to map the stored numeric values to the display characteristics of that value.

An example **COLORMAP** table for geological raster data:

<table>
<thead>
<tr>
<th>CELL VALUE</th>
<th>Red</th>
<th>Green</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>255</td>
<td>255</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>82</td>
<td>123</td>
<td>67</td>
</tr>
<tr>
<td>3</td>
<td>142</td>
<td>230</td>
<td>98</td>
</tr>
<tr>
<td>4</td>
<td>96</td>
<td>121</td>
<td>228</td>
</tr>
<tr>
<td>5</td>
<td>145</td>
<td>231</td>
<td>243</td>
</tr>
<tr>
<td>6</td>
<td>255</td>
<td>51</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>203</td>
<td>188</td>
<td>224</td>
</tr>
<tr>
<td>8</td>
<td>195</td>
<td>135</td>
<td>75</td>
</tr>
<tr>
<td>9</td>
<td>204</td>
<td>102</td>
<td>255</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The table above shows how each cell value corresponds to specific red, green, and blue values, which are then mapped to a color. This is visualized in the diagram on the right, where each cell is filled with a color that matches the values in the table.
Raster Data Concepts – (Digital Imagery)

- **Digital Imagery** - a specialized type of raster data

  - Examples include:
    - Satellite imagery
    - Airborne photographs
    - others…
Raster Data: Digital Images

Each band collected at different wavelength for later processing and/or display

<table>
<thead>
<tr>
<th>Wavelength (μm)</th>
<th>Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4</td>
<td>Ultraviolet</td>
</tr>
<tr>
<td>0.5</td>
<td>Blue</td>
</tr>
<tr>
<td>0.6</td>
<td>Green</td>
</tr>
<tr>
<td>0.7</td>
<td>Red</td>
</tr>
</tbody>
</table>

Band 1

Band 2

Band 3
Some bands may accentuate different features
Blocking

- Index very large rasters into smaller blocks
- Interleave multi-band raster
  - Band sequential (BSQ)
  - Band interleaved by pixel (BIP)
  - Band interleaved by line (BIL)
Pyramidal structures show a hierarchical organization, with each level being a representation of the raw data at a coarser resolution. The pyramid level decreases from level 0 (raw data) to level 2, indicating a process of data aggregation or summarization.
GeoRaster: Oracle’s Raster Loader

- Oracle’s minimum support for loaders and exporters includes:
  - TIFF/GeoTIFF
  - ESRI World File
  - JPEG
  - GIF
  - BMP
  - PNG
- Oracle relies on partners to import from / export to many formats
GeoRaster - Features/Functionality

• Store, index, and retrieve raster data
• Store, maintain, and retrieve GeoRaster metadata
• Analysis functionality:
  • Generate pyramids
  • Copy
  • Change format: Interleaving, blocking
  • Subset: Crop, cut, clip by band or layer
  • Scaling: Enlarge or reduce
  • Generate the spatial extent of an image
  • Tile adjacent images to build a mosaic of the data
  • Georectified/Georeferenced images supported

• MapViewer supports visualization of GeoRaster data
Oracle Spatial 10\textsuperscript{g} New Feature

Geocoder

- Geocoding Engine included in Oracle Spatial
- Generates latitude/longitude (points) from address
- Supports:
  - International addressing standardization
  - Formatted and unformatted addresses
  - Fuzzy matching
  - Transaction and batch capabilities
- Data dictionary completely extensible
- Base data available from NAVTEQ & Tele Atlas
  - Download sample data from NAVTEQ
Oracle Spatial 10\textsuperscript{g} New Feature

Router

- Routing algorithms included in Oracle Spatial
- Generates driving directions
- XML API
- Base data available from NAVTEQ & Tele Atlas
  - Download sample data from NAVTEQ
Oracle Spatial 10g
New Feature
Persistent Topology
Introduction
Topology Example

• Land parcel features
  • Land Parcel 1 associated with face F1
  • Land Parcel 2 associated with face F2
  • Both faces include edge E3.

• Stream features
  • Stream 1 associated with edge E3 (and edges E1 and E5)
Oracle Spatial 10g

New Feature

Network

Data Model
Network Data Model

- Open Data Model For Graph Analysis
  - Store network (graph) structure in the database
  - Maintains connectivity of the network
  - Attributes at link and node level
- Supports Network solutions (Tracing & Routing)
  - Transportation and Transit Solutions
  - Field Service, Logistics
  - Location based Services and Telematics
- Bio-Info Pathways (Life Sciences)
  - Biological Pathways
  - Protein-Protein Interaction
- Network Viewer
Oracle Spatial 10\textsuperscript{g}
Spatial Analysis and Mining
Spatial Analysis and Mining

• Everything is related to everything else, but nearby things are more related than distant things.

Tobler’s first law of geography
Spatial Analytic Functions

- Discovery based on Spatial Patterns
  - Cluster analysis
  - Location prospecting
### SDO_SAM.AGGREGATES_FOR_GEOMETRY: Example

#### Query
```sql
SELECT SDO_SAM.AGGREGATES_FOR_GEOMETRY(
    'GEOD_COUNTIES', 'GEOM',
    'sum', 'totpop',
    SDO_GEOMETRY(2001, 8307,
        SDO_POINT_TYPE(-73.943849, 40.6698,NULL),
        NULL, NULL),
    'distance=3 unit=mile')
FROM DUAL;
```

#### Results
<table>
<thead>
<tr>
<th>COUNTY</th>
<th>ST</th>
<th>TOTPOP</th>
<th>BY WINDOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queens</td>
<td>NY</td>
<td>1951598</td>
<td>00.5437756</td>
</tr>
<tr>
<td>Kings</td>
<td>NY</td>
<td>2300664</td>
<td>31.0430579</td>
</tr>
<tr>
<td>New York</td>
<td>NY</td>
<td>1487536</td>
<td>00.0188785</td>
</tr>
</tbody>
</table>

#### Example
```sql
SELECT SDO_SAM.AGGREGATES_FOR_GEOMETRY(
    'GEOD_COUNTIES', 'GEOM',
    'sum', 'totpop',
    SDO_GEOMETRY(2001, 8307,
        SDO_POINT_TYPE(-73.943849, 40.6698,NULL),
        NULL, NULL),
    'distance=3 unit=mile')
FROM DUAL;
```

#### Output
```
723570.362
```
Oracle Spatial 10\textsuperscript{g}
Some Miscellaneous New Features
Geodetic Optimized Rectangle Densified Along Latitude Lines

- `SDO_CS.VIEWPORT_TRANSFORM` no longer necessary
- Backported to 9.2.0.6
- Can span the 180 meridian
New SQL/MM Methods for SDO_GEOMETRY

- GET_WKB() – Get Well Known Text
- GET_WKT() – Get Well Known Binary

```sql
set long 500;
SELECT A.GEOM.GET_WKT()
FROM polygon_table a
WHERE id = 1;

A.GEOM.GET_WKT()
----------------
POLYGON ((146.0 66.0, 148.0 66.0, 148.0 68.0, 146.0 68.0, 146.0 66.0))
```
New SQL/MM Constructors for **SDO_GEOMETRY**

- Constructor input can be either:
  - SQL/MM Well-Known Text (WKT)
  - SQL/MM Well-Known Binary (WKB)

- These constructors return an **SDO_GEOMETRY** object:

```sql
SELECT SDO_GEOMETRY(
    'POLYGON ((146.0 66.0, 148.0 66.0,
    148.0 68.0, 146.0 68.0, 146.0 66.0))', 8307)
FROM dual;
```

Return value

```sql
SDO_GEOMETRY(2003, 8307, NULL,
    SDO_ELEM_INFO_ARRAY(1, 1003, 1),
    SDO_ORDINATE_ARRAY(146,66, 148,66, 148,68, 146,68, 146,66))
```
Oracle Spatial 10\textsuperscript{g} New Features: Summary

- GeoRaster data type
- Persistent Topology data type
- Network Data Model
- Spatial Analysis and Mining
- Geocoder in the database
- Routing Engine
- Core Feature
  - Transportable Tablespace Support for Spatial Indexes
  - New Functions
    - Point\_At\_Bearing
    - Simplify
    - others...
Oracle Application Server 10g
MapViewer
Oracle Application Server 10\textsuperscript{g} MapViewer

- Web Map Server
  - Standard feature of the Oracle Application Server
  - Integrated with Oracle Spatial and Oracle Locator
- Easily publishes data stored in Oracle’s native spatial data type (SDO\_GEOMETRY) to the web
- Provides an XML API, Java API and JSP Tag library
OGC Compliant Web Map Service (WMS)

- Supports the following requests:
  - GetMap
  - GetFeatureInfo
  - GetCapabilities

- MapViewer can:
  - Generate OGC WMS compliant maps
  - Render OGC WMS compliant maps generated by another OGC compliant WMS
  - Render vector and raster data on maps generated by another OGC compliant WMS
MapViewer Oracle Workspace Manager Support

• **Workspace Manager**
  - Oracle Database feature that lets you version-enable one or more tables in the database
  - Users can create workspaces
  - Users can go to workspaces
  - Edits to versioned enabled tables in a workspace can only be seen by users in that workspace

• **MapViewer** supports map requests from:
  - A specific workspace
  - A savepoint in a workspace
MapViewer: Map
Oracle10g Locator & Spatial Features

**Oracle Locator**
- All Data Types
- Spatial Operators
  - Topological
  - Distance
- Distance Function
- Implicit Coordinate Transformations
- Long Transactions
- Table Partitioning*
- Object Replication*
- Oracle Label Security

**Oracle Spatial 10g**
- All Locator features
- GeoRaster Data Type
- Topology Data Model
- Network Data Model
- Geocoding
- Routing
- Coordinate Transforms
- Linear Referencing
- Spatial functions
  - aggregates
  - buffer, centroid, union, etc

**Bundled Feature**
Standard & Enterprise Edition

**Licensed Option**
Enterprise Edition Only
Leverage Oracle’s Spatial Technologies

- Every organization wants to cut costs
- Oracle Spatial Technologies Bundle
  - Oracle Locator
    - Oracle Standard Edition
    - Oracle Enterprise Edition
  - Oracle Application Server MapViewer
    - Java Edition
    - Standard Edition
    - Enterprise Edition
- Leverage what you own
Oracle Spatial 10\textsuperscript{g} Release 2
GeoRaster: Compression

• Natively support two industry standard compression techniques
  • JPEG (lossy)
    – JPEG-B (abbreviated baseline JPEG format)
    – JPEG-F (full-format baseline JPEG format)
  • DEFLATE (lossless)
    – (a.k.a. ZIP)
  • each block is compressed and uncompressed individually

• All GeoRaster operations work on compressed/uncompressed GeoRaster objects
  • Automatic decompression on sub-set operations
Questions & Answers

For more information visit our web site at:
http://www.oracle.com/technology/products/spatial